AVO International

Megger BMM80, BMM2000,BMM2080, BMM2500 and BMM2580 Service Manual

Warning: Only suitably trained and qualified persons should undertake servicing of this product after reading the section on safety precautions.

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This document refers to instruments built with PCB 5440-254 Editions A4 onwards

Contents

Introduction

The Megger BMM80, BMM2000, BMM2080, BMM2500 and BMM2580 series of combined insulation/multi-meter testers use the same basic construction, with differences in components fitted, and in the stored configuration data . They are compact battery powered multi-function test instruments designed to enable an electrician to speedily test electrical installations to national and international standards. Low resistance and multi-voltage Insulation tests can be carried out. To complement the above functions the BMM series has mV, mA and uF, depending on which model, to allow telecoms and HVAC engineers to also use the instrument. The instrument will accept a wide range of mV transducers in the two 4mm terminals, further increasing its flexibility .The instrument is designed for safety and complies with EN 61010-1 (1993) and the relevant parts of EN61557.

The BMM series was launched at the end of January 2000 to enhance the BM400/80 range of insulation testers with additional multimeter functions and backlight. The BMM80 replaces the BM80, the BMM2000's and BMM2500's are wholly new instruments.

These differences are listed below.

	1000V	**500V**	**250V**	**100V**	**50V**	**V**	**mV**	**Ω**	**Buzzer**	**kΩ**	**uF**	**mA**	**RS232**
BMM80	√	√	√	√	√	√	√	√	√	√	√		
BMM2000	√	√	√			√	√	√	√	√		√	
BMM2080	√	√	√	√	√	√	√	√	√	√	√	√	
BMM2500	√	√	√			√	√	√	√	√		√	√
BMM2580	√	√	√	√	√	√	√	√	√	√	√	√	√

PCB Part Number and Edition
This manual refers to PCB 5440-254 (A4 onwards). The part number and edition of the PCB in the instrument you have can be found by marks in the copper at the top of the PCB that has the fuse fitted (main pcb).

Safety Precautions

While servicing the instruments suitable protection from mains supply voltages will need to be provided. For instance when measuring voltage this can include a 30mA RCD, isolation transformers and barriers.
High Voltages up to 1000V may be present inside the instrument, and capacitors may remain charged after test.
Take care to mark the position of all cable and wire fastenings on dismantling the instrument, and reinstate these after service.
Ensure that the inter-board insulator is in place and is not damaged . This is relied on for safety separation of the two boards and also for separation from the RS232 socket.
All replacement items must be of a type approved by AVO International Ltd to maintain product safety.
Before a repaired instrument is returned to the user a full test must be performed to ensure that the instrument is safe to use. All protective devices (fuses) must be present and fully operational.
A 4kV flash test is normally performed between all inputs (Positive and Negative terminals) and all pins of the serial connector.

Disassembly and Re-assembly

1. Disassembly

First disconnect all test leads, open the battery compartment and unclip the battery holder from the instrument. Remove the four screws, and lift the rear part of the case off. To remove the PCB pull the range knob off, and remove the PCB retaining screw from the middle of the PCB's. The PCB's can then be taken out of the front panel .

When the PCB's are removed they can be taken apart using a suitable lever to disengage the 3mm board spacers . Be careful not to damage the tracks or the inter-board insulator. The PCB can then be laid out flat ready for diagnostic work to be carried out or components to be replaced.

If a fault is considered to be in the measurement part of the circuit, the PCB may not require removing from the front cover, as the majority of the measurement circuits are on the back board. The top board contains mostly micro and control circuitry .

Particular attention needs to be paid to the inter-board edge connections, to ensure that they are not over flexed and snapped.

2. Display removal

There are components under the display, and unfortunately removal of the display is difficult because of the large number of pins that need to be unsoldered. If a display fault is obvious (e.g. marks or cracks), it is easier to cut the legs with a pair of wire cutters and then clean up the PCB afterwards. If the backlight must be removed, extreme caution should be used if damage is to be avoided. This component is quite fragile, as the four connection points are not metal pins, but small strips of double-sided pcb material which can easily break off. Re-assembly is straightforward, but it is worth checking that everything is working correctly beforehand. Clean the PCB holes of solder and bend the legs of the display slightly outwards so that it can be 'sprung' into place with the legs making contact with the PCB. (The epoxy seal on the display should be on the left-hand side, when viewed from the front). If there are contact problems, water can be applied sparingly with a small paint brush to each leg in turn, which will make adequate connection for a short while. Do not get water onto any other part of the circuit, as some parts are very sensitive to leakage. Dry the board afterwards with gentle heat, such as warm air from a hair-dryer. Do not forget to fit the backlight before final re-assembly.

3. Rotary switch.

This is a low voltage switch of simple construction, and indication of its position is provided by two voltages. See circuit diagram, sheet 5 for a table of expected voltages. To switch the instrument off, it shuts down the linear power supply by taking the shutdown pin low on the regulator . The fixed contacts are copper PCB pads, coated with Electrolube grease to reduce oxidation. The moving contacts are nickel-silver discs, one each side of the board, each having three points of contact. Two helical springs hold the discs in contact with the board. The spring pressure is sufficient to clean away dirt and contamination as the discs rotate. The resistance of the switch should not exceed 5ohms at each point of contact.

Life expectancy is 100,000 operations with the correct lubricant, when the discs will need replacing. A similar life will be obtained even without lubrication, the main purpose of which is to prevent the build up of copper oxide when the instrument is not used regularly. If the switch is disassembled and cleaned, it may be re-lubricated with almost any contact grease.

The switch can be disassembled by removing the centre screw. Re-assembly can be difficult and it is best to leave the springs out the first time just for practice. This gives you a chance to see how the parts fit together before they going flying all over the room.

4. Reassembly

This re-assembly procedure assumes that the instrument has been stripped down and the boards separated. You will need up to seven (7) cable ties (AVO part number 25274-417). These hold the wires internally to prevent the failure of a soldered joint causing a safety hazard.
Before folding the boards together ensure that all the spacers are present. Make sure that the inter-board insulator is in position, and that it sits correctly between the RS232 connector and the PCB (where applicable) . The tie-wraps that are placed towards the centre of the board also need to be pre-fitted as they cannot be put in place once the board is folded.
Check that the rotary switch is in a valid position - OFF is the best position, this corresponds to the largest notch on the switch mechanism pointing to the 9 o'clock position when viewed from the fuse clip side of the PCB. Place the PCB into the front panel, and wiggle the switch until it is fully engaged with the front cover ident mechanism . Screw the board to the front cover.

With the two instrument halves side by side the wiring loom can be re-connected.
The wires are terminated by looping the stripped ends around the harwin pins, and soldering.
Labels for the wires are marked in the PCB resist, and relate to the following connections.

SW	Blue.
PR	White.
+VE	Red from +ve terminal.
-VE	Red from –ve terminal.
A	Top of Red link on board.
A	Bottom of Red link on board.

If, for any reason, the terminal wires need re-soldering, a heat-sink must be inserted into the terminals to avoid the mouldings softening and distorting the terminal housings. The instrument's test-lead can be used.

Now check that the rotary switch and push buttons work as expected. A battery can be temporarily attached at this point to check the instrument powers up.

Cable ties are now used to ensure that the wires cannot cause a hazard if the solder joint fails. These are needed as follows:

1. Around Blue and White wires through hole in PCB.
2. Around Red (-ve) wire through hole in PCB.
3. Around Red (+ve) and Red (current link) wires through hole bottom of PCB .
4. Around Red (current link) through hole in top of PCB .
5. Around Battery wires and through the tab of TR25 (TO220) transistor.
6. Around Blue, White and Red (-ve) wires next to terminals forming a loom.
7. Around Battery and Red (-ve) wires next to terminals forming a loom.
8. Clip the Battery leads and the Red (current link) through the clip on top of the relay .

NOTE: The red (current) link is not present on the BMM80.

The back can then be screwed onto the front panel of the instrument with the original four screws.

Critical Components

The following components are safety related and if faulty must be replaced by an approved part. When inspecting an instrument for a suspected fault, these components must be checked for damage before connecting the instrument to any supply voltage.

HIGH INTEGRITY COMPONENTS

The following components are HIGH INTEGRITY. This means that the safety of the customer relies on these components. You therefore need to be sure that the correct components are used.

Circuit Reference	Description	Part Number	Manufacturer and Reference
R187,R175,R194,R179	Resistor 750k VR37	26837-066	Philips VR37 5%
R150,R155,R160	Resistor 10M VR37	26837-130	Philips VR37 1%
Fuse 500mA	500V F type 10kA HRC	25950-039	SIBA 70 065 63

Safety related mains rated components.

Circuit reference	**Description**	**Part Number**	**Manufacturer and Reference**	**Rating**
D36/D29/D31/D30	Diode 1N4007	28863-082	1N4007 (1000 V)	1kV
ZD2	Diode IN5355 Zener	28920-065	1N5355B	18V, 5% ,5W
D24	Diode BY448	28920-064	BY448(1500V)Fast Recovery	1500V
D330,D331,D332,D338	Diode 1N4007	28863-082	1N4007 (1000 V)	1kV
D19/D22	Diode 1N4007	28863-082	1N4007 (1000 V)	1kV
D25/D32	Diode BA159	28863-160	BA159	1A,1000V
RL1/RL2	Relays	25980-057	Takamisawa JS5-K	1 kV a.c. rms

BMM Series Circuit Description

Overview

Most of the functions of the instrument share a common core of hardware, which performs control, measurement, and display of results. This includes:

1. Power supplies
2. Microcontroller system
3. LCD and backlight
4. EEPROM
5. User controls
6. Control of hardware
7. 12-bit a/d converter system
8. EEPROM
9. RS232 communications

These are described in Section 1.

Section 2 deals with each type of measurement individually by switch position, with details of any special circuit blocks not already dealt with in Section 1.

Signal names and pin names are in uppercase and enclosed in single quotes. Pin names are in italics.

See also the supplementary circuit diagrams and the block diagram

Section 1

1. Power supplies

1.1 Battery

See sheet 5 of the circuit diagram

A few circuits are powered directly from the battery. These are, the overall power on/off switching circuit (sheet 5), 5V regulator VR1 (sheet 5), HV inverter transformer (sheet 4), current source amplifier (sheet 9), and the battery check circuit (sheet 6). The instrument is protected against battery reversal by the combination of TR23 and fuse FS2 (sheet 5). The fuse is a bimetallic self-resetting thermal type.

1.2 +5V rail

See sheet 5

A straightforward linear regulator (VR1) is used to provide the main 5V supply. This is less efficient than a switch mode supply, but is cheaper, simpler and causes less RF emissions. Cooling for VR1 is provided not only by the aluminium heat sink, but also by the tab and body of TR23, which are at 0V potential. The heatsink provides a useful ground connection for oscilloscopes, probes etc. The control signal, 'POWER ON', ('*SHDN-*' pin on VR1) enables or disabled the output from the 5V regulator. This signal is driven low when the instrument shuts down, or when the rotary switch is turned to the 'off' position.

1.3 -5V rail

See sheet 5.

This rail is produced by the action of charge pump IC2, which inverts the +5V supply. Tantalum capacitors are used in the circuit because of their superior performance over aluminium types. Unused components around the IC are to allow for the use of alternative integrated circuits, should the need arise.

For more information consult a Maxim MAX860 data sheet.

1.4 Auxiliary 5V rails

See sheet 5.

As an energy saving measure, the main 5V rails do not power all of the circuitry, Certain sections, such as the HV inverter control section, and insulation current measurement, are supplied from the auxiliary rails (+/-5V(A)). They are connected to the main 5V lines by fet switches TR2 (p-channel) and TR3 (n-channel). When a measurement is initiated, for example by pressing the ‘test’ button or detecting a load at the terminals, the extra 5V rails are turned ‘on’ by putting a low level on 'AUX POWER OFF'. This signal is the correct polarity to drive TR2, but has to be inverted (by TR7) in order to control TR3.
Note that 'A' in +/-5V(A) stands for 'auxiliary', not 'analogue'.

1.5 0V rails

Three separate 0V returns are provided - one to handle digital sections of the circuit, one for analogue, and one for signals. 0V(D) and 0V(A) originate by the 5V regulator (VR1, sheet 5), but 0V is taken off near RL3 (sheet 1). Very little current flows along the 0V signal line, and in fact in certain places the positive current flowing into it is deliberately cancelled by a negative current (e.g. R10 & R11, sheet 3). This ensures that its potential is the same everywhere on the printed circuit board. Thus it can be used as a reliable reference point for accurate measurements.
Note that 'A' in 0V(A) stands for 'analogue', not 'auxiliary'.

1.6 Power on/off circuit

See sheet 5.

Consider the instrument with the rotary switch in the ‘off’ position, as it appears on the circuit diagram. IC6 & VR1 are powered up at all times. IC6 (pins 1 - 6) is configured as a simple latch, with ‘set’ and ‘clear’ inputs. Pins 8 & 9 are pulled to battery voltage. If the instrument is now turned on, by turning the rotary switch, pins 8 & 9 are pulled down by R52, providing a brief high level pulse on pin 5 via C1 & R84. This clears the latch, putting a low level on pin 4. This is inverted by IC6 pins 11,12,13 to produce a logic 1 on VR1 ‘*SHDN-*‘ pin (‘POWER ON’), which turns on the main power to the instrument.
Conversely, power is turned ‘off’ by a high level on IC6 pin 1 or 2. This is done either via D7 from the rotary switch or via the ‘OFF’ signal from the microcontroller. When the instrument shuts itself down, ‘OFF’ is set high. This produces a logic 1 on IC6 pin 1 after level shifting to battery voltage by TR5 & TR8.

1.7 Battery check circuit

See sheet 6

This circuit uses an LM339 comparator (IC9). The LM339 has ‘open collector’ outputs, which can sink current, but not source it. I.e. they can pull ‘down’, but rely on an external resistor to pull ‘up’.
Under normal circumstances IC9 pins 10,11 & 13 play no part in the battery voltage check, since pin 13 is in its ‘open’ condition. The battery voltage is simply halved by the potential divider R76/R92 and fed to a channel of the 8-bit a/d converter for measurement, as ‘BATT/2’. However, there could be a problem if the batteries are too low to produce a full 5V rail. This is because the micro’s a/d converter uses 5V as its reference and would give erroneous results (too large). Thus a bad battery could go undetected. The IC9 circuit overcomes this. There is a quasi-constant voltage on pin 10, and IC9 can detect if the battery voltage is very low. If so, ‘BATT/2’ is pulled down by pin 13 to guarantee a low reading from the a/d.
When the instrument is turned ‘off’ (‘POWER OFF’ = battery voltage) TR10 disconnects R76 & R92 to reduce battery drain.

1.8 Power consumption.

The overall power consumption depends on the battery voltage, and also varies between instruments due to the spread in parameters of the components. Approximate figures for the battery current are given below. (Battery voltage 8V).

Switch Position	Current
RCL	40mA
Insulation, before test, no volts present	40mA
Insulation, before test, volts present	65mA
Insulation, testing, 50V range, open circuit	110mA
Insulation, testing, 50V range, short circuit	160mA
Insulation, testing, 1000V range open circuit	210mA
Insulation, testing, 1000V range short circuit	160mA
Off/shutdown	25uA
Voltage, no volts present	40mA
Voltage, volts present	65mA
mV	65mA
Continuity, open circuit	40mA
Continuity, 2k load	65mA
Continuity, short circuit	325mA
Buzzer, open circuit	40mA
Buzzer, 2k load	65mA
Buzzer, short circuit	350mA
Kilohms	65mA
Capacitance	65mA
mA, before test, no volts present	40mA
mA, before test, volts present	65mA
mA, testing	110mA

2. Micro controller system

2.1 Microcontroller

See sheet 7

The micro has on-board 2K of RAM and also 60K of ROM, which contains the program instructions. It runs from an 8MHz crystal. It has a built-in 8-bit 12-channel a/d converter (with a conversion time of a few microseconds), numerous timers, interrupt pins, i/o ports, an RS232 port and a display driver.

Special port usage -

Port 1:
Bit 1 - timer output for buzzer drive
Bit 3 - interrupt pin for frequency measurement
Bit 5 - interrupt pin for external a/d converter
Bit 7 - interrupt pin for pulse timing

Port 3
Pseudo data bus for interface with push buttons, latches, a/d converter, diode links.

Port 4
Bits 1 & 2 - serial input and output for RS232 communication.
Bit 3 - interrupt pin for voltage detection.

Port 5, 6, 7, 8 & 9
Display drivers

Port B, C
8-bit a/d converter channels

Other port bits are general-purpose input/output.

Timer usage.
The on-board timers are used for many tasks including key-press timing, pulse timing, frequency measurements, and buzzer control.

For further information consult a Hitachi H8/3837 data book.

2.2 Watchdog/reset circuit

See sheet 11.

IC303 is configured as two linked monostables. At power up, C314 and C322 are initially in a discharged condition, which forces both ‘Q’ outputs to be logic 0 (pins 4 & 12). Thus the ‘RELAY ENABLE’ line is low and the ‘RESET-‘ line to the microcontroller is high. A short time later (a few ns) C314 has charged, enabling the right-hand half of IC303. A few ms later, C322 has charged, which enables the left-hand half of IC303 and also starts monostable action in the right-hand half, driving ‘RESET-‘ low. After about 40ms the right-hand monostable times out and the microcontroller begins executing code. Following an initialisation sequence, the micro pulses the ‘WATCHDOG’ signal high for a few microseconds to start to the ‘watchdog’ action. This pulse must be repeated every few ms, or an automatic reset will be generated. This is a safety device, which restarts the system in the event of a 'crash'. Once the watchdog has been started, the ‘RELAY ENABLE’ signal goes high, allowing the relay control signals to function. Prior to this, the relays are prevented from being energised - another safety precaution.

2.3 Brownout detector

See sheet 11

If the 5V rail dips excessively due to a surge or loss of power, the voltage on pin 7 of IC307 will drop below that on pin 6, as the latter is quasi-constant at about 0.6V, and is also supported by C333. Thus IC307 pin 1 is driven low, thereby forcing a microcontroller reset through the action of IC303.
Note: IC307 has ‘open collector’ outputs.

2.4 8-bit a/d converter

See sheet 7

The 3837 microcontroller (IC306) uses the voltage on its ‘*AVCC’* pin (i.e. 5V), as a reference to calculate the value on the selected input channel. The inputs are on pins 93-100 and 1-4 (ports B & C). The input range is 0V to +5V, and cannot be negative. Only one channel can be read at any given time - this is selected by software. The conversion time is 15.5us. Only 8 of the 12 channels are used on the BMM series.

Channels 0 & 1 sense the position of the rotary switch
Channel 2 measures the battery voltage
Channels 3 & 4 sense the voltage on the positive terminal (scope < 10V)
    The main use for this is on the buzzer range.
    Secondary uses include overload sensing on mV & capacitance
    & blown fuse detection on mA
Channel 5 is used for blown fuse detection on continuity and buzzer ranges.
Channels 6 & 7 are used at start-up to self-check the 2.5V reference and the -5V rail, (special modes only).

3. LCD and Backlight

The display (LC300, sheet 7), is a three-way multiplexed, one-third bias transflective type driven directly by the microcontroller. The contrast level is set by resistor chain R352, R365, R353 & R366. Each of the 40 segment drivers on the micro (‘SEG(XY)’), can control up to 3 display segments each. On the BMM series, 2 drivers are unused. If all 3 of the segments under control of a particular driver are ‘on’, the waveform will be a 4.5V square wave. When all segments are off, the square wave should be only about 1.5V in amplitude. The frequency should be 250Hz. The backplane signals (‘COM(1) - ‘COM(3)’), are complex waveforms with steps at three different voltage levels.
The backlight (BL300, sheet 11) is an led type having a row of leds down each side. To prevent the backlight current from affecting the 5V rail, each set of leds is driven from the battery rail using quasi-constant current sources. When the ‘BACKLIGHT ON’ signal is high, TR302 is turned ‘on’ and a voltage is developed across D300 & D301 which is approximately independent of the supply. The volt drop across TR300 b-e junction is also fairly constant, resulting in a controlled current through R300 & R303, and therefore through one half of the backlight. The other half is driven by TR301 in a similar arrangement, thereby ensuring equal brightness at the two edges of the backlight. The plastic diffuser spreads the light fairly evenly across the full width of the display.

4. EEPROM

See sheet 7

IC308 is an 8kbyte non-volatile memory, which stores results, calibration data, and certain parameters such as ohms null, along with the selected foreign printer language (if required). It also holds the all-important set-up data, which takes the form of a 32-bit string. This gives the instrument its identity, telling it which family member to be, and which features to allow. This data is transferred to the instrument during setting-up on the 'test & calibrate' fixture. Prior to this, the EEPROM is blank, and all its bits are set to 1. In this situation, the instrument defaults to a basic model, with just enough features enabled so that it can be adequately checked on the functional tester.
EEPROMS manufactured by Xilog can also be used on the BMM series. They are not directly equivalent to the Microchip type, but the instrument auto-detects which kind has been fitted, and then uses the appropriate protocol.

There is little to go wrong with the EEPROM system as it has a simple 2-wire serial link direct from the microcontroller. ‘SCL/AD CE-’ is the serial clock line, which also doubles up as the 7109 a/d converter chip select line. All EEPROM data is inputted and outputted via the ‘SDA’ signal.

For further information consult a Microchip 24C64 data sheet.

5. User Controls

5.1 Rotary switch

See sheet 5.

The rotary switch merely acts as a position indicator and an on/off control. It does not switch any measurement signals.
The switch rings on the component side of the pcb (SW2), select the function. The resistor chain R136….R108 provides seven different voltage tappings to the outermost set of contacts. In each switch position, the raised pips on the switch plate touch one contact on each of the three concentric rings. This impresses a unique pair of voltages on the ‘SWITCH A’ and ‘SWITCH B’ signals. These voltages are read by two of the 8-bit a/d converter channels, and the microcontroller is able to deduce the angular position of the switch.
The switch rings on the underside (SW1) control power on/off. In the ‘off’ position, battery voltage is put onto IC6 pin 2, which forces a low level onto the 5V regulator ‘*SHDN*-‘ pin (‘POWER ON’ signal). For more details see the ‘Power on/off ‘ circuit description, elsewhere in this document.

5.2 Push buttons

At regular intervals, the ‘KEYS-‘ signal (sheet 7), normally high, is taken low for a few microseconds. If any of the yellow buttons (SW300, SW301, SW303, SW304) are pressed, the corresponding line on the data bus (‘D(0)’ - ‘D(3)’) will be pulled low by one of the diodes D303 - D306. Otherwise, the data line will be high, owing to the pull-up resistors R382 etc. At the same time, the 4 auxiliary diodes are read (D319, D320, D325 & D326). If a particular diode is fitted, logic 0 will be asserted on the appropriate data line. The group of 8 diagnostic diodes is checked similarly, by pulling the ‘DIODES-‘ signal low.
The ‘test’ button (SW302, sheet 11) has its own connection to the microcontroller. There is a pull-down resistor on sheet 5 (R204), so the level on the 'TEST BUTTON' line is low, except when the button is pressed. This signal feeds through series resistors R50, R49 & R48 and then to the microcontroller as the ‘TEST’ signal.

5.3 SP1 probe

See sheet 5

The SP1 probe optional accessory has 3 connections to the instrument. Two are for the push button (PL5 & PL6), which effectively connects in parallel with the ‘test’ button in the instrument. R93, R96, R49, D6, D40 & R48 provide token overload protection as these connections are exposed to the outside world.
The third connection from the probe is for the measurement, and goes to the -ve input terminal. This is not on the pcb, and is not shown on the circuit diagram.

6. Control of hardware

6.1 Relays

See sheet 1.

RL1 and RL2 are standard, high-voltage relays, which are controlled via latch 1 (IC3 sheet 4). Transistors TR27 and TR28 (sheet 1) are necessary because the latch cannot directly handle the required 50mA coil currents. RL1 is energised for insulation, continuity and buzzer tests. RL2, if fitted, is energised for mA measurements only. TR26 is a safety device, which prevents either relay from being energised until the microcontroller has gained control of the circuit following a power-up.
RL3 is a bistable-latching relay, which uses very little power compared to a standard type. The circuit symbol for this component is somewhat misleading as it implies that each coil controls one group of contacts. This is not the case. Each coil controls both sets of contacts, which operate together as a 2-pole changeover switch. The ‘set’ coil forces one condition, and the ‘reset’ coil forces the other. A brief pulse, approximately 10 ms long, is applied to the appropriate coil, and neither coil remains energised. For instance, a low level pulse on ‘NEG TERM CTRL 2’ will put the contacts into the default configuration shown on the circuit diagram. The negative terminal is thus directly connected to 0V(A), the condition required for most measurements. A low-level pulse on ‘NEG TERM CTRL 1’ flips RL3 into its other state in which the negative terminal disconnects from 0V(A). Any current returning via the negative terminal is now diverted into the integrator via R158 (sheet 3). This configuration is used when small currents need to be measured, i.e. on insulation test & some kilohms ranges. As a precaution against accidental disturbance, RL3 status is refreshed at regular intervals, by periodically re-pulsing the appropriate coil. ***Note*** that D326 (sheet 7) must be fitted, or the drive signals for RL3 will be incorrect. This diode tells the micro that a latching relay is fitted, and not a standard relay or fet (TR19, sheet 1), which are cost saving alternatives for switching the -ve terminal.

6.2 Latches

These are used for general-purpose control of relays, analogue switches and other circuit elements. They act as outputs only and cannot be used as inputs. The 4 latches are IC3 (sheet 4), IC10 (sheet 3), IC314 (sheet 10) & IC309 (sheet 8). They are of 8-bit addressable type. Only one output pin can be written to at any given time. The ‘LATCH X ENABLE-‘ line is normally high. The address of the bit to be written is set up as a binary pattern on ‘D(0)’ - ‘D(2)’. The data to be written is set up on ‘D(3)’. The ‘LATCH X ENABLE-‘ signal is then pulsed low for a few microseconds, during which the level on ‘D(3)’ (‘*DATA IN’*), is copied and latched into the selected output. To write to the entire latch, this process occurs eight times, selecting each bit in turn. A problem with latches is that unwanted glitches on the ‘LATCH X ENABLE-‘ line can cause random data to be written. Thus the latches distant for the microcontroller have a small capacitor fitted locally on the ‘LATCH X ENABLE-‘ signal. As an additional anti-noise measure, the latches are refreshed regularly, i.e. all the data it is periodically rewritten from copies which are held in RAM.
Each latch has an RC network connected to its ‘*RESET-*‘ pin, which serves to clear all the outputs to logic 0 at power-up.

For further information consult a High-Speed CMOS 74HC259 data sheet

6.3 Analogue switches and multiplexers

These are used to alter the circuit configuration, and to route signals to the 7109 a/d converter's input and reference. The 4053 types are simple changeover switches (3 per package). The symbol used on the circuit diagram shows the situation that occurs when the control signals are at logic 0. A logic 1 on the switch control pin, '*SW*', changes the state. The 4052 multiplexers act like 1-pole 4-way switches (2 per package). They have 2 pins, ('*A*' & '*B*'), for channel selection. The binary pattern set up here determines which way the switch is pointed. If the '*INH'* line is high (pin 6), all switches are open circuit, with no channel selected. The symbol used on the circuit diagram shows the situation that occurs when the '*A*' & '*B*' control signals are at logic 1.
There is no latching action on the analogue switches - the desired control signals must be maintained at all times.

For further information consult CMOS CD4052 & CD4053 data sheets

7. 12-bit A/D converter system

See sheet 8.

All displayed measurement results make use of use the 7109 a/d converter (IC301), except on capacitance and buzzer ranges. The 7109 is a dual-slope integrating type, and in the BMM is always used in fixed reference mode, not ratiometric mode. References are derived from the 5V rail. R317 & R325 provide a 2.5V tapping, which is buffered by IC300 pins 1,2 & 3 for use in several circuits. This is further divided by resistor chain R341 etc. Assuming that the TR304 is ‘off’, there is a nominal 1500mV on IC305 pin 1 and 150mV on pin 5. These are reduced to 900mV and 90mV if ‘AD REF REDUCE’ signal is high. The particular reference required is selected by IC305.

Usage is as follows.

Channel 0: 900mV, mV high range, mA high range.
Channel 0: 1500 mV, voltage high range, insulation, kilohms high ranges.
Channel 1: 90 mV, mV low range, mA low range.
Channel 1: 150mV, voltage low range, continuity, kilohms low ranges.
Channel 2: 2500 mV, diagnostics.
Channel 3: not used.

The ‘AD REF-‘ signal need not be switched as it always connects to 0V. However it is routed through IC305 to give options for the future.

The a/d inputs are switched by IC302 independently of IC305, (different control signals).

Usage is as follows.

Channel 0: mV dc, mA dc, continuity, kilohms.
Channel 1: voltage, mV ac, mA ac.
Channel 2: insulation.
Channel 3: diagnostics.

Latch 4 (IC309) controls the input and reference multiplexers.

The a/d converter oscillator (IC301 pin 20) runs at about 25kHz, determined by R326, R331 and C318. This results in an integration time of 100ms, giving good rejection of 50Hz & 60Hz hum. Conversions are executed under the micro’s control, by taking the ‘AD RUN’ line high. The ‘AD STATUS’ signal connects to an interrupt pin on the micro, and goes low when a conversion is finished. The result is then read a byte at a time by means of the ‘LBEN-‘ and the ‘HBEN-‘ signals. With the ‘SCL/AD CE-‘ line high to deselect IC301, a low level is asserted on ‘LBEN-‘. Then ‘SCL/AD CE-‘ is taken low briefly while the low order byte of data is read. This sequence then repeats for the high byte, using ‘HBEN-‘.
The mechanics of the dual-slope a/d conversion technique are too complex to describe here, but the end result is that the converter gives the sign of the input voltage, an overrange flag, and a 12-bit reading equal to:

(input voltage/reference voltage) * 2048

For further information consult a Maxim MAX7109 data sheet.

8. RS232 communications

The RS232 link consists of two transceivers, optically isolated from one another, and capable of bi-directional data transfer. Thus, results stored within the instrument can be transferred to a personal computer under the PC's control. Each transceiver uses a single led to act as both emitter and detector. The communications link operates at 9600 baud and the format is:

1 start bit
8 data bits
2 stop bits
No parity

For the end customer, the only use for the RS232 output is on the RCL range position, for retrieving stored results. However, it is also used in manufacture, during testing and setting-up.

8.1 Non-isolated transceiver

See sheet 6

This is the simpler of the two circuits since it is powered from the normal instrument supply rails. In the 'idle' condition, not sending or receiving, the 'SERIAL OUT' signal is kept high, turning off TR1, and applying a -1.0V bias to IC1 pin 5. This op-amp's dc feedback is via R23 only since TR4 is cut off. Thus pins 5,6 & 7 all sit at -1.0V, leaving led D4 reverse biased (and off).

8.1.1 Transmit

In the 'idle' condition, 'SERIAL OUT' is at logic 1. Taking 'SERIAL OUT' low turns on TR1, applying a +2.5V signal to IC1 pin 5. There is now an additional dc feedback path available through R18 and TR4 The result is that pin 6 rises to 2.5V as well, and a forward current of about 12mA is driven through led D4, via R13 & TR4. Light from D4 is detected by led D704 on the isolated transceiver pcb, and thus information transfer can occur. The 'SERIAL OUT' line is fed from a special serial port of the microcontroller, port 4, which facilitates the encoding and transmission of the required data in RS232 format.

8.1.2 Receive

When light of its own characteristic wavelength falls on led D4, a small reverse current is generated, making it suitable for use as a detector. Keeping the led reverse biased improves the sensitivity, as is the case in ‘idle’ mode with TR1 off. In the BMM situation, approx. 35uA is generated in D4 when the corresponding isolated emitter (D704 sheet 12) is ‘on’. D2 & D5 (sheet 6) prevent the op-amp from saturating. In ‘idle’ condition IC1 pin 7 potential (-1.0V), is higher than the -1.5V threshold set at pin 2 by R2 and R4. The second half of IC1 is used as a comparator, and so in idle condition the ‘SERIAL IN’ line is at a high level. Current produced in D4 while receiving, will drive IC1 pin 7 further negative, causing the comparator to change state and ‘SERIAL IN’ to be pulled low. Connection to the microcontroller is again on the dedicated serial port, which facilitates the receiving and decoding of the bitstream on ‘SERIAL IN’.
Normally when ‘SERIAL OUT’ is pulled low, ‘SERIAL IN’ remains high. However, this is not the case if the calibrate diode (D3) is fitted. This is the means by which the presence of this diode can be detected. The ‘SERIAL IN’ and ‘SERIAL OUT’ connections are also the means by which manufacturing data, such as the set-up information, the second printer language, and the serial number, are entered into the instrument and subsequently stored in the EEPROM. Test pads carrying +5V, 0V, ‘SI’ & ‘SO’ are made available in the accessible area of the battery compartment (TP76 - TP79). They can thus be contacted by probes on the ‘test & calibrate’ fixture, allowing bi-directional communication. A switchable diode in the fixture (analogous to D3) allows selection between the BMM’s ‘normal’ and ‘calibrate’ modes. In 'calibrate' mode, measurement results on all ranges, including buzzer, are outputted to the battery compartment interface every 2 seconds, allowing the functional test gear to be semi-automated. For further information see Appendix 15, ‘Download to a computer’, the section entitled 'Data-logging /Real-time transmission information'.

Note that results are also transmitted if the 'send mode', 'test mode' or 'diagnostics' diodes are fitted (D323, D313 or D321).

8.2 Isolated transceiver

See sheet 12.

This operates in an almost identical fashion to the non-isolated module except for the derivation of the power supply. This has to come up from the PC to which the instrument is connected. In ‘idle’ condition, IC700 receives power through R710 & D705 and so provides a regulated 5V output on pin 1. C700 & C701 can hold up the power supply during periods of activity. IC702 is a special purpose quad RS232 transceiver chip with built-in charge pumps to produce +/-9V supplies (approx.). IC702 also performs the necessary level shifting to interface between RS232 levels and 5V logic levels. The remainder of the circuit is almost identical to the RS232 transceiver on sheet 6. There are minor differences in the voltage levels at the op-amp inputs, due to having a different negative rail, but the method of operation is identical.

Section 2

Some supplementary (simplified) diagrams are available to help to explain certain sections of the circuit. They contain extra information, such as logic levels and analogue switch configurations. Some components are omitted for clarity, such as those which are irrelevant or ‘not fitted’, or required only for noise rejection or overload protection.

See also the overall block diagram.

1. RCL Switch Position.

In the RCL switch position, no actual measurements are possible. It is used to retrieve previously stored results to the instrument’s display, using the keypads. Alternatively, stored or logged data can be sent to a PC or a printer via the RS232 (9-pin) connector. This interface makes use of a special port (port 4) on the microcontroller, which is designed for serial communications. In the RCL switch position, port 4 is configured for both transmitting and receiving, allowing bi-directional data transfer via the optical link.
For further information see the 'RS232 Communications' section and also Appendix 15.
When 'download' commands are received, stored result data is read from the EEPROM, and has formatting characters added before being transmitted. The purpose of the formatting is to make the BMM output compatible with various PC software packages.
A printout of results can be obtained by pressing the 'test' button. Numeric results are read from the EEPROM and then combined with appropriate words from tables held in ROM (English language printout), or EEPROM (foreign language). The desired foreign language is selected and loaded in to the instrument at the set-up stage, on the 'test & calibrate' fixture.

Note: the auxiliary 5V rails are not necessary for RS232 communications and are turned off to save power.

2. Insulation Test Switch Positions

Refer also to the simplified input circuit for insulation test (supplementary sheet 1).

When the ‘test’ button is pressed, to initiate an insulation test, ‘HV ON‘ signal (sheet 4) is taken to logic 1, turning on the hv inverter. A high voltage is produced, which is then connected to the +ve terminal, by energising relay RL1, sheet 1. (‘HV INS RLY-‘ is taken low). The current to be measured flows through the test specimen into the -ve terminal. Since RL3 is set in ‘disconnect’ mode, all this current must flow via R158 (sheet 3) into the current measurement circuit. The 12-bit a/d converter measures a proportion of the output voltage, and the microcontroller uses this result, along with the current measurement result, to calculate the resistance under test. When the test is stopped by pressing the ‘test’ button again, the hv is turned off, and RL1 is de-energised. Any stored energy on a capacitive test load is quickly discharged through the discharge resistors R187, R175, R194 & R179.

2.1 HV Inverter

See sheet 4
Refer also to the simplified circuit diagram for the inverter, which shows the output set for 1kV (Supplementary sheet 2).

The essential parts of the inverter circuit are

A. Transformer, switching device & sundry components
B. Reference
C. Feedback
D. Oscillator
E. Current limit
F. Control circuit

A. Energy is stored in the core of transformer T1 while switch TR25 is 'on', and then transferred into the secondary circuit when TR25 is turned 'off'. The rectifying effect of diodes D32 and D25 causes a positive voltage to be produced on capacitor C44. Power is continuously transferred from primary to secondary by providing a pulse train on the gate of TR25. The amount of power transfer, and therefore the magnitude of C44's voltage, is varied by changing the mark/space ratio of the pulse train.

B. The 2.5V level produced at R317/R325 junction (sheet 8) is buffered by IC300 to become '+2.5V REF', and then divided down by R182 - R185 (sheet 4) to provide a 2.0V reference at IC8 pin 6.

C. A proportion of the output of voltage on C44 is fed back to IC8 pin 5 through R161 & R123. This signal is used by the 12-bit a/d converter during insulation measurements. It is used in order to calculate the output voltage. The lower leg of the output voltage divider, between R123 and 0V, depends on which range has been selected. Three control lines, 'INS 50V', 'INS V SEL 1', & 'INS V SEL 2', select the output voltage via multiplexer IC7. The two halves of IC7 are paralleled to reduce the effective 'on' resistance of the switches. To obtain 50V output, the multiplexer is turned 'off', ('INS 50V' high), leaving about 400k resistance in the feedback voltage divider. On other voltage settings this is less, giving a higher output voltage. The unused resistors around IC7 allow for generation of special voltages if required.

D. The basic oscillator consists of IC4 pins 8, 9 & 14, plus C10, and R55/R54/R41. This produces a sawtooth wave on C10, and a square wave on IC4 pin 1. There is one discharge path for C10 via R41 & R54 into pin 14, but note that there is another path through TR9 and R27/R28 into pin 1. It is this (variable) path which allows control over the mark/space ratio at TR25 gate.
Note: IC4 has 'open collector' outputs.

E. Return current to T1 secondary must flow in via TR16 and resistors R149, R152, & R153, and this pulls TR18 emitter downwards in potential. TR16 is turned 'on' by a logic 0 on 'IOC DISCONNECT'. Note that that current flow through TR16 is from emitter to collector. As the output current increases, there comes a point when eventually TR18 emitter will be pulled below its base and TR18 will turn 'on', squashing the 2V reference on IC8 pin 6, and therefore reducing the output voltage to zero. This feature allows the inverter to deliver 1mA at its rated voltage but less than 2mA into a short circuit.

F. A fraction of the output voltage, as described in section C, is compared to the 2.0V reference by IC8 pins 5 & 6 (error amplifier), producing an error signal on pin 7. This signal modifies the behaviour of the oscillator, allowing the 'on' time of fet TR25 to be changed. The overall circuit feedback is negative, thereby resulting in a stable controlled output voltage on C44.
The master control of the inverter is 'HV ON'. This is level shifted up to battery voltage by TR15 & TR17. If 'HV ON' is taken high by the microcontroller, R151 gets connected to 'BATTERY +VE' and acts as a pull-up resistor for IC4 pin 2. Without this, (if 'HV ON' is low), there can be no drive to TR25 gate, since IC4 has an open-collector output.

2.2 Insulation test voltage measurement

On any given insulation test voltage setting, the signal at IC8 pin 5 (sheet 4) is a fixed proportion of the output voltage. This signal (‘INS IN HI’), is routed through IC302 (sheet 8) and measured by the 12-bit a/d converter IC301. The 1500mV a/d reference is used. The microcontroller knows the condition of multiplexer IC7 (sheet 4), and the circuit component values, and is therefore able to calculate the output voltage.

2.3 Insulation test current measurement

See sheet 3
Refer also to the simplified circuit diagram for the integrator (supplementary sheet 3).

The current which needs to be measured during an insulation test, can be anywhere between a few nA and a couple of mA. To cope with this huge dynamic range without lots of switching, an integrator method is used. Current flowing into the input of the integrator (IC13, sheet 3) causes its output to ramp down in a linear fashion. The transit time between two reference voltage levels is recorded, giving a measure of the input current. This interval varies from about 100us (at short circuit) to 2s (at open circuit), but it is relatively easy to measure such wide-ranging values using a timer on the microcontroller.

For correct integrator action, ‘PULSE SOURCE SEL’ must be at logic 0, so that IC13 pin 6 is connected through IC5 pins 4 & 5 into the comparators (IC9).
Note that IC9 has ‘open collector’ outputs.

The integrator action involves a repeating loop, which consists of four phases, as described below.

Reset Phase
To return the integrator output to a high level (approx. 3V), ‘INS I MEAS-’ is taken high. This causes IC9 pin 1 to go low, drawing ‘reset’ current out of IC13 input through TR14, R140 & R141. This is always sufficient to overcome the measurement current flowing in, and so IC13 pin 6 (integrator output) rapidly ramps up. When it reaches 3V, the reset current will be automatically turned off. There is still a small ‘pre-charge’ current flowing in via TR13, TR11 R111 & R142, and so the integrator output will dither around 3V as long as ‘INS I MEAS-‘ is high. ‘PULSE MEAS’ signal is low when the integrator has been reset.

Pre-charge Phase
To initiate a measurement ‘INS I MEAS-‘ is taken low. IC9 pin 1 goes open circuit and the ‘reset’ current is turned off, with TR14 acting as a low leakage diode. The integrator now ramps downward until the upper threshold level on the comparators (1.7V approx.) is reached. ‘PULSE MEAS ‘ is driven high, turning off the pre-charge current. Measurement phase has started. TR11 now acts as a low leakage diode.

Measurement Phase
Now, the only current flowing into the integrator is the current to be measured, plus the ‘injected’ current through R112 & R142, which is a known quantity. Its purpose is to ensure a maximum measurement time of about 2s even at open circuit. As the integrator output ramps downwards, it subsequently crosses the lower threshold on the comparators, which is set at about 0.25V for insulation tests. This drives the ‘PULSE MEAS’ signal low again, and the measurement is complete. The microcontroller starts a timer at the rising edge on ‘PULSE MEAS’, and stops it at the falling edge. From the pulse duration it can calculate the current.

Post-measurement Phase
Pre-charge current is now on again, and the ramp continues down towards 0V, until the reset current is triggered again by the microcontroller. The integrator output will dither around 0V as long as ‘INS I MEAS-‘ is low.

2.4 Blown fuse detection

If the current measurement result is below 100uA, then the hv inverter is not heavily loaded, and there should be enough voltage present at the +ve terminal to activate the voltage detector and the 'V DETECT A-' signal (sheet 10) should be at logic 0. If not, then the microcontroller assumes that the fuse has blown. (See 'Voltage detector' section).

3. Off Switch Position

The effect of the rotary switch is to force a low level onto the *'SHDN-'* pin of regulator VR1 (sheet 5).(See 'Power on/off circuit' section of this document). This turns off all supplies except the battery rail itself. The only power being dissipated is in T1 primary circuit, sheet 4 (negligible), IC6 circuit & VR1, sheet 5 (a few uA each), and IC304 circuit, sheet 9 (a few uA). The total current flow from the battery should be <50uA. The same situation occurs after autoshutdown.

4. Voltage Switch Position

To reduce the power consumption, measurement circuits are not powered up until a voltage is detected at the terminals. When this occurs, auxiliary supplies are turned on by sending 'AUX POWER OFF' (sheet 5) to a logic 0. Then measurements begin, using the ac-dc converter (sheet 1|) in conjunction with the 12-bit a/d converter (sheet 8).
If the 500mA fuse has blown, this has no effect on voltage measurements, except to increase the input impedance, since the discharge resistors R187 etc (sheet 1) are then no longer connected.
Blown fuse is not detected on the voltage range.

4.1 Voltage detector

IC11 pins 1, 2 & 3 (sheet 2) act as a simple zero crossing detector. There is an inverting action, and the pairs of clipping diodes (D17 & D18, D20 & D21), in the feedback paths, limit the output to less than +/-1V. An ac input will produce a square wave at IC11 pin 1. This signal, ('V DETECT OUTPUT'), connects through IC310 pins 1 & 15 (sheet 10) to the window comparator circuit IC307. For voltage measurement, the 'DISCHARGE' signal is at logic 1, meaning that the comparator thresholds on IC307 pins 11 & 8 are +/-50mV. 'V DETECT A-' signal goes low in response to a positive terminal voltage, 'FREQ/V DETECT B-' goes low for a negative input. If no voltage is detected, both signals are high. Note that IC307 has 'open collector' outputs.
At certain times (on other ranges than voltage), 'DISCHARGE' signal is low, which has the effect of connecting the +ve terminal to +5V (see sheet 1). This would cause unwanted triggering of the voltage detector, so the 'DISCHARGE' signal also de-sensitises the voltage detector by increasing the comparator thresholds on IC307 (sheet 10).
See also 'Default voltmeter' section.

4.2 Frequency measurement.

See sheet 10.
Refer also to the simplified circuit diagram for frequency measurement (supplementary sheet 4).

The voltage detector hardware is also used for frequency measurement. When an ac voltage is present on the terminals, 5V square waves will be produced on the 'V DETECT A- ' and 'FREQ/V DETECT B-' signals (sheet 10). See 'Voltage detector' section. The 'FREQ/V DETECT B-' signal connects to a timer interrupt pin on the microcontroller. To determine frequency, the interval between falling edges is measured, and several readings are averaged out. The micro is able to calculate frequency from this data. The 'V DETECT A-' signal plays no part in frequency measurement.

4.3 Voltage measurement

See sheet 1.
Refer also to the simplified input circuit diagram for voltage measurement (supplementary sheet 5).

The negative terminal is directly connected to 0V(A) by RL3. ‘MV TEST’ is at logic 0 & ‘DISCHARGE’ is logic 1, which connects the +ve terminal via R187 etc, to 0V(A), resulting in an input impedance of approximately 200kohms. 'VOLTS TEST' is set to logic 1, and thus input current from the positive terminal flows via R155 and through IC12 pins 13 & 14 into the ac-dc converter (IC15 pins 1,2 & 3). For positive inputs, IC15 feedback is via R196 & D26, and for negative inputs via R195 & D28. The output signal for measurement is taken differentially across D26 and D28 and fed through some filtering components to IC302 (sheet 8) and on to the 12-bit a/d converter (IC301). This voltage is always a positive dc and so the nature of the terminal voltage has to be determined by examining the voltage detector output signals. The a/d measurement uses the 150mV reference for terminal voltages <100V, or 1500mV for larger inputs. Ranging is automatic and cannot be overridden.

4.4 Instrument set-up.

During manufacturing, certain information must be loaded into the instrument's EEPROM. The most important piece of data is a 32-bit set-up string, which gives the instrument its identity, telling it which family member to be, and which features to allow. For a BM25XX, the serial number and foreign language words are also loaded. The voltage switch position is used for this operation, because it is not envisaged that there will ever be a BMM model without a voltage range. The data is transferred from the PC which controls the 'test & calibrate' jig, via the instrument’s battery compartment interface (TP76 - TP79).

4.5 Default voltmeter

If the rotary switch is not in the voltage position, and some other measurement is being carried out, the microcontroller nonetheless constantly monitors the terminal voltage. If excessive voltage is detected, the micro may interrupt the measurement in progress and start up the voltmeter. This is known as the 'default voltmeter'. An audible warning is given by sounding the buzzer intermittently. Buzzer frequency is 1.35kHz, to distinguish it from the continuity buzzer sound (2kHz). Note that frequency measurement is not available in default voltmeter.

There are two methods of monitoring the +ve terminal.

A. Use the normal voltage detector circuit, but in its desensitised mode. When 'DISCHARGE' (sheet 10) is low, the thresholds to the IC307 comparators are increased to approx. +150mV and -500mV. Under these conditions, 'V DETECT A-' is driven to logic 0 for terminals voltages >10V, and 'FREQ/V DETECT B-' responds at about -3V.

B. Use the 'POSTERM MONITOR1' and 'POSTERM MONITOR2' lines. These are effectively the outputs from IC14 (sheet 1) and IC15 pin 7, and connect to the micro's 8-bit a/d converter, enabling quick measurements of the terminal voltage to be made (maximum 10V). 'POSTERM MONITOR1' is used for +ve inputs, and 'POSTERM MONITOR2' for -ve inputs.

The table below shows when the default voltmeter is allowed, and which voltage detection method is used.

Test type	**Default voltmeter**	**Monitoring method**
Recall	Inhibited	-
Insulation before test	Allowed	A
Insulation during test	Inhibited	-
mV (version P1.3 onwards)	Allowed	B
Continuity before contact detected	Allowed	A
Continuity after contact detected	Inhibited	-
Buzzer before contact detected	Allowed	A
Buzzer after contact detected	Inhibited	-
Kilohms	Allowed	B
Capacitance	Allowed	A & B
mA before test	Normal voltmeter	-
mA during test	Inhibited	-

The default voltmeter can be completely disabled by fitting diode link D322

5. mV Switch Position

See sheet 1.
Refer also to the simplified input circuit diagrams for mV measurement (supplementary sheets 6 & 7).

A high input impedance is required for mV, to be compatible with transducers which may be used as accessories on this range. The discharge resistors R187, R175, R194 & R179 are therefore disconnected by taking the 'MV TEST' signal (IC16 pin 10) to a high level. The voltage on the negative terminal is 0V, as it is directly connected to 0V(A) by RL3. The input voltage is subject to a gain of -0.47 in IC14, before being measured.

5.1 mV dc

See sheet 1
Refer also to the simplified input circuit diagram for mV dc measurement (supplementary sheet 6).

IC14 output (‘INPUT AMPLIFIER’) provides the measurement signal, not only on mV ranges, but also on continuity and kilohms. Potentiometer R172, along with the divider network R168 & R163, allows the amplifier to be nulled by shifting the ground reference by a few millivolts. Capacitor C40 is fitted to keep the op-amp stable and also to swamp the stray capacitance, so that the frequency response with ac inputs is predictable. TR20 & TR21 are used as low-leakage diodes for overload protection. The ‘INPUT AMPLIFIER’ signal passes through R170 and IC16 pins 13 & 14 ('MA TEST-' is high) to R327 (sheet 8), and through IC302 channel 0, to the 12-bit a/d converter. For inputs < 200mV, the 90mV a/d reference is used, for the upper range, 900mV is required. Ranging is automatic and cannot be overridden.
If the fuse has blown, this has no effect on mV measurements.
Blown fuse is not detected on mV ranges.

5.2 mV ac

See sheet 1
Refer also to the simplified input circuit diagram for mV ac measurement (supplementary sheet 7).

The ‘INPUT AMPLIFIER’ signal from IC14 (sheet 1) is also routed through R162 and IC12 pins 1 & 15, 3 & 4, into the ac-dc converter, IC15 pins 1, 2 & 3. The two switches of IC12 are in parallel to reduce the effective 'on' resistance. The differential output from D28 & D26 connects to multiplexer IC302 (sheet 8). The only action required to change from dc mV measurement to ac mV is therefore to point IC302 to channel 1 instead of channel 0.

Frequency on ac mV, is measured in a very similar way to the method used on the voltage range, but the small input signal needs boosting before it can be routed to the comparator circuit. Thus IC14 output (sheet 1) is amplified by IC11 pins 5, 6 & 7 (sheet 2). This output is clipped by D9 & D10 to prevent saturation. The resulting 'FREQUENCY MEAS' signal is switched into the dual comparator circuit (IC307, sheet 10) through IC310 pins 2 and 15, since 'FREQ SOURCE SEL' is at logic 0 during mV measurements.

6. mA Switch Position

Measurement of mA and mV have a lot in common, so it is logical to describe mA measurements here, even though out of sequence as regards switch position.

See sheet 1
Refer also to the simplified circuit diagrams for mA measurement (supplementary sheets 8 & 9).

6.1 mA measurement

Immediately after turning the range switch to mA position, the instrument operates as though set for voltage measurement. When a mA test has been initiated by holding down the 'test' button, RL2 is energised and measurement current from the positive terminal flows to ground through RL2, L1, and R178. The negative terminal is directly connected to 0V(A) by RL3. The measurement signal is the voltage developed across R178. It is normally too low to cause any significant conduction in the protection diodes D36 & D29. This voltage is fed through R193 to the switch IC16, and also through R188 & IC12, into the ac-dc converter, as 'MV TEST' is at logic 0. The situation is almost identical to that on mV except that the measurement voltage originates from R178, and the ''MA TEST-' and 'MV TEST' signals are low. The same a/d converter channels are used, i.e. channel 0 for dc, or channel 1 for ac. For inputs < 200mA, the 90mV a/d reference is used, for the upper range, 900mV is required. Ranging is automatic and cannot be overridden.

Frequency measurement is exactly as for mV.

6.2 Blown fuse detection

The input circuitry on mA presents an impedance of <2 ohms between the terminals, so under normal circumstances the voltage at the terminals will be <2V. However, if the fuse blows, the source voltage of the external circuit will be present, and this is likely to be many volts. The positive terminal voltage is constantly monitored, by two channels of the 8-bit a/d converter. The output of the input amplifier, IC14 pin 1 (sheet 1), is filtered by R169 & C43, and passed to the a/d converter as 'POSTERM MONITOR2'. Similarly, the output of the IC15 ('INPUT INVERTER', pin 7), becomes 'POSTERM MONITOR1' (sheet 11). The micro can thus measure input voltages of both polarities, up to a maximum of about 10V. If the terminal voltage is found to be greater than 6V or so, it is assumed that the fuse has blown.

7. Continuity Switch Position

As a power saving measure, the continuity measurement circuits are not switched on until 'contact' has been detected, i.e. a resistance of <3kohms has been connected to the terminals. Once contact has been detected, relay RL1 is energised and the terminals are connected to a constant current source circuit. The voltage at the terminals is measured by the 12-bit a/d converter, and as the current is a known quantity, the microcontroller can then calculate the resistance under test. Range selection is automatic, but this can be partially overridden by pressing the 'lock' button, if fitted. This may be useful during faultfinding. If the result is overrange, then a quick check is performed at 200uA test current. If the load appears to be >5k, relay RL1 is de-energised again and the circuit reverts to the 'contact detect' configuration. The quick check makes a rapid measurement of the terminal voltage by using the 'POSTERM MONITOR2' signal (sheet 11). This is approximately half the terminal voltage and is read by the 8-bit a/d converter, allowing an approximate calculation of the load resistance to be made. During continuity measurements the 'IOC DISCONNECT' signal is set high. This disconnects the hv inverter output circuit (transformer secondary) from 0V(A). Otherwise there can be errors when there is a high level of 50Hz hum present.

7.1 Contact circuit

Refer also to the simplified input circuit diagram for contact detect (supplementary sheet 10).

RL1 & RL2 (sheet 1) are de-energised, and the 'DISCHARGE' and 'MV TEST' signals are both at logic 0. This connects the positive terminal through RL1, RL2, R187 etc. and the switch IC16, to +5V. The voltage on the positive terminal is approximately halved by the combination of IC14, and IC15 pins 5, 6 & 7. IC15 output ('INPUT INVERTER' signal) then passes on to the detector circuit (sheet 11). The ‘2K TRIGGER’ signal is high, which produces a reference voltage of about 25mV on comparator IC307 pin 4. For open circuit terminals, ‘INPUT INVERTER’ exceeds this level and so ‘CONTACT DETECT-‘ signal is high. At <3kohms load, this signal changes to a low level. In response to this, the micro energises RL1 (sheet 1), in order to connect the current source circuit.
Note that IC307 (sheet 11) has ‘open collector’ outputs.

7.2 Current source

See sheet 9
Refer also to the simplified circuit diagrams for the current source (supplementary sheets 11 & 12)

There are 4 almost identical sections, generating currents of 200uA, 2mA, 20mA & 200mA. The 200mA current is used for loads up to about 2.5ohms, the 20mA for loads up to 25ohms, and so on. The microcontroller auto-ranges the current source setting to suit the load conditions. This can be partially overridden by pressing the ‘lock’ button, if fitted. (This may be of use during faultfinding, if there are problems with the auto-ranging or with the current sources).
Consider the simplified circuit which shows the 200mA section on its own with the switching and the other sections removed (supplementary sheet 11).
The resistor chain R357 etc. produces a reference voltage of 4.3V on IC304 pin 3 (‘CURRENT REF LO’). If <200mA is flowing through R359, then the op-amp output will be driven more negative, turning ‘on’ p-channel fet TR305 harder, and allowing increased current to flow through TR305 and R359. Thus the negative feedback stabilises the current until the voltage on TR305 source pin is also 4.3V. Current through R359 is then 200mA (actually 209.4mA nominally). This flows through D338 and then via D24 (sheet 4) to ‘HV INVERTER’ signal, which connects to the output terminal. Capacitors C334 & C338 (sheet 9) are required to give stability with inductive loads. The full current source circuit with all four channels is essentially the same, but it uses multiplexer IC313 to select only one of the p-channel fets, as required, using the control signals ‘I CTRL(0)’ - ‘I CTRL(2)’. The fet source resistors R359, R381, R396 & R407 differ by factors of 10 to give 10-fold reductions in the current. There is a complication, in that channels which are meant to be ‘off’, can leak current through their fets and cause errors. This is prevented by diverting any leakage into an absorbing circuit. Refer to the simplified circuit with 2 channels shown (supplementary sheet 12). This shows the 200mA current ‘on’ with the 20mA section ‘off’ and leakage from the 20mA section being made to flow through D329 & IC312 into the ‘sink’ TR308. The principle is the same in the full 4-channel situation. One section is ‘on’ and the leakage from the other three is diverted.
The purpose of the ‘POWER OFF’ connection into IC304 is to guarantee a 0V output when the instrument is switched ‘off’, since IC304 remains powered up. This reduces battery drain.

7.3 Voltage measurement on continuity

See sheet 1
Refer also to the simplified input circuit diagram for continuity measurement (supplementary sheet 13).

This is performed in a similar way as on the mV range. IC14 output passes through the switch IC16 and multiplexer IC302 (sheet 8) to the 12-bit a/d converter.
However the reference for the a/d is 150mV, instead of the 90mV used for mV measurements.

7.4 Blown fuse detection

If the current source is delivering the expected current, then the controlling op-amp IC304 (sheet 9) settles with its inputs equal and its output positive, since only a small gate-source voltage (<-5V) is normally required to turn on the relevant p-channel fet. However if the load is an open circuit, the amplifier will go into saturation and IC304 output will hit the -5V rail. This signal is modified by R323 & R329 to become 'I SOURCE MONITOR', and is measured by a channel of the 8-bit a/d converter. If the continuity voltage measurement appears very small, but IC304 is in saturation, then it is assumed that the fuse has blown.

8. Buzzer Switch Position

Refer also to the simplified input circuit diagrams for continuity and buzzer range (supplementary sheets 10 & 13).

This range operates in a very similar way to continuity measurement. Contact detection & current source work exactly the same. Before contact is detected, the buzzer is 'off' and the display shows '>3k'. After contact detection, this changes to '<3k'. RL1 (sheet 1) is then energised to connect the +ve terminal to the 200mA current source (sheet 9), and intermittent buzzer action begins. The -ve terminal is always connected to 0V(A) by RL3. The +ve terminal voltage is monitored using the 'INPUT INVERTER' signal, from IC15 pin 7 (sheet 1). After filtering by R399 & C340 (sheet 11), it becomes 'POSTERM MONITOR1' which can be measured in a few us by the 8-bit a/d converter. The 12-bit a/d converter is not used on the buzzer range. If the terminal voltage is below about 1V, the display shows '<5ohms', and the buzzer is sounded continuously. If it subsequently rises above about 1.5V, the buzzer action becomes intermittent again and '<3k' is shown. If the terminal voltage becomes >3V, a quick check is performed at 200uA current, as on the continuity range. If the load appears to be >5k, RL1 is de-energised and the circuit reverts to the 'contact detect' configuration.

Blown fuse detection works in a similar way as for continuity. If IC304 is in saturation, but the +ve terminal voltage is small, then it is assumed that the fuse has blown.

The buzzer itself (WD300, sheet 11) is an electromechanical type and is driven by means of a timer output pin on the microcontroller. This can be set to toggle automatically at a frequency set by software (in this case 4kHz, to give a 2kHz buzzer note). The micro output must be buffered by TR303, as it cannot provide enough current for a direct drive. D307 protects against inductive spikes from the coil of WD300.

9. Kilohms Switch Position

Two different measurement methods are used depending on the load under test. The terminal voltage is always measured, regardless of load, but at values >250k or so, the current flowing into the -ve terminal is also determined, using the integrator method, exactly as for insulation test. At lower values the current is not measured. Range selection is automatic, but this can be partially overridden by pressing the 'lock' button, if fitted. This may be useful during faultfinding.
On kilohms measurements, the open circuit voltage is 5V and the short circuit current is 25-30uA.
If the fuse has blown, the instrument gives a low reading at open circuit.
Blown fuse is not detected.

9.1 Lower ranges

See sheet 1.
Refer also to the simplified input circuit diagram for low kilohms ranges (supplementary sheet 10).

The input circuit is the same as that for contact detection on continuity and buzzer ranges. Both relays are de-energised. ‘DISCHARGE’ and ‘MV TEST’ are low, causing the +ve terminal to connect through RL1, RL2 & R187 etc., and through the switch IC16, to +5V. The -ve terminal is connected to 0V(A) through RL3. When a load resistor is put across the terminals, it forms a potential divider with R187 etc., thereby developing a voltage between 0V & 5V. This voltage is measured just as for continuity measurements, using IC14 output as the measurement signal for the 12-bit a/d converter. On the 10kohm range, the 150mV a/d reference is used. On the 100k range and above, it is 1500mV. Since the circuit component values and the source voltage (5V) are known to the microcontroller, the kilohms result can be calculated from the voltage measurement.

9.2 Upper ranges

Refer also to the simplified circuit diagrams for high kilohms ranges (supplementary sheets 3 & 14).

Beyond a few hundred kilohms, the previous method does not give enough resolution on the measurement, and the -ve terminal current must be measured as well. This is done exactly as on insulation test. RL3 (sheet 1) is put into ‘disconnect’ mode, in which current returning into the –ve terminal is diverted through R158 (sheet 3) into the integrator. (The +ve terminal circuit is exactly the same as on the lower kilohms ranges). The microcontroller calculates the resistance from the current and voltage results.

9.3 Diode test.

There is a diode test feature incorporated in the kilohms function, but this is only enabled on the BMM80. The diode symbol is shown on the display if the resistance reading is between 12k and 33k. This corresponds to a terminal voltage in the range of about 0.3V to 0.7V, i.e the forward volt drop of a silicon pn junction. A reverse connected diode will read overrange.

10. Capacitance Switch Position

Refer also to the simplified circuit diagrams for capacitance measurement (supplementary sheets 15 & 16).

This measurement is made by repeatedly charging and discharging the capacitance under test between two reference voltage levels, and measuring the discharge times. The 12-bit a/d converter is not used. During the charge phase, the open circuit voltage is 5V and the short circuit current is 25-30uA.
If the fuse has blown, the instrument reads overrange at open circuit.
Blown fuse is not detected.

Charge Phase
The +ve terminal connects through RL1 & RL2, to R187 etc., (sheet 1) and then through the switch IC16 (pins 2 & 15) to pin 4. During the charge phase 'DISCHARGE' is low and so there is a connection from IC16 pin 4 to pin 5. The -ve terminal is always connected to 0V(A) through RL3. Thus the test capacitance will charge up towards 5V through a resistance of 750k/4. When the charge voltage reaches a pre-set limit, the microcontroller initiates a discharge.

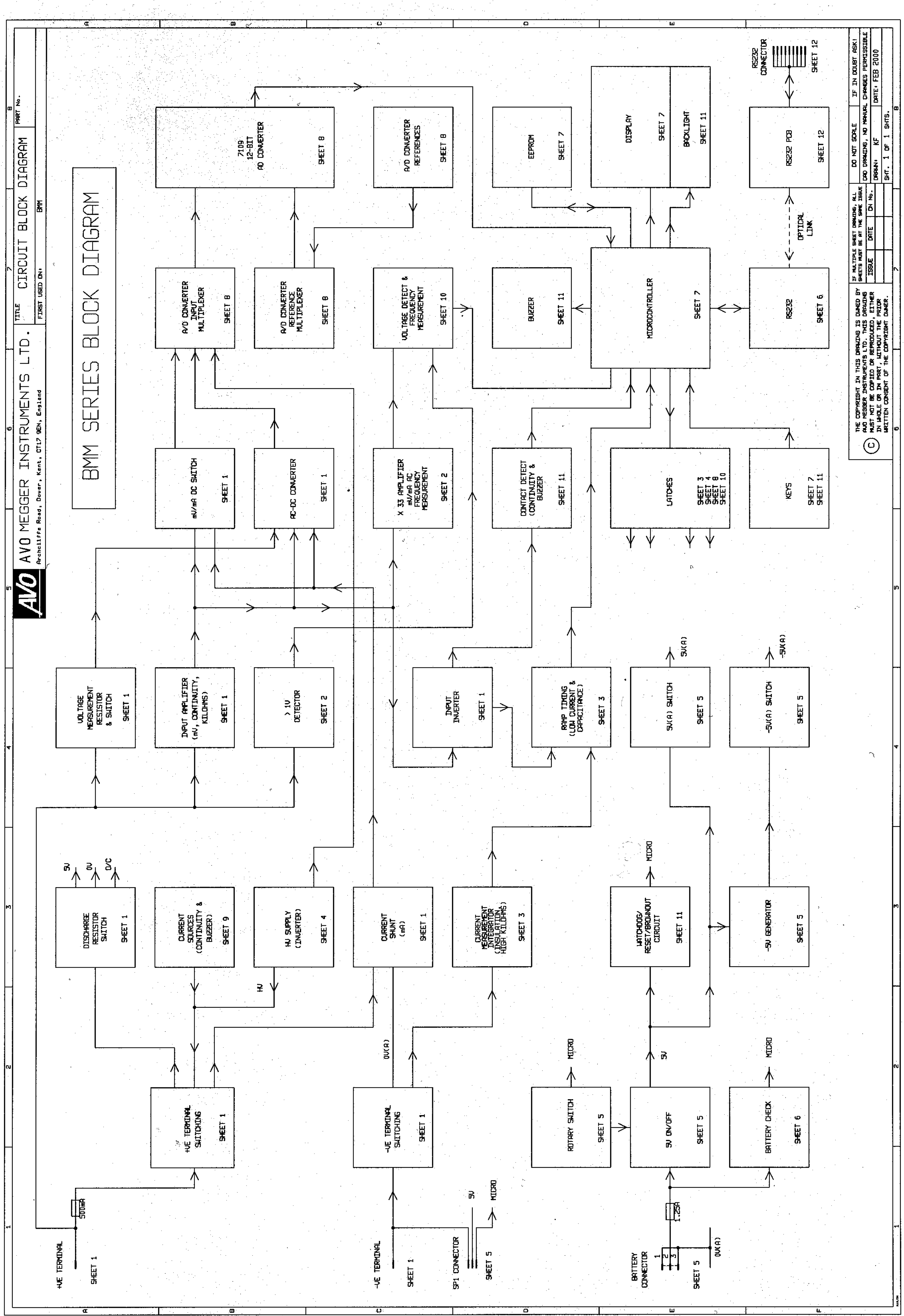
Discharge Phase
All that happens to start the discharge, is that the 'DISCHARGE' signal (sheet 1) is taken high, connecting IC16 pin 4 to pin 3 and thus discharging the load through R187 etc. The +ve terminal voltage is inverted and scaled in IC14, and again in IC15 (pins 5, 6 & 7), resulting in an approximately half-size copy of the +ve terminal voltage at IC15 output. After passing through R24 this becomes the 'CAP MEAS' signal, which is fed through to the second part of the capacitance measurement circuit, the timing section (sheet 3). This employs the same piece of circuitry as is used for timing the integrator ramps during insulation tests. The signal 'PULSE SOURCE SEL' is at logic 1, however, which has two effects. Firstly the 'CAP MEAS' line (i.e. not the integrator output) is switched through IC5 pins 3 & 4 to the comparator circuit, instead of the integrator output. Secondly, the lower comparator threshold is set to be 1.0V instead of the 0.25V level, which is used during integrator pulse timing. This gives approximately the same range of time intervals to be measured as on insulation tests. As the voltage on 'CAP MEAS' decays, 'PULSE MEAS' goes from low to high and then low again, signalling the end of the discharge phase. At this point the micro toggles the 'DISCHARGE' signal (sheet 1) to begin the charge phase again. To help the microcontroller keep track of what is happening at the terminal, it also uses the 'POSTERM MONITOR1' a/d channel, which is actually the same voltage as 'CAP MEAS'. This is just for monitoring purposes, the actual capacitance result is calculated only from the pulse length on 'PULSE MEAS' during discharge. This period varies from about 2s (at 10uF load) down to 100us at open circuit. The non-zero time at open circuit is due mainly to the effect of capacitor C40 (sheet 1) plus other stray capacitance around IC14. Similar length pulses appear on 'PULSE MEAS' during the charging phase, but these are used only for monitoring, not for calculation of the result.

11. Diagnostics Switch Position

See Appendix 9 for details of the instrument diagnostics.

Appendices

Appendix 1 Supplementary Circuit Diagrams



AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE CIRCUIT BLOCK DIAGRAM
FIRST USED ON: BMM
BMM SERIES BLOCK DIAGRAM
7109 12-BIT AD CONVERTER SHEET 8
A/D CONVERTER REFERENCES SHEET 8
EEPROM SHEET 7
DISPLAY SHEET 7
BACKLIGHT SHEET 11
RS232 CONNECTOR SHEET 12
RS232 PCB SHEET 12
OPTICAL LINK
A/D CONVERTER INPUT MULTIPLEXER SHEET 8
A/D CONVERTER REFERENCE MULTIPLEXER SHEET 8
VOLTAGE DETECT & FREQUENCY MEASUREMENT SHEET 10
BUZZER SHEET 11
MICROCONTROLLER SHEET 7
RS232 SHEET 6
mV/mA DC SWITCH SHEET 1
AC-DC CONVERTER SHEET 1
X 33 AMPLIFIER mV/mA AC FREQUENCY MEASUREMENT SHEET 2
CONTACT DETECT (CONTINUITY & BUZZER SHEET 11
LATCHES SHEET 3 SHEET 4 SHEET 8 SHEET 10
KEYS SHEET 7 SHEET 11
VOLTAGE MEASUREMENT RESISTOR & SWITCH SHEET 1
INPUT AMPLIFIER (mV, CONTINUITY, KILOHMS) SHEET 1
> 1V DETECTOR SHEET 2
INPUT INVERTER SHEET 1
RAMP TIMING (LOW CURRENT & CAPACITANCE) SHEET 3
5V(A) SWITCH SHEET 5
5V(A)
-5V(A) SWITCH SHEET 5
-5V(A)
5V 0V D/C
DISCHARGE RESISTOR SWITCH SHEET 1
CURRENT SOURCES (CONTINUITY & BUZZER) SHEET 9
HV SUPPLY (INVERTER) SHEET 4
HV
CURRENT SHUNT (mA) SHEET 1
CURRENT MEASUREMENT INTEGRATOR (INSULATION, HIGH KILOHMS) SHEET 3
WATCHDOG/ RESET/BROWNOUT CIRCUIT SHEET 11
MICRO
-5V GENERATOR SHEET 5
+VE TERMINAL SWITCHING SHEET 1
0V(A)
-VE TERMINAL SWITCHING SHEET 1
MICRO
ROTARY SWITCH SHEET 5
5V
5V ON/OFF SHEET 5
MICRO
BATTERY CHECK SHEET 6
500mA
+VE TERMINAL SHEET 1
-VE TERMINAL SHEET 1
5V MICRO
SP1 CONNECTOR SHEET 5
1.25A
BATTERY CONNECTOR 1 2 3 SHEET 5
0V(A)
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INDEX TO SUPPLEMENTARY CIRCUIT DIAGRAM

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TITLE: SUPPLEMENTARY CCT DIAGRAM | PART No.
FIRST USED ON: BMM

SHEET NUMBER	CONTENTS
1	INSULATION, I/P CCT
2	INSULATION, HV INVERTER 1kV OUTPUT
3	INSULATION & HIGH KILOHMS, CURRENT MEASUREMENT (INTEGRATOR)
4	VOLTAGE & mV & mA, FREQUENCY MEASUREMENT
5	VOLTAGE, I/P CCT.
6	MILLIVOLTS, I/P CCT DC
7	MILLIVOLTS, I/P CCT AC
8	MILLIAMPS, I/P CCT DC
9	MILLIAMPS, I/P CCT AC
10	CONT & BUZZER, I/P CCT BEFORE CONTACT DETECTED; KOHMS, I/P CCT LOW RANGES
11	CONT & BUZZER, CURRENT SOURCE SINGLE CHANNEL
12	CONT & BUZZER, CURRENT SOURCE 2 CHANNELS
13	CONT & BUZZER, I/P CCT AFTER CONTACT DETECTED
14	KOHMS, I/P CCT HIGH RANGES
15	CAPACITANCE, SECTION 1
16	CAPACITANCE, SECTION 2
17	INDEX

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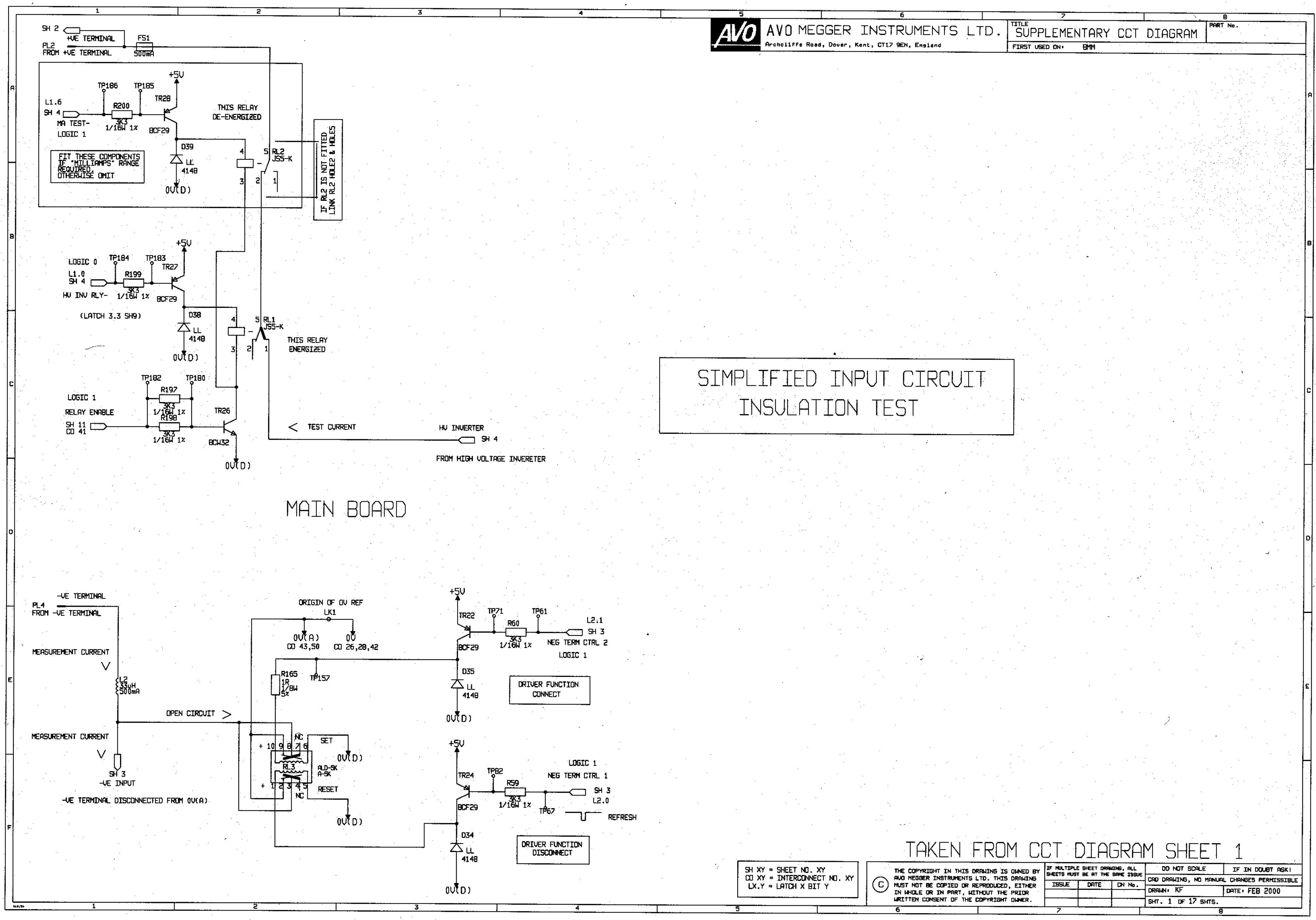
AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE SUPPLEMENTARY CCT DIAGRAM
PART No.
FIRST USED ON: BMM
SIMPLIFIED INPUT CIRCUIT
INSULATION TEST
MAIN BOARD
SH 2 +VE TERMINAL
PL2 FROM +VE TERMINAL
FS1 500mA
+5V
TP186 TP185
TR28
L1.6 SH 4
R200 3K3 1/16W 1%
MA TEST- LOGIC 1
BCF29
THIS RELAY DE-ENERGIZED
D39
LL 4148
0V(D)
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED, OTHERWISE OMIT
RL2 J55-K
IF RL2 IS NOT FITTED LINK RL2 HOLE2 & HOLE5
LOGIC 0
TP184 TP183
TR27
L1.0 SH 4
R199 3K3 1/16W 1%
HV INV RLY-
BCF29
(LATCH 3.3 SH9)
D38
LL 4148
RL1 J55-K
THIS RELAY ENERGIZED
TP182 TP180
LOGIC 1
RELAY ENABLE
SH 11 CD 41
R197 3K3 1/16W 1%
R198 3K3 1/16W 1%
TR26
BCW32
< TEST CURRENT
HV INVERTER
SH 4
FROM HIGH VOLTAGE INVERETER
PL4 FROM -VE TERMINAL
-VE TERMINAL
MEASUREMENT CURRENT
L2 33uH 500mA
OPEN CIRCUIT >
MEASUREMENT CURRENT
SH 3 -VE INPUT
-VE TERMINAL DISCONNECTED FROM 0V(A)
ORIGIN OF 0V REF
LK1
0V(A) CD 43,50
0V CD 26,28,42
R165 1R 1/8W 5%
TP157
NC
SET
RL3 ALD-SK A-5K
RESET
TR22
TP71 TP61
R60 3K3 1/16W 1%
L2.1 SH 3
NEG TERM CTRL 2
LOGIC 1
D35
DRIVER FUNCTION CONNECT
TR24
TP82
R59 3K3 1/16W 1%
TP67
LOGIC 1
NEG TERM CTRL 1
SH 3 L2.0
REFRESH
D34
DRIVER FUNCTION DISCONNECT
TAKEN FROM CCT DIAGRAM SHEET 1
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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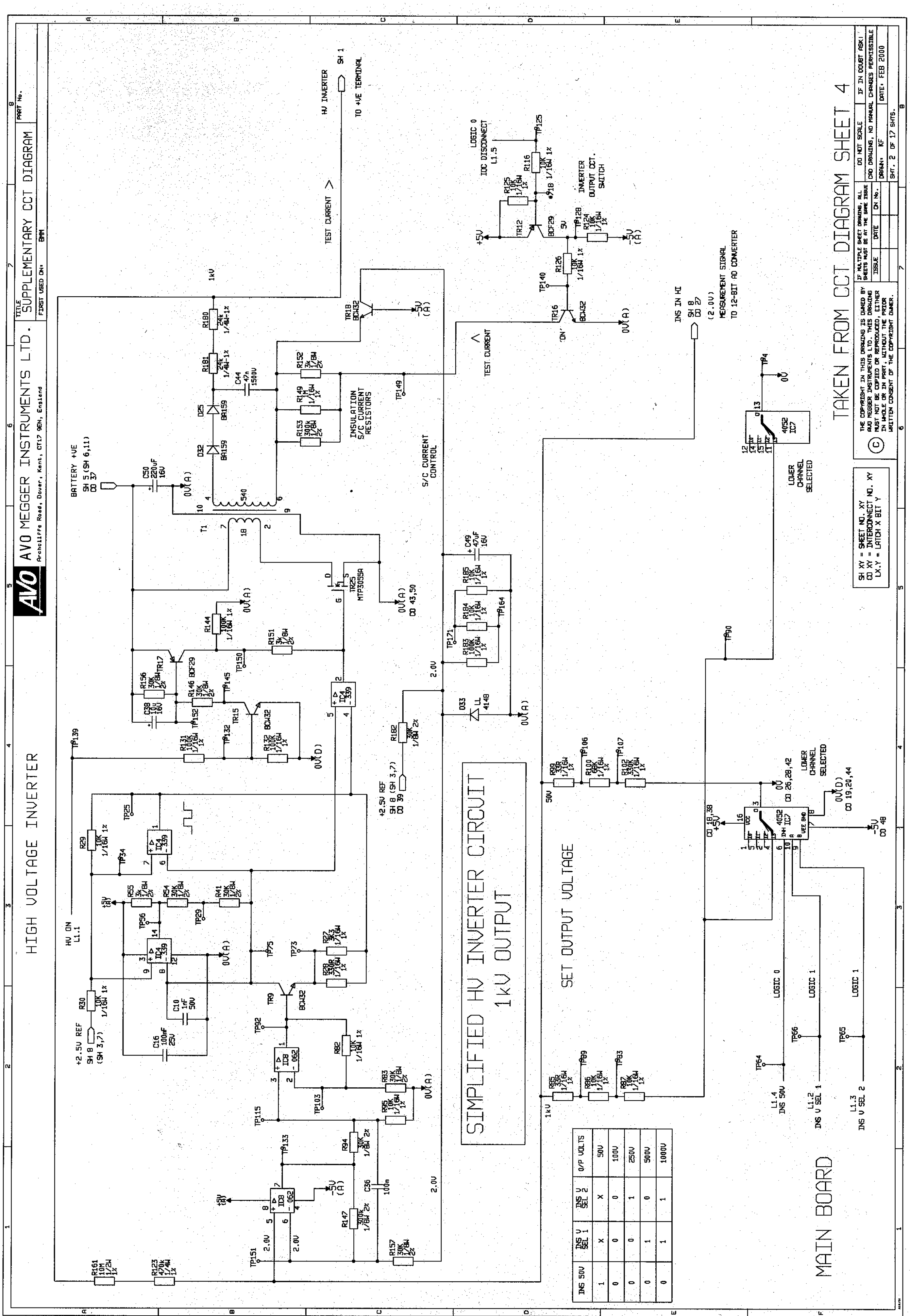
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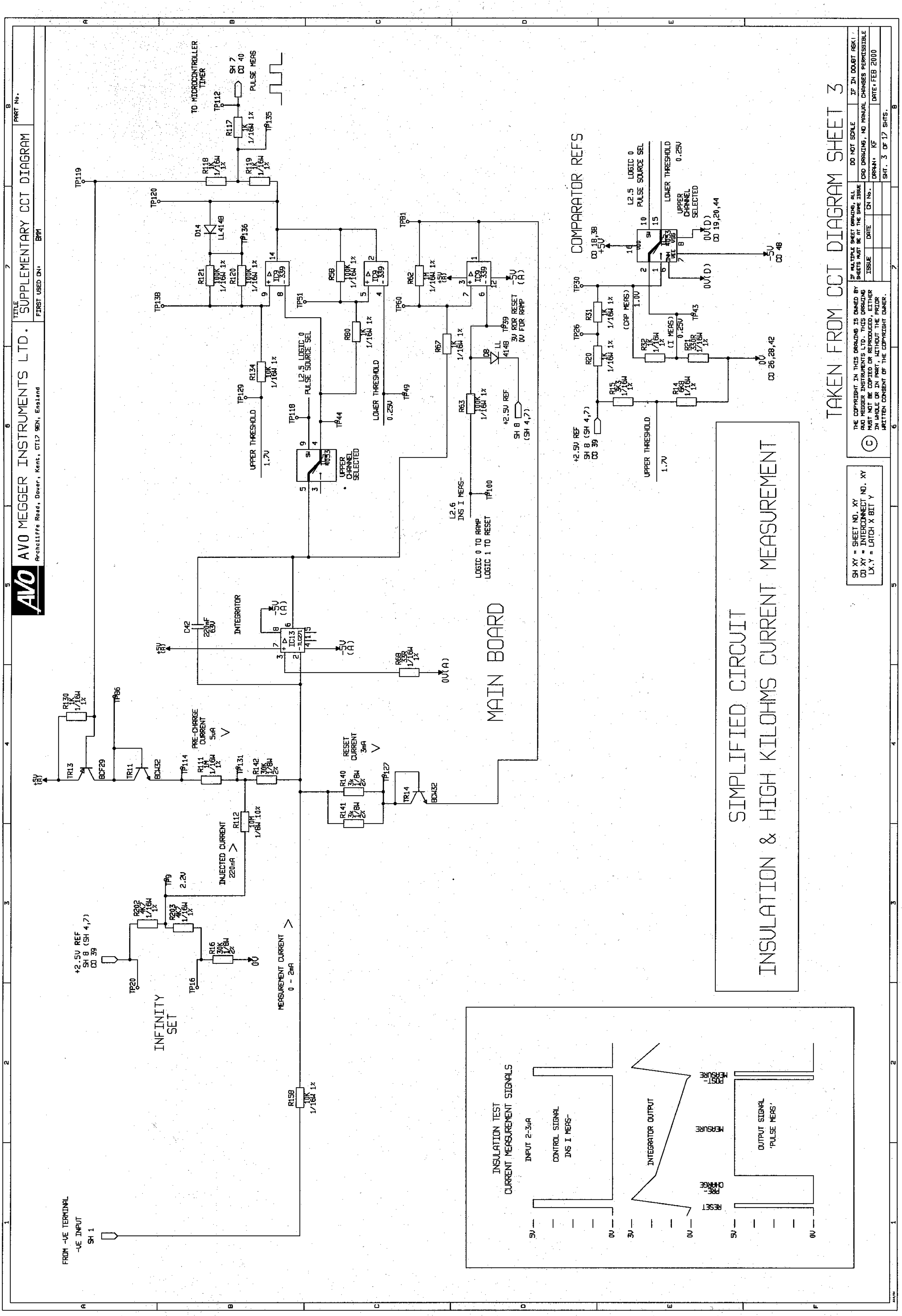
SUPPLEMENTARY CCT DIAGRAM
HIGH VOLTAGE INVERTER
SIMPLIFIED HV INVERTER CIRCUIT
1kV OUTPUT
SET OUTPUT VOLTAGE
MAIN BOARD
TAKEN FROM CCT DIAGRAM SHEET 4
INSULATION S/C CURRENT RESISTORS
S/C CURRENT CONTROL
TEST CURRENT
HV INVERTER
TO +VE TERMINAL
BATTERY +VE
MEASUREMENT SIGNAL TO 12-BIT AD CONVERTER
INVERTER OUTPUT CCT. SWITCH
LOGIC 0 IDC DISCONNECT
LOWER CHANNEL SELECTED
INS 50V | INS V SEL 1 | INS V SEL 2 | O/P VOLTS
1 | X | X | 50V
0 | 0 | 0 | 100V
0 | 0 | 1 | 250V
0 | 1 | 0 | 500V
0 | 1 | 1 | 1000V
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
DATE: FEB 2000
SHT. 2 OF 17 SHTS.



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SUPPLEMENTARY CCT DIAGRAM
FIRST USED ON: BMM
PART No.
SIMPLIFIED CIRCUIT
INSULATION & HIGH KILOHMS CURRENT MEASUREMENT
TAKEN FROM CCT DIAGRAM SHEET 3
COMPARATOR REFS
MAIN BOARD
INFINITY SET
INTEGRATOR
INSULATION TEST
CURRENT MEASUREMENT SIGNALS
INPUT 2-3uA
CONTROL SIGNAL
INS I MEAS-
INTEGRATOR OUTPUT
OUTPUT SIGNAL
'PULSE MEAS'
RESET
PRE-CHARGE
MEASURE
POST-MEASURE
FROM -VE TERMINAL
-VE INPUT
SH 1
MEASUREMENT CURRENT
0 - 2mA
INJECTED CURRENT
220nA
PRE-CHARGE CURRENT
5uA
RESET CURRENT
3mA
TO MICROCONTROLLER TIMER
SH 7
CO 40
PULSE MEAS
UPPER THRESHOLD
1.7V
LOWER THRESHOLD
0.25V
L2.5 LOGIC 0
PULSE SOURCE SEL
UPPER CHANNEL SELECTED
L2.6
INS I MEAS-
LOGIC 0 TO RAMP
LOGIC 1 TO RESET
+2.5V REF
SH 8 (SH 4,7)
CO 39
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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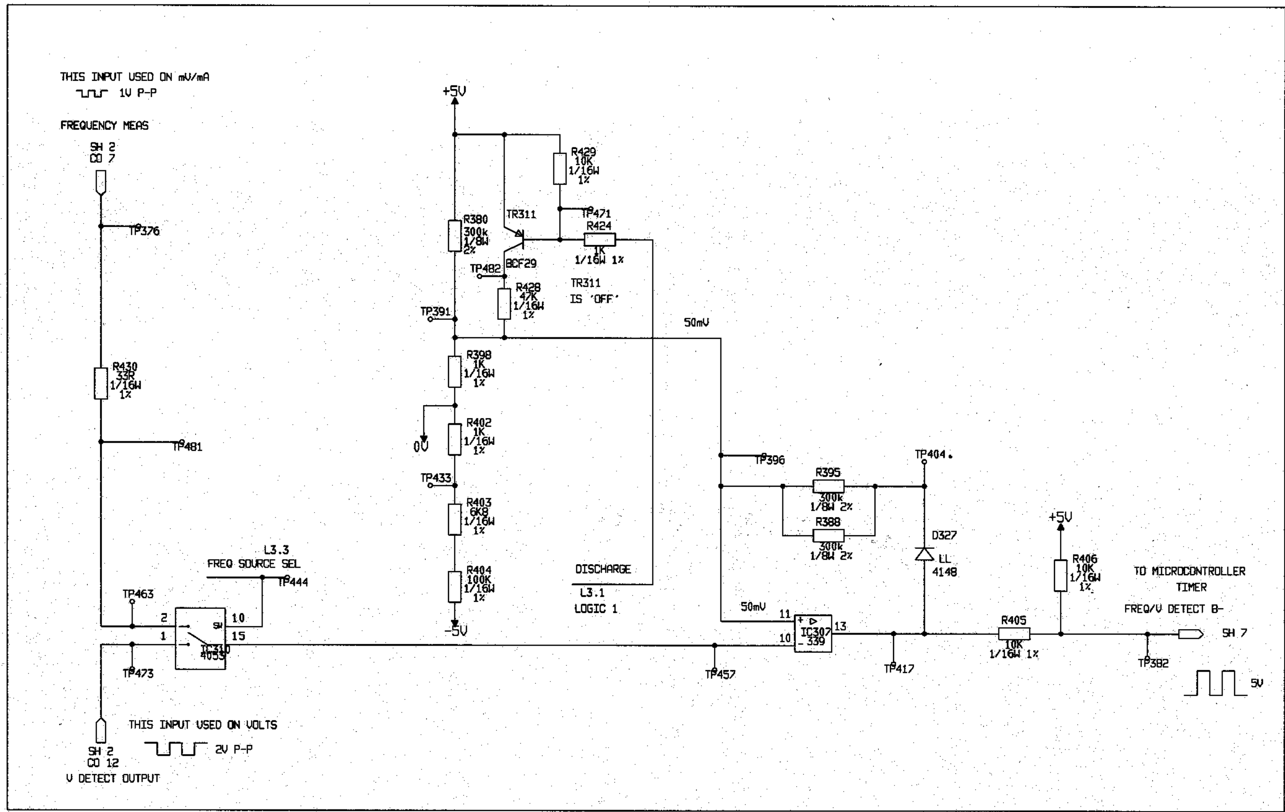

SIMPLIFIED CIRCUIT
FREQUENCY MEASUREMENT
VOLTAGE & mV & mA

DISPLAY BOARD

TAKEN FROM CCT DIAGRAM SHEET 10

SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y

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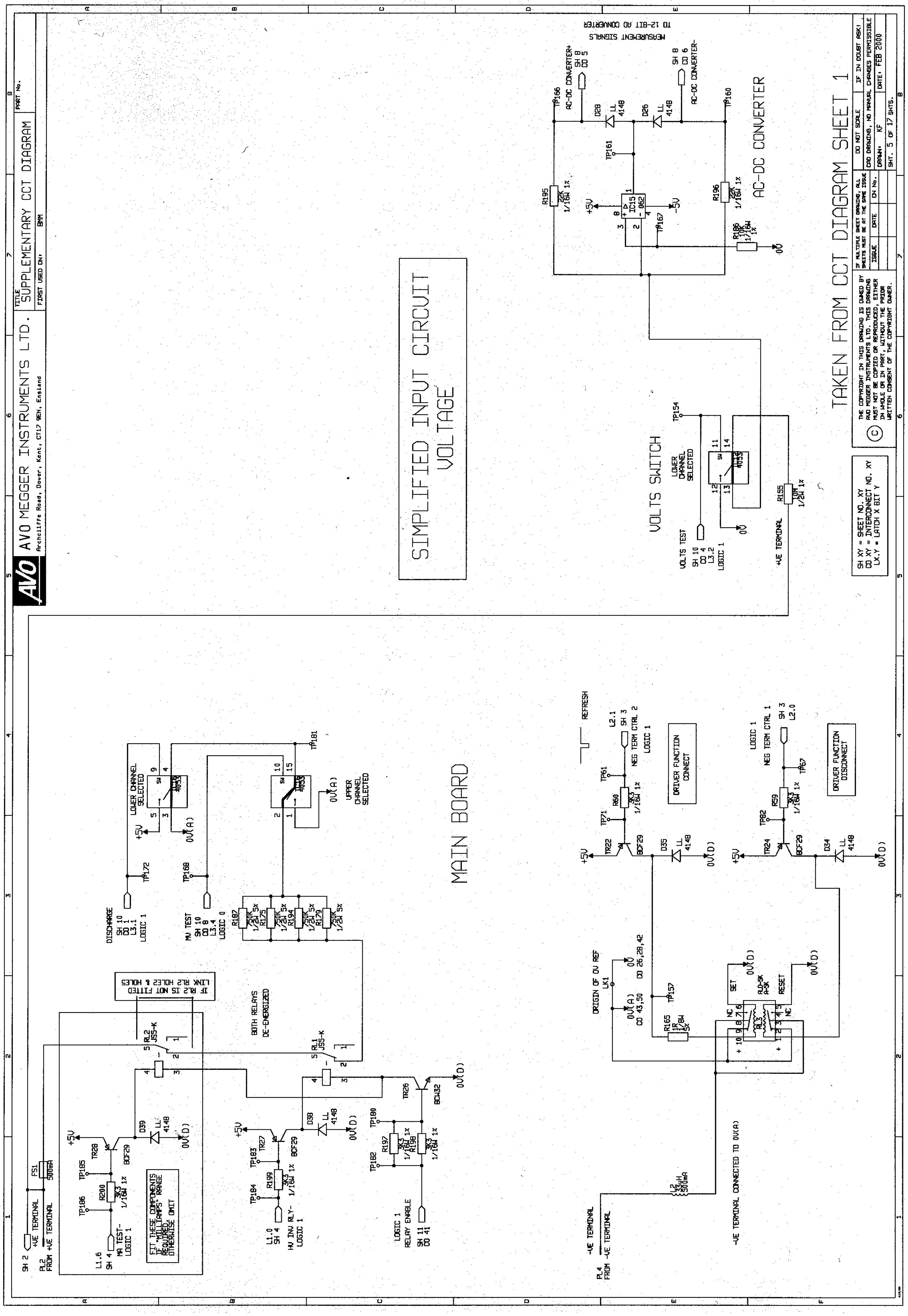
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TITLE SUPPLEMENTARY CCT DIAGRAM
SIMPLIFIED INPUT CIRCUIT VOLTAGE
TAKEN FROM CCT DIAGRAM SHEET 1
MAIN BOARD
AC-DC CONVERTER
VOLTS SWITCH
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
BOTH RELAYS DE-ENERGIZED
IF RL2 IS NOT FITTED LINK RL2 HOLE2 & HOLE5
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED. OTHERWISE OMIT
-VE TERMINAL CONNECTED TO 0V(A)
ORIGIN OF 0V REF
MEASUREMENT SIGNALS TO 12-BIT AD CONVERTER
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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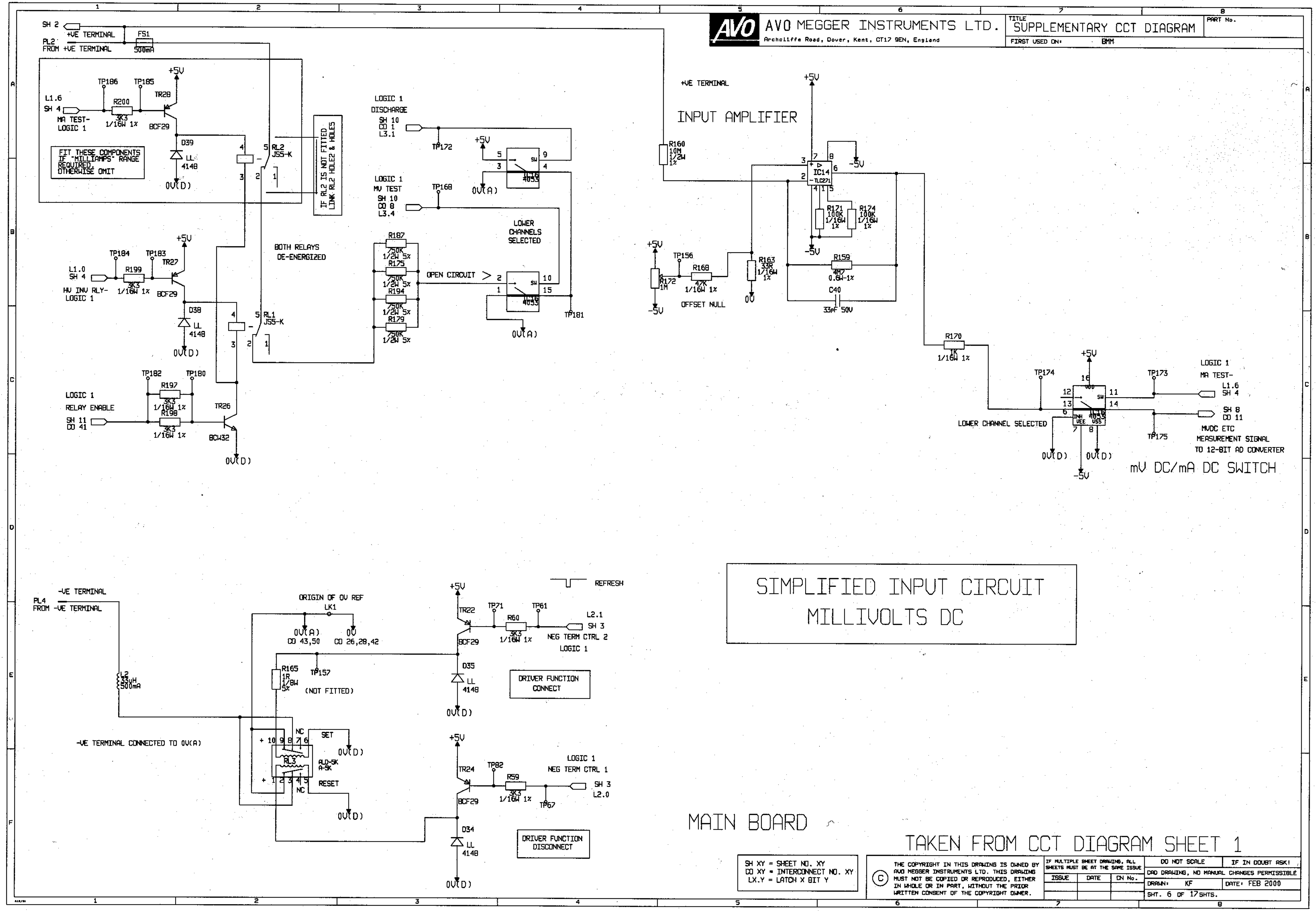
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TITLE SUPPLEMENTARY CCT DIAGRAM
PART No.
FIRST USED ON: BMM
INPUT AMPLIFIER
+VE TERMINAL
SH 2
PL2 FROM +VE TERMINAL
FS1 500mA
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED, OTHERWISE OMIT
IF RL2 IS NOT FITTED LINK RL2 HOLE2 & HOLE5
BOTH RELAYS DE-ENERGIZED
LOGIC 1 DISCHARGE SH 10 CO 1 L3.1
LOGIC 1 MV TEST SH 10 CO 8 L3.4
LOWER CHANNELS SELECTED
OPEN CIRCUIT
L1.6 SH 4 MA TEST- LOGIC 1
L1.0 SH 4 HV INV RLY- LOGIC 1
LOGIC 1 RELAY ENABLE SH 11 CO 41
OFFSET NULL
LOWER CHANNEL SELECTED
LOGIC 1 MA TEST- L1.6 SH 4
SH 8 CO 11
MVDC ETC MEASUREMENT SIGNAL TO 12-BIT AD CONVERTER
mV DC/mA DC SWITCH
PL4 FROM -VE TERMINAL
-VE TERMINAL
-VE TERMINAL CONNECTED TO 0V(A)
ORIGIN OF 0V REF
LK1
0V(A) CO 43,50
0V CO 26,28,42
(NOT FITTED)
REFRESH
L2.1 SH 3 NEG TERM CTRL 2 LOGIC 1
LOGIC 1 NEG TERM CTRL 1 SH 3 L2.0
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
SIMPLIFIED INPUT CIRCUIT
MILLIVOLTS DC
MAIN BOARD
TAKEN FROM CCT DIAGRAM SHEET 1
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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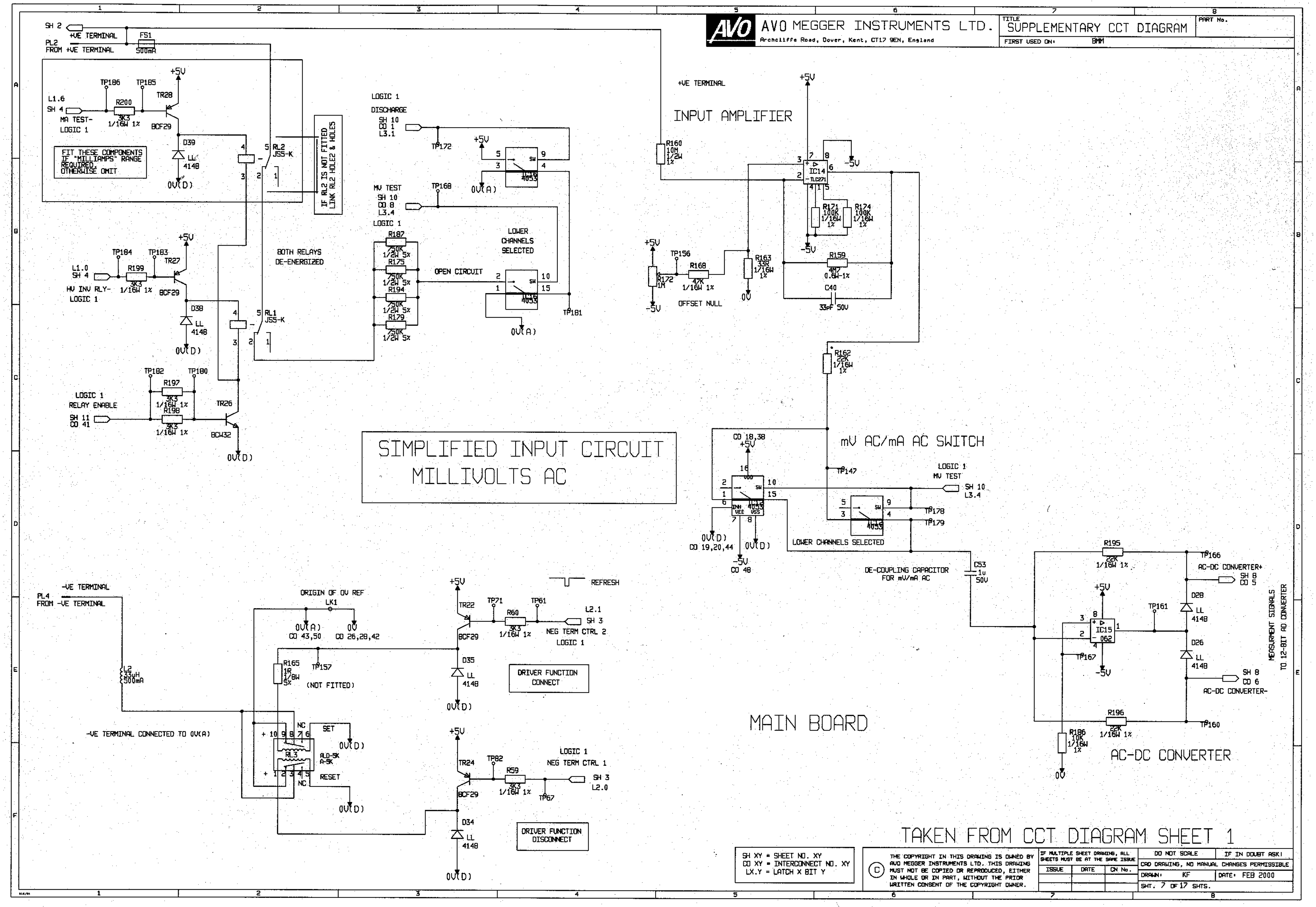
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TITLE SUPPLEMENTARY CCT DIAGRAM
FIRST USED ON: BMM
PART No.
SIMPLIFIED INPUT CIRCUIT
MILLIVOLTS AC
INPUT AMPLIFIER
mV AC/mA AC SWITCH
AC-DC CONVERTER
MAIN BOARD
TAKEN FROM CCT DIAGRAM SHEET 1
SH 2
+VE TERMINAL
PL2
FROM +VE TERMINAL
FS1
500mA
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED, OTHERWISE OMIT
IF RL2 IS NOT FITTED LINK RL2 HOLE2 & HOLE5
BOTH RELAYS DE-ENERGIZED
L1.6
SH 4
MA TEST-
LOGIC 1
L1.0
SH 4
HV INV RLY-
LOGIC 1
LOGIC 1
RELAY ENABLE
SH 11
CD 41
LOGIC 1
DISCHARGE
SH 10
CD 1
L3.1
MV TEST
SH 10
CD 8
L3.4
LOGIC 1
LOWER CHANNELS SELECTED
OPEN CIRCUIT
OFFSET NULL
+VE TERMINAL
LOGIC 1
MV TEST
SH 10
L3.4
LOWER CHANNELS SELECTED
DE-COUPLING CAPACITOR FOR mV/mA AC
AC-DC CONVERTER+
SH 8
CD 5
AC-DC CONVERTER-
SH 8
CD 6
MEASUREMENT SIGNALS TO 12-BIT AD CONVERTER
-VE TERMINAL
PL4
FROM -VE TERMINAL
-VE TERMINAL CONNECTED TO 0V(A)
ORIGIN OF 0V REF
LK1
CD 43,50
CD 26,28,42
(NOT FITTED)
REFRESH
NEG TERM CTRL 2
LOGIC 1
L2.1
SH 3
DRIVER FUNCTION CONNECT
LOGIC 1
NEG TERM CTRL 1
SH 3
L2.0
DRIVER FUNCTION DISCONNECT
SET
RESET
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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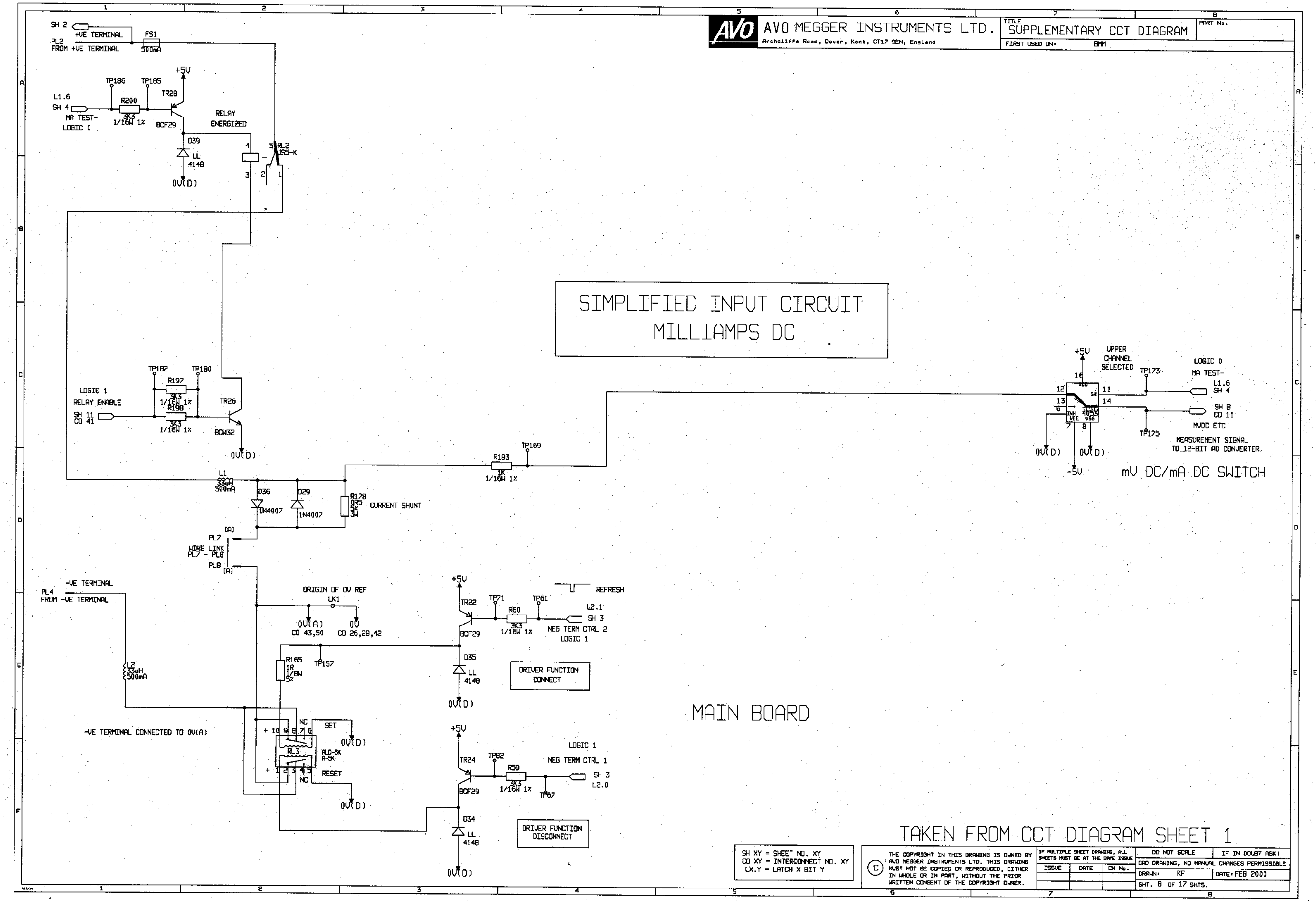
DATE: FEB 2000
SHT. 7 OF 17 SHTS.


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE SUPPLEMENTARY CCT DIAGRAM
PART No.
FIRST USED ON: BMM
SIMPLIFIED INPUT CIRCUIT
MILLIAMPS DC
mV DC/mA DC SWITCH
MAIN BOARD
TAKEN FROM CCT DIAGRAM SHEET 1
SH 2
+VE TERMINAL
PL2
FROM +VE TERMINAL
FS1
500mA
TP186
TP185
L1.6
SH 4
MA TEST-
LOGIC 0
R200
3K3
1/16W 1%
TR28
BCF29
+5V
RELAY
ENERGIZED
D39
LL
4148
0V(D)
RL2
JS5-K
TP182
TP180
R197
3K3
1/16W 1%
R198
LOGIC 1
RELAY ENABLE
SH 11
CO 41
TR26
BCW32
L1
33uH
500mA
D36
1N4007
D29
R178
0R5
5%
3W
CURRENT SHUNT
R193
1K
1/16W 1%
TP169
PL7
WIRE LINK
PL7 - PL8
PL8
[A]
-VE TERMINAL
PL4
FROM -VE TERMINAL
L2
33uH
500mA
-VE TERMINAL CONNECTED TO 0V(A)
ORIGIN OF 0V REF
LK1
0V(A)
CO 43,50
0V
CO 26,28,42
R165
1R
1/8W
5%
TP157
RL3
ALD-5K
A-5K
SET
RESET
NC
+5V
TR22
BCF29
TP71
R60
TP61
REFRESH
L2.1
SH 3
NEG TERM CTRL 2
LOGIC 1
D35
DRIVER FUNCTION
CONNECT
TR24
TP82
R59
TP67
NEG TERM CTRL 1
L2.0
D34
DRIVER FUNCTION
DISCONNECT
UPPER
CHANNEL
SELECTED
TP173
TP175
SW
4053
INH
VEE
VSS
VDD
-5V
L1.6
SH 8
CO 11
MVDC ETC
MEASUREMENT SIGNAL
TO 12-BIT AD CONVERTER
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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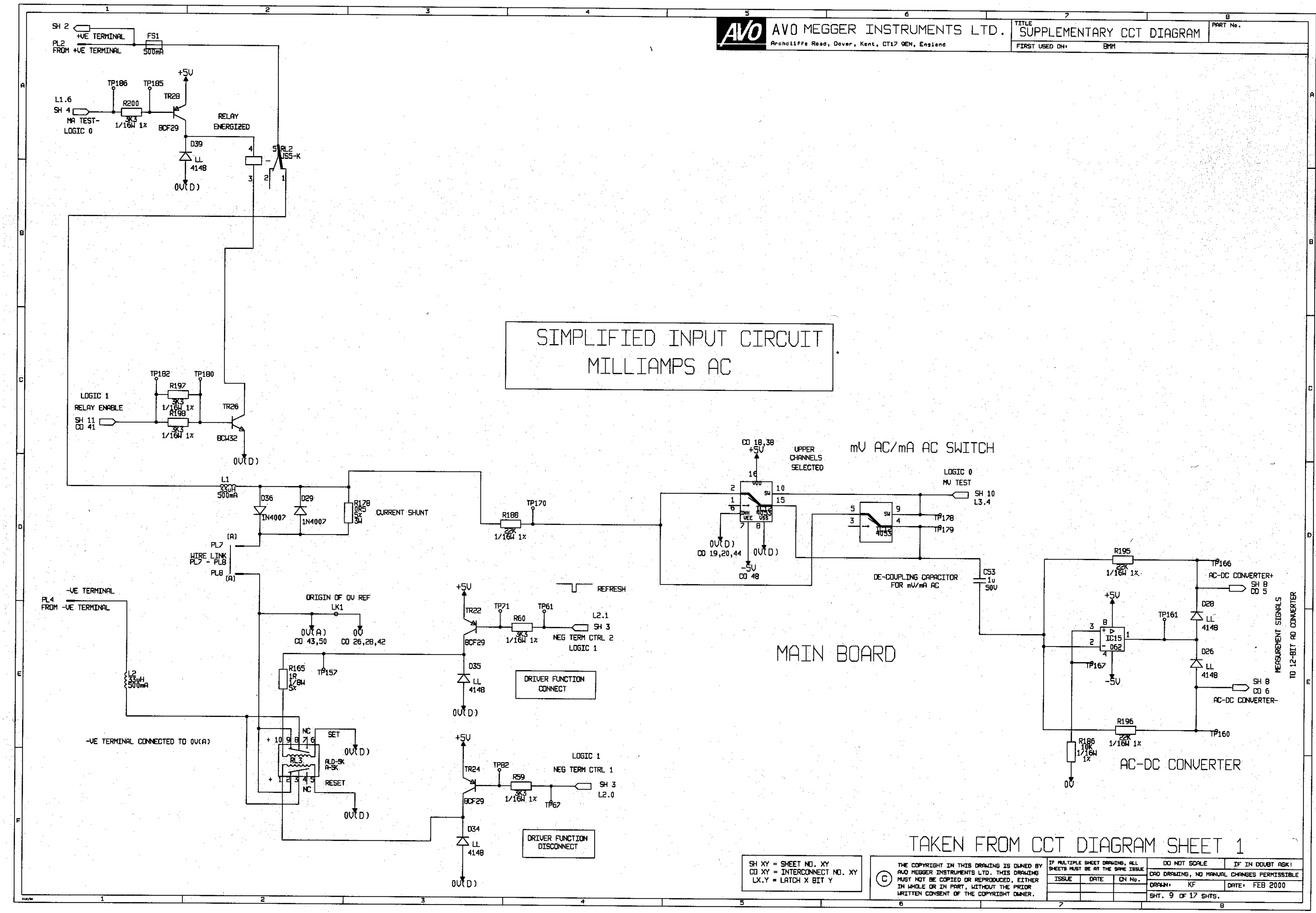
DATE: FEB 2000
SHT. 8 OF 17 SHTS.


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE SUPPLEMENTARY CCT DIAGRAM
FIRST USED ON: BMM
PART No.
SIMPLIFIED INPUT CIRCUIT
MILLIAMPS AC
mV AC/mA AC SWITCH
MAIN BOARD
AC-DC CONVERTER
TAKEN FROM CCT DIAGRAM SHEET 1
SH 2
+VE TERMINAL
PL2
FROM +VE TERMINAL
FS1
500mA
TP186
TP185
R200
3K3
1/16W 1%
TR28
BCF29
L1.6
SH 4
MA TEST-
LOGIC 0
RELAY
ENERGIZED
D39
LL
4148
0V(D)
RL2
US5-K
TP182
TP180
R197
R198
LOGIC 1
RELAY ENABLE
SH 11
CO 41
TR26
BCW32
L1
33uH
500mA
D36
1N4007
D29
1N4007
R178
0R5
5%
3W
CURRENT SHUNT
R188
22K
1/16W 1%
TP170
PL7
WIRE LINK
PL7 - PL8
PL8
[A]
-VE TERMINAL
PL4
FROM -VE TERMINAL
L2
33uH
500mA
-VE TERMINAL CONNECTED TO 0V(A)
ORIGIN OF 0V REF
LK1
0V(A)
CO 43,50
0V
CO 26,28,42
R165
1R
1/8W
5%
TP157
RL3
ALD-5K
A-5K
SET
RESET
NC
TR22
TR24
TP71
TP61
R60
3K3
NEG TERM CTRL 2
LOGIC 1
L2.1
SH 3
D35
D34
DRIVER FUNCTION
CONNECT
DRIVER FUNCTION
DISCONNECT
REFRESH
TP82
R59
TP67
NEG TERM CTRL 1
L2.0
CO 18,38
+5V
UPPER
CHANNELS
SELECTED
IC12
4053
VDD
VEE
VSS
INH
0V(D)
CO 19,20,44
-5V
CO 48
LOGIC 0
MV TEST
SH 10
L3.4
SW
IC13
TP178
TP179
DE-COUPLING CAPACITOR
FOR mV/mA AC
C53
1u
50V
R195
22K
1/16W 1%
TP166
AC-DC CONVERTER+
SH 8
CO 5
D28
D26
IC15
062
TP161
TP167
R186
10K
R196
TP160
AC-DC CONVERTER-
SH 8
CO 6
MEASUREMENT SIGNALS
TO 12-BIT AD CONVERTER
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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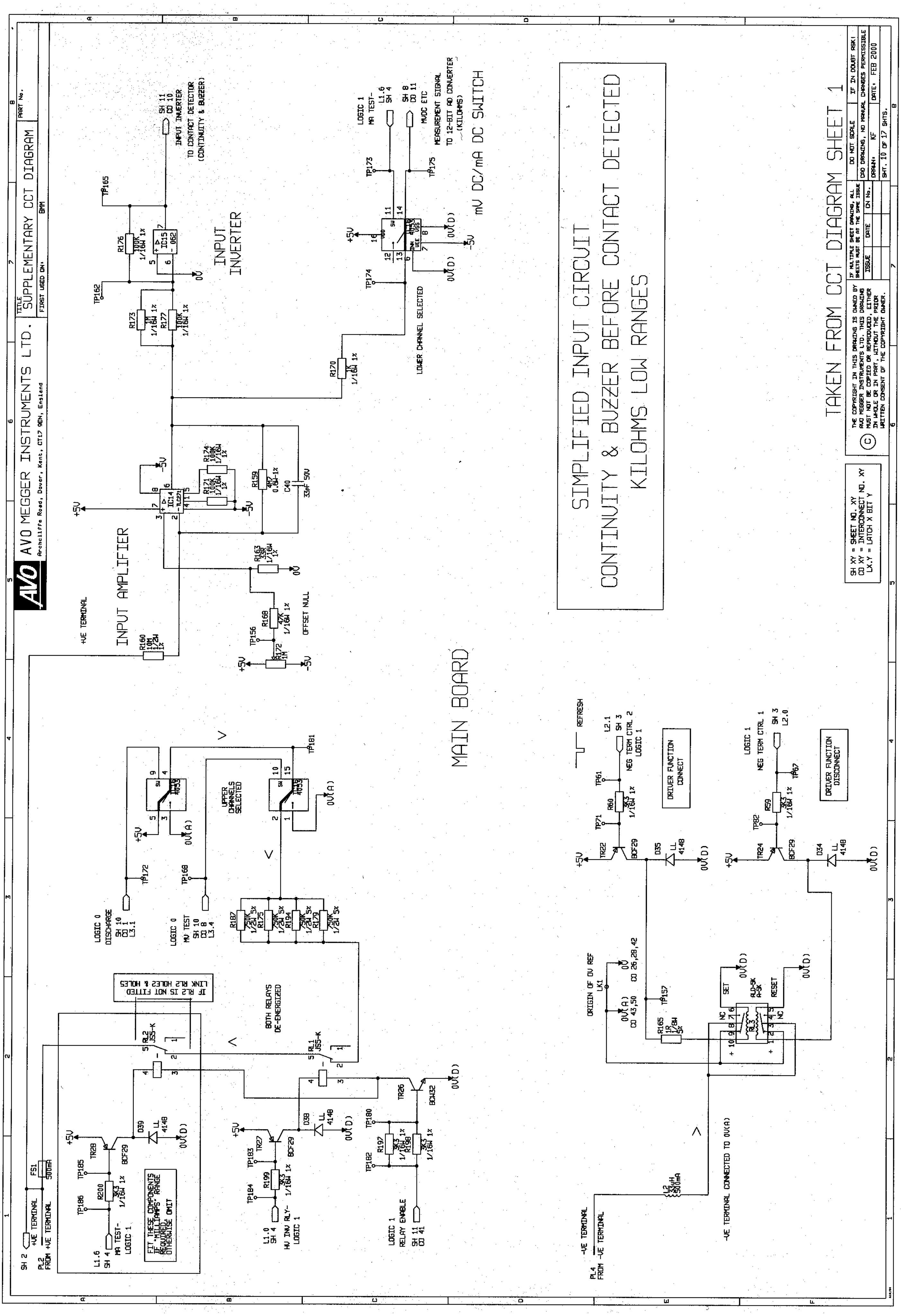
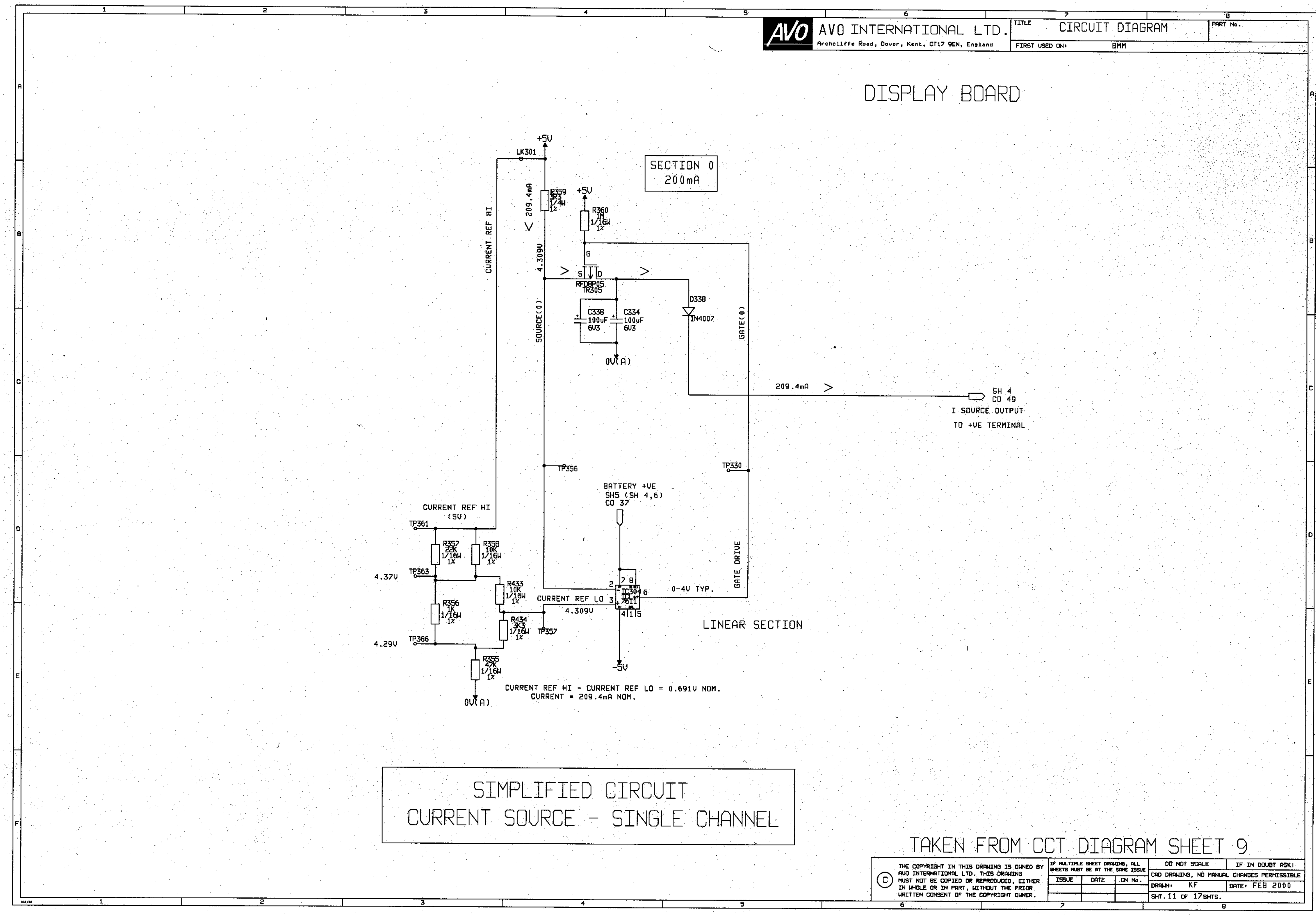
SHT. 9 OF 17 SHTS.


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
SUPPLEMENTARY CCT DIAGRAM
SIMPLIFIED INPUT CIRCUIT
CONTINUITY & BUZZER BEFORE CONTACT DETECTED
KILOHMS LOW RANGES
TAKEN FROM CCT DIAGRAM SHEET 1
INPUT AMPLIFIER
INPUT INVERTER
MAIN BOARD
mV DC/mA DC SWITCH
OFFSET NULL
LOWER CHANNEL SELECTED
UPPER CHANNELS SELECTED
BOTH RELAYS DE-ENERGIZED
IF RL2 IS NOT FITTED LINK RL2 HOLES & HOLES
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED. OTHERWISE OMIT
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
ORIGIN OF 0V REF
-VE TERMINAL CONNECTED TO 0V(A)
+VE TERMINAL
-VE TERMINAL
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
DO NOT SCALE
IF IN DOUBT ASK!
DATE: FEB 2000
SHT. 10 OF 17 SHTS.


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE CIRCUIT DIAGRAM
PART No.
FIRST USED ON: BMM
DISPLAY BOARD
SECTION 0
200mA
+5V
LK301
R359 3R3 1/4W 1%
209.4mA
CURRENT REF HI
4.309V
SOURCE(0)
+5V
R360 1M 1/16W 1%
G
S D
RFD8P05 TR305
D338 1N4007
C338 100uF 6V3
C334 100uF 6V3
0V(A)
GATE(0)
209.4mA
SH 4
CD 49
I SOURCE OUTPUT
TO +VE TERMINAL
TP356
TP330
BATTERY +VE
SH5 (SH 4,6)
CO 37
GATE DRIVE
0-4V TYP.
IC304 7611
CURRENT REF LO
4.309V
LINEAR SECTION
-5V
CURRENT REF HI
(5V)
TP361
R357 22K 1/16W 1%
R358 10K 1/16W 1%
TP363
4.37V
R433 10K 1/16W 1%
R356 1K 1/16W 1%
R434 3K3 1/16W 1%
TP357
TP366
4.29V
R355 47K 1/16W 1%
0V(A)
CURRENT REF HI - CURRENT REF LO = 0.691V NOM.
CURRENT = 209.4mA NOM.
SIMPLIFIED CIRCUIT
CURRENT SOURCE - SINGLE CHANNEL
TAKEN FROM CCT DIAGRAM SHEET 9
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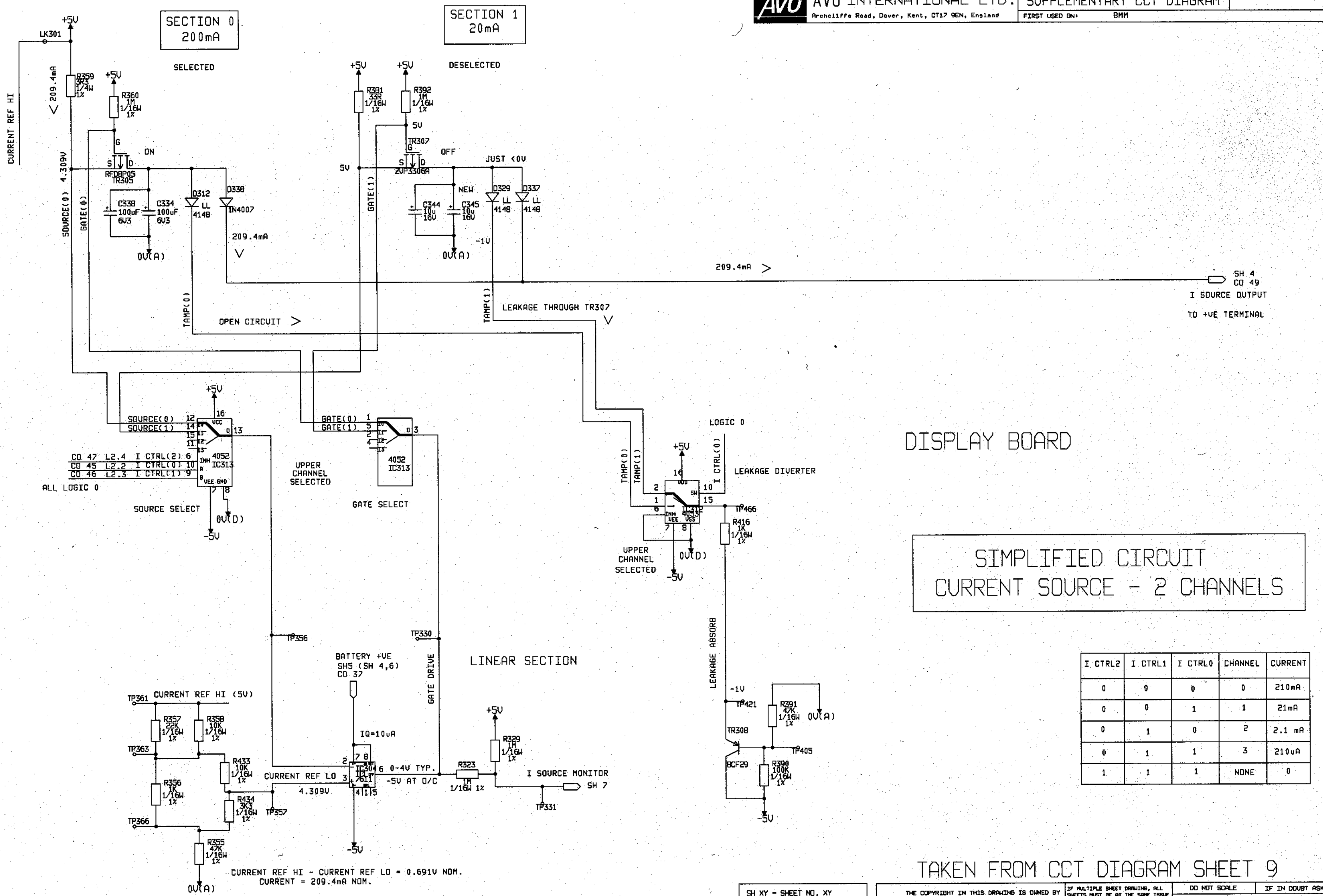
SHT. 11 OF 17SHTS.



SIMPLIFIED CIRCUIT
CURRENT SOURCE - 2 CHANNELS

I CTRL2	I CTRL1	I CTRL0	CHANNEL	CURRENT
0	0	0	0	210mA
0	0	1	1	21mA
0	1	0	2	2.1 mA
0	1	1	3	210uA
1	1	1	NONE	0

TAKEN FROM CCT DIAGRAM SHEET 9

SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y

AVO INTERNATIONAL LTD. Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE: SUPPLEMENTARY CCT DIAGRAM

FIRST USED ON: BMM

PART No.

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE

ISSUE	DATE	CN No.

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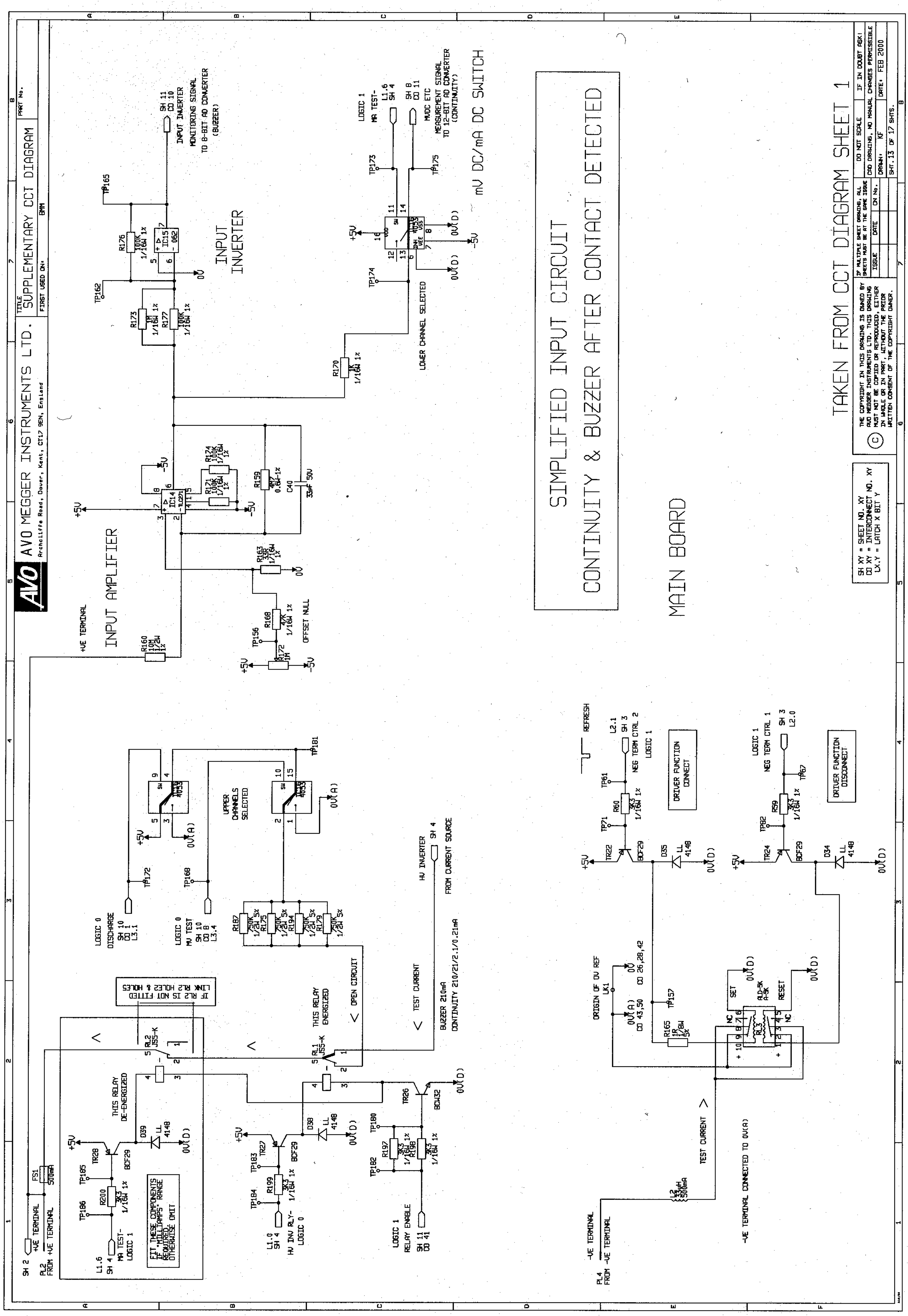
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE

DRAWN: KF | DATE: FEB 2000

SHT.12 OF 17 SHTS.



AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE
SUPPLEMENTARY CCT DIAGRAM
FIRST USED ON:
PART No.
SIMPLIFIED INPUT CIRCUIT
CONTINUITY & BUZZER AFTER CONTACT DETECTED
MAIN BOARD
TAKEN FROM CCT DIAGRAM SHEET 1
INPUT AMPLIFIER
INPUT INVERTER
mV DC/mA DC SWITCH
OFFSET NULL
LOWER CHANNEL SELECTED
UPPER CHANNELS SELECTED
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
THIS RELAY ENERGIZED
THIS RELAY DE-ENERGIZED
OPEN CIRCUIT
TEST CURRENT
BUZZER 210mA
CONTINUITY 210/21/2.1/0.21mA
FROM CURRENT SOURCE
HV INVERTER
IF RL2 IS NOT FITTED LINK RL2 HOLE2 & HOLE5
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED. OTHERWISE OMIT
-VE TERMINAL CONNECTED TO 0V(A)
ORIGIN OF 0V REF
+VE TERMINAL
FROM +VE TERMINAL
-VE TERMINAL
FROM -VE TERMINAL
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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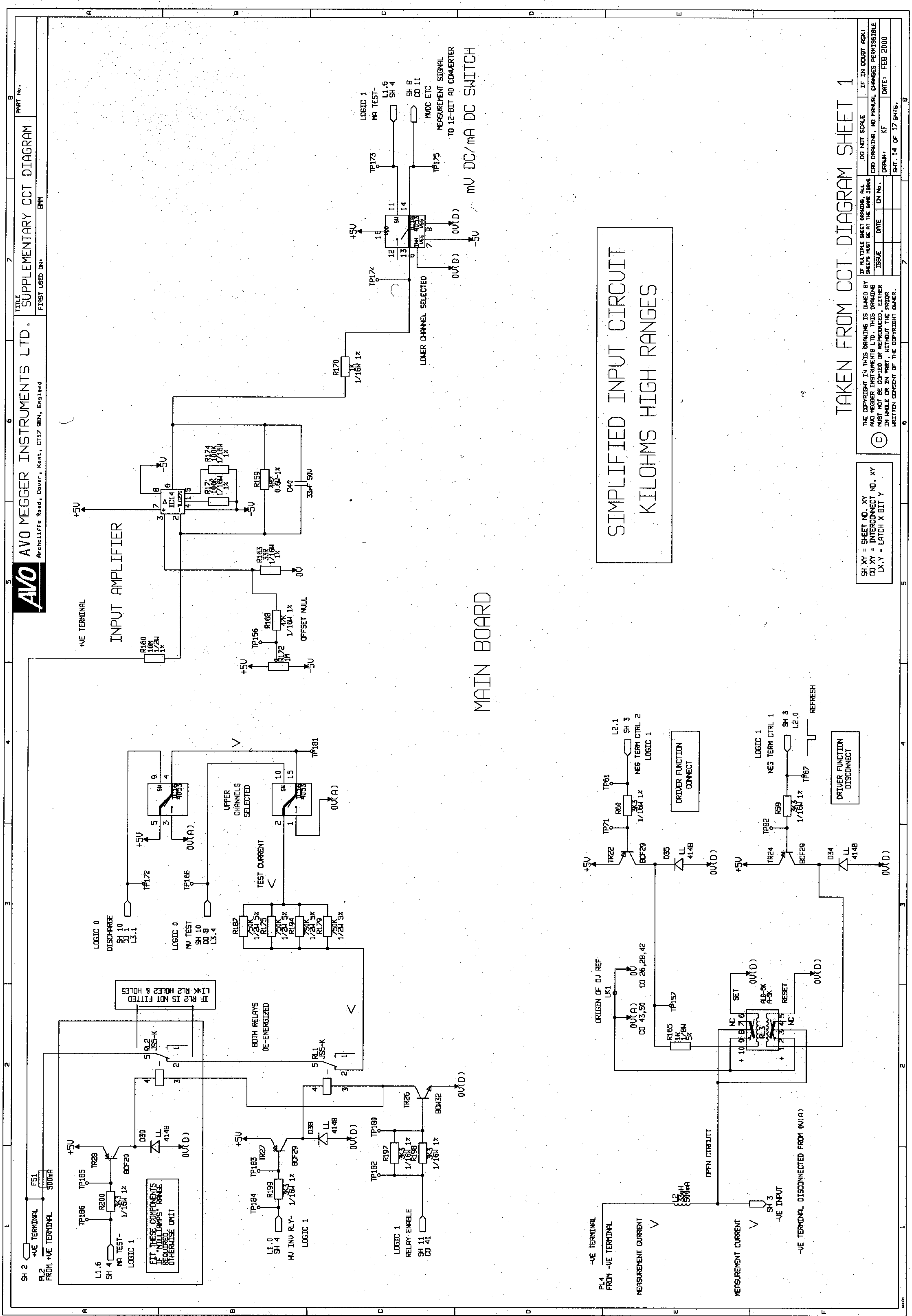
SHT.13 OF 17 SHTS.



AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE SUPPLEMENTARY CCT DIAGRAM
FIRST USED ON: BMM
PART No.
SIMPLIFIED INPUT CIRCUIT
KILOHMS HIGH RANGES
TAKEN FROM CCT DIAGRAM SHEET 1
MAIN BOARD
INPUT AMPLIFIER
mV DC/mA DC SWITCH
+VE TERMINAL
OFFSET NULL
LOWER CHANNEL SELECTED
UPPER CHANNELS SELECTED
TEST CURRENT
BOTH RELAYS DE-ENERGIZED
IF RL2 IS NOT FITTED LINK RL2 HOLES 2 & HOLES
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED. OTHERWISE OMIT
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
ORIGIN OF 0V REF
OPEN CIRCUIT
-VE TERMINAL DISCONNECTED FROM 0V(A)
MEASUREMENT CURRENT
MEASUREMENT SIGNAL TO 12-BIT AD CONVERTER
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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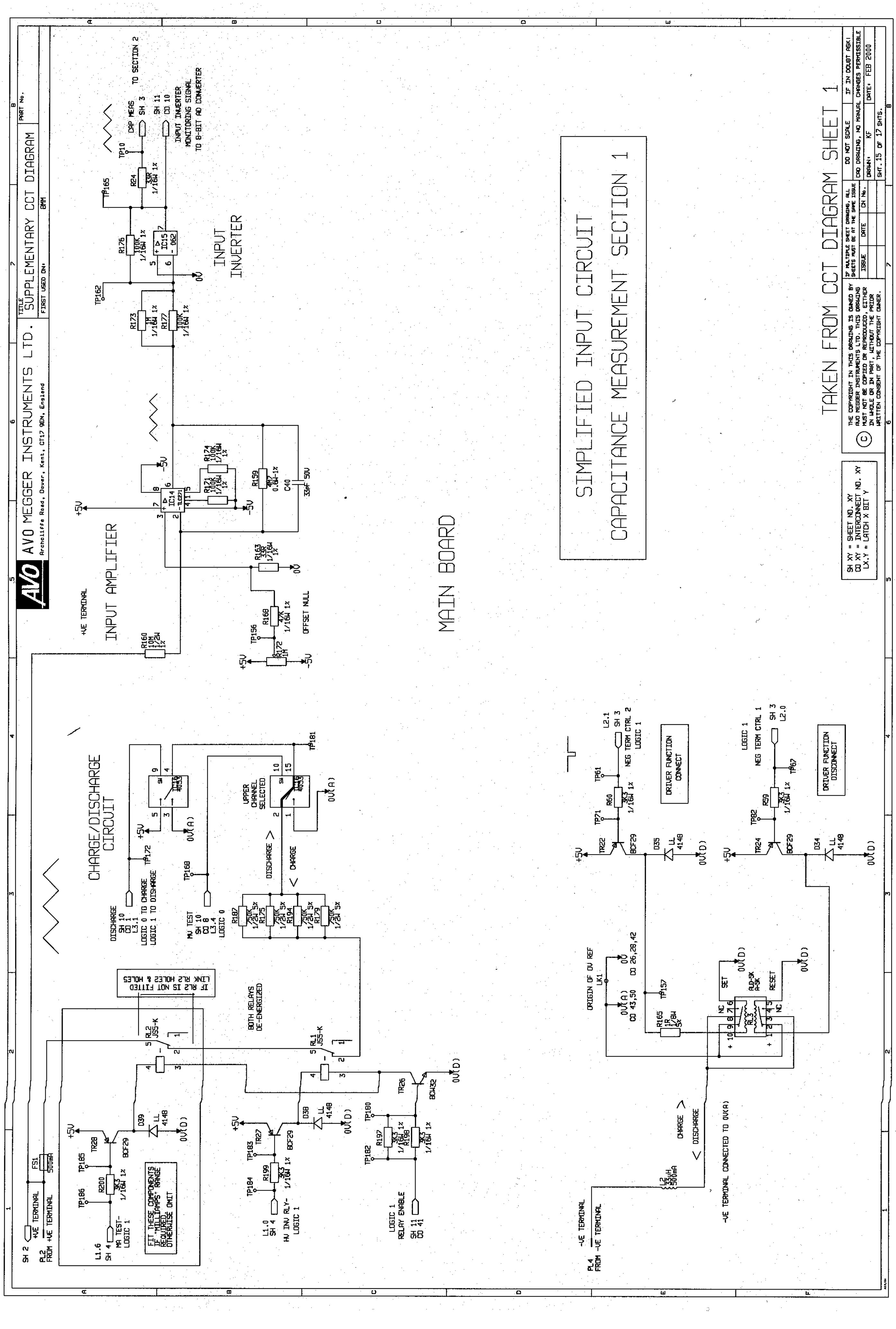
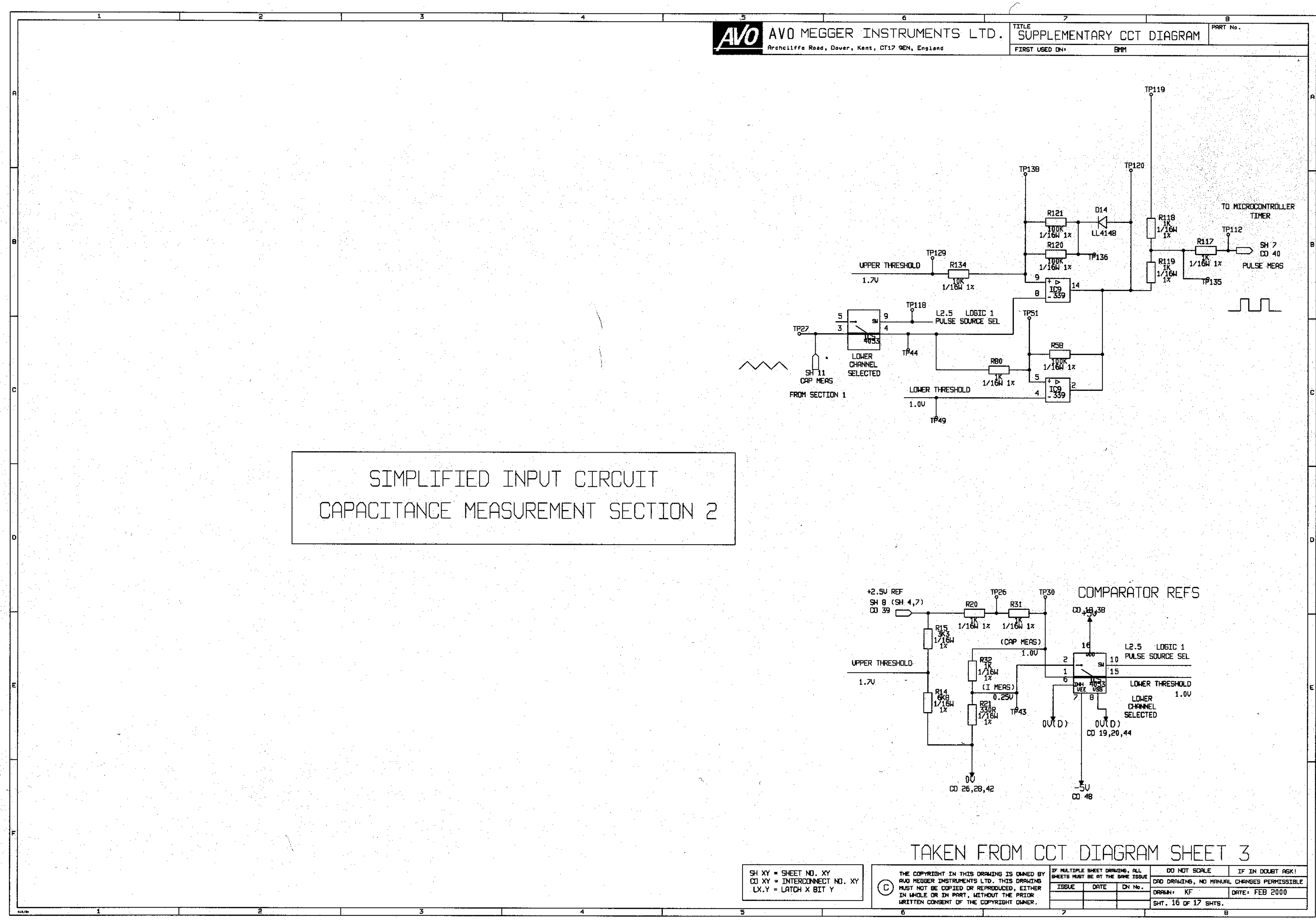
DRAWN: KF
DATE: FEB 2000
SHT. 14 OF 17 SHTS.


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
SUPPLEMENTARY CCT DIAGRAM
SIMPLIFIED INPUT CIRCUIT
CAPACITANCE MEASUREMENT SECTION 1
TAKEN FROM CCT DIAGRAM SHEET 1
INPUT AMPLIFIER
INPUT INVERTER
MAIN BOARD
CHARGE/DISCHARGE CIRCUIT
OFFSET NULL
TO SECTION 2
CAP MEAS
INPUT INVERTER MONITORING SIGNAL TO 8-BIT AD CONVERTER
UPPER CHANNEL SELECTED
DISCHARGE
CHARGE
LOGIC 0 TO CHARGE
LOGIC 1 TO DISCHARGE
BOTH RELAYS DE-ENERGIZED
IF RL2 IS NOT FITTED LINK RL2 HOLE2 & HOLE5
FIT THESE COMPONENTS IF "MILLIAMPS" RANGE REQUIRED. OTHERWISE OMIT
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
NEG TERM CTRL 2
NEG TERM CTRL 1
ORIGIN OF 0V REF
-VE TERMINAL CONNECTED TO 0V(A)
+VE TERMINAL
-VE TERMINAL
PL2 FROM +VE TERMINAL
PL4 FROM -VE TERMINAL
RELAY ENABLE
HV INJ RLY-
MA TEST-
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
DO NOT SCALE
IF IN DOUBT ASK!
DATE: FEB 2000
SHT. 15 OF 17 SHTS.


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
SUPPLEMENTARY CCT DIAGRAM
FIRST USED ON: BMM
SIMPLIFIED INPUT CIRCUIT
CAPACITANCE MEASUREMENT SECTION 2
TO MICROCONTROLLER TIMER
SH 7
CD 40
PULSE MEAS
UPPER THRESHOLD
1.7V
LOWER THRESHOLD
1.0V
L2.5 LOGIC 1
PULSE SOURCE SEL
LOWER CHANNEL SELECTED
SH 11
CAP MEAS
FROM SECTION 1
COMPARATOR REFS
+2.5V REF
SH 8 (SH 4,7)
CD 39
(CAP MEAS)
(I MEAS)
0.25V
0V
CD 26,28,42
-5V
CD 48
0V(D)
CD 19,20,44
TAKEN FROM CCT DIAGRAM SHEET 3
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
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DATE: FEB 2000
SHT. 16 OF 17 SHTS.

Appendix 2 Circuit Diagrams

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM

PART No.

FIRST USED ON: BMM2000

SHEET NUMBER	CONTENTS
1 (MAIN)	RELAYS, INPUT AMPLIFIERS, AC-DC CONVERTER, CURRENT SHUNT
2 (MAIN)	VOLTAGE DETECTOR/FREQUENCY MEASUREMENT - INPUT STAGES
3 (MAIN)	CURRENT MEASUREMENT (INSULATION TEST), LATCH 2
4 (MAIN)	HIGH VOLTAGE INVERTER, LATCH 1
5 (MAIN)	BATTERY CONNECTOR, POWER SUPPLIES, ROTARY SWITCH
6 (MAIN)	RS232 (NON-ISOLATED), BATTERY CHECK
7 (DISPLAY)	MICROCONTROLLER, DISPLAY, PUSH BUTTONS (NOT 'TEST'), EEPROM, DIODE LINKS
8 (DISPLAY)	A/D CONVERTER, A/D REFERENCES, LATCH 4
9 (DISPLAY)	CURRENT SOURCE (OHMS, BUZZER)
10 (DISPLAY)	VOLTAGE DETECTOR/FREQUENCY MEASUREMENT, LATCH 3
11 (DISPLAY)	CONTACT DETECTOR, BACKLIGHT, BUZZER, TEST BUTTON, BROWNOUT, WATCHDOG/RESET
12 (RS232)	RS232 (ISOLATED)

SHEET 25

MAIN INDEX SHEET 1

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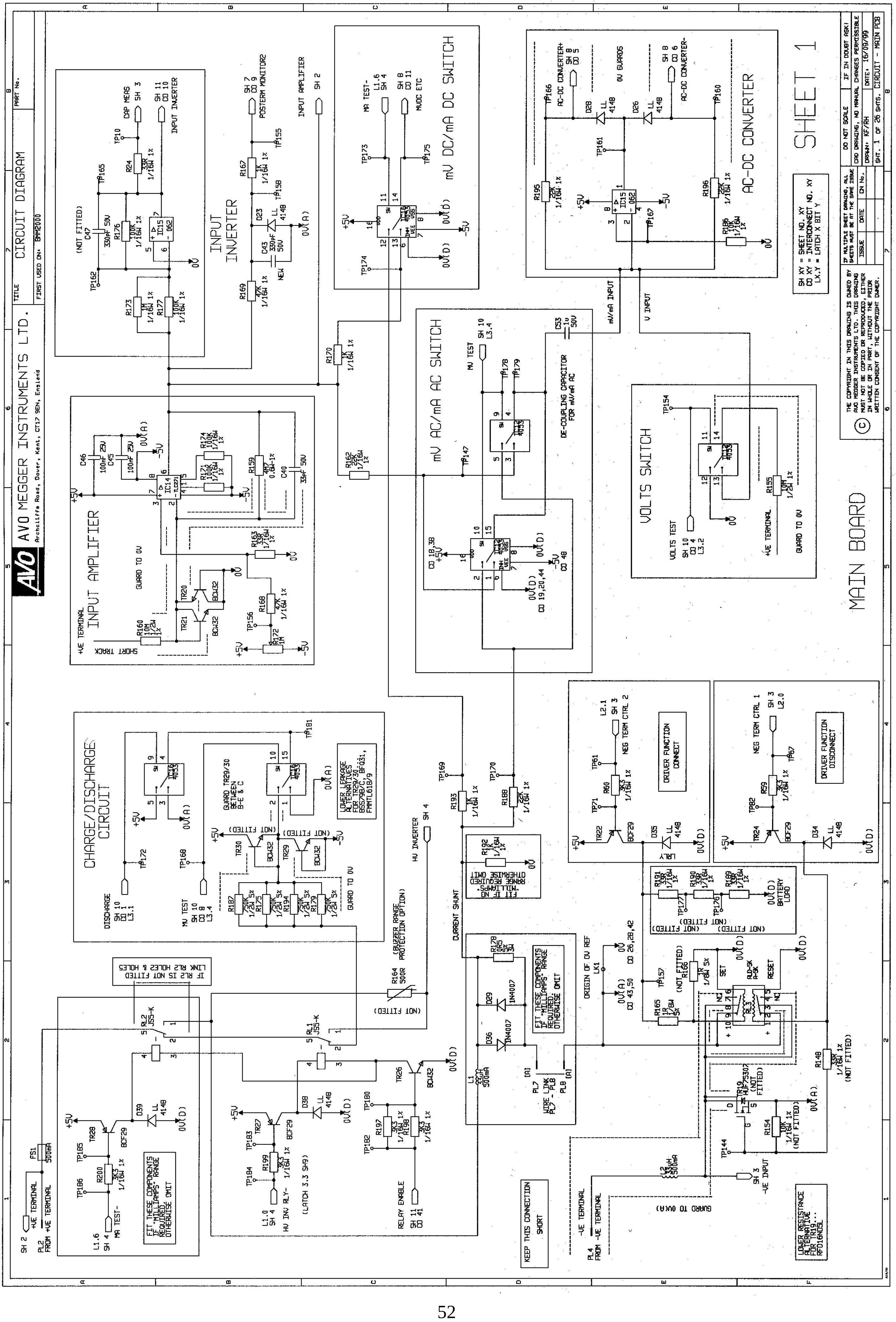
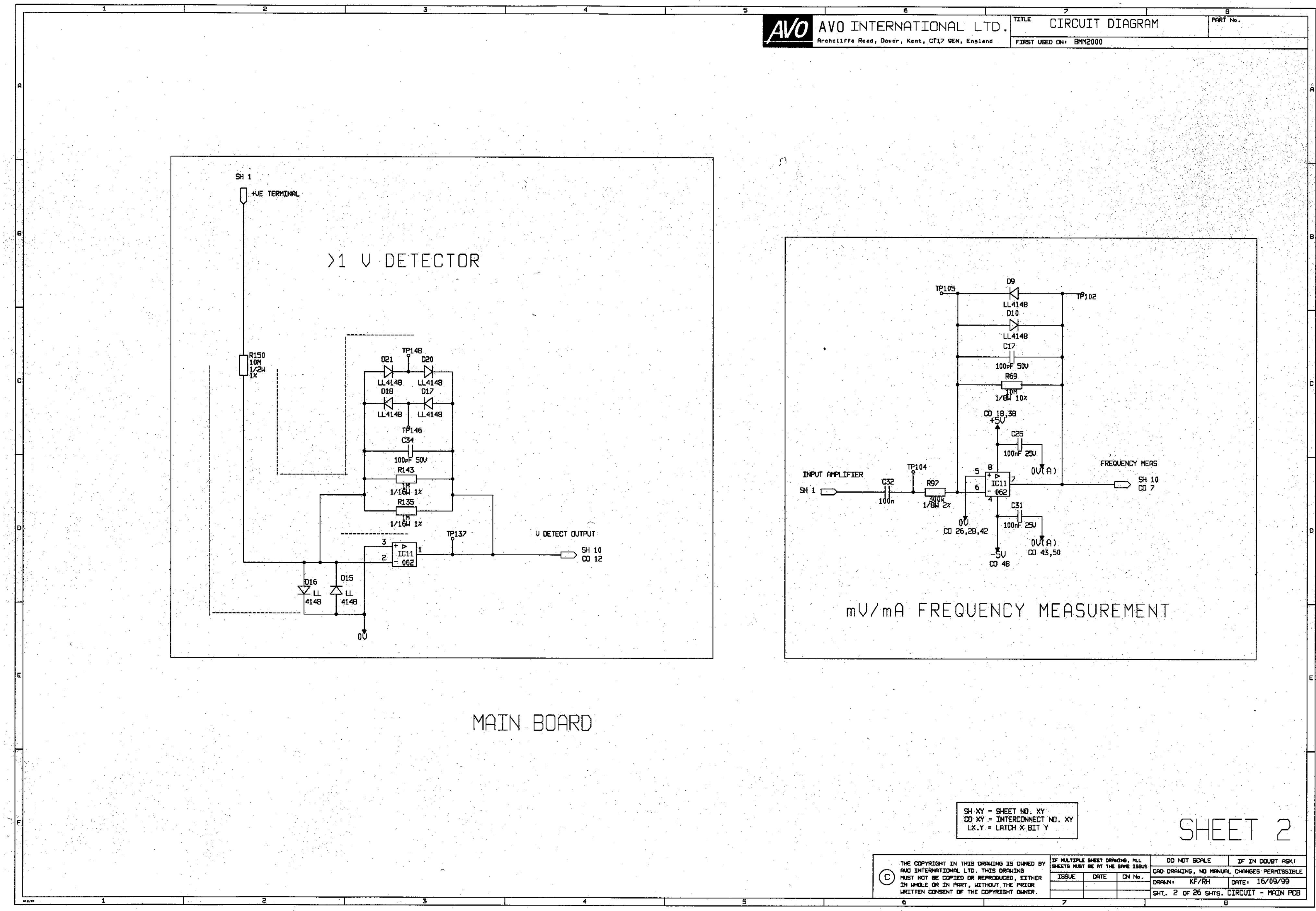
DRAWN: KF — DATE: 16/09/99

SHT. 25 OF 26 SHTS. INDEX SHEET 1



AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
INPUT AMPLIFIER
INPUT INVERTER
mV DC/mA DC SWITCH
mV AC/mA AC SWITCH
AC-DC CONVERTER
VOLTS SWITCH
CHARGE/DISCHARGE CIRCUIT
DRIVER FUNCTION CONNECT
DRIVER FUNCTION DISCONNECT
KEEP THIS CONNECTION SHORT
SHEET 1
MAIN BOARD


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.
>1 V DETECTOR
SH 1
+VE TERMINAL
R150 10M 1/2W 1%
TP148
D21 LL4148
D20 LL4148
D18 LL4148
D17 LL4148
TP146
C34 100pF 50V
R143 1M 1/16W 1%
R135 1M 1/16W 1%
TP137
IC11 062
D16 LL 4148
D15 LL 4148
0V
V DETECT OUTPUT
SH 10 CO 12
mV/mA FREQUENCY MEASUREMENT
INPUT AMPLIFIER
SH 1
C32 100n
TP104
R97 300k 1/8W 2%
TP105
D9 LL4148
D10 LL4148
C17 100pF 50V
R69 10M 1/8W 10%
TP102
CO 18,38 +5V
C25 100nF 25V
0V(A)
C31 100nF 25V
0V(A) CO 43,50
0V CO 26,28,42
-5V CO 48
FREQUENCY MEAS
SH 10 CO 7
MAIN BOARD
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SHEET 2
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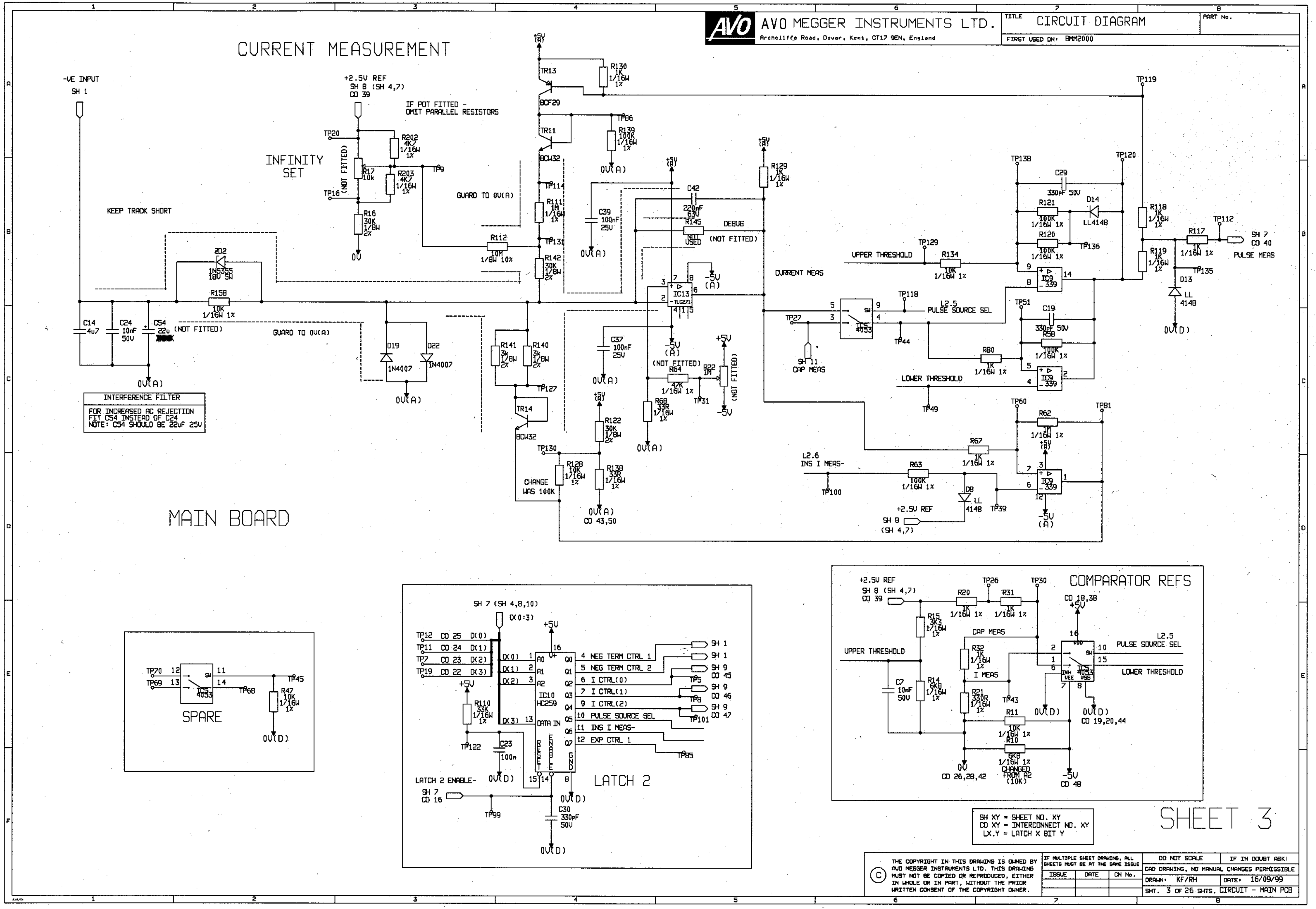
DRAWN: KF/RH
DATE: 16/09/99
SHT. 2 OF 26 SHTS. CIRCUIT - MAIN PCB



CURRENT MEASUREMENT
AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
INFINITY SET
IF POT FITTED - OMIT PARALLEL RESISTORS
KEEP TRACK SHORT
GUARD TO 0V(A)
INTERFERENCE FILTER
FOR INCREASED AC REJECTION FIT C54 INSTEAD OF C24
NOTE: C54 SHOULD BE 22uF 25V
MAIN BOARD
CHANGE WAS 100K
UPPER THRESHOLD
LOWER THRESHOLD
CURRENT MEAS
L2.5 PULSE SOURCE SEL
L2.6 INS I MEAS-
PULSE MEAS
SPARE
LATCH 2
LATCH 2 ENABLE-
4 NEG TERM CTRL 1
5 NEG TERM CTRL 2
6 I CTRL(0)
7 I CTRL(1)
9 I CTRL(2)
10 PULSE SOURCE SEL
11 INS I MEAS-
12 EXP CTRL 1
COMPARATOR REFS
CHANGED FROM R2 (10K)
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SHEET 3
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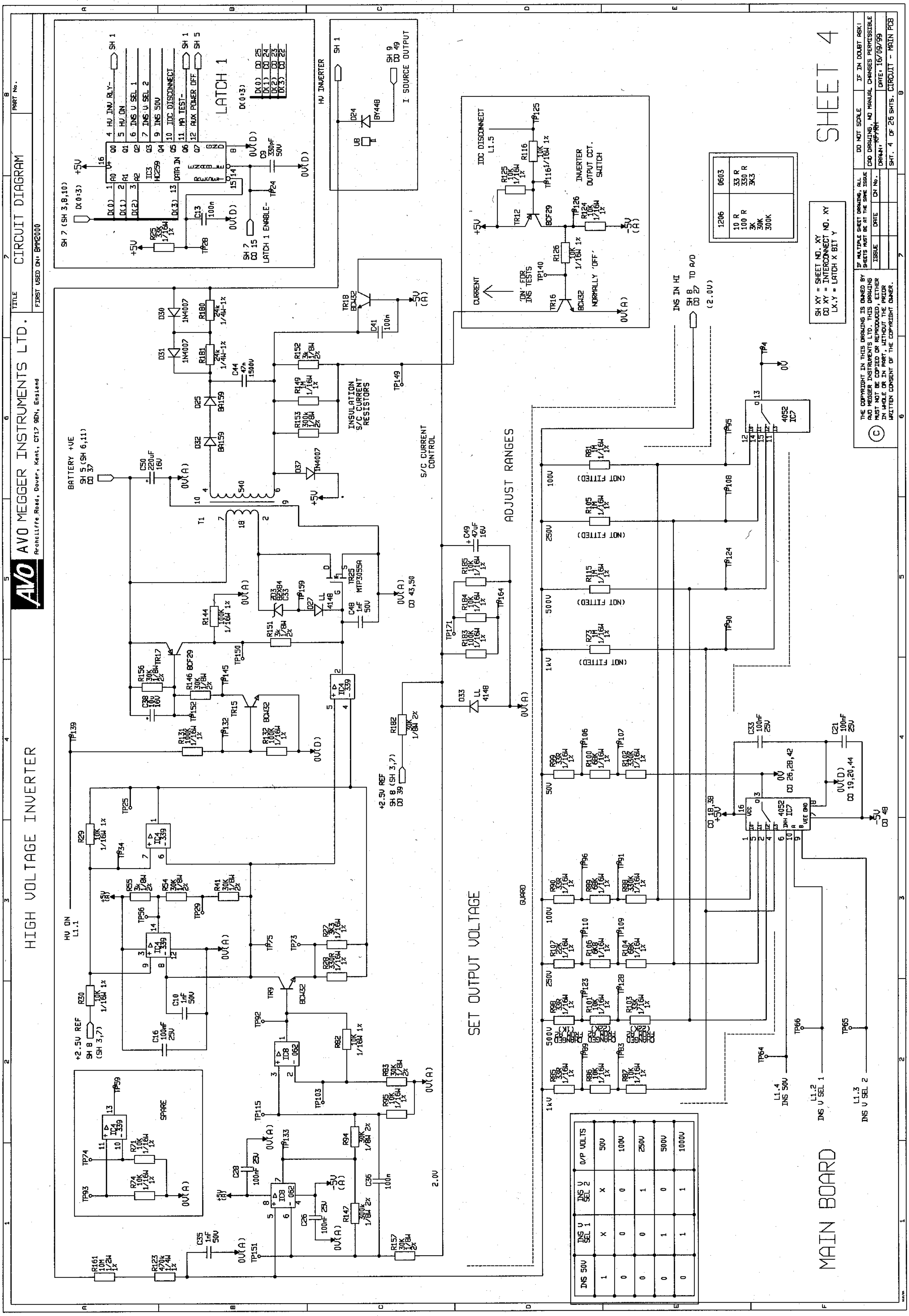
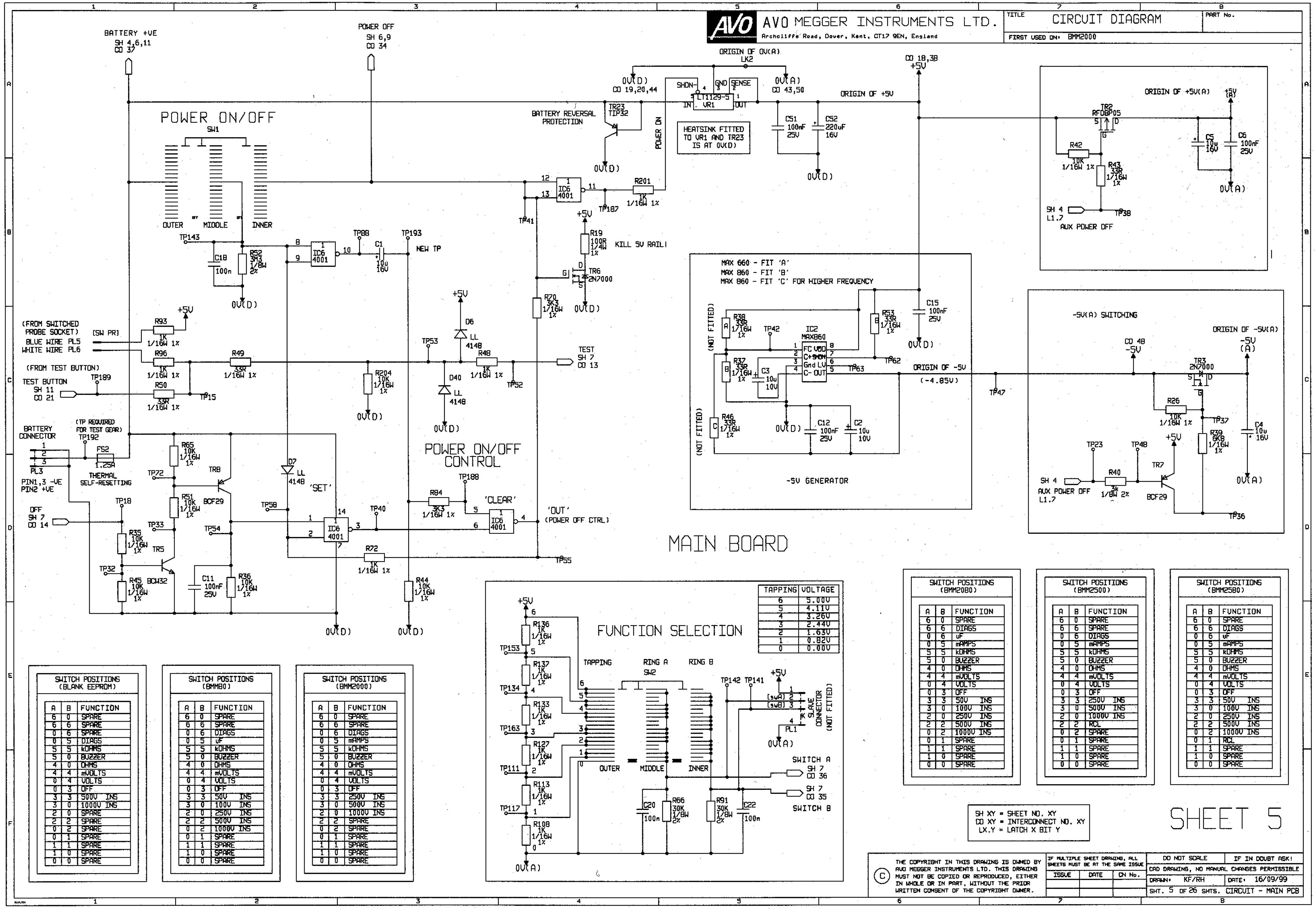
DRAWN: KF/RH
DATE: 16/09/99
SHT. 3 OF 26 SHTS. CIRCUIT - MAIN PCB


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
HIGH VOLTAGE INVERTER
SET OUTPUT VOLTAGE
ADJUST RANGES
LATCH 1
HV INVERTER
I SOURCE OUTPUT
IDC DISCONNECT
INVERTER OUTPUT CCT. SWITCH
INSULATION S/C CURRENT RESISTORS
S/C CURRENT CONTROL
BATTERY +VE
SPARE
GUARD
INS IN HI
TO A/D
(NOT FITTED)
SH XY = SHEET NO. XY
CD XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SHEET 4
MAIN BOARD
DO NOT SCALE
IF IN DOUBT ASK!
DATE: 16/09/99
SHT. 4 OF 26 SHTS.
CIRCUIT - MAIN PCB
INS 50V | INS V SEL 1 | INS V SEL 2 | O/P VOLTS
1 | X | X | 50V
0 | 0 | 0 | 100V
0 | 0 | 1 | 250V
0 | 1 | 0 | 500V
0 | 1 | 1 | 1000V


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
POWER ON/OFF
POWER ON/OFF CONTROL
MAX 660 - FIT 'A'
MAX 860 - FIT 'B'
MAX 860 - FIT 'C' FOR HIGHER FREQUENCY
-5V GENERATOR
-5V(A) SWITCHING
HEATSINK FITTED TO VR1 AND TR23 IS AT 0V(D)
BATTERY REVERSAL PROTECTION
KILL 5V RAIL!
MAIN BOARD
FUNCTION SELECTION
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SHEET 5
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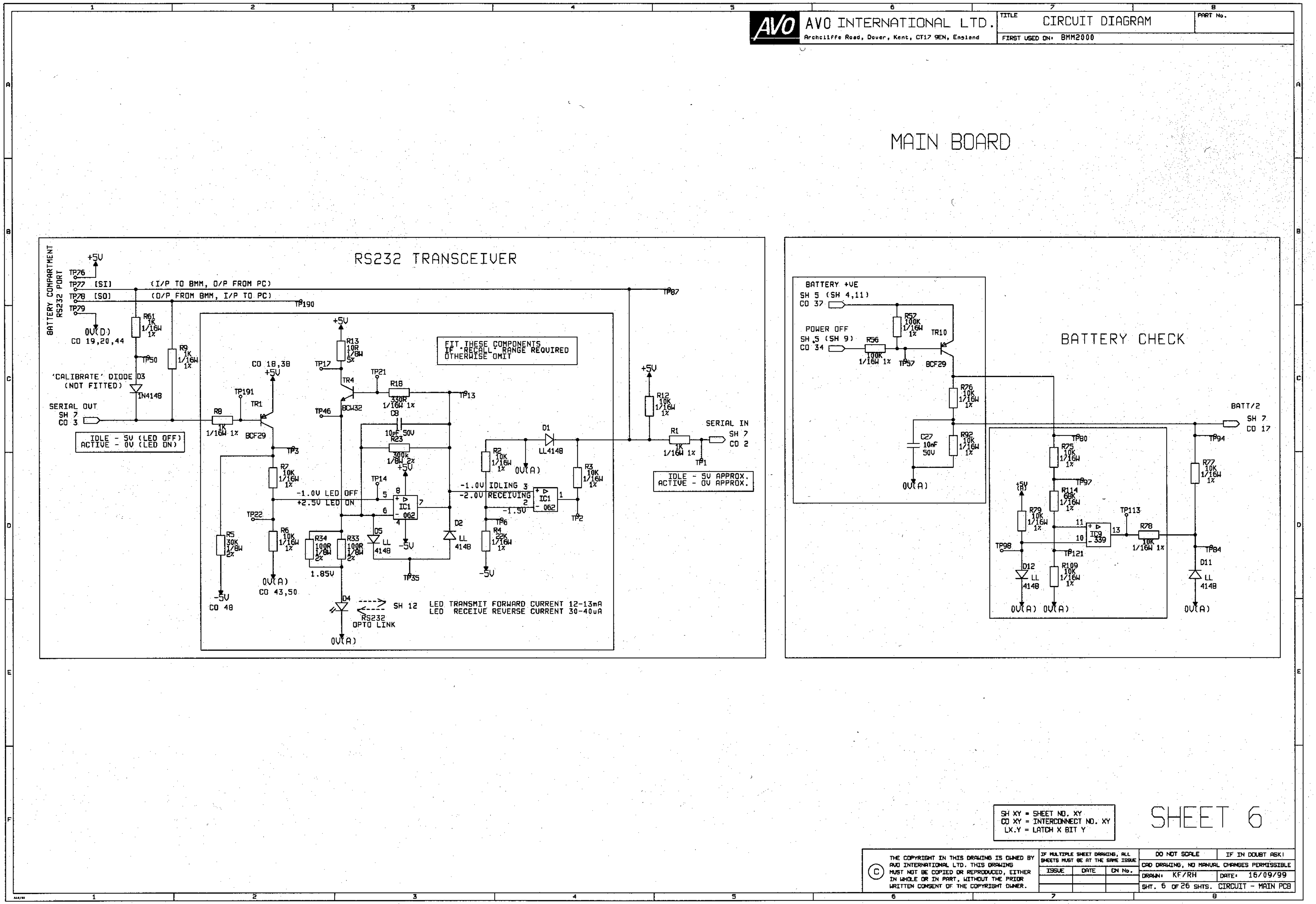
DATE: 16/09/99
SHT. 5 OF 26 SHTS. CIRCUIT - MAIN PCB


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.
MAIN BOARD
RS232 TRANSCEIVER
BATTERY CHECK
BATTERY COMPARTMENT RS232 PORT
(I/P TO BMM, O/P FROM PC)
(O/P FROM BMM, I/P TO PC)
'CALIBRATE' DIODE (NOT FITTED)
SERIAL OUT SH 7 CO 3
IDLE - 5V (LED OFF)
ACTIVE - 0V (LED ON)
FIT THESE COMPONENTS IF 'RECALL' RANGE REQUIRED OTHERWISE OMIT
SERIAL IN SH 7 CO 2
IDLE - 5V APPROX.
ACTIVE - 0V APPROX.
RS232 OPTO LINK
LED TRANSMIT FORWARD CURRENT 12-13mA
LED RECEIVE REVERSE CURRENT 30-40uA
BATTERY +VE SH 5 (SH 4,11) CO 37
POWER OFF SH 5 (SH 9) CO 34
BATT/2 SH 7 CO 17
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SHEET 6
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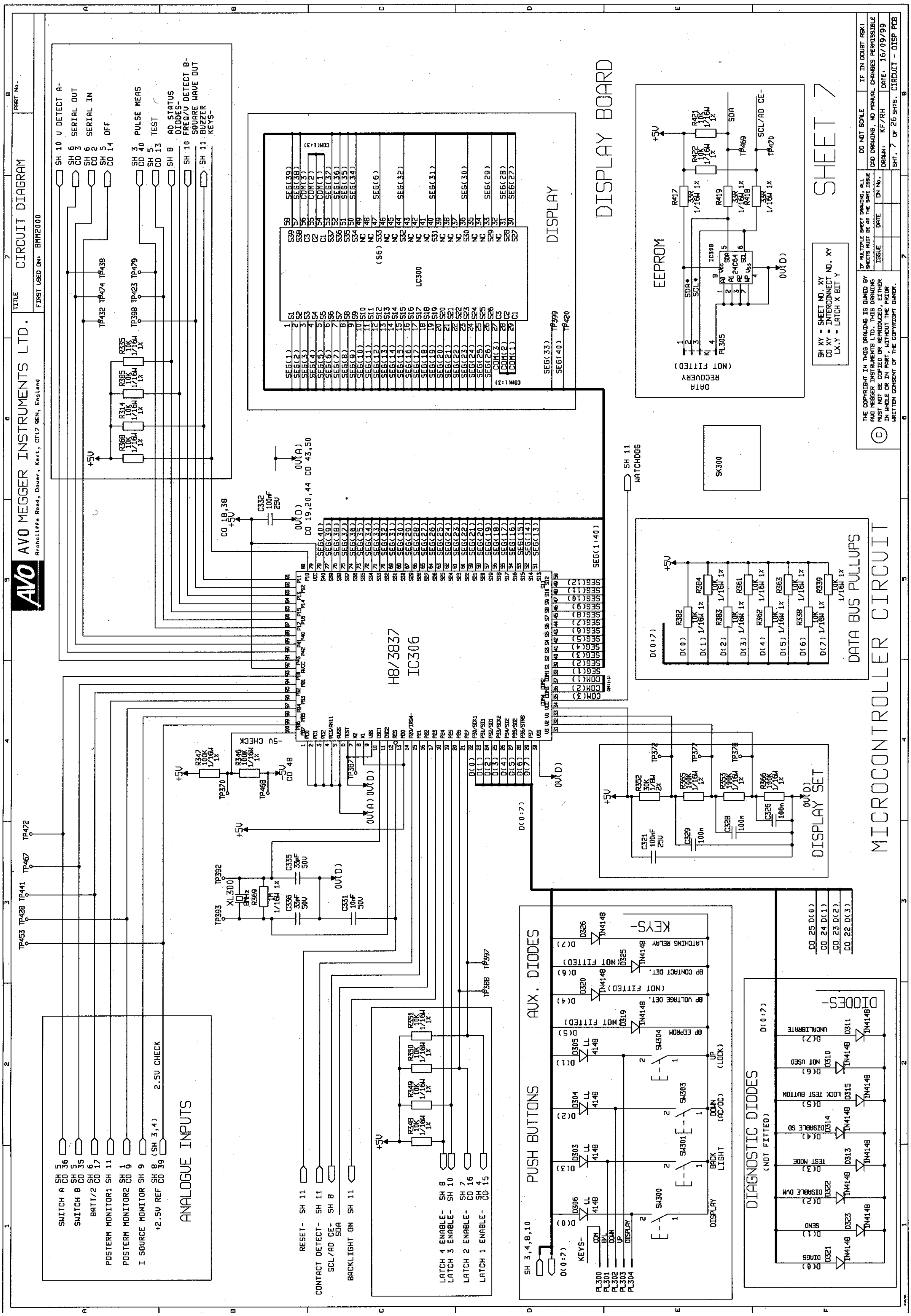
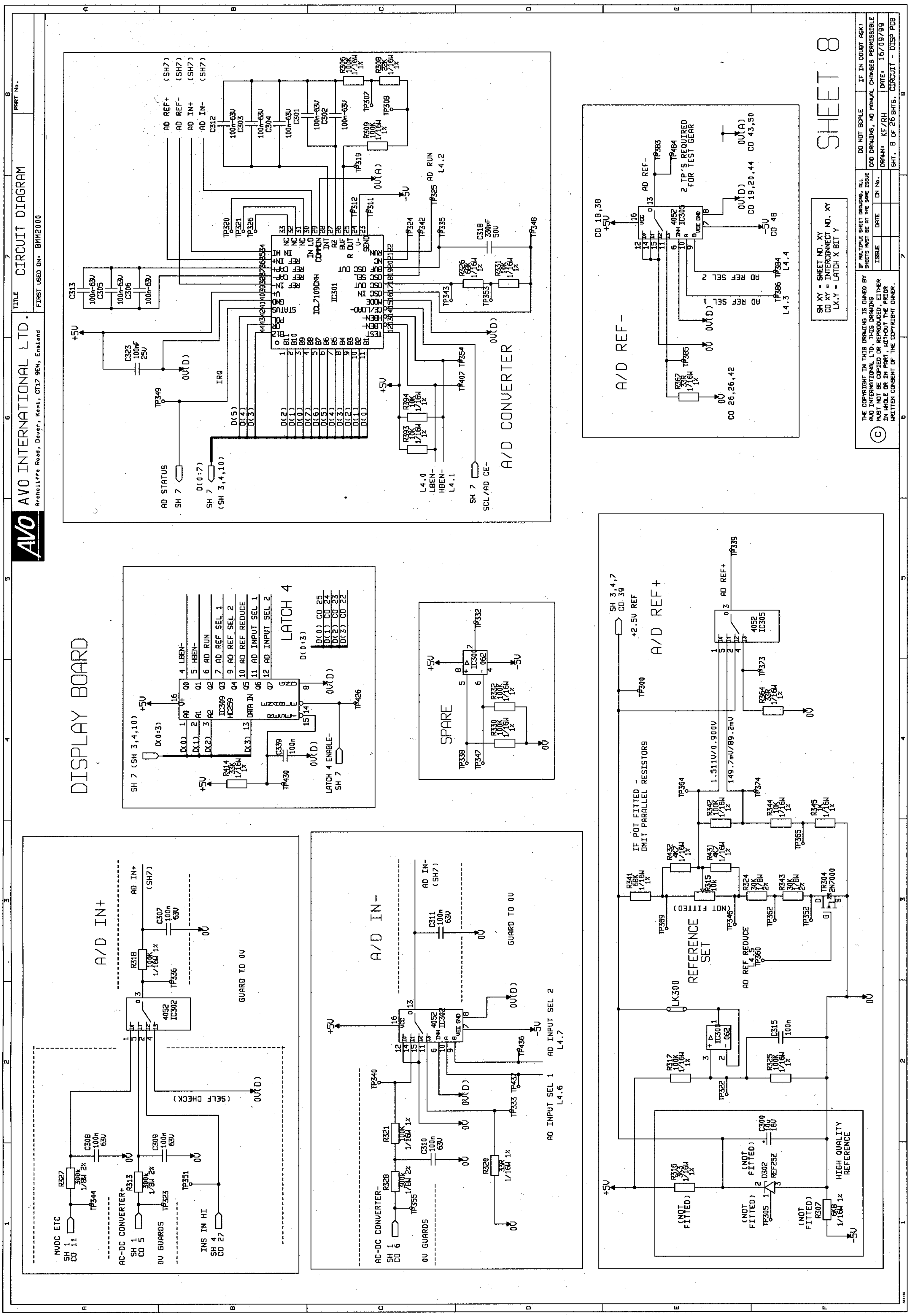
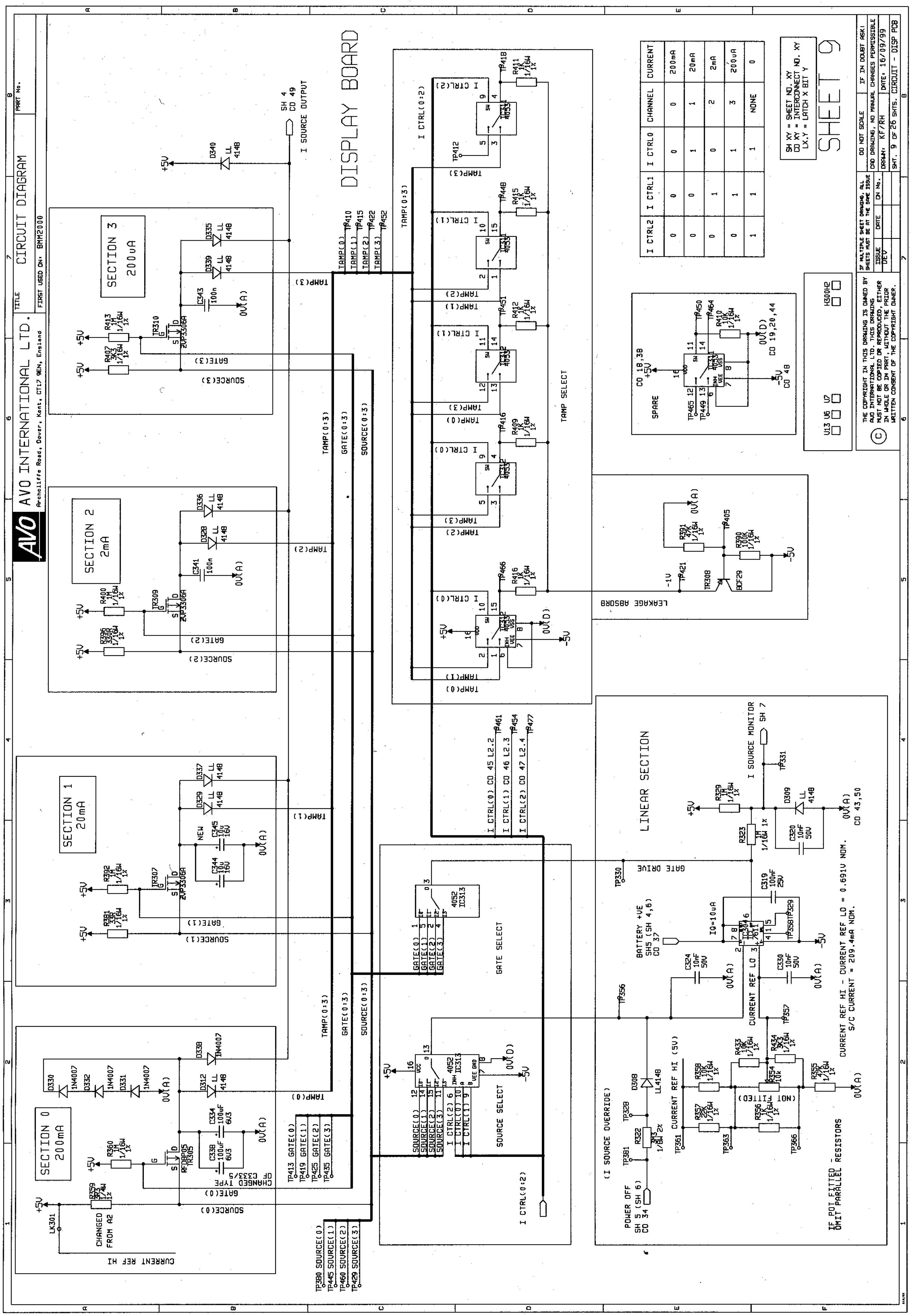
ISSUE DATE CN No.
DO NOT SCALE
IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF/RH
DATE: 16/09/99
SHT. 6 OF 26 SHTS. CIRCUIT - MAIN PCB


AVO MEGGER INSTRUMENTS LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
DISPLAY BOARD
DISPLAY
LC300
EEPROM
24C04
SHEET 7
H8/3837
IC306
MICROCONTROLLER CIRCUIT
DATA BUS PULLUPS
DISPLAY SET
ANALOGUE INPUTS
PUSH BUTTONS
AUX. DIODES
DIAGNOSTIC DIODES
(NOT FITTED)
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
DO NOT SCALE
IF IN DOUBT ASK!
DATE: 16/09/99
DRAWN: KF/RH
SHT. 7 OF 26 SHTS. CIRCUIT - DISP PCB


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.
A/D CONVERTER
DISPLAY BOARD
LATCH 4
SPARE
A/D REF-
A/D REF+
A/D IN+
A/D IN-
REFERENCE SET
HIGH QUALITY REFERENCE
GUARD TO 0V
2 TP'S REQUIRED FOR TEST GEAR
IF POT FITTED - OMIT PARALLEL RESISTORS
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SHEET 8
DO NOT SCALE
IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF/RH
DATE: 16/09/99
SHT. 8 OF 26 SHTS.
CIRCUIT - DISP PCB


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
DISPLAY BOARD
SHEET 9
SECTION 0 200mA
SECTION 1 20mA
SECTION 2 2mA
SECTION 3 200uA
TAMP SELECT
GATE SELECT
SOURCE SELECT
LINEAR SECTION
LEAKAGE ABSORB
SPARE
I SOURCE OUTPUT
I SOURCE MONITOR
CURRENT REF HI
CURRENT REF LO
GATE DRIVE
BATTERY +VE
POWER OFF
(I SOURCE OVERRIDE)
IF R0I FITTED - OMIT PARALLEL RESISTORS
CURRENT REF HI - CURRENT REF LO = 0.691V NOM.
S/C CURRENT = 209.4mA NOM.
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
DRAWN: KF/RH
DATE: 16/09/99
SHT. 9 OF 26 SHTS. CIRCUIT - DISP PCB
I CTRL2 | I CTRL1 | I CTRL0 | CHANNEL | CURRENT
0 | 0 | 0 | 0 | 200mA
0 | 0 | 1 | 1 | 20mA
0 | 1 | 0 | 2 | 2mA
0 | 1 | 1 | 3 | 200uA
1 | 1 | 1 | NONE | 0
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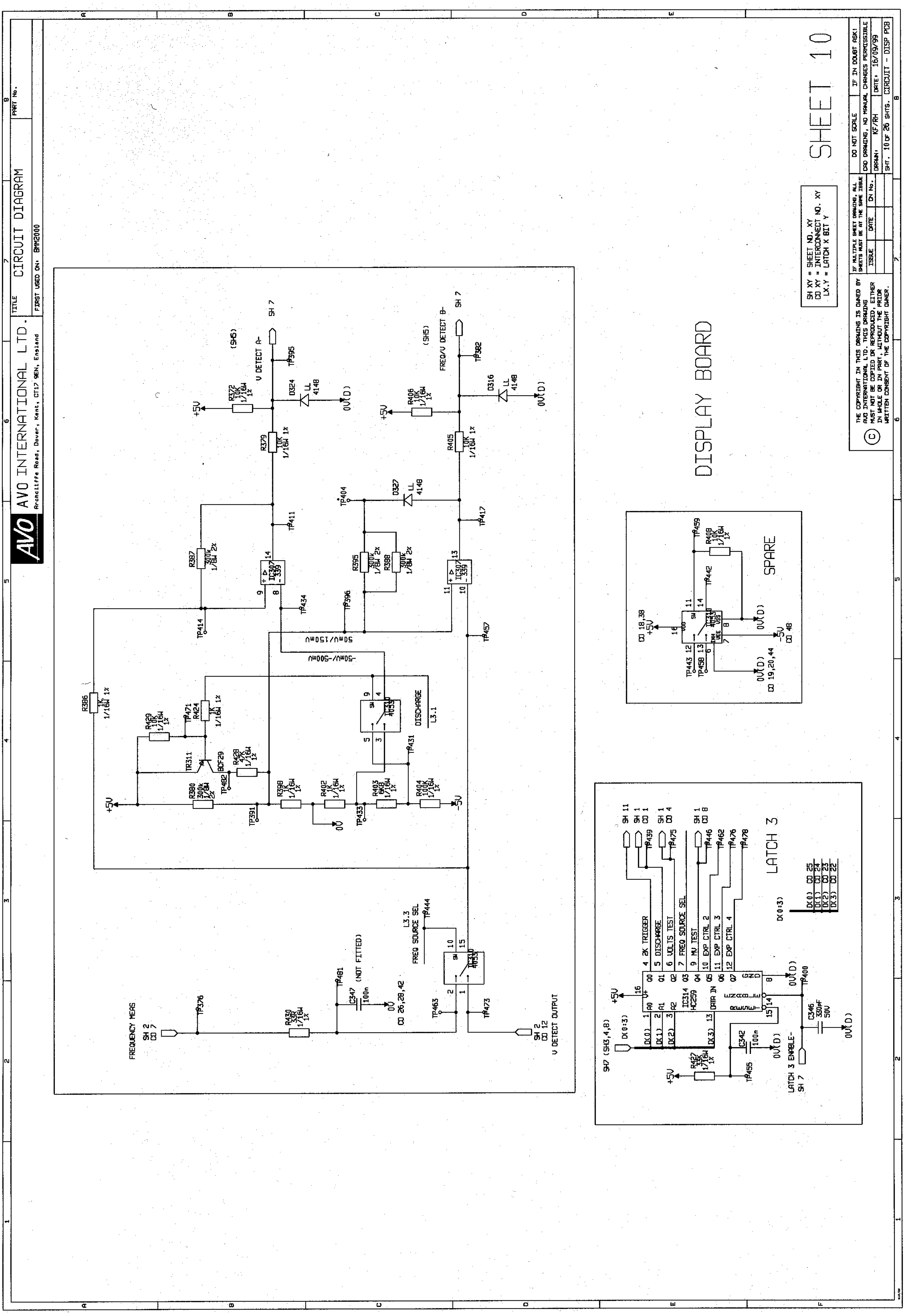
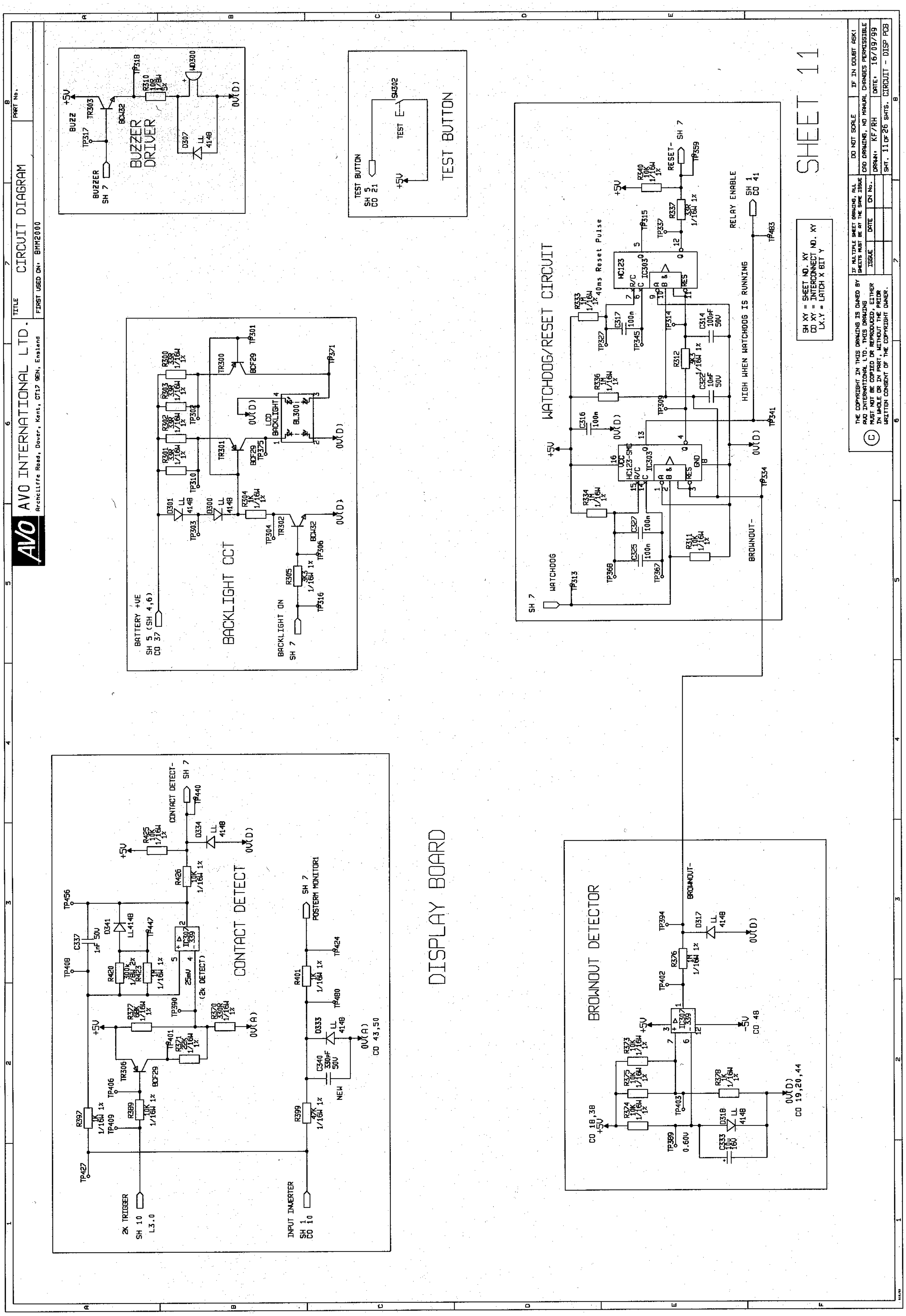
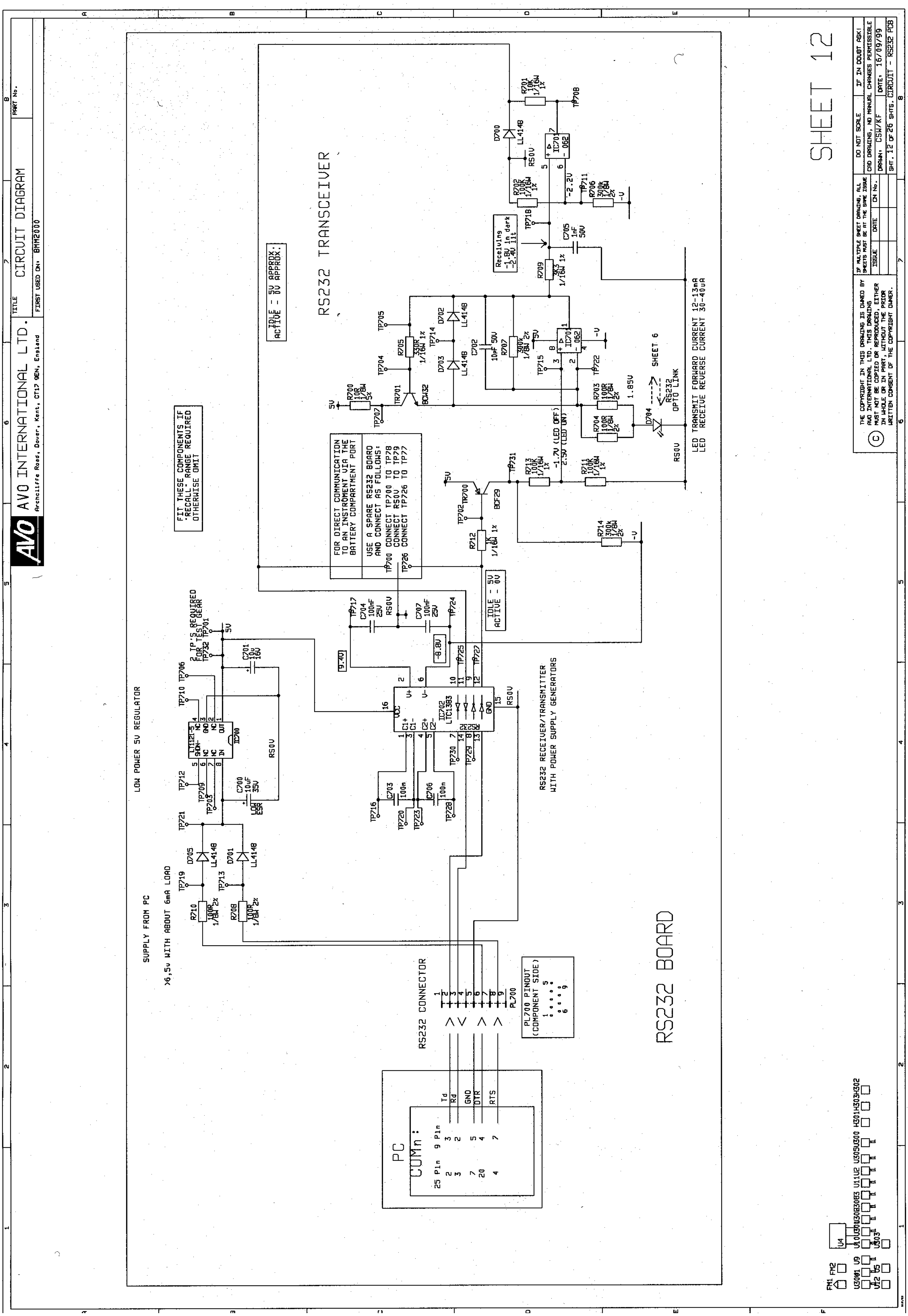

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.
DISPLAY BOARD
SHEET 10
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
SPARE
LATCH 3
V DETECT A-
FREQ/V DETECT B-
FREQUENCY MEAS
V DETECT OUTPUT
FREQ SOURCE SEL
DISCHARGE
(NOT FITTED)
LATCH 3 ENABLE-
DO NOT SCALE
IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF/RH
DATE: 16/09/99
SHT. 10 OF 26 SHTS.
CIRCUIT - DISP PCB


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
BUZZER DRIVER
TEST BUTTON
WATCHDOG/RESET CIRCUIT
40ms Reset Pulse
HIGH WHEN WATCHDOG IS RUNNING
RELAY ENABLE
RESET-
WATCHDOG
BROWNOUT-
BACKLIGHT CCT
BATTERY +VE
BACKLIGHT ON
CONTACT DETECT
CONTACT DETECT-
2K TRIGGER
INPUT INVERTER
POSTERM MONITOR1
DISPLAY BOARD
BROWNOUT DETECTOR
SHEET 11
SH XY = SHEET NO. XY
CO XY = INTERCONNECT NO. XY
LX.Y = LATCH X BIT Y
DO NOT SCALE
IF IN DOUBT ASK!
DRAWN: KF/RH
DATE: 16/09/99
SHT. 11 OF 26 SHTS.
CIRCUIT - DISP PCB



AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England
CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
SHEET 12
RS232 TRANSCEIVER
RS232 BOARD
RS232 CONNECTOR
LOW POWER 5V REGULATOR
SUPPLY FROM PC
>6,5v WITH ABOUT 6mA LOAD
RS232 RECEIVER/TRANSMITTER
WITH POWER SUPPLY GENERATORS
FIT THESE COMPONENTS IF
'RECALL' RANGE REQUIRED
OTHERWISE OMIT
FOR DIRECT COMMUNICATION
TO AN INSTRUMENT VIA THE
BATTERY COMPARTMENT PORT
USE A SPARE RS232 BOARD
AND CONNECT AS FOLLOWS:
CONNECT TP700 TO TP78
CONNECT RS0V TO TP79
CONNECT TP726 TO TP77
IDLE = 5V APPROX.
ACTIVE = 0V APPROX.
IDLE = 5V
ACTIVE = 0V
LED TRANSMIT FORWARD CURRENT 12-13mA
LED RECEIVE REVERSE CURRENT 30-40uA
RS232 OPTO LINK
SHEET 6
PL700 PINOUT
(COMPONENT SIDE)
PC
COMn:
25 Pin
9 Pin
Td
Rd
GND
DTR
RTS
DO NOT SCALE
IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: CSW/KF
DATE: 16/09/99
SHT. 12 OF 26 SHTS.
CIRCUIT - RS232 PCB

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM

PART No.

FIRST USED ON: BMM2000

SHEET NUMBER	CONTENTS
13	SHEET NUMBER TABLE - RESISTORS (MAIN)
14	SHEET NUMBER TABLE - RESISTORS (DISPLAY, RS232)
15	SHEET NUMBER TABLE - CAPACITORS
16	SHEET NUMBER TABLE - DIODES, TRANSISTORS
17	SHEET NUMBER TABLE - INTEGRATED CIRCUITS, MISCELLANEOUS
18	SHEET NUMBER TABLE - TEST POINTS (MAIN)
19	SHEET NUMBER TABLE - TEST POINTS (DISPLAY, RS232)
20	NOT USED COMPONENTS TABLE 1
21	NOT USED COMPONENTS TABLE 2
22	NOT USED COMPONENTS TABLE 3
23	NOT USED COMPONENTS TABLE 4 (SUMMARY)
24	INTER-BOARD CONNECTIONS LIST
25	MAIN INDEX SHEET 1 (CIRCUIT)
26	MAIN INDEX SHEET 2 (AUXILIARY)

SHEET 26

MAIN INDEX SHEET 2

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SHT. 26 OF 26 SHTS. | INDEX SHEET 2

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM | PART No.

FIRST USED ON: BMM2000

SHEET NUMBER TABLE - RESISTORS (MAIN)

		R25	4	R50	5	R75	6	R100	4	R125	4	R150	2	R175	1	R200	1
R1	6	R26	4	R51	5	R76	6	R101	4	R126	4	R151	4	R176	1	R201	5
R2	6	R27	4	R52	5	R77	6	R102	4	R127	5	R152	4	R177	1	R202	3
R3	6	R28	4	R53	5	R78	6	R103	4	R128	3	R153	4	R178	1	R203	3
R4	6	R29	4	R54	4	R79	6	R104	4	R129	3	R154	1	R179	1	R204	5
R5	6	R30	4	R55	4	R80	3	R105	4	R130	3	R155	1	R180	4	----	
R6	6	R31	3	R56	6	R81	4	R106	4	R131	4	R156	4	R181	4		
R7	6	R32	3	R57	6	R82	4	R107	4	R132	4	R157	4	R182	4		
R8	6	R33	6	R58	3	R83	4	R108	5	R133	5	R158	3	R183	4		
R9	6	R34	6	R59	1	R84	5	R109	6	R134	3	R159	1	R184	4		
R10	3	R35	5	R60	1	R85	4	R110	3	R135	2	R160	1	R185	4		
R11	3	R36	5	R61	6	R86	4	R111	3	R136	5	R161	1	R186	1		
R12	6	R37	5	R62	3	R87	4	R112	3	R137	5	R162	1	R187	1		
R13	6	R38	5	R63	3	R88	4	R113	5	R138	3	R163	1	R188	1		
R14	3	R39	5	R64	3	R89	4	R114	6	R139	3	R164	1	R189	1		
R15	3	R40	5	R65	5	R90	4	R115	4	R140	3	R165	1	R190	1		
R16	3	R41	4	R66	5	R91	5	R116	4	R141	3	R166	1	R191	1		
R17	3	R42	5	R67	3	R92	6	R117	3	R142	3	R167	1	R192	1		
R18	6	R43	5	R68	3	R93	5	R118	3	R143	2	R168	1	R193	1		
R19	5	R44	5	R69	2	R94	4	R119	3	R144	4	R169	1	R194	1		
R20	3	R45	5	R70	5	R95	4	R120	3	R145	3	R170	1	R195	1		
R21	3	R46	5	R71	4	R96	5	R121	3	R146	4	R171	1	R196	1		
R22	3	R47	3	R72	5	R97	2	R122	3	R147	4	R172	1	R197	1		
R23	6	R48	5	R73	4	R98	4	R123	4	R148	1	R173	1	R198	1		
R24	1	R49	5	R74	4	R99	4	R124	4	R149	4	R174	1	R199	1		

R17, R22 & R172 ARE POTENTIOMETERS

SHEET 13

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SHT. 13 OF 26 SHTS. | RESISTORS-MAIN

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM

PART No.

FIRST USED ON: BMM2000

SHEET NUMBER TABLE - RESISTORS (DISPLAY, RS232)

R300	11	R325	8	R350	7	R375	11	R400	9	R425	11	R700	12
R301	11	R326	8	R351	7	R376	11	R401	11	R426	11	R701	12
R302	11	R327	8	R352	7	R377	11	R402	10	R427	10	R702	12
R303	11	R328	8	R353	7	R378	11	R403	10	R428	10	R703	12
R304	11	R329	9	R354	9	R379	10	R404	10	R429	10	R704	12
R305	11	R330	8	R355	9	R380	10	R405	10	R430	10	R705	12
R306	8	R331	8	R356	9	R381	9	R406	10	R431	8	R706	12
R307	8	R332	8	R357	9	R382	7	R407	9	R432	8	R707	12
R308	8	R333	11	R358	9	R383	7	R408	10	R433	9	R708	12
R309	8	R334	11	R359	9	R384	7	R409	9	R434	9	R709	12
R310	11	R335	7	R360	9	R385	7	R410	9	----		R710	12
R311	11	R336	11	R361	7	R386	10	R411	9			R711	12
R312	11	R337	11	R362	7	R387	10	R412	9			R712	12
R313	8	R338	7	R363	7	R388	10	R413	9			R713	12
R314	7	R339	7	R364	8	R389	11	R414	8			R714	12
R315	8	R340	11	R365	7	R390	9	R415	9			----	
R316	8	R341	8	R366	7	R391	9	R416	9				
R317	8	R342	8	R367	8	R392	9	R417	7				
R318	8	R343	8	R368	7	R393	8	R418	7				
R319	--	R344	8	R369	7	R394	8	R419	7				
R320	8	R345	8	R370	11	R395	10	R420	11				
R321	8	R346	7	R371	11	R396	9	R421	7				
R322	9	R347	7	R372	10	R397	11	R422	7				
R323	9	R348	7	R373	11	R398	10	R423	11				
R324	8	R349	7	R374	11	R399	11	R424	10				

R315 & R354 ARE POTENTIOMETERS

SHEET 14

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DRAWN: KF | DATE: 16/09/99

SHT. 14 OF 26 SHTS. RES - DISP,RS232

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM

PART No.

FIRST USED ON: BMM2000

SHEET NUMBER TABLE - CAPACITORS

			C25	2		C50	4		C300	8		C325	11					C700	12
C1	5		C26	4		C51	5		C301	8		C326	7					C701	12
C2	5		C27	6		C52	5		C302	8		C327	11					C702	12
C3	5		C28	4		C53	1		C303	8		C328	7					C703	12
C4	5		C29	3		C54	3		C304	8		C329	7					C704	12
C5	5		C30	3		---			C305	8		C330	9					C705	12
C6	5		C31	2					C306	8		C331	7					C706	12
C7	3		C32	2					C307	8		C332	7					C707	12
C8	6		C33	4					C308	8		C333	11					----	
C9	4		C34	2					C309	8		C334	9						
C10	4		C35	4					C310	8		C335	7						
C11	5		C36	4					C311	8		C336	7						
C12	5		C37	3					C312	8		C337	11						
C13	4		C38	4					C313	8		C338	9						
C14	3		C39	3					C314	11		C339	8						
C15	5		C40	1					C315	8		C340	11						
C16	4		C41	4					C316	11		C341	9						
C17	2		C42	3					C317	11		C342	10						
C18	5		C43	1					C318	8		C343	9						
C19	3		C44	4					C319	9		C344	9						
C20	5		C45	1					C320	9		C345	9						
C21	4		C46	1					C321	7		C346	10						
C22	5		C47	1					C322	11		C347	10						
C23	3		C48	4					C323	8		----							
C24	3		C49	4					C324	9									

SHEET 15

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE

ISSUE	DATE	CN No.

DO NOT SCALE | IF IN DOUBT ASK!

CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE

DRAWN: KF | DATE: 16/09/99

SHT. 15 OF 26 SHTS. CAPACITORS

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE	CIRCUIT DIAGRAM	PART No.
FIRST USED ON: BMM2000		

SHEET NUMBER TABLES - DIODES

		D25	4	D300	11	D325	7	D700	12
D1	6	D26	1	D301	11	D326	7	D701	12
D2	6	D27	4	D302	8	D327	10	D702	12
D3	6	D28	1	D303	7	D328	9	D703	12
D4	6	D29	1	D304	7	D329	9	D704	12
D5	6	D30	4	D305	7	D330	9	D705	12
D6	5	D31	4	D306	7	D331	9	----	
D7	5	D32	4	D307	11	D332	9		
D8	3	D33	4	D308	9	D333	11		
D9	2	D34	1	D309	9	D334	11		
D10	2	D35	1	D310	7	D335	9		
D11	6	D36	1	D311	7	D336	9		
D12	6	D37	4	D312	9	D337	9		
D13	3	D38	1	D313	7	D338	9		
D14	3	D39	1	D314	7	D339	9		
D15	2	D40	5	D315	7	D340	9		
D16	2	---		D316	10	D341	11		
D17	2			D317	11	----			
D18	2			D318	11				
D19	3			D319	7				
D20	2			D320	7				
D21	2			D321	7				
D22	3			D322	7				
D23	1			D323	7				
D24	4			D324	10				

ZD1	--
ZD2	3
ZD3	4

D4 & D704 ARE LEDS

SHEET NUMBER TABLE - TRANSISTORS

		TR25	4	TR300	11	TR700	12
TR1	6	TR26	1	TR301	11	TR701	12
TR2	5	TR27	1	TR302	11	-----	
TR3	5	TR28	1	TR303	11		
TR4	6	TR29	1	TR304	8		
TR5	5	TR30	1	TR305	9		
TR6	5	----		TR306	11		
TR7	5			TR307	9		
TR8	5			TR308	9		
TR9	4			TR309	9		
TR10	6			TR310	9		
TR11	3			TR311	10		
TR12	4			-----			
TR13	3						
TR14	3						
TR15	4						
TR16	4						
TR17	4						
TR18	4						
TR19	1						
TR20	1						
TR21	1						
TR22	1						
TR23	5						
TR24	1						

SHEET 16

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE

ISSUE	DATE	CN No.

DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 16 OF 26 SHTS. DIODES + TRANS

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.

SHEET NUMBER TABLE - MISCELLANEOUS

AD CONVERTER (IC301)	8	PL300	7
BACKLIGHT (BL300)	11	PL301	7
BATTERY CONNECTOR (PL3)	5	PL302	7
BL300	11	PL303	7
BUZZER (WD300)	11	PL304	7
DISPLAY (LC300)	7	PL305	7
EEPROM (IC308)	7	PL700	12
FS1 (500mA)	1	PUSH BUTTONS	7,11
FS2 (1.5A RST/3A T)	5	RL1 (HV INVERTER)	1
L1	1	RL2 (MILLIAMPS)	1
L2	1	RL3 (-VE TERMINAL)	1
LATCH 1 (IC3)	4	SK300	7
LATCH 2 (IC10)	3	SW1 (POWER)	5
LATCH 3 (IC314)	10	SW2 (FUNCTION)	5
LATCH 4 (IC309)	8	SW300 ('DISPLAY')	7
LC300	7	SW301 ('BACKLIGHT')	7
LED 1 (D4)	6	SW302 ('TEST')	11
LED 2 (D704)	12	SW303 ('DOWN/'AC DC')	7
LK1	5	SW304 ('UP'/'LOCK')	7
LK2	1	T1	4
LK300	8	VR1	5
LK301	9	WD300	11
MICRO (IC306)	7	WIRE LINK (PL7-PL8)	1
PL1	5	WIRE LINK (RL2 PIN 2-5)	1
PL2	1	ZD1	--
PL3	5	ZD2	3
PL4	1	ZD3	4
PL5	5	+VE TERMINAL	1,2
PL6	5	-VE TERMINAL	1
PL7	1	5V REGULATOR (VR1)	5
PL8	1		

SHEET NUMBER TABLE - INTEGRATED CIRCUITS

			IC300	8	IC700	12
IC1	6		IC301	8	IC701	12
IC2	5		IC302	8	IC702	12
IC3	4		IC303	11	-----	
IC4	4		IC304	9		
IC5	3		IC305	8		
IC6	5		IC306	7		
IC7	4		IC307	10,11		
IC8	4		IC308	7		
IC9	3,6		IC309	8		
IC10	3		IC310	10		
IC11	2		IC311	9		
IC12	1		IC312	9		
IC13	3		IC313	9		
IC14	1		IC314	10		
IC15	1		-----			
IC16	1					

SHEET 17

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE
ISSUE | DATE | CN No.
DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 17 OF 26 SHTS. | ICS + MISC

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM | PART No.

FIRST USED ON: BMM2000

SHEET NUMBER TABLE - TEST POINTS (MAIN)

		TP25	4	TP50	6	TP75	4	TP100	3	TP125	4	TP150	4	TP175	1
TP1	6	TP26	3	TP51	3	TP76	6	TP101	3	TP126	4	TP151	4	TP176	1
TP2	6	TP27	3	TP52	5	TP77	6	TP102	2	TP127	3	TP152	4	TP177	1
TP3	6	TP28	4	TP53	5	TP78	6	TP103	4	TP128	4	TP153	5	TP178	1
TP4	4	TP29	4	TP54	5	TP79	6	TP104	2	TP129	3	TP154	1	TP179	1
TP5	3	TP30	3	TP55	5	TP80	6	TP105	2	TP130	3	TP155	1	TP180	1
TP6	6	TP31	3	TP56	4	TP81	3	TP106	4	TP131	3	TP156	1	TP181	1
TP7	3	TP32	5	TP57	6	TP82	1	TP107	4	TP132	4	TP157	1	TP182	1
TP8	3	TP33	5	TP58	5	TP83	4	TP108	4	TP133	4	TP158	1	TP183	1
TP9	3	TP34	4	TP59	4	TP84	6	TP109	4	TP134	5	TP159	4	TP184	1
TP10	1	TP35	6	TP60	3	TP85	3	TP110	4	TP135	3	TP160	1	TP185	1
TP11	3	TP36	5	TP61	1	TP86	3	TP111	5	TP136	3	TP161	1	TP186	1
TP12	3	TP37	5	TP62	5	TP87	6	TP112	3	TP137	2	TP162	1	TP187	5
TP13	6	TP38	5	TP63	5	TP88	5	TP113	6	TP138	3	TP163	5	TP188	5
TP14	6	TP39	3	TP64	4	TP89	4	TP114	3	TP139	4	TP164	4	TP189	5
TP15	5	TP40	5	TP65	4	TP90	4	TP115	4	TP140	4	TP165	1	TP190	6
TP16	3	TP41	5	TP66	4	TP91	4	TP116	4	TP141	5	TP166	1	TP191	6
TP17	6	TP42	5	TP67	1	TP92	4	TP117	5	TP142	5	TP167	1	TP192	5
TP18	5	TP43	3	TP68	3	TP93	4	TP118	3	TP143	5	TP168	1	TP193	5
TP19	3	TP44	3	TP69	3	TP94	6	TP119	3	TP144	1	TP169	1	-----	
TP20	3	TP45	3	TP70	3	TP95	4	TP120	3	TP145	4	TP170	1		
TP21	6	TP46	6	TP71	1	TP96	4	TP121	6	TP146	2	TP171	4		
TP22	6	TP47	5	TP72	5	TP97	6	TP122	3	TP147	1	TP172	1		
TP23	5	TP48	5	TP73	4	TP98	6	TP123	4	TP148	2	TP173	1		
TP24	4	TP49	3	TP74	4	TP99	3	TP124	4	TP149	4	TP174	1		

TP76, TP77, TP78 & TP79 ARE THE BATTERY COMPARTMENT RS232 PORT

SHEET 18

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE | ISSUE | DATE | CN No.

DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 18 OF 26 SHTS. | TPS - MAIN

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.

SHEET NUMBER TABLE - TEST POINTS (DISPLAY, RS232)

TP300	8	TP325	8	TP350	8	TP375	11	TP400	10	TP425	9	TP450	9	TP475	10	TP700	12	TP725	12
TP301	11	TP326	8	TP351	8	TP376	10	TP401	11	TP426	8	TP451	9	TP476	10	TP701	12	TP726	12
TP302	11	TP327	11	TP352	8	TP377	7	TP402	11	TP427	11	TP452	9	TP477	9	TP702	12	TP727	12
TP303	11	TP328	9	TP353	8	TP378	7	TP403	11	TP428	7	TP453	7	TP478	10	TP703	12	TP728	12
TP304	11	TP329	9	TP354	8	TP379	--	TP404	10	TP429	9	TP454	9	TP479	7	TP704	12	TP729	12
TP305	8	TP330	9	TP355	8	TP380	9	TP405	9	TP430	8	TP455	10	TP480	11	TP705	12	TP730	12
TP306	11	TP331	9	TP356	9	TP381	9	TP406	11	TP431	10	TP456	11	TP481	10	TP706	12	TP731	12
TP307	8	TP332	8	TP357	9	TP382	10	TP407	8	TP432	7	TP457	10	TP482	10	TP707	12	TP732	12
TP308	8	TP333	8	TP358	9	TP383	8	TP408	11	TP433	10	TP458	10	TP483	11	TP708	12	-----	
TP309	11	TP334	11	TP359	11	TP384	8	TP409	11	TP434	10	TP459	10	TP484	8	TP709	12		
TP310	11	TP335	8	TP360	8	TP385	8	TP410	9	TP435	9	TP460	9	-----		TP710	12		
TP311	8	TP336	8	TP361	9	TP386	8	TP411	10	TP436	8	TP461	9			TP711	12		
TP312	8	TP337	11	TP362	8	TP387	7	TP412	9	TP437	8	TP462	10			TP712	12		
TP313	11	TP338	8	TP363	9	TP388	7	TP413	9	TP438	7	TP463	10			TP713	12		
TP314	11	TP339	8	TP364	8	TP389	11	TP414	10	TP439	10	TP464	9			TP714	12		
TP315	11	TP340	8	TP365	8	TP390	11	TP415	9	TP440	11	TP465	9			TP715	12		
TP316	11	TP341	11	TP366	9	TP391	10	TP416	9	TP441	7	TP466	9			TP716	12		
TP317	11	TP342	8	TP367	11	TP392	7	TP417	10	TP442	10	TP467	7			TP717	12		
TP318	11	TP343	8	TP368	11	TP393	7	TP418	9	TP443	10	TP468	7			TP718	12		
TP319	8	TP344	8	TP369	8	TP394	11	TP419	9	TP444	10	TP469	7			TP719	12		
TP320	8	TP345	11	TP370	7	TP395	10	TP420	7	TP445	9	TP470	7			TP720	12		
TP321	8	TP346	8	TP371	11	TP396	10	TP421	9	TP446	10	TP471	10			TP721	12		
TP322	8	TP347	8	TP372	7	TP397	7	TP422	9	TP447	11	TP472	7			TP722	12		
TP323	8	TP348	8	TP373	8	TP398	7	TP423	7	TP448	9	TP473	10			TP723	12		
TP324	8	TP349	8	TP374	8	TP399	7	TP424	11	TP449	9	TP474	7			TP724	12		

SHEET 19

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE
ISSUE | DATE | CN No.

DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 19 OF 26 SHTS. TPS - DISP,RS232

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM | PART No.
FIRST USED ON: BMM2000

COMP REF	SHT NO.	BMM 80	BMM 2000 2080	BMM 2500 2580	USAGE/COMMENTS
C8	6	X	X	FITTED	RS232
C47	1	X	X	X	OPTION
C54	3	X	X	X	OPTION
C300	8	X	X	X	OPTION
C347	10	X	X	X	OPTION
C700	12	X	X	FITTED	RS232
C701	12	X	X	FITTED	RS232
C702	12	X	X	FITTED	RS232
C703	12	X	X	FITTED	RS232
C704	12	X	X	FITTED	RS232
C705	12	X	X	FITTED	RS232
C706	12	X	X	FITTED	RS232
C707	12	X	X	FITTED	RS232
D1	6	X	X	FITTED	RS232
D2	6	X	X	FITTED	RS232
D3	6	X	X	X	CALIBRATE
D4	6	X	X	FITTED	RS232
D5	6	X	X	FITTED	RS232
D29	1	X	FITTED	FITTED	MILLIAMPS
D36	1	X	FITTED	FITTED	MILLIAMPS
D39	1	X	FITTED	FITTED	MILLIAMPS
D302	8	X	X	X	OPTION
D310	7	X	X	X	NOT USED
D311	7	X	X	X	UNCALIBRATE
D313	7	X	X	X	TEST MODE
D314	7	X	X	X	SHUTDOWN DISABLE

COMP REF	SHT NO.	BMM 80	BMM 2000 2080	BMM 2500 2580	USAGE/COMMENTS
D315	7	X	X	X	NOT USED
D319	7	X	X	X	BYPASS EEPROM
D320	7	X	X	X	BYPASS VOLT DET
D321	7	X	X	X	DIAGNOSTICS
D322	7	X	X	X	DISABLE DVM
D323	7	X	X	X	TRANSMIT RESULTS
D325	7	X	X	X	BYPASS CONT DET
D700	12	X	X	FITTED	RS232
D701	12	X	X	FITTED	RS232
D702	12	X	X	FITTED	RS232
D703	12	X	X	FITTED	RS232
D704	12	X	X	FITTED	RS232
D705	12	X	X	FITTED	RS232
IC1	6	X	X	FITTED	RS232
IC700	12	X	X	FITTED	RS232
IC701	12	X	X	FITTED	RS232
IC702	12	X	X	FITTED	RS232
L1	1	X	FITTED	FITTED	MILLIAMPS

SHEET 20

NOT USED COMPONENTS TABLE 1

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE
ISSUE | DATE | CN No.

DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 20 OF 26 SHTS. NOT USED LIST

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE: CIRCUIT DIAGRAM
PART No.
FIRST USED ON: BMM2000

COMP REF	SHT NO.	BMM 80	BMM 2000 2080	BMM 2500 2580	USAGE/COMMENTS
PL1	5	X	X	X	ENGINEERING
PL7	1	X	FITTED	FITTED	MILLIAMPS
PL8	1	X	FITTED	FITTED	MILLIAMPS
PL300	7	X	X	X	ENGINEERING
PL301	7	X	X	X	ENGINEERING
PL302	7	X	X	X	ENGINEERING
PL303	7	X	X	X	ENGINEERING
PL304	7	X	X	X	ENGINEERING
PL305	7	X	X	X	ENGINEERING
PL700	12	X	X	FITTED	RS232
R2	6	X	X	FITTED	RS232
R3	6	X	X	FITTED	RS232
R4	6	X	X	FITTED	RS232
R5	6	X	X	FITTED	RS232
R6	6	X	X	FITTED	RS232
R7	6	X	X	FITTED	RS232
R8	6	X	X	FITTED	RS232
R13	6	X	X	FITTED	RS232
R17	3	X	X	X	OPTION
R18	6	X	X	FITTED	RS232
R22	3	X	X	X	OPTION
R23	6	X	X	FITTED	RS232
R33	6	X	X	FITTED	RS232
R34	6	X	X	FITTED	RS232
R38	5	X	X	X	OPTION
R46	5	X	X	X	OPTION
R64	3	X	X	X	OPTION
R73	4	X	X	X	OPTION
R81	4	X	X	X	OPTION

COMP REF	SHT NO.	BMM 80	BMM 2000 2080	BMM 2500 2580	USAGE/COMMENTS
R105	4	X	X	X	OPTION
R115	4	X	X	X	OPTION
R145	3	X	X	X	DIAGNOSTICS
R148	1	X	X	X	OPTION
R154	1	X	X	X	OPTION
R164	1	X	X	X	OPTION
R166	1	X	X	X	OPTION
R178	1	X	FITTED	FITTED	MILLIAMPS
R189	1	X	X	X	OPTION
R190	1	X	X	X	OPTION
R191	1	X	X	X	OPTION
R192	1	FITTED	X	X	NOT MILLIAMPS
R200	1	X	FITTED	FITTED	MILLIAMPS
R307	8	X	X	X	OPTION
R315	8	X	X	X	OPTION
R316	8	X	X	X	OPTION
R354	9	X	X	X	OPTION

SHEET 21

NOT USED COMPONENTS TABLE 2

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE

ISSUE	DATE	CN No.

DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 21 OF 26 SHTS. | NOT USED LIST

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM

FIRST USED ON: BMM2000

PART No.

COMP REF	SHT NO.	BMM 80	BMM 2000 2080	BMM 2500 2580	USAGE/COMMENTS
R700	12	X	X	FITTED	RS232
R701	12	X	X	FITTED	RS232
R702	12	X	X	FITTED	RS232
R703	12	X	X	FITTED	RS232
R704	12	X	X	FITTED	RS232
R705	12	X	X	FITTED	RS232
R706	12	X	X	FITTED	RS232
R707	12	X	X	FITTED	RS232
R708	12	X	X	FITTED	RS232
R709	12	X	X	FITTED	RS232
R710	12	X	X	FITTED	RS232
R711	12	X	X	FITTED	RS232
R712	12	X	X	FITTED	RS232
R713	12	X	X	FITTED	RS232
R714	12	X	X	FITTED	RS232
RL2	1	X	FITTED	FITTED	MILLIAMPS
RL2-					
LINK	1	FITTED	X	X	NOT MILLIAMPS
SK300	7	X	X	X	ENGINEERING
SW300	7	X	FITTED	FITTED	DISPLAY KEY
SW304	7	X	FITTED	FITTED	UP/LOCK KEY

COMP REF	SHT NO.	BMM 80	BMM 2000 2080	BMM 2500 2580	USAGE/COMMENTS
TR1	6	X	X	FITTED	RS232
TR4	6	X	X	FITTED	RS232
TR19	1	X	X	X	OPTION
TR28	1	X	FITTED	FITTED	MILLIAMPS
TR29	1	X	X	X	OPTION
TR30	1	X	X	X	OPTION
TR700	12	X	X	FITTED	RS232
TR701	12	X	X	FITTED	RS232
PL7/8					
LINK	1	X	FITTED	FITTED	MILLIAMPS

SHEET 22

NOT USED COMPONENTS TABLE 3

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE

ISSUE	DATE	CN No.

DO NOT SCALE | IF IN DOUBT ASK!

CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE

DRAWN: KF | DATE: 16/09/99

SHT. 22 OF 26 SHTS. NOT USED LIST

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE CIRCUIT DIAGRAM
FIRST USED ON: BMM2000
PART No.

NOT USED - SUMMARY

BMM80
C8,C47,C54
C300,C347
C700-C707
D1,D2,D3,D4,D5,D36,D39
D302,D310,D311,D313-D315,
D319-D323,D325
D700-D705
IC1
IC700-IC702
L1
PL1,PL7,PL8
PL300-PL305
PL700
R2-R8,R13,R17,R18,R22,R23,
R33,R34,R38,R46,R64,R73,
R81,R105,R115,R145,R148,
R154,R164,R166,R178,
R189-R191,R200
R307,R315,R316,R354
R700-R714
RL2
SK300
SW300,SW304
TR1,TR4,TR19,TR28,TR29,TR30
TR700,TR701
WIRE LINK (SK1-SK2)

BMM2000,BMM2080
C8,C47,C54
C300,C347
C700-C707
D1,D2,D3,D4,D5
D302,D310,D311,D313-D315,
D319-D323,D325
D700-D705
IC1
IC700-IC702
PL1
PL300-PL305
PL700
R2-R8,R13,R17,R18,R22,R23,
R33,R34,R38,R46,R64,R73,R81,
R105,R115,R145,R148,R154,
R164,R166,R189-R192
R307,R315,R316,R354
R700-R714
SK300
TR1,TR4,TR19,TR29,TR30
TR700,TR701
WIRE LINK (RL2)

BMM2500,BMM2580
C47,C54
C300,C347
D3
D302,D310,D311,D313-D315,
D319-D323,D325
PL1
PL300-PL305
R17,R22,R38,R46,R64
R73,R81,R105,R115,R145,
R148,R154,R164,R166,
R189-R192
R307,R315,R316,R354
SK300
TR19,TR29,TR30
WIRE LINK (RL2)

NOT USED COMPONENTS TABLE 4

SHEET 23

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE
ISSUE | DATE | CN No.

DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 23 OF 26 SHTS. NOT USED LIST

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent, CT17 9EN, England

TITLE: CIRCUIT DIAGRAM | PART No.
FIRST USED ON: BMM2000

INTERBOARD CONNECTIONS LIST

(UPPER SECTION)

NUMBER	NAME	MAIN BOARD SHEET NUMBER(S)	DISPLAY BOARD SHEET NUMBER(S)
1	DISCHARGE	1	10
2	SERIAL IN	6	7
3	SERIAL OUT	6	7
4	VOLTS TEST	1	10
5	AC-DC CONVERTER+	1	8
6	AC-DC CONVERTER-	1	8
7	FREQUENCY MEAS	2	10
8	MV TEST	1	10
9	POSTERM MONITOR 2	1	7
10	INPUT INVERTER	1	11
11	MVDC ETC	1	8
12	V DETECT OUTPUT	2	10
13	TEST	5	7
14	OFF	5	7
15	LATCH 1 ENABLE-	4	7
16	LATCH 2 ENABLE-	3	7
17	BATT/2	6	7
18	+5V	1,2,3,4,5,6	7,8,9,10,11
19	0V(D)	1,3,4,5,6	7,8,9,10,11
20	0V(D)	1,3,4,5,6	7,8,9,10,11
21	TEST BUTTON	5	11
22	D(3)	3,4	7,8,10
23	D(2)	3,4	7,8,10
24	D(1)	3,4	7,8,10
25	D(0)	3,4	7,8,10

(LOWER SECTION)

NUMBER	NAME	MAIN BOARD SHEET NUMBER(S)	DISPLAY BOARD SHEET NUMBER(S)
26	0V	1,2,3,4	8,10
27	INS IN HI	4	8
28	0V	1,2,3,4	8,10
29	.NOT USED	--	--
30	NOT USED	--	--
31	NOT USED	--	--
32	NOT USED	--	--
33	NOT USED	--	--
34	POWER OFF	5,6	9
35	SWITCH B	5	7
36	SWITCH A	5	7
37	BATTERY +VE	4,5,6	9,11
38	+5V	1,2,3,4,5,6	7,8,9,10,11
39	+2.5V REF	3,4	7,8
40	PULSE MEAS	3	7
41	RELAY ENABLE	1	11
42	0V	1,2,3,4	8,10
43	0V(A)	1,3,4,5,6	7,8,9,11
44	0V(D)	1,3,4,5,6	7,8,9,10,11
45	I CTRL(0)	3	9
46	I CTRL(1)	3	9
47	I CTRL(2)	3	9
48	-5V	1,2,3,4,5,6	7,8,9,10,11
49	I SOURCE OUTPUT	4	9
50	0V(A)	1,3,4,5,6	7,8,9,11

SHEET 24

NOTE: CONNECTION NO. 1 IS AT THE TOP OF THE BOARD (DISPLAY END)

IF MULTIPLE SHEET DRAWING, ALL SHEETS MUST BE AT THE SAME ISSUE | ISSUE | DATE | CN No.
DO NOT SCALE | IF IN DOUBT ASK!
CAD DRAWING, NO MANUAL CHANGES PERMISSIBLE
DRAWN: KF | DATE: 16/09/99
SHT. 24 OF 26 SHTS. INTERCONNECTIONS

Appendix 3 Calibration Information

1. Description.

In order to perform full calibration, the instrument should be put into 'calibrate mode'.
There are three ways to do this:

a. Connect an external 'calibrate' diode to the battery compartment test pads. Anode to 'SI'. Cathode to 'SO'. (This is the method used on the dedicated ‘test and calibrate’ jig).

b. Fit the internal 'calibrate' diode (D3).

c. Set the 'calibrate' bit in the EEPROM stored settings. This can be done via the instruments RS232 socket (if fitted) or via the battery compartment test pads. A PC is required, equipped with suitable software to send and receive RS232 serial data. If the EEPROM is blank, (all its bits are set to 1), the instrument will automatically be in ‘calibrate’ mode.

Battery Compartment Connections...

Pad 1 (top)	TP76	+5V	
Pad 2	TP77	SI	(serial data in, to instrument)
Pad 3	TP78	SO	(serial data out, from instrument)
Pad 4 (bottom)	TP79	0V	

If successfully put into ‘calibrate’ mode, the instrument should briefly display the message 'CAL' during the switch-on sequence.

All adjustments are performed using a semi-automatic method. The input amplifier zero point is a special case as it must first be coarsely adjusted with potentiometer R172, to bring the millivolts dc zero reading below 50digits. This is carried out on the functional test gear. Normally the adjustment is set as close as possible to zero, so that this point does not need any re-calibration.
In calibrate mode, the 'backlight' key is used to perform calibration and does not have its usual function. To calibrate any given point, set up the required conditions, wait a few seconds for the reading to stabilise, and then press the 'backlight' key. If the calibration has been successful, the instrument subsequently responds by turning on the backlight for a short time and showing the adjusted reading. If the calibration cannot be performed, there will be no action and the backlight will not turn on.

Reasons for this could be:

Instrument not in 'calibrate’ mode.
Wrong value of resistance, voltage etc., being used as test load.
Megohms infinity being calibrated while resistance being displayed.
Megohms scale being calibrated while current being displayed.
Continuity scale being calibrated with null 'off'.
Excessive errors in the reading due to instrument fault.
Backlight button not working.

To reset any particular calibration point to its default value, (software version P1.3 or later), perform a calibration while holding down the 'ac/dc' key.
In this case, the response is that the display reading is blanked for a short while.
The backlight does not turn on.

The detailed workings of the semi-automatic calibration method are as follows.

Calibration constants.
There is an array of about a dozen calibration constants stored in the EEPROM, each one associated with a particular type of measurement. At the first-ever power-up of the instrument, the microcontroller detects that the EEPROM is blank, and initializes all calibration constants to 1. During measurements, the final part of any result calculation is division by the relevant calibration constant. When a semi-automatic calibration is performed, the micro divides the measured result by the expected result to obtain a new calibration constant. This is then stored in the EEPROM, overwriting the previous value.

Input amplifier zero constant.
There is a constant stored in EEPROM which represents the error due to the input offset voltage of the input amplifier (Vio). At the first-ever power-up of the instrument, the micro initialises this constant to 0. It is used to calculate an a/d converter correction, which is then subtracted from all a/d readings that involve the input amplifier. When a semi-automatic calibration (null) is performed, several successive a/d readings are averaged to obtain a new input amplifier zero constant. This is then stored in the EEPROM, overwriting the previous value.

2. Order of Calibrations.

There are two stipulations as regards the sequence in which calibrations can be performed.
a. Insulation test infinity must be set before insulation test scale factor or kilohms high end scale factor.
b. Input amplifier zero must be set up before dc mV scale factor, continuity scale factor or kilohms scale factors. Otherwise order is irrelevant, as the calibration points are independent.
For example:
Ohms calibration does not affect kilohms, or vice-versa.
Ac milliamps calibration does not disturb dc milliamps, or vice-versa.
Kilohms high end calibration does not affect kilohms low end point or vice-versa.
One logical calibration sequence is as given below, beginning on the insulation test range, and working through in the order of the switch positions.

3. Calibration Sequence.

3.1. Insulation Range.

There are two calibration points - infinity and scale factor.
Setting up the infinity affects the insulation scale factor (and also the kilohms high end scale factor).
Setting up the insulation scale factor does not affect the infinity.
Therefore, the infinity setting must be performed before the scale setting.
Select 500V insulation test switch position.

3.1.1. Insulation Infinity Set.

This calibration point also affects the insulation test scale factor and the kilohms high end scale factor.
Remove the test leads from the instrument.
Select 'Leakage Current' as the displayed quantity by pressing the 'display' button or the 'ac/dc' button if necessary - the 'uA' symbol should be present on the display.
Press the 'test' button to start a test. The test button has a latching action in ‘calibrate’ mode.
Wait plenty of time for the reading to stabilise - it may take longer to settle than other measurements.

Calibrate, by pressing the 'backlight' button.

Press the 'test' button to stop the test.

3.1.2. Insulation Scale Factor.

Calibration of this point does not disturb any other, but it is affected by the insulation infinity setting.
Make sure the insulation infinity has already been set up. (See section 3.1.1). Connect a 9 Megohm load to the terminals.
Select 'Insulation Resistance' as the displayed quantity by pressing the 'display' button or the 'ac/dc' button if necessary - the 'Mohm' symbol should be present on the display.
Press the 'test' button to start a test.

Calibrate.

Press the 'test' button to stop the test.

3.2. Volts Range Scale Factor.

This calibration point is fully independent of all others.
Select volts switch position.
Apply 90V 50Hz to the terminals.

Calibrate.

3.3. Input Amplifier Zero Adjust.

This is normally set up on the functional test gear, but if it needs to be changed, the potentiometer can be re-adjusted. However, this may not be convenient, so the semi-automatic method can be used if the instrument has been screwed together.
Apply a short circuit to the terminals.

3.3.1 Potentiometer Method.

Select mV switch position.
Select dc mV by pressing the 'ac/dc' button if necessary – the ‘dc’ symbol should be present on the display.
Turn off the null feature by pressing the 'test' button if necessary. The 'null' symbol must not be present on the display.

Adjust potentiometer R172 for a reading of +/-0.0mV
(Note that the instrument does not need to be in calibrate mode for this.)

3.3.2 Alternative Method (Semi-automatic).

The 'vio null disable' bit in the EEPROM stored settings must be clear. This will have been done automatically if the instrument has been set up using the dedicated ‘test and calibrate’ fixture.
Select buzzer range whilst holding down the 'ac/dc' button.

Calibrate.
The 'null' symbol should appear during the null process, which will take about 15 seconds.
During the null, the true (uncorrected) a/d converter reading is shown, for information. This should be <50 to guarantee a successful null.

3.4. Millivolts Range (mV).

There are two calibration points, for dc scale factor and ac scale factor.
Select mV switch position.

3.4.1. DC Millivolts Scale Factor.

Calibration of this point does not disturb any other, but it is affected by the input amplifier zero.
Make sure that the input amplifier has been zeroed, (See section 3.3).
Select dc measurements by pressing the 'ac/dc' button if necessary - the 'dc' symbol should be present on the display.
Make sure the mV null feature is turned 'off' by pressing the 'test' button if necessary - the 'null' symbol should not be present on the display.
Apply +90mV to the terminals.

Calibrate.

3.4.2. AC Millivolts Scale Factor.

This calibration point is fully independent of all others.
Select ac measurements by pressing the 'ac/dc' button - the 'ac' symbol should be present on the display.
Apply 90mV 50Hz to the terminals.

Calibrate.

3.5. Ohms Range Scale Factor.

Calibration of this point does not disturb any other, but it is affected by the input amplifier zero.
Make sure that the input amplifier has already been zeroed. (See section 3.3).
Select ohms switch position.
Apply a short circuit to the terminals.
Null out lead and stray resistance by pressing the 'test' button - the 'null' symbol should be present on the display.
Connect a 9 ohm load to the terminals.

Calibrate.

3.6. Kilohms Range.

There are two calibration points, since two different methods of measurement are used to cover the wide resistance range.

3.6.1. Kilohms High End Scale Factor.

Calibration of this point does not disturb any other, but it is affected by the insulation infinity setting and the input amplifier zero setting.
Make sure that the input amplifier has already been zeroed. (See section 3.3).
Make sure the insulation infinity has already been set up. (See section 3.1.1).
Select kilohms switch position.
Connect a 900 kilohm load to the terminals.

Calibrate.

3.6.2. Kilohms Low End Scale Factor.

Calibration of this point does not disturb any other, but it is affected by the input amplifier zero setting.
Make sure that the input amplifier has already been zeroed. (See section 3.3).
Connect a 9 kilohm load to the terminals.

Calibrate.

3.7. Capacitance Range (uF) Scale Factor.

This calibration point is fully independent of all others.
Select uF switch position.
With the leads connected, but open circuited, check the reading. If greater than 2 digits (0.2nF), null out the stray capacitance by pressing the 'test' button. The ‘null’ symbol should then be present on the display.
Connect a capacitance of 90nF to the terminals.

Calibrate.

3.8. Current Range (mA).

There are two calibration points, for dc scale factor and ac scale factor.
Select mA switch position and hold down the 'test' button until a mA test starts.

3.8.1. DC Milliamps Scale Factor.

This calibration point is fully independent of all others.
Select dc measurement by pressing the 'ac/dc' button if necessary - the 'dc' symbol should be present on the display.
Apply +90mA to the terminals.

Calibrate.

3.8.2. AC Milliamps Scale Factor.

This calibration point is fully independent of all others.
Select ac measurements by pressing the 'ac/dc' button if necessary - the 'ac' symbol should be present on the display.
Apply 90mA 50Hz to the terminals.

Calibrate.

3.9. After Calibration.

The instrument must be restored to normal operation by removing the calibrate diode, or by clearing the 'calibrate' bit in the EEPROM stored settings, as appropriate. The 'CAL' message should then not be shown during the switch-on sequence.

4. Uncalibration.

Sometimes it may be necessary to temporarily return the instrument to an uncalibrated condition, for example during faultfinding.
To do this, fit the 'uncalibrate' diode D311.
The display should briefly show the message 'unc' during the switch-on sequence.
In uncalibrate mode the stored calibration data is ignored, but it is not erased or overwritten.
Thus the instrument reverts exactly to its previous state when the D311 is removed.

5. Calibration Procedure

AVO Part no 6172-463

	RANGE	APPLY	COMMENTS	ACTION
1.	**MΩ** 500V	O/C(0.00uA)	Press ac/dc key to select leakage I	Press Back-light to Calibrate Press Test-Button to start Test
2.	**MΩ** 500V	9 M**Ω**	Press ac/dc key to select resistance.	Press Back-light to Calibrate Press Test-Button to start Test
3.	**V**	90V 50Hz		Press Back-light to Calibrate
4.	**mV**	90mV DC		Press Back-light to Calibrate
5.	**mV**	90mV 50Hz	Press ac/dc key to select ac.	Press Back-light to Calibrate
6.	**Ω**	0 **Ω**		Press Test-button to apply zero.
7.	**Ω**	9 **Ω**		Press Back-light to Calibrate
8.	**k Ω**	9k**Ω**		Press Back-light to Calibrate
9.	**k Ω**	900k **Ω**		Press Back-light to Calibrate
10.	**uF**	90nF		Press Back-light to Calibrate
11.	**mA**	90mA DC	Press Test-Button to enter mA	Press Back-light to Calibrate
12.	**mA**	90mA 50Hz	Press Test-Button to enter mA	Press Back-light to Calibrate Press ac/dc key to select ac.

Appendix 4 Test Specifications

Initial Instrument Setup AVO Part no 6172-463

This calibration procedure is applicable to the BMM80,BMM2000,BMM2080,BMM2500 and BMM2580 range of instruments . Use test gear fixture T. no. 473 . Assemble instrument and screw case together . Do not fit the battery compartment .

* For the BMM2500 series the instruments need to be flash tested . Connect the RS232 lead and the terminal leads to the UUT and Flash test to 4kV ac using FT4/6 between the terminals (earth on the FT4/6) and the RS232 lead(High on the FT4/6) . The test should be carried out for 2 seconds , if any breakdown occurs reject the instrument , and do not attempt any further testing.

The Flash test can only be carried out by a suitably qualified Technician in the CM400/LCB instrument test cell.

- Connect the PP3 battery connector to the test jig . Place the instrument on the test jig and insert the test leads from the calibration unit (1 black lead ,1 red lead and 1 SP1 connector).

- For BMM2500 series instruments connect the RS232 lead directly to the instruments RS232 connector and **not to** the test jig , the operation of the instruments RS232 interface is then tested . For all other variants the RS232 lead should be connected to the test box.

- From the main menu select option “1) Instrument Setup”

- From this menu select option “4) Select Instrument” , select the appropriate option for the unit under test.

- From this menu select option “2) Finished Product” , Follow the on screen instructions. Enter an alternative variant code only if the UUT is a BMM2500 series as follows.

Product	**Variant Code**
BMM2500	BMM2500
BMM2500RS	BMM2500RS
BMM2500FDD	BMM2500NL
BMM2500SIP	BMM2500IT
BMM2500FNS	BMM2500FL
BMM2500EFG	BMM2500FR
BMM2580	BMM2580
BMM2580RS	BMM2580RS
BMM2580FDD	BMM2580NL
BMM2580SIP	BMM2580IT
BMM2580FNS	BMM2580FL
BMM2580EFG	BMM2580FR

- Press “return” on the Keyboard .

- For BMM2500 series Select option “3) Store serial number” . Enter the serial number of the instrument in the following format : BMMXXXX XXXX XXXX i.e. BMM2580 000100 1009 and press return.

- When downloading is complete select option “5) Quit “ to quit back to the main menu .

- Switch the instrument to the OFF position.

- Select Calibrate mode on the Test box.

Product Verification AVO Part no 6172-464

This production test specification is applicable to the BMM80,BMM2000,BMM2080,BMM2500 and BMM2580 range of instruments . Use test gear fixture T. no. 473 . Assemble instrument and screw case together . Do not fit the battery compartment . Carry out calibration procedure 6172-463 before attempting any tests.

- Connect the PP3 battery connector to the test jig . Place the instrument on the test jig and insert the test leads from the calibration unit (1 black lead ,1 red lead and 1 SP1 connector).
- If the instrument being tested is a BMM2500 series plug the RS232 test lead directly into the instrument and **not** into the test box . This then verifies the operation of the instruments RS232 interface.
- Switch the instrument to the OFF position.
- Select Test mode on the Test box.
- From the main menu select the appropriate option to test the UUT .
- Select the Test 1000V range from the menu and follow the on screen instructions.

	RANGE	**APPLY**	**COMMENTS**	**READ**
1.	1000V	1 MΩ	Press SP1 Test Button	0.97MΩ - 1.03M Ω 2mA> s/c >1mA On Test Box Output Volts >1000v On Test Box
2.		9 MΩ	Press SP1 Test Button	8.82MΩ - 9.18MΩ
3.		500 MΩ	Press SP1 Test Button	495MΩ - 515MΩ
1.	500V	0 MΩ	Press Test Button	0.00 MΩ
2.		100kΩ	Press Test Button	< 2mA On Test Box
3.		250kΩ	Press Test Button	0.23MΩ - 0.27MΩ
4.		500kΩ	Press Test Button	0.48kΩ - 0.52kΩ 2mA > s/c > 1mA On Test Box Output Volts >500V On Test Box
5.		500MΩ	Press Test Button	495MΩ – 515MΩ
6.		10GΩ	Press Test Button	9.7GΩ – 10.5GΩ
7.		0 MΩ	Press Test Button	0.00M (Low Battery)
1.	250V	250kΩ	Press Test Button	0.23MΩ - 0.27MΩ 2mA > s/c >1mA On Test Box Output Volts >250v On Test Box
2.		500 MΩ	Press Test Button	495MΩ - 515MΩ
1.	100V	500MΩ.	Press Test Button	490MΩ - 520MΩ Output Volts >100v On Test Box
1.	50V	500MΩ	Press Test Button	485MΩ - 522MΩ Output Volts >50v On Test Box

RANGE	APPLY	COMMENTS	READ
1. V	o/c		000V
2.	5.0Vdc		4.7V-5.3V
3.	-5.0Vdc		-4.7V - -5.3V
4.	240Vdc		237V - 243V
5.	5.0V(ac 50Hz)		4.7V-5.3V
6.	240V(ac 50Hz)		237V - 243V
6.1*(Not BMM80)*		Press return key to display frequency	49.8Hz-50.2Hz
1. mV	s/c	Press ac/dc key to toggle	0.3 mV dc / 0.3mV ac
2.	100mVdc		95mV - 105mV
3.	1000mV		950mV - 1050mV
4.	100mV(ac50Hz)	Press ac/dc key to select ac	97.8mV – 102.2mV(freq=50.0)
5.	1000mV(ac50Hz)	Press ac/dc key to select ac	978mV – 1022mV(freq=50.0)
1. Ω's	0Ω	Press Test button to Zero reading	-0.00Ω - 0.01Ω
2	2Ω		s/c >200mA On Test Box
3.	90Ω		88.1Ω - 91.9Ω
4.	O/C		5V> O/C voltage>4V On Test Box
5.	0Ω(Low Battery)		-0.00Ω - 0.01Ω
5.1*(Not BMM80)*		Press Lock key to Lock ohms in high range	Check for Lock Symbol on Display
1. 5Ω Buzzer	4Ω		Buzzer on
2.	9Ω		Intermittent Buzzer
3.	3kΩ		Buzzer off
1. KΩ	0Ω		0.00kΩ - 0.01kΩ
2.	50kΩ		47.4kΩ - 52.6kΩ
3.	900kΩ		873kΩ - 927kΩ
4.	9 MΩ		8.82 MΩ -9.18 MΩ
5.	∞		Pointer must indicate infinity
1. uF	10nF		9.6nF - 10.4nF
2.	900nF		852nF - 948nF
1. mA	o/c	Press ac/dc key to toggle	0.0mA dc/0.2mA ac
2.	10.0mA dc		9.5mA - 10.5mA
3.	100.0mA dc		97.9mA - 102.1mA
4.	500mA dc		487mA - 513mA
5.	10.0mA ac 50Hz	Press ac/dc key to select ac	9.5mA - 10.5mA(freq=50.0)
6.	100.0mA ac 50Hz	Press ac/dc key to select ac	97.9mA - 102.1mA(freq=50.0)

Battery Check

1. 500V	9v to UUT	Press Test Button	<200mA On Test Box
2. 500V	5.85to UUT	Low battery indicator appears	
3. OFF(Standby)		9v to UUT	< 20uA On Test Box

When the full set of tests is completed the Instrument can be removed and the label affixed over the programming aperture in the battery compartment.

Appendix 5 List of Errors – BMM series

Error No.	Type	Description
Error 1	software	attempt made to display number > 1999
Error 2	software	invalid decimal point number
Error 3	software	invalid interrupt or routine or action routine
Error 4	software	event buffer overflow
Error 5	software	invalid latch control parameter
Error 6	hardware	unstable readings from rotary switch (cal/test/diags only)
Error 7	hardware	rotary switch data error (cal/test/diags only)
Error 8	software	invalid internal ad parameter
Error 9		not used
Error 10	software	invalid analogue switch configure parameter
Error 11	not used	
Error 12	hardware	a/d converter (7109) failure
Error 13		not used
Error 14	software	watchdog has been disabled
Error 15	hardware	internal ad failure
Error 16		not used
Error 17	hardware	RS232 receive error
Error 18	software	invalid inverter voltage setting parameter
Error 19	hardware	integrator not resetting - PULSE MEAS signal stays high
Error 20		not used
Error 21		not used
Error 22	hardware	EEPROM acknowledge failure
Error 23	hardware	EEPROM checksum error
Error 24	software	EEPROM addressing error
Error 25	software	invalid test type
Error 26	software	invalid connection parameter for result storage/retrieval
Error 27	software	invalid parameter for ohms current source control (not used after V1.2)
Error 28	software	invalid parameter for ohms display range
Error 29	software	invalid parameter for kilohms display range
Error 30		not used
Error 31	software	RS232 error
Error 32		not used
Error 33	software	system hang-up error
Error 34	hardware	data bus fault
Error 35	hardware	data bus fault
Error 36	hardware	data bus fault
Error 37		not used
Error 38	software	string to be transmitted is too long
Error 39	hardware	2.5V reference out of limits (cal/test/diags only)
Error 40	hardware	-5V supply fault (cal/test/diags only)
Error 41	hardware	EEPROM set-up bits error- posistor protect mode requested with milliamps range enabled
Error 42	software	capacitance measurement logical flow error
Error 43	software	arc segment number too large
Error 44	software	invalid parameter for ohms hardware range
Error 45	software	invalid parameter for kilohms hardware range
Error 46	software	invalid parameter retrieved for insulation test voltage

Appendix 6 Instrument Final Specifications

SPECIFICATION

All quoted accuracy's are at +20ºC.)

Insulation

Nominal Test Voltage(d.c.):	250V,500V,1000V(BMM2000/BMM2500) 50V,100V,250V,500V,1000V (BMM80/BMM2080/BMM2580)
Test voltage accuracy:	+15% maximum on open circuit
Short circuit current:	< 2 mA
Test Current on load:	1mA at min. pass value of insulation specified in BS7671, HD384 and IEC364, 2mA max.

Accuracy:
(BMM80/BMM2080/BMM2580)

Range	Full Scale	Accuracy
1000 V	200 GΩ	± 2% ± 2 digits ±0,2% per GΩ
500V	100 GΩ	± 2% ± 2 digits ±0,4% per GΩ
250 V	50 GΩ	± 2% ± 2 digits ±0,8% per GΩ
100 V	20 GΩ	± 2% ± 2 digits±2,0% per GΩ
50 V	10 GΩ	± 2% ± 2 digits±4,0% per GΩ

Accuracy:
(BMM2000/BMM2500)

Range	Full Scale	Accuracy
1000 V	20 GΩ	± 2% ± 2 digits ±0,2% per GΩ
500V	10 GΩ	± 2% ± 2 digits ±0,4% per GΩ
250 V	5 GΩ	± 2% ± 2 digits ±0,8% per GΩ

Note: Above specifications only apply when high quality silicone leads are being used.

Measuring Range:	0,01 MΩ to 200GΩ (0 -100 GΩ on analogue scale).
EN61557 Operating range:	0,10Ω to 1,00GΩ
Leakage Current:	10% +/- 3digits

Continuity

Measuring Range:	0,01 Ω to 99,9 Ω (0 to 10 Ω on analogue scale)
EN61557 Operating range:	0,10Ω to 99,9Ω
Accuracy:	± 2% ± 2 digits
Open circuit voltage:	5 V ± 1 V
Test current:	210 mA ± 10 mA (0 - 2 Ω)
Zero offset at probe tips:	0,10 Ω typical
Lead resistance zeroing:	Up to 9,99 Ω
Noise rejection:	1V rms 50/60Hz
Buzzer:	Operates at less than 5Ω (approx).

Resistance	
Measuring Range:	0,01 kΩ to 9,99MΩ (0 to 100 MΩ on analogue scale)
Accuracy:	± 3% ± 2 digits
Open circuit voltage:	5 V ±1 V
Short circuit current:	25 µA ± 5 µA
Voltage	
Measuring Range:	+/-1V to +/-500V (0 to 1000V on analogue scale)
Accuracy:	0 - 500 V d.c. ±2% ±3 digit 0 - 500 V a.c (50/60Hz) ±2% ±3 digits 0 - 500 V 400 Hz a.c. ± 5% ±3 digits
Input resistance:	approx 200kΩ.
Detector Threshold:	1V
Millivolts	
Measuring Range:	+/-0,1mV to +/-1999mV (0 to 1000mV on analogue scale)
Accuracy:	0,1mV to 10mV d.c. or a.c.(50/60 Hz) ± 2% ±5 digits 10mV to 1999mV d.c. or a.c. (50/60 Hz)± 2% ±3 digits 0,1mV to 10mV a.c.(16-460 Hz) ± 5% ±7 digits 10mV to 1999mV a.c. (16-460 Hz) ± 5% ±5 digits
d.c. milliVolts zeroing:	Up to 9,9mV
Input resistance:	>3MΩ
Capacitance(BMM80/BMM2080/BMM2580)	
Measuring Range:	0,1nF to 9,99uF
Accuracy:	+/-3% +/-2 digits +/-0,2nF
uF zeroing:	Up to 10nF
Milli-amps(BMM2000/BMM2080/BMM2500/BMM2580)	
Measuring Range:	0,1mA to 500mA (0 to 1000mA on analogue scale)
Accuracy:	0,1mA to 10mA d.c. or a.c.(50/60 Hz) ± 2% ±5 digits 10mA to 500mA d.c. or a.c. (50/60 Hz)± 2% ±3 digits 0,1mA to 10mA a.c.(16-460 Hz) ± 5% ±7 digits 10mA to 500mA a.c. (16-460 Hz) ± 5% ±5 digits
Frequency	
Measuring range:	16Hz to 460Hz
Accuracy:	+/-1% +/-1digit

Appendix 7 Function of Diode Links

1. General

Various diode links can be fitted in order to put the instrument into special modes for calibration, faultfinding etc.
If any diode is fitted (except the latching relay diode), the 'diode' symbol is shown on the display at start-up, at the same time as the version number. This is to warn against diodes being accidentally left fitted in the instrument.

2. Link Functions

2.1 'Calibrate' link

Can be fitted in order to calibrate the instrument.
Display shows 'CAL' at start-up.
Performs display test at start-up.
Version number and code checksum are transmitted at start-up.
Backlight does not work as normal.
Backlight keypress causes auto-calibration, calibration constants are stored in EEPROM. (See Appendix 3 for details).
On buzzer range, buzzer does not sound - backlight is used instead of buzzer.
Autoshutdown is disabled.
Test button is in latching mode on insulation test.
Certain negative readings which are normally suppressed, are shown for information.
RS232 receive, rotary switch and battery errors are indicated.
Data bus self-test, 2.5V self-test, and -5V self-test errors are reported.
Results are transmitted via RS232.

2.2 'Uncalibrate' link

Can be fitted in order to make instrument behave as though not calibrated.
Display shows 'unc' at start-up.
Stored calibration data is ignored, i.e. not erased or overwritten. Unity is used for all calibration multipliers, and zero for the input amplifier zero correction.

2.3 'Diagnostics' link

Can be fitted in order to assist with fault-finding.
Performs a display test at start-up.
Version number and code checksum are transmitted at start-up.
Special sequence of tests then available in DIAGNOSTICS switch position. (See Appendix 9 for details).
Display shows 'diA' when diagnostics range selected.
Test button is in latching mode on insulation test.
Certain negative readings, which are normally suppressed, are shown for information.
Battery check bypassed, dead battery or blown fuse ignored.
Hang-up error ignored.
Integrator reset time allowance hugely extended to assist faultfinding.
Data bus self-test, 2.5V self-test, and -5V self-test errors are reported.
Logging interval is fixed at 2s for rapid checking and memory filling.
If an error occurs, display shows 'FXY' where XY is the error number. System halts as for normal error, but conditions are held to allow faultfinding.

2.4 'Test' link

Can be fitted for detailed testing of the instrument.
More information is made available than in normal operating mode, but without the diagnostic features or the ability to change the calibration.
Display shows 'tES' at start-up.
Performs display test at start-up.
Version number and checksum are transmitted at start-up.
Certain negative readings, which are normally suppressed, are shown for information.
Autoshutdown is disabled.
Test button is in latching mode on insulation test.
RS232 receive, rotary switch and battery errors are indicated.
Data bus self-test, 2.5V self-test, and -5V self-test errors are reported.
Results transmitted via RS232.

2.5 'Shutdown disable' link.

Can be fitted to prevent autoshutdown occurring. No autoshutdown occurs, except in the case of very low battery.

2.6 'Default voltmeter disable' link.

Can be fitted to assist faultfinding, in the event that a fault causes nuisance activation of the dvm.
Default voltmeter will not function.
Voltmeter works as normal in volts and mA switch positions.

2.7 'Bypass eeprom' link

Can be fitted to assist faultfinding in the event of a EEPROM fault, as this can effectively lock out the instrument completely.
Display shows 'bPE' at start-up.
System will partially work with a faulty or missing EEPROM.
EEPROM version bits will all be set to 0 - there may be some unexpected side effects.

2.8 'Bypass voltage detector' link.

Can be fitted to assist faultfinding of voltage measurement, if the voltage detector is not working.
Voltmeter range indicates right down to 0.0V, no 1V trigger level.

2.9 'Bypass contact detector' link.

Can be fitted to assist faultfinding of continuity measurement, if the contact detector is not working.
Continuity always operates in measurement mode, no 3kilohms trigger point.
In-range values are handled ok, but there may be some unexpected side effects for inputs > 3k.

2.10 'Latching test button' link.

Can be fitted to obtain latching test button action.
On insulation function, test button always has 'push-to-start', 'push-to-stop' mode of operation.

2.11 'Negative terminal latching relay' link.

This should be fitted on all current BMM variants.
This diode tells the software that the -ve terminal is controlled by a latching relay and not by a non-latching relay or fet.

3. Further information.

3.1 Main diodes (display pcb)

Relative positions and orientations

(Top left-hand corner
of display)

Not used	Instrument test →	Diagnostics ←
Uncalibrate →	Shutdown disable →	Default voltmeter disable ←
	Latching test button →	Not used

Function	**Data line**
Diagnostic link (D321)	0
Send mode enable link (D323)	1
Default voltmeter disable link (D322)	2
Test mode link (D313)	3
Shutdown disable link (D314)	4
Latching test button enable link (D315)	5
Not used	6
Uncalibrate link (D311)	7

3.2 Auxiliary diodes (display pcb)

Relative positions and orientations

bypass eeprom ↓	Bypass voltage detector ↓	bypass contact detector ↓	latching relay ↓

Function	**Data line**
Bypass voltage detector link (D320)	4
Bypass eeprom link (D319)	5
Bypass contact detector link (D325)	6
Neg term latching relay link (D326)	7

3.2 Calibrate diode (main pcb)

Function	**Data line**
Calibrate link (D3) ←	Serial out

Appendix 8 Production Software / Known problems

Comments on production software

Version P1.0 instruments

Checksum on Stag programmer is C57B
Checksum on BMM is 379

Only BMM80, BMM2000, BMM2080 made as there was a bug in download.

No BMM2500 or BMM2580 made.
1kv warning was disabled as there was a bug present.
Megohms inhibit level set at 25V
Ad vio correction (semi-automatic null) feature not enabled.
A4 pcbs.

Version P1.1 instruments

Checksum on Stag programmer is 803B
Checksum on BMM is 059

Only 5 made, all BMM2500 family

1kv warning was disabled as there was a bug present.
Megohms inhibit level set at 25V
Ad vio correction (semi-automatic null) feature not enabled.
A4 pcbs.

Version P1.2 instruments

Checksum on Stag programmer is C700
Checksum on BMM is 768

1kv warning was still disabled due to additional bugs
Megohms inhibit level set at 25V
Ad vio correction feature (semi-automatic null) is now enabled.
A4 pcbs.

Version >P1.2 instruments

One only made, for ATS, to fix bug in download
(a second download did not send the initial circuit number)

Version P1.3 instruments -

Checksum on Stag programmer is 63D8
Checksum on BMM is 984

1kv warning now ok but initially it was not enabled
So as to allow all version 1.2 instruments to pass through to FPS.
Megohms inhibit level set at 25V.
Milliamps auto cut-off feature introduced.
A4/A5 pcbs.

BMM - Bugs from production version P1.0 onwards

Bugs on P1.0

1. Logging stops after normal shutdown time - 5 mins. Does not matter as P1.0 was not used on instruments with RCL - fixed.

2. Beep given when log memory full can interfere with measurements and cause error messages. Does not matter as P1.0 was not used on instruments with RCL - fixed.

3. Bugs found in ad null feature. Does not matter as ad null is not enabled on P1.0 - fixed.

4. Current spike drawn from batteries during autoshutdown while insulation test is running - fixed.

5. Connection data on stored insulation tests is incorrectly downloaded - recall and print are ok. Does not matter as P1.0 was not used on instruments with RCL - fixed.

6. mA ac reading can be negative - fixed.

7. Can upset millivolts nulling by rapid repeated test key pressing.

Bugs on P1.1

1. When negative sign suppressed on ac millivolts, reading not being set to zero - fixed.

2. In cal mode on 2000/2500, milliamps in wrong position in calibrate mode - fixed.

3. 1000V ins range, if test button pressed and released quickly error33 results - fixed.

4. Instrument does not respond to very low battery during insulation pre-test.

5. –5V self-check not working - uses wrong ad channel following A2-A3 board change. (measures 0v so is ok) - fixed

6. Reset sequence takes a long time - done.

7. Need cut-off on milliamps to save fuse if over 500mA current - done on P1.3.

8. Make ohms calibration require offset null to be on - done.

9. Refresh of latches not happening on all functions - done on P1.3.

10. No default voltmeter on millivolts - done on P1.3.

11. Battery check not being done on top kilohms range - done on P1.3.

Bugs on P1.2

1. Need cut-off on milliamps to save fuse if over 500ma current - done.

2. No default voltmeter on millivolts - fixed.

3. Rapid pressing of ac/dc key in ma caused hang-up - error33 - fixed

4. Circuit numbers not always present in download. No problem with Powersuite or Download Manager - fixed

5. Battery not being checked on kilohms top range - fixed

6. Latches/relay not always being refreshed on ohms, kilohms, cap measurement -fixed
Latches and negative term relay now refreshed on ohms & kilohms (P1.3).
Latches but not negative term relay now refreshed on cap (P1.3).

7. Error33 follows abort 1kV warning when external volts present - fixed

8. 'Default voltmeter disable link' not working on capacitance - fixed

9. Error31 if >39 RS232 characters received during calibrate mode - fixed

10. Cannot store insulation test result while volts on terminals.

11. Lock symbol not shown when in lock mode on ohms and returning from default voltmeter - fixed

12. Spurious 'log' messages shown - fixed
A. After megohms logging session ended by pressing test button, followed by default voltmeter followed by exit from default voltmeter
B. After abort from any logging session due to blown fuse or dead battery

13. It was possible to get into set-up menu in 'RCL' position by holding down backlight key and then pressing up or down key - fixed

14. During insulation test with large capacitive load, a result could appear after the test which did not appear during the test. 'Result available' flag was being set in the wrong place - fixed

15. Voltmeter. If ac input and frequency being displayed and input suddenly changed to dc, display freezes - fixed

16. Ohms range. Can get confused with inductive loads if in range lock mode - fixed

17. Ohms range with relays closed and small negative volts on terminals and offset null off, reading is zero, but pointer shows overrange - fixed

18. Milliamps. When test attempted with > 25V on terminals, warning has wrong buzzer frequency - fixed

<u>Bugs on P1.3</u>

1. Can upset millivolts nulling by rapid repeated test key pressing.

2. Maybe we should show checksum on display in diagnostic mode.

3. Cannot store insulation test result while volts on terminals.

4. Insulation test - strange things can happen during the test when there is a large ac voltage on the terminals and a low circuit resistance. Current flows via protection network and exceeds integrator dynamic range.

5. Millivolts - strange things can happen with large ac voltage on +ve terminal and negative lead trailing. Jumps into default voltmeter but then reads <1V (due to much lower input impedance on volts compared to mV.

6. It is possible to get into the log confirm screen on milliamps or insulation unexpectedly. If the terminal volts are too high and a test is attempted, the instrument gives a warning message, beeps and then exits from default voltmeter. If the backlight key is held down during this time, and logging has been enabled via the setup menu, then the log confirm message will be shown.

Appendix 9 Diagnostic Mode

1. Entry into Diagnostic Mode.

To access diagnostic mode, diode D321 must be fitted.

2. General features during normal operation.

Display test is carried out at start-up (all segments on).
Version number and code checksum are transmitted at start-up.
Data bus, -5V and +2.5V self-checks are carried out at start-up.
Test results are transmitted via the serial interface at 2 second intervals.
If logging is enabled, the logging interval is fixed at 2 seconds.
System hang-up error (error33) is disabled.
RS232 receive error (error31) is enabled.
Switch reading errors (error6 and error7) are enabled.
A/d converter failure is detected (error12).
Battery check always returns full scale value (good battery).
Abort test (due to detection of blown fuse or dead battery) is disabled.
Time allowed for integrator reset is 10mins (normally 250ms).
Warning triangle shows some a/d reading errors.
Warning triangle shows some pulse detection errors.
If a system error occurs, the fault number is displayed as 'FXY' and the conditions at the time of the fault are sustained as far as is possible. (This assists fault-finding, because when an error occurs in normal operating mode, the microcontroller reconfigures all the hardware into a known state. This can make it difficult to find the cause of the error).

3. Special features during normal operation.

During normal measurements, there are some differences to facilitate faultfinding. On all measurement functions, the results are transmitted via the battery compartment test pads and via the RS232 diode, if fitted.
Other features are listed below.

3.1. Insulation test.

Latching test button action is enabled. Leakage current display is available, by pressing the 'display' button or the 'ac/dc' button. Actual sign of leakage current is shown.

3.2. Volts

Actual sign of the a/d converter input is shown.

3.3. Millivolts

Actual sign of the a/d converter input is shown (on ac mV).

3.4. Ohms.

Actual sign of the reading is shown.

3.5. Buzzer.

No special action.

3.6. Kilohms.

Actual sign of the reading is shown.

3.7. Capacitance.

'A' is displayed while the charge phase is in progress (leading edge of ‘A’ is a rising edge).
'V' is displayed while the discharge phase is in progress (leading edge of ‘V’ is a falling edge).
'<' is displayed if the input is stuck low, (charge is being attempted).
'>' is displayed if the input is stuck high, (discharge is being attempted).

3.8. Milliamps.

Actual sign of the a/d converter input is shown, (on ac mA).

4. Special diagnostic tests.

The diagnostic test sequence can be made available by...
i. Removing the rotary switch, or
ii. Turning it past the last function (clockwise, as viewed from the front of the instrument), or
iii. Locating the switch in between normal positions.

Display shows 'diA' for about 1 second, followed by...

Test 1 – General

Display test - all display segments are turned 'on'.
Power supply rails - all rails are turned 'on'. Check 5V, 5V(A), +2.5V REF. Check that -5V and -5V(A) are greater than 4.7V in magnitude.
Data bus is released - all data lines are pulled to 5V
Backlight is turned 'on'
Buzzer is turned 'off'.
RS232 led (if fitted) is turned 'on' (i.e. in transmit mode).
Integrator is reset – ramp-up occurs, then output holds at 3V approximately.
+ve terminal is connected to 0V(A), via 750k discharge resistors.
-ve terminal connected to 0V(A), by latching relay action.

Press the 'up/lock' button to change some elements...

Backlight 'off'.
Buzzer 'on'.
RS232 led 'off' (i.e. in receive mode).
Integrator is activated – ramp-down occurs, then output holds at 0V approximately.
+ve terminal is connected to 5V, via 750k discharge resistors.
-ve terminal is disconnected from 0V(A) by latching relay action.

Press the 'up/lock' button again to get back to the initial conditions for test 1.
Press the 'test' button to move on to Test 2.

Test 2 - Microcontroller a/d converter

Display shows '<> 0' briefly, to indicate channel 0.
Display then shows a/d reading for that channel.
Reading is also transmitted via RS232. Transmitted data is prefixed with 'Ca' ('Channel analogue').

Press the 'up/lock' button to move to the next a/d channel.
Press the 'test' button to move on to Test 3

Test 3 - 7109 A/D Converter

The +a/d reference pin is connected to 2.5V.
The -a/d reference pin is connected to 0V.
The +ve a/d input pin is connected to 0V(D).
The -ve a/d input pin is connected to 0V.
The a/d conversion rate is set for about 2 per second.
The 'dc' symbol blinks briefly with each conversion.
The display shows the sign, and the a/d reading divided by 4.

Thus the 'dc' symbol should blink regularly and the reading should be < 5 digits.

Press the 'test' button to move on to Test 4.

Test 4 - Watchdog/reset circuit

Watchdog resets are suspended, and the display shows the analogue pointer sweeping clockwise across the scale. At approximately the halfway point, the watchdog circuit should time-out, and generate a system reset

Appendix 10 Interboard Connections

Bmm2000 interboard connections - pcb version A4
(numbered from the top end of the board, downwards)

NUMBER	NAME	MAIN BOARD SHEET(S)	DISPLAY BOARD SHEET(S)
1	DISCHARGE	1	10
2	SERIAL IN	6	7
3	SERIAL OUT	6	7
4	VOLTS TEST	1	10
5	AC-DC CONVERTER+	1	8
6	AC-DC CONVERTER-	1	8
7	FREQUENCY MEAS	2	10
8	MV TEST	1	10
9	POSTERM MONITOR2	1	7
10	INPUT INVERTER	1	11
11	MVDC ETC	1	8
12	V DETECT OUTPUT	2	10
13	TEST	5	7
14	OFF	5	7
15	LATCH 1 ENABLE-	4	7
16	LATCH 2 ENABLE-	3	7
17	BATT/2	6	7
18	+5V	1,2,3,4,5,6	7,8,9,10,11
19	0V(D)	1,3,4,5,6	7,8,9,10,11
20	0V(D)	1,3,4,5,6	7,8,9,10,11
21	TEST BUTTON	5	11
22	D(3)	3,4	7,8,10
23	D(2)	3,4	7,8,10
24	D(1)	3,4	7,8,10
25	D(0)	3,4	7,8,10
26	0V	1,2,3,4	8,10
27	INS IN HI	4	8
28	0V	1,2,3,4	8,10
29	NOT USED	--	--
30	NOT USED	--	--
31	NOT USED	--	--
32	NOT USED	--	--
33	NOT USED	--	--
34	POWER OFF	5,6	9
35	SWITCH B	5	7
36	SWITCH A	5	7
37	BATTERY +VE	4,5,6	9,11
38	+5V	1,2,3,4,5,6	7,8,9,10,11
39	+2.5V REF	3,4	7,8
40	PULSE MEAS	3	7
41	RELAY ENABLE	1	11
42	0V	1,2,3,4	8,10
43	0V(A)	1,3,4,5,6	7,8,9,11
44	0V(D)	1,3,4,5,6	7,8,9,10,11
45	I CTRL(0)	3	9
46	I CTRL(1)	3	9
47	I CTRL(2)	3	9
48	-5V	1,2,3,4,5,6	7,8,9,10,11
49	I SOURCE OUTPUT	4	9
50	0V(A)	1,3,4,5,6	7,8,9,11

Appendix 11 LCD PINOUT

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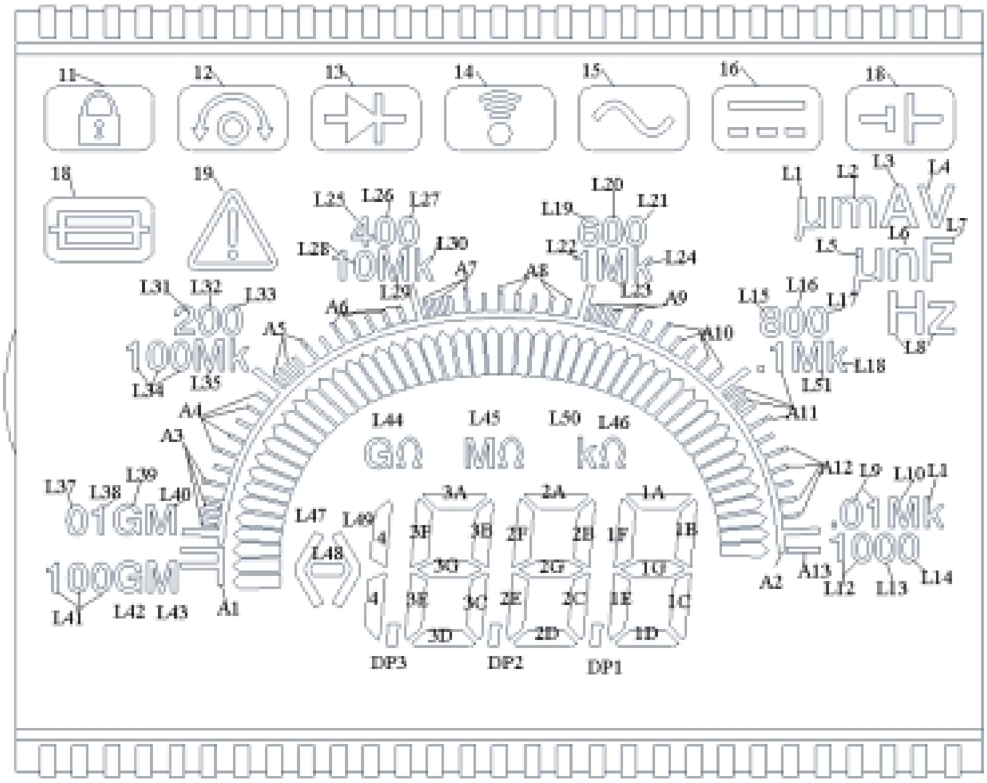


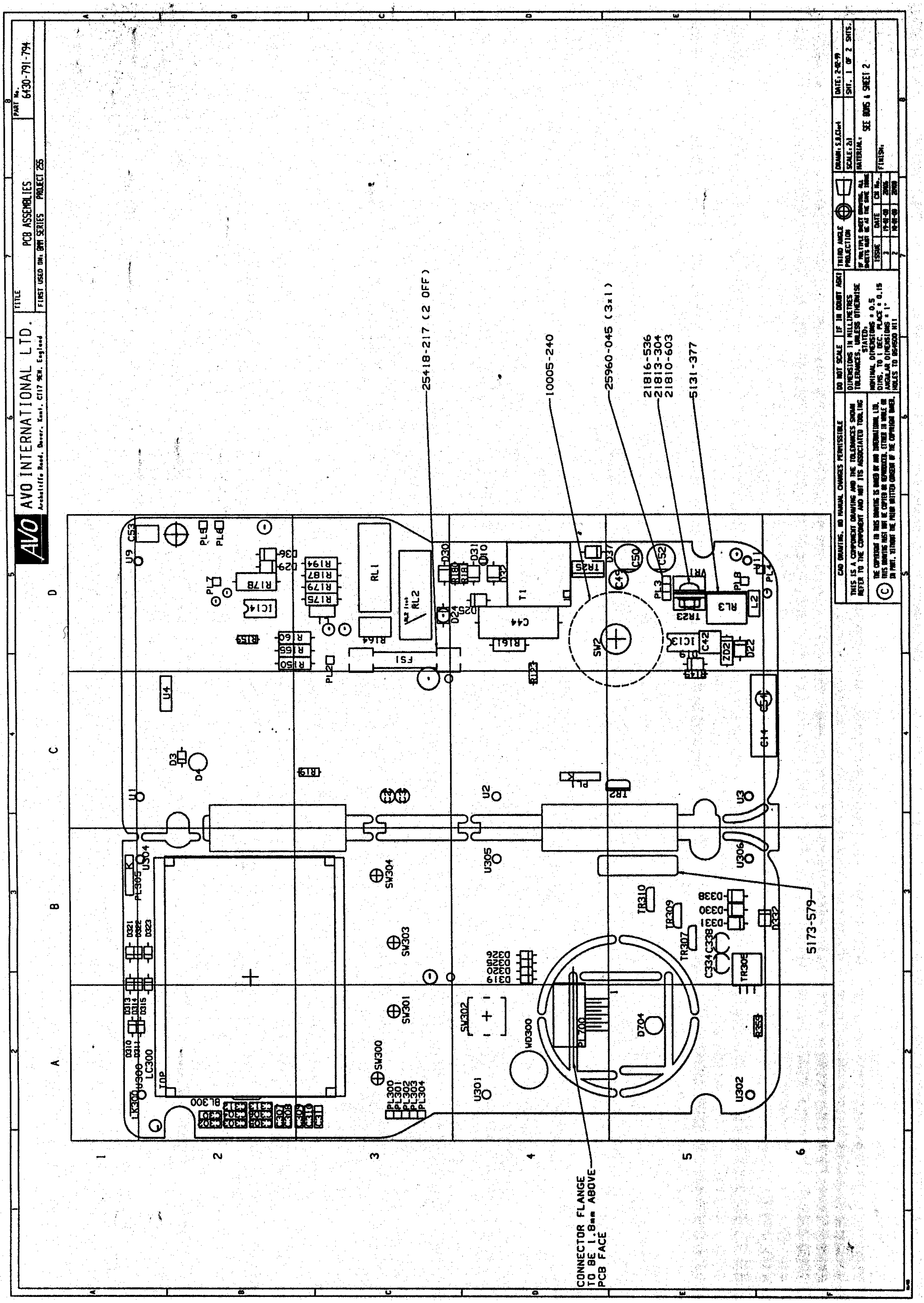
1

LCD PIN	SEGMENT		
	BACKPLANE1	BACKPLANE2	BACKPLANE3
1	B6	B5	L49
2	B7	B8	4
3	B10	B9	DP3
4	B11	B12	3E
5	B14	B13	3F
6	NC	L44	3D
7	B15	B16	3G
8	B18	B17	3A
9	B19	B20	3C
10	NC	L45	3B
11	B22	B21	DP2
12	B23	B24	2E
13	B26	B25	2F
14	B27	B28	2D
15	B30	B29	2G
16	B31	B32	2A
17	B34	B33	2C
18	L50	L46	2B
19	B35	B36	DP1
20	B38	B37	1E
21	B39	B40	1F
22	B42	B41	1D
23	B43	B44	1G
24	B46	B45	1A
25	B47	B48	1C
26	B50	B49	1B
27	NC	NC	BACKPLANE3
28	NC	BACKPLANE2	NC
29	BACKPLANE1	NC	NC

LCD PIN	SEGMENT		
	BACKPLANE1	BACKPLANE2	BACKPLANE3
30	A2	A4/A6/A8 A10/A12	NC
31	NC	L13	L8
32	NC	NC	NC
33	17	L4	L7
34	NC	NC	NC
35	NC	NC	NC
36	16	L3	L6
37	NC	NC	NC
38	NC	NC	NC
39	NC	NC	NC
40	15	L2	L5
41	NC	NC	NC
42	NC	NC	NC
43	NC	NC	NC
44	14	L1	NC
45	NC	NC	NC
46	NC	NC	NC
47	13	NC	NC
48	NC	NC	NC
49	NC	NC	NC
50	12	19	NC
51	11	18	NC
52	L37/L31/L25 L19/L15/L12	L32/L26/L20 L16	L33/L27/L21 L17/L14
53	A13/L9/A11 L22/A9/L28 A7/L34/A5/L38 A3/A1/L41	L10/L51/L23 L29/L35/L39 L42	L11/L18/L24 L30/L36/L40 L43
54	BACKPLANE1	NC	NC
55	NC	BACKPLANE2	NC
56	NC	NC	BACKPLANE3
57	B2	B1	L47
58	B3	B4	L48

Appendix 12 PCB Layout Drawings

Conventional Component Layout Drawing


AVO INTERNATIONAL LTD.
PCB ASSEMBLIES
6430-791-794
25418-217 (2 OFF)
10005-240
25960-045 (3x1)
21816-536
21813-304
21810-603
5131-377
5173-579
CONNECTOR FLANGE
TO BE 1.8mm ABOVE
PCB FACE
DO NOT SCALE
THIRD ANGLE PROJECTION

6430-794

SEE PCB KIT 6132-032 (BMM2500/2580)

REF.	P.No.	GRID	REF.	P.No.	GRID	REF.	P.No.	GRID	REF.	P.No.	GRID	REF.	P.No.	GRID
BL300	6180-418	A2	C338	26970-126	B5	D330	28863-082	B5	PL305	N/F	B2	SV302	25975-107	A4
C2	26970-084	C3	D3	N/F	C2	D331	28863-082	B5	PL700	25960-096	A4	T1	6131-767	D4
C3	26970-084	C3	D4	28920-039	C2	D332	28863-082	B6	R19	26900-025	C3	TR2	27960-041	C5
C14	27889-636	C6	D19	28863-082	D5	D338	28863-082	B5	R123	26900-134	C4	TR23	28940-028	D5
C42	26970-137	D5	D22	28863-082	D5	D704	28920-039	A5	R145	N/F	C5	TR25	28940-037	D4
C44	26970-087	D4	D24	28920-064	D4	FS1	25950-039	D3	R150	26837-130	D3	TR305	27960-041	B5
C49	27889-956	D5	D25	28863-160	D4	IC13	20000-471	D5	R155	26837-130	D3	TR307	20000-308	B5
C50	26970-109	D5	D29	28863-082	D2	IC14	20000-471	D2	R159	26837-189	D2	TR309	20000-308	B5
C52	26970-109	D5	D30	28863-082	D3	L1	27900-049	D3	R160	26837-130	D3	TR310	20000-308	B5
C53	27889-996	D1	D31	28863-082	D4	L2	27900-049	D5	R161	26837-130	D4	VR1	28900-099	D5
C54	N/F	C5	D32	28863-160	D4	LC300	6280-326	A2	R164	N/F	D3	VD300	27920-011	A4
C301	27889-827	A2	D36	28863-082	D2	LK300	25925-010	A1	R175	26837-066	D3	ZD2	28920-065	D5
C302	27889-827	A2	D37	28863-082	D5	PL1	N/F	C4	R178	26837-177	D2			
C303	27889-827	A2	D310	N/F	A1	PL2	25960-045	C3	R179	26837-066	D3			
C304	27889-827	A2	D311	N/F	A2	PL3	25960-045	D5	R180	26900-161	D4			
C305	27889-827	A2	D313	N/F	A1	PL4	25960-045	D6	R181	26900-161	D4			
C306	27889-827	A2	D314	N/F	A1	PL5	25960-045	D2	R187	26837-066	D3			
C307	27889-827	A2	D315	N/F	A2	PL6	25960-045	D2	R194	26837-066	D3			
C308	27889-827	A2	D319	N/F	B4	PL7	25960-045	D2	R359	26900-286	A5			
C309	27889-827	A3	D320	N/F	B4	PL8	25960-045	D5	RL1	25980-057	D3			
C310	27889-827	A3	D321	N/F	B1	PL300	N/F	A3	RL2	25980-057	D3			
C311	27889-827	A3	D322	N/F	B2	PL301	N/F	A3	RL3	25980-059	D5			
C312	27889-827	A2	D323	N/F	B2	PL302	N/F	A3	SK1		D2			
C313	27889-827	A2	D325	N/F	B4	PL303	N/F	A3	SK2		D5			
C334	26970-126	B5	D326	28433-801	B4	PL304	N/F	A3	SK300	N/F	A2			

6430-793

SEE PCB KIT 6132-031 (BMM2000/2080)

REF.	PtNo	GRID
BL300	6180-418	A2
C2	26970-084	C3
C3	26970-084	C3
C14	27889-636	C6
C42	26970-137	D5
C44	26970-087	D4
C49	27889-956	D5
C50	26970-109	D5
C52	26970-109	D5
C53	27889-996	D1
C54	N/F	C5
C301	27889-827	A2
C302	27889-827	A2
C303	27889-827	A2
C304	27889-827	A2
C305	27889-827	A2
C306	27889-827	A2
C307	27889-827	A2
C308	27889-827	A2
C309	27889-827	A3
C310	27889-827	A3
C311	27889-827	A3
C312	27889-827	A2
C313	27889-827	A2
C334	26970-126	B5

REF.	PtNo	GRID
C338	26970-126	B5
D3	N/F	C2
D4	N/F	C2
D19	28863-082	D5
D22	28863-082	D5
D24	28920-064	D4
D25	28863-160	D4
D29	28863-082	D2
D30	28863-082	D3
D31	28863-082	D4
D32	28863-160	D4
D36	28863-082	D2
D37	28863-082	D5
D310	N/F	A1
D311	N/F	A2
D313	N/F	A1
D314	N/F	A1
D315	N/F	A2
D319	N/F	B4
D320	N/F	B4
D321	N/F	B1
D322	N/F	B2
D323	N/F	B2
D325	N/F	B4
D326	28433-801	B4

REF.	PtNo	GRID
D330	28863-082	B5
D331	28863-082	B5
D332	28863-082	B6
D338	28863-082	B5
D704	N/F	A5
FS1	25950-039	D3
IC13	20000-471	D5
IC14	20000-471	D2
L1	27900-049	D3
L2	27900-049	D5
LC300	6280-326	A2
LK300	25925-010	A1
PL1	N/F	C4
PL2	25960-045	C3
PL3	25960-045	D5
PL4	25960-045	D6
PL5	25960-045	D2
PL6	25960-045	D2
PL7	25960-045	D2
PL8	25960-045	D5
PL300	N/F	A3
PL301	N/F	A3
PL302	N/F	A3
PL303	N/F	A3
PL304	N/F	A3

REF.	PtNo	GRID
PL305	N/F	B2
PL700	N/F	A4
R19	26900-025	C3
R123	26900-134	C4
R145	N/F	C5
R150	26837-130	D3
R155	26837-130	D3
R159	26837-189	D2
R160	26837-130	D3
R161	26837-130	D4
R164	N/F	D3
R175	26837-066	D3
R178	26837-177	D2
R179	26837-066	D3
R180	26900-161	D4
R181	26900-161	D4
R187	26837-066	D3
R194	26837-066	D3
R359	26900-286	A5
RL1	25980-057	D3
RL2	25980-057	D3
RL3	25980-059	D5
SK1		D2
SK2		D5
SK300	N/F	A2

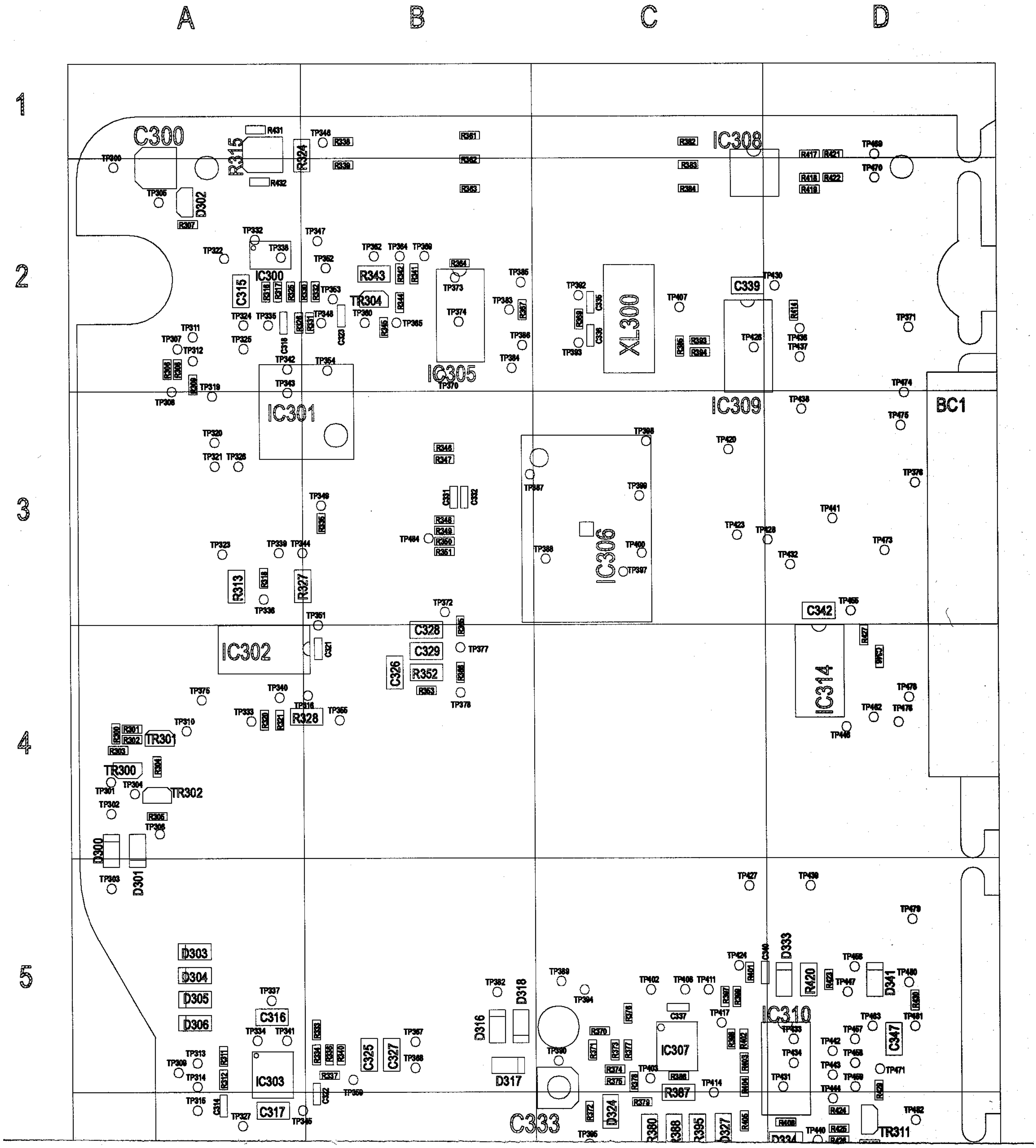
REF.	PtNo	GRID
SW302	25975-107	A4
T1	6131-767	D4
TR2	27960-041	C5
TR23	28940-028	D5
TR25	28940-037	D4
TR305	27960-041	B5
TR307	20000-308	B5
TR309	20000-308	B5
TR310	20000-308	B5
VR1	28900-099	D5
VD300	27920-011	A4
ZD2	28920-065	D5

6430-792

SEE PCB KIT 6132-030 (BMM80)

REF.	P/No	GRID	REF.	P/No	GRID	REF.	P/No	GRID	REF.	P/No	GRID	REF.	P/No	GRID
BL300	6180-418	A2	C338	26970-126	B5	D330	28863-082	B5	PL305	N/F	B2	SW302	25975-107	A4
C2	26970-084	C3	D3	N/F	C2	D331	28863-082	B5	PL700	N/F	A4	T1	6131-767	D4
C3	26970-084	C3	D4	N/F	C2	D332	28863-082	B6	R19	26900-025	C3	TR2	27960-041	C5
C14	27889-636	C6	D19	28863-082	D5	D338	28863-082	B5	R123	26900-134	C4	TR23	28940-028	D5
C42	26970-137	D5	D22	28863-082	D5	D704	N/F	A5	R145	N/F	C5	TR25	28940-037	D4
C44	26970-087	D4	D24	28920-064	D4	FS1	25950-039	D3	R150	26837-130	D3	TR305	27960-041	B5
C49	27889-956	D5	D25	28863-160	D4	IC13	20000-471	D5	R155	26837-130	D3	TR307	20000-308	B5
C50	26970-109	D5	D29	N/F	D2	IC14	20000-471	D2	R159	26837-189	D2	TR309	20000-308	B5
C52	26970-109	D5	D30	28863-082	D3	L1	N/F	D3	R160	26837-130	D3	TR310	20000-308	B5
C53	27889-996	D1	D31	28863-082	D4	L2	27900-049	D5	R161	26837-130	D4	VR1	28900-099	D5
C54	N/F	C5	D32	28863-160	D4	LC300	6280-326	A2	R164	N/F	D3	VD300	27920-011	A4
C301	27889-827	A2	D36	N/F	D2	LK300	25925-010	A1	R175	26837-066	D3	ZD2	28920-065	D5
C302	27889-827	A2	D37	28863-082	D5	PL1	N/F	C4	R178	N/F	D2			
C303	27889-827	A2	D310	N/F	A1	PL2	25960-045	C3	R179	26837-066	D3	RL2 LINK	25925-004	D3
C304	27889-827	A2	D311	N/F	A2	PL3	25960-045	D5	R180	26900-161	D4			
C305	27889-827	A2	D313	N/F	A1	PL4	25960-045	D6	R181	26900-161	D4			
C306	27889-827	A2	D314	N/F	A1	PL5	25960-045	D2	R187	26837-066	D3			
C307	27889-827	A2	D315	N/F	A2	PL6	25960-045	D2	R194	26837-066	D3			
C308	27889-827	A2	D319	N/F	B4	PL7	N/F	D2	R359	26900-286	A5			
C309	27889-827	A3	D320	N/F	B4	PL8	N/F	D5	RL1	25980-057	D3			
C310	27889-827	A3	D321	N/F	B1	PL300	N/F	A3	RL2	N/F	D3			
C311	27889-827	A3	D322	N/F	B2	PL301	N/F	A3	RL3	25980-059	D5			
C312	27889-827	A2	D323	N/F	B2	PL302	N/F	A3	SK1		D2			
C313	27889-827	A2	D325	N/F	B4	PL303	N/F	A3	SK2		D5			
C334	26970-126	B5	D326	28433-801	B4	PL304	N/F	A3	SK300	N/F	A2			

Surface Mount   Component Layout Drawing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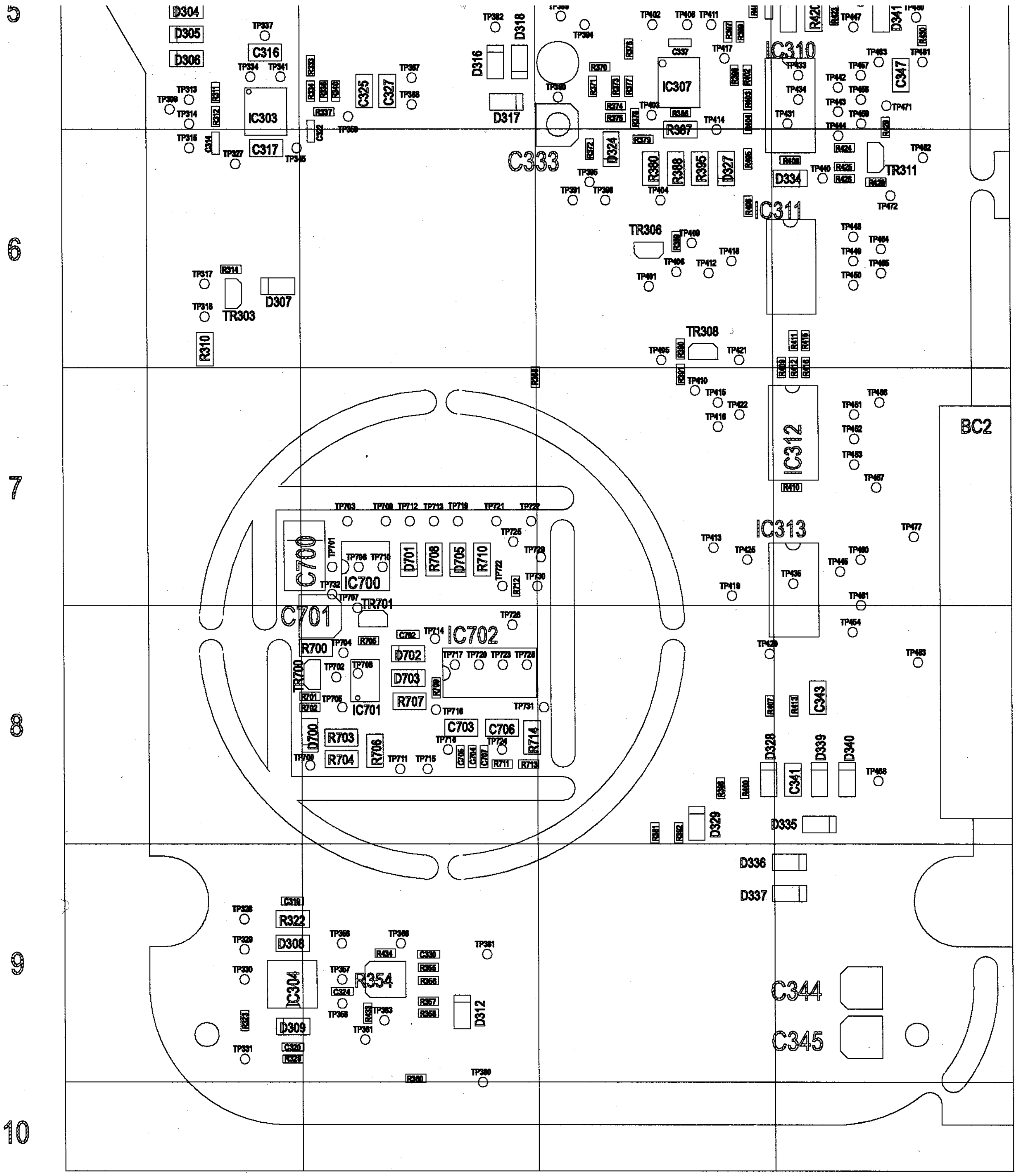
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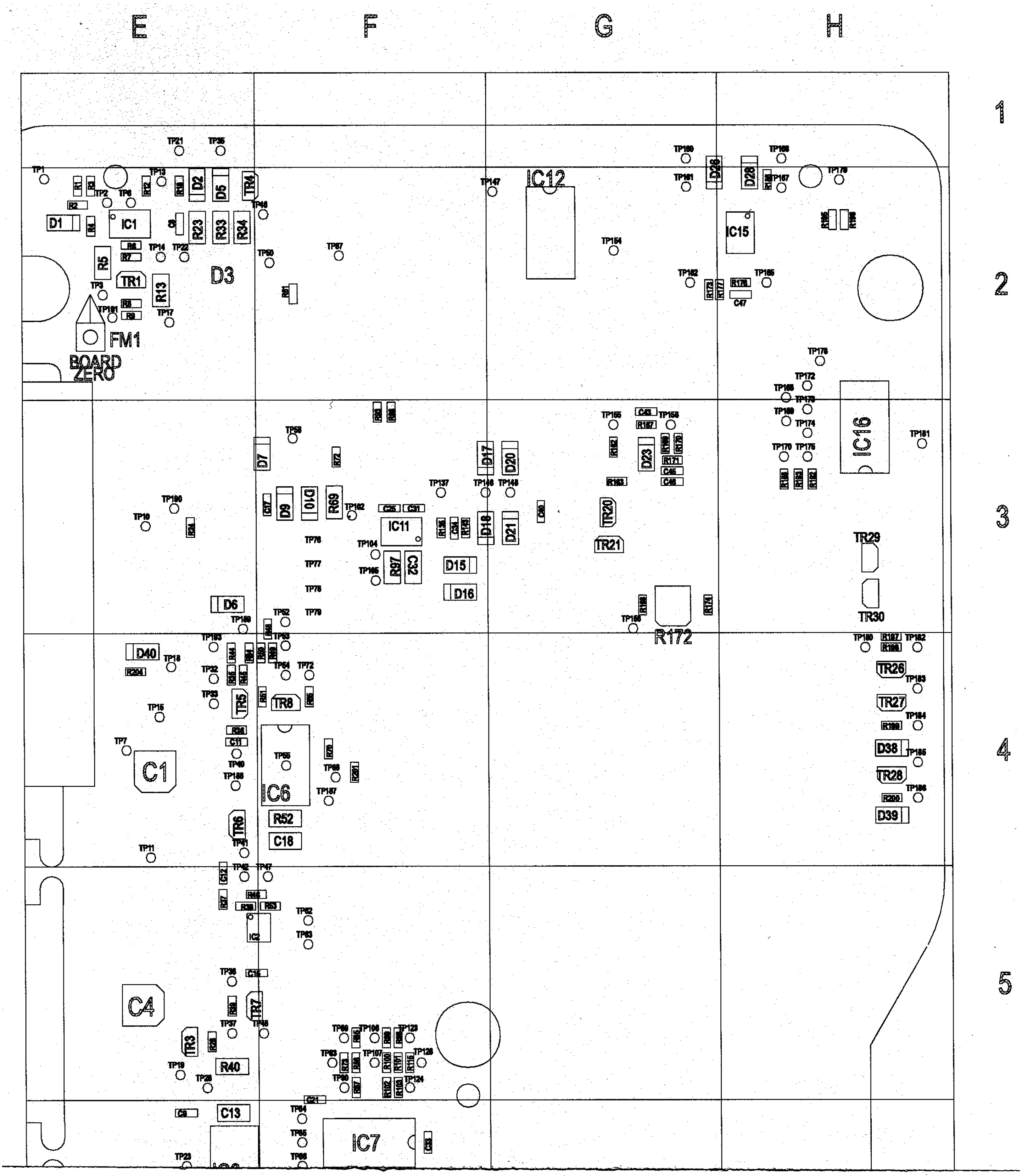
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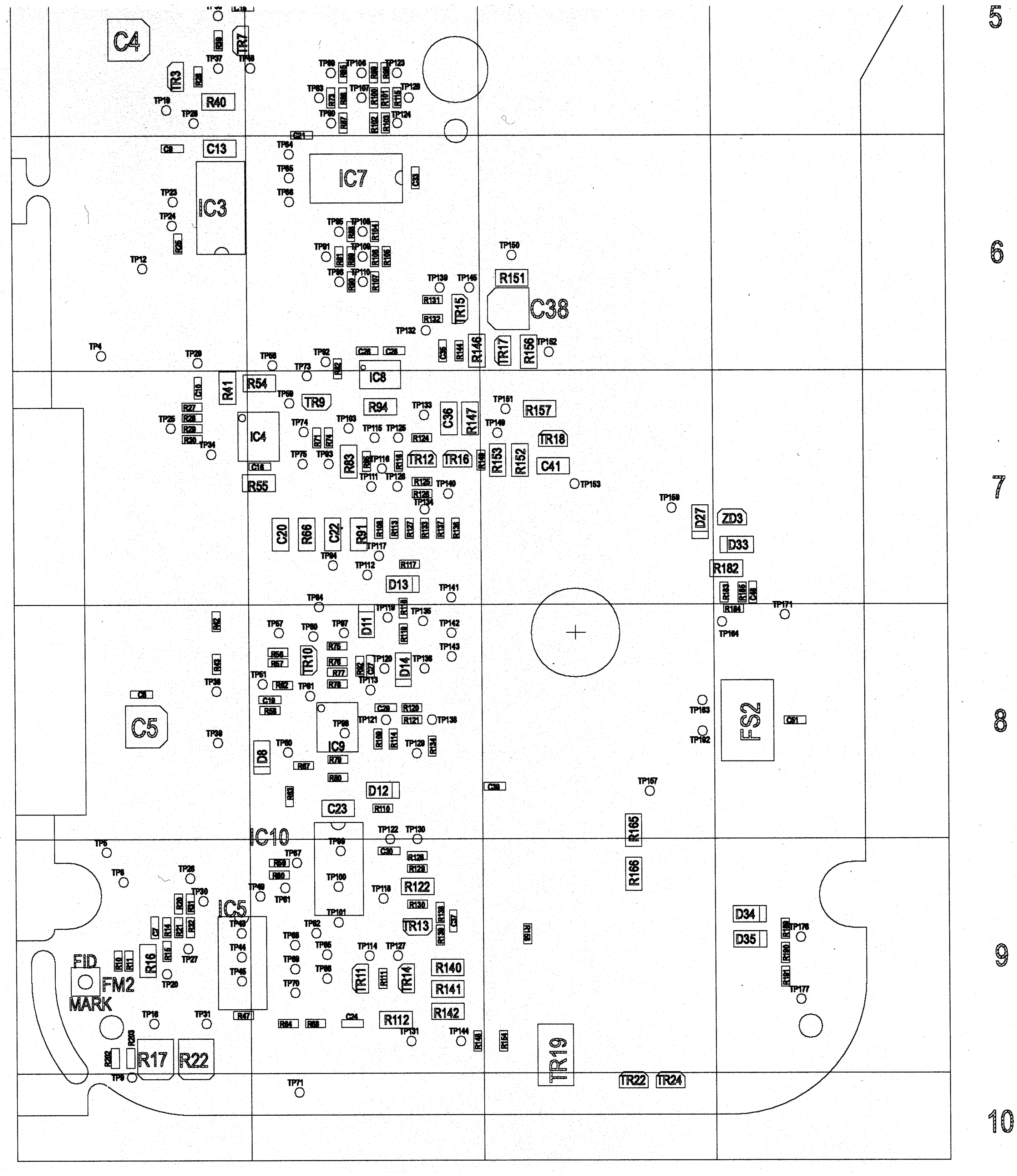
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R41
R54
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C36
R147
R157
IC4
TR18
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TR12
TR16
R153
R152
C41
R55
C20
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FM2
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TR11
TR14
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R141
R142
R112
R17
R22
TR19
TR22
TR24

6430-790 FITTING LIST (BMM2500 SERIES)

REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID
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C4	32000-023	E5	C30	32000-028	F9	C320	32000-025	A9	C347	N/F	D5	D20	31000-002	G3	D324	31000-002	C6	IC8	30000-104	F7	R1	33000-031	E2
C5	32000-023	E8	C31	32000-029	F3	C321	32000-029	B4	C700	32000-022	B7	D21	31000-002	G3	D327	31000-002	C6	IC9	31000-028	F8	R2	33000-037	E2
C6	32000-029	E8	C32	32000-004	F3	C322	32000-025	B6	C701	32000-023	A8	D23	31000-002	G3	D328	31000-002	D8	IC10	30000-101	E9	R3	33000-037	E2
C7	32000-025	E9	C33	32000-029	F6	C323	32000-029	B2	C702	32000-032	B8	D26	31000-002	H2	D329	31000-002	C8	IC11	30000-104	F3	R4	33000-038	E2
C8	32000-032	E2	C34	32000-030	F3	C324	32000-025	B9	C703	32000-004	B8	D27	31000-002	G7	D333	31000-002	D5	IC12	30000-024	G2	R5	33000-004	E2
C9	32000-028	E6	C35	32000-027	F6	C325	32000-004	B5	C704	32000-029	B8	D28	31000-002	H2	D334	31000-002	D6	IC15	30000-104	H2	R6	33000-037	E2
C10	32000-027	E7	C36	32000-004	F7	C326	32000-004	B4	C705	32000-027	B8	D33	31000-002	H7	D335	31000-002	C8	IC16	30000-024	H3	R7	33000-037	E2
C11	32000-029	E4	C37	32000-029	F9	C327	32000-004	B5	C706	32000-004	B8	D34	31000-002	H9	D336	31000-002	C9	IC300	30000-104	A2	R8	33000-031	E2
C12	32000-029	E5	C38	32000-023	G8	C328	32000-004	B4	C707	32000-029	B8	D35	31000-002	H9	D337	31000-002	C9	IC301	30000-007	A3	R9	33000-031	E2
C13	32000-004	E6	C39	32000-029	G8	C329	32000-004	B4	D1	31000-002	E2	D38	31000-002	H4	D339	31000-002	D8	IC302	30000-066	A4	R10	33000-036	E9
C15	32000-029	E5	C40	32000-031	G3	C330	32000-025	B9	D2	31000-002	E2	D39	31000-002	H4	D340	31000-002	D8	IC303	30000-105	A5	R11	33000-037	E9
C16	32000-029	F7	C41	32000-004	G7	C331	32000-025	B3	D5	31000-002	E2	D300	31000-002	A5	D341	31000-002	D5	IC304	30000-106	A9	R12	33000-037	E2
C17	32000-030	F3	C43	32000-028	G3	C332	32000-029	B3	D6	31000-002	E3	D301	31000-002	A5	D700	31000-002	B8	IC305	30000-066	B2	R13	33000-021	E2
C18	32000-004	F4	C45	32000-029	G3	C333	32000-023	B6	D7	31000-002	F3	D302	N/F	A2	D701	31000-002	B7	IC306	306139-082	C3	R14	33000-036	E9
C19	32000-028	F8	C46	32000-029	G3	C335	32000-031	C2	D8	31000-002	F8	D303	31000-002	A5	D702	31000-002	B8	IC307	31000-028	C5	R15	33000-034	E9
C20	32000-004	F7	C47	N/F	H2	C336	32000-031	C2	D9	31000-002	F3	D304	31000-002	A5	D703	31000-002	B8	IC308	30000-102	C1	R16	33000-004	E9
C21	32000-029	F6	C48	32000-027	H7	C337	32000-027	C5	D10	31000-002	F3	D305	31000-002	A5	D705	31000-002	B7	IC309	30000-101	C3	R17	N/F	E9
C22	32000-004	F7	C51	32000-029	H8	C339	32000-004	C2	D11	31000-002	F8	D306	31000-002	A5	FS2	35000-005	H8	IC310	30000-024	C5	R18	33000-030	E2
C23	32000-004	F8	C300	N/F	A1	C340	32000-028	D5	D12	31000-002	F8	D307	31000-002	A6	IC1	30000-104	E2	IC311	30000-024	C6	R20	33000-031	E9
C24	32000-025	F9	C314	32000-030	A6	C341	32000-004	D8	D13	31000-002	F7	D308	31000-002	A9	IC2	30000-103	E5	IC312	30000-024	D7	R21	33000-030	E9
C25	32000-029	F3	C315	32000-004	A2	C342	32000-004	D3	D14	31000-002	F8	D309	31000-002	A9	IC3	30000-101	E6	IC313	30000-066	C7	R22	N/F	E9
C26	32000-029	F6	C316	32000-004	A5	C343	32000-004	D8	D15	31000-002	F3	D312	31000-002	B9	IC4	31000-028	F7	IC314	30000-101	D4	R23	33000-008	E2
C27	32000-025	F8	C317	32000-004	A6	C344	32000-023	C9	D16	31000-002	F3	D316	31000-002	B5	IC5	30000-024	E9	IC700	31000-023	B7	R24	33000-028	E3
C28	32000-029	F6	C318	32000-028	A2	C345	32000-023	C9	D17	31000-002	G3	D317	31000-002	B5	IC6	30000-009	F4	IC701	30000-104	B8	R25	33000-039	E6

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R27	33000-034	E7	R52	33000-025	F4	R77	33000-037	F8	R102	33000-043	F5	R128	33000-037	F9	R156	33000-004	G6	R191	N/F	H9	R313	33000-008	A3
R28	33000-030	E7	R53	33000-028	F5	R78	33000-037	F8	R103	33000-039	F5	R129	33000-031	F9	R157	33000-004	G7	R192	N/F	H3	R314	33000-037	A6
R29	33000-037	E7	R54	33000-004	F7	R79	33000-037	F8	R104	33000-041	F6	R130	33000-031	F9	R158	33000-037	G9	R193	33000-031	H3	R315	N/F	A1
R30	33000-037	E7	R55	33000-006	F7	R80	33000-031	F8	R105	N/F	F6	R131	33000-042	F6	R162	33000-038	G3	R195	33000-038	H2	R316	N/F	A2
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R33	33000-013	E2	R58	33000-042	F8	R83	33000-004	F7	R108	33000-031	F7	R134	33000-037	F8	R166	N/F	G9	R198	33000-034	H4			
R34	33000-013	E2	R59	33000-034	F9	R84	33000-034	E4	R109	33000-037	F8	R135	33000-044	F3	R167	33000-031	G3	R199	33000-034	H4	R320	33000-028	A4
R35	33000-037	E4	R60	33000-034	F9	R85	33000-028	F5	R110	33000-039	F8	R136	33000-031	F7	R168	33000-040	G3	R200	33000-034	H4	R321	33000-042	A4
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R37	33000-028	E5	R62	33000-044	F8	R87	33000-037	F5	R112	33000-005	F9	R138	33000-028	F9	R170	33000-031	G3	R202	33000-035	E9	R323	33000-044	A9
R38	N/F	E5	R63	33000-042	F8	R88	33000-043	F6	R113	33000-031	F7	R139	33000-042	F9	R171	33000-042	G3	R203	33000-035	E9	R324	33000-004	B2
R39	33000-036	E5	R64	N/F	F9	R89	33000-041	F6	R114	33000-041	F8	R140	33000-006	F9	R172	34000-009	G4	R300	33000-028	A4	R325	33000-042	A2
R40	33000-006	E5	R65	33000-037	F4	R90	33000-028	F6	R115	N/F	F5	R141	33000-006	F9	R173	33000-044	G2	R301	33000-028	A4	R326	33000-041	B2
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R43	33000-028	E8	R68	33000-028	F9	R93	33000-031	F3	R118	33000-031	F8	R144	33000-042	F6	R177	33000-042	H2	R304	33000-031	A4	R329	33000-044	A9
R44	33000-037	E4	R69	33000-005	F3	R94	33000-004	F7	R119	33000-031	F8	R146	33000-004	G6	R182	33000-004	H7	R305	33000-034	A4	R330	33000-042	B2
R45	33000-037	E4	R70	33000-034	F4	R95	33000-037	F7	R120	33000-042	F8	R147	33000-008	F7	R183	33000-042	H7	R306	33000-042	A2	R331	33000-037	B2
R46	N/F	E5	R71	33000-037	F7	R96	33000-031	F3	R121	33000-042	F8	R148	N/F	F9	R184	33000-037	H8	R307	N/F	A2	R332	33000-042	B2
R47	33000-037	E9	R72	33000-031	F3	R97	33000-008	F3	R122	33000-004	F9	R149	33000-044	G7	R185	33000-037	H7	R308	33000-038	A2	R333	33000-044	B5
R48	33000-031	F4	R73	N/F	F5	R98	33000-028	F5	R124	33000-037	F7	R151	33000-006	G6	R186	33000-037	H2	R309	33000-042	A3	R334	33000-044	B5
R49	33000-028	F4	R74	33000-037	F7	R99	33000-028	F5	R125	33000-037	F7	R152	33000-006	G7	R188	33000-038	H3	R310	33000-021	A8	R335	33000-037	B3
R50	33000-028	F4	R75	33000-037	F8	R100	33000-041	F5	R126	33000-037	F7	R153	33000-008	G7	R189	N/F	H9	R311	33000-037	A5	R336	33000-044	B5

REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID	REF.	PtNo	GRID
R337	33000-028	B5	R363	33000-037	B2	R388	33000-008	C6	R413	33000-044	D8	R703	33000-013	B8	TR15	31000-001	F6			
R338	33000-037	B1	R364	33000-028	B2	R389	33000-037	C6	R414	33000-039	D2	R704	33000-013	B8	TR16	31000-001	F7	ZD3	31000-014	H7
R339	33000-037	B2	R365	33000-042	B4	R390	33000-042	C6	R415	33000-031	D6	R705	33000-030	B8	TR17	31000-004	G6			
R340	33000-037	B5	R366	33000-042	B4	R391	33000-040	C7	R416	33000-031	D7	R706	33000-008	B8	TR18	31000-001	G7	BC1	5131-385	D3
R341	33000-041	B2	R367	33000-028	B2	R392	33000-044	C8	R417	33000-028	D1	R707	33000-008	B8	TR19	N/F	G10	BC2	5131-385	D7
R342	33000-042	B2	R368	33000-037	C7	R393	33000-037	C2	R418	33000-028	D2	R708	33000-013	B7	TR20	31000-001	G3			
R343	33000-004	B2	R369	33000-044	C2	R394	33000-037	C2	R419	33000-028	D2	R709	33000-034	B8	TR21	31000-001	G3	D40	31000-002	E4
R344	33000-037	B2	R370	33000-030	C5	R395	33000-008	C6	R420	33000-008	D5	R710	33000-013	B7	TR22	31000-004	G10	R204	33000-037	E4
R345	33000-031	B2	R371	33000-038	C5	R396	33000-030	C8	R421	33000-037	D1	R711	33000-042	B8	TR24	31000-004	G10			
R346	33000-042	B3	R372	33000-037	C6	R397	33000-031	C5	R422	33000-037	D2	R712	33000-031	B7	TR26	31000-001	H4			
R347	33000-042	B3	R373	33000-037	C5	R398	33000-031	C5	R423	33000-044	D5	R713	33000-042	B8	TR27	31000-004	H4			
R348	33000-037	B3	R374	33000-037	C5	R399	33000-040	C5	R424	33000-031	D6	R714	33000-008	C8	TR28	31000-004	H4			
R349	33000-037	B3	R375	33000-037	C5	R400	33000-044	C8	R425	33000-037	D6	TR1	31000-004	E2	TR29	N/F	H3			
R350	33000-037	B3	R376	33000-044	C5	R401	33000-031	C5	R426	33000-037	D6	TR3	31000-016	E5	TR30	N/F	H3			
R351	33000-037	B3	R377	33000-041	C5	R402	33000-031	C5	R427	33000-039	D4	TR4	31000-001	E2	TR300	31000-004	A4			
R352	33000-004	B4	R378	33000-031	C5	R403	33000-036	C5	R428	33000-040	D8	TR5	31000-001	E4	TR301	31000-004	A4			
R353	33000-042	B4	R379	33000-037	C6	R404	33000-042	C6	R429	33000-037	D6	TR6	31000-016	E4	TR302	31000-001	A4			
R354	N/F	B9	R380	33000-008	C6	R405	33000-037	C6	R430	33000-028	D5	TR7	31000-004	F5	TR303	31000-001	A6			
R355	33000-040	B9	R381	33000-028	C8	R406	33000-037	C6	R431	33000-035	D5	TR8	31000-004	F4	TR304	31000-016	B2			
R356	33000-031	B9	R382	33000-037	C1	R407	33000-034	C8	R432	33000-035	D5	TR9	31000-001	F7	TR306	31000-004	C6			
R357	33000-038	B9	R383	33000-037	C2	R408	33000-037	D6	R433	33000-037	D5	TR10	31000-004	F8	TR308	31000-004	C6			
R358	33000-037	B9	R384	33000-037	C2	R409	33000-031	D7	R434	33000-034	D5	TR11	31000-001	F9	TR311	31000-004	D6			
R360	33000-044	B9	R385	33000-037	C2	R410	33000-037	D7	R700	33000-021	A8	TR12	31000-004	F7	TR700	31000-004	B8			
R361	33000-037	B1	R386	33000-031	C5	R411	33000-031	D6	R701	33000-037	A8	TR13	31000-004	F9	TR701	31000-001	B8			
R362	33000-037	B2	R387	33000-008	C6	R412	33000-031	D7	R702	33000-042	A8	TR14	31000-001	F9	XL300	35000-006	C2			

6430-789 FITTING LIST (BMM2000 SERIES)

REF.	PtNo	GRID
C1	32000-023	E4
C4	32000-023	E5
C5	32000-023	E8
C6	32000-029	E8
C7	32000-025	E9
C8	N/F	E2
C9	32000-028	E6
C10	32000-027	E7
C11	32000-029	E4
C12	32000-029	E5
C13	32000-004	E6
C15	32000-029	E5
C16	32000-029	F7
C17	32000-030	F3
C18	32000-004	F4
C19	32000-028	F8
C20	32000-004	F7
C21	32000-029	F6
C22	32000-004	F7
C23	32000-004	F8
C24	32000-025	F9
C25	32000-029	F3
C26	32000-029	F8
C27	32000-025	F8
C28	32000-029	F6

REF.	PtNo	GRID
C29	32000-028	F8
C30	32000-028	F9
C31	32000-029	F3
C32	32000-004	F3
C33	32000-029	F8
C34	32000-030	F3
C35	32000-027	F6
C36	32000-004	F7
C37	32000-029	F9
C38	32000-023	G6
C39	32000-029	G8
C40	32000-031	G3
C41	32000-004	G7
C43	32000-028	G3
C45	32000-029	G3
C46	32000-029	G3
C47	N/F	H2
C48	32000-027	H7
C51	32000-029	H8
C300	N/F	A1
C314	32000-030	A6
C315	32000-004	A2
C316	32000-004	A5
C317	32000-004	A6
C318	32000-028	A2

REF.	PtNo	GRID
C319	32000-029	A9
C320	32000-025	A9
C321	32000-029	B4
C322	32000-025	B6
C323	32000-029	B2
C324	32000-025	B9
C325	32000-004	B5
C326	32000-004	B4
C327	32000-004	B5
C328	32000-004	B4
C329	32000-004	B4
C330	32000-025	B9
C331	32000-025	B3
C332	32000-029	B3
C333	32000-023	B6
C335	32000-031	C2
C336	32000-031	C2
C337	32000-027	C5
C339	32000-004	C2
C340	32000-028	D5
C341	32000-004	D8
C342	32000-004	D3
C343	32000-004	D8
C344	32000-023	C9
C345	32000-023	C9

REF.	PtNo	GRID
C346	32000-028	D4
C347	N/F	D5
C700	N/F	B7
C701	N/F	A8
C702	N/F	B8
C703	N/F	B8
C704	N/F	B8
C705	N/F	B8
C706	N/F	B8
C707	N/F	B8
D1	N/F	E2
D2	N/F	E2
D5	N/F	E2
D6	31000-002	E3
D7	31000-002	F3
D8	31000-002	F8
D9	31000-002	F3
D10	31000-002	F3
D11	31000-002	F8
D12	31000-002	F8
D13	31000-002	F7
D14	31000-002	F8
D15	31000-002	F3
D16	31000-002	F3
D17	31000-002	G3

REF.	PtNo	GRID
D18	31000-002	G3
D20	31000-002	G3
D21	31000-002	G3
D23	31000-002	G3
D26	31000-002	H2
D27	31000-002	G7
D28	31000-002	H2
D33	31000-002	H7
D34	31000-002	H9
D35	31000-002	H9
D38	31000-002	H4
D39	31000-002	H4
D300	31000-002	A5
D301	31000-002	A5
D302	N/F	A2
D303	31000-002	A5
D304	31000-002	A5
D305	31000-002	A5
D306	31000-002	A5
D307	31000-002	A6
D308	31000-002	A9
D309	31000-002	A9
D312	31000-002	B9
D316	31000-002	B5
D317	31000-002	B5

REF.	PtNo	GRID
D318	31000-002	B5
D324	31000-002	C6
D327	31000-002	C8
D328	31000-002	D8
D329	31000-002	C8
D333	31000-002	D5
D334	31000-002	D6
D335	31000-002	C8
D336	31000-002	C9
D337	31000-002	C9
D339	31000-002	D8
D340	31000-002	D6
D341	31000-002	D5
D700	N/F	B8
D701	N/F	B7
D702	N/F	B8
D703	N/F	B8
D705	N/F	B7
FS2	35000-005	H8
IC1	N/F	E2
IC2	30000-103	E5
IC3	30000-101	E6
IC4	31000-028	F7
IC5	30000-024	E9
IC6	30000-009	F4

REF.	PtNo	GRID
IC7	30000-066	F8
IC8	30000-104	F7
IC9	31000-028	F8
IC10	30000-101	E9
IC11	30000-104	F3
IC12	30000-024	G2
IC15	30000-104	H2
IC16	30000-024	H3
IC300	30000-104	A2
IC301	30000-007	A3
IC302	30000-066	A4
IC303	30000-105	A5
IC304	30000-106	A9
IC305	30000-066	B2
IC306	306139-082	C3
IC307	31000-028	C5
IC308	30000-102	C1
IC309	30000-101	C3
IC310	30000-024	C5
IC311	30000-024	C6
IC312	30000-024	D7
IC313	30000-066	C7
IC314	30000-101	D4
IC700	N/F	B7
IC701	N/F	B8

REF.	PtNo	GRID
IC702	N/F	B8
R1	33000-031	E2
R2	N/F	E2
R3	N/F	E2
R4	N/F	E2
R5	N/F	E2
R6	N/F	E2
R7	N/F	E2
R8	N/F	E2
R9	33000-031	E2
R10	33000-036	E9
R11	33000-037	E9
R12	33000-037	E2
R13	N/F	E2
R14	33000-036	E9
R15	33000-034	E9
R16	33000-004	E9
R17	N/F	E9
R18	N/F	E2
R20	33000-031	E9
R21	33000-030	E9
R22	N/F	E9
R23	N/F	E2
R24	33000-028	E3
R25	33000-039	E6

REF.	PtNo	GRID
R26	33000-037	E5
R27	33000-034	E7
R28	33000-030	E7
R29	33000-037	E7
R30	33000-037	E7
R31	33000-031	E9
R32	33000-031	E9
R33	N/F	E2
R34	N/F	E2
R35	33000-037	E4
R36	33000-037	E4
R37	33000-028	E5
R38	N/F	E5
R39	33000-036	E5
R40	33000-006	E5
R41	33000-004	E7
R42	33000-037	E8
R43	33000-028	E8
R44	33000-037	E4
R45	33000-037	E4
R46	N/F	E5
R47	33000-037	E9
R48	33000-031	F4
R49	33000-028	F4
R50	33000-028	F4

REF.	PtNo	GRID
R51	33000-037	F4
R52	33000-025	F4
R53	33000-028	F5
R54	33000-004	F7
R55	33000-006	F7
R56	33000-042	F8
R57	33000-042	F8
R58	33000-042	F8
R59	33000-034	F9
R60	33000-034	F9
R61	33000-031	F2
R62	33000-044	F8
R63	33000-042	F8
R64	N/F	F9
R65	33000-037	F4
R66	33000-004	F7
R67	33000-031	F8
R68	33000-028	F9
R69	33000-005	F3
R70	33000-034	F4
R71	33000-037	F7
R72	33000-031	F3
R73	N/F	F5
R74	33000-037	F7
R75	33000-037	F8

REF.	PtNo	GRID
R76	33000-037	F8
R77	33000-037	F8
R78	33000-037	F8
R79	33000-037	F8
R80	33000-031	F8
R81	N/F	F6
R82	33000-037	F7
R83	33000-004	F7
R84	33000-034	E4
R85	33000-028	F5
R86	33000-037	F5
R87	33000-037	F5
R88	33000-043	F6
R89	33000-041	F6
R90	33000-028	F6
R91	33000-004	F7
R92	33000-037	F8
R93	33000-031	F3
R94	33000-004	F7
R95	33000-037	F7
R96	33000-031	F3
R97	33000-008	F3
R98	33000-028	F5
R99	33000-028	F5
R100	33000-041	F5

REF.	PtNo	GRID
R101	33000-037	F5
R102	33000-043	F5
R103	33000-039	F5
R104	33000-041	F6
R105	N/F	F6
R106	33000-036	F6
R107	33000-038	F6
R108	33000-031	F7
R109	33000-037	F8
R110	33000-039	F8
R111	33000-044	F9
R112	33000-005	F9
R113	33000-031	F7
R114	33000-041	F8
R115	N/F	F5
R116	33000-037	F7
R117	33000-031	F7
R118	33000-031	F8
R119	33000-031	F8
R120	33000-042	F8
R121	33000-042	F8
R122	33000-004	F9
R124	33000-037	F7
R125	33000-037	F7
R126	33000-037	F7

REF.	PtNo	GRID
R127	33000-031	F7
R128	33000-037	F9
R129	33000-031	F9
R130	33000-031	F9
R131	33000-042	F6
R132	33000-042	F6
R133	33000-031	F7
R134	33000-037	F8
R135	33000-044	F3
R136	33000-031	F7
R137	33000-031	F7
R138	33000-028	F9
R139	33000-042	F9
R140	33000-006	F9
R141	33000-006	F9
R142	33000-004	F9
R143	33000-044	F3
R144	33000-042	F6
R146	33000-004	G6
R147	33000-008	F7
R148	N/F	F9
R149	33000-044	G7
R151	33000-006	G6
R152	33000-006	G7
R153	33000-008	G7

REF.	PtNo	GRID
R154	N/F	G9
R156	33000-004	G6
R157	33000-004	G7
R158	33000-037	G9
R162	33000-038	G3
R163	33000-028	G3
R165	33000-014	G9
R166	N/F	G9
R167	33000-031	G3
R168	33000-040	G3
R169	33000-040	G3
R170	33000-031	G3
R171	33000-042	G3
R172	34000-009	G4
R173	33000-044	G2
R174	33000-042	G3
R176	33000-042	H2
R177	33000-042	H2
R182	33000-004	H7
R183	33000-042	H7
R184	33000-037	H8
R185	33000-037	H7
R186	33000-037	H2
R188	33000-038	H3
R189	N/F	H9

REF.	PtNo	GRID
R190	N/F	H9
R191	N/F	H9
R192	N/F	H3
R193	33000-031	H3
R195	33000-038	H2
R196	33000-038	H2
R197	33000-034	H4
R198	33000-034	H4
R199	33000-034	H4
R200	33000-034	H4
R201	33000-031	F4
R202	33000-035	E9
R203	33000-035	E9
R300	33000-028	A4
R301	33000-028	A4
R302	33000-028	A4
R303	33000-028	A4
R304	33000-031	A4
R305	33000-034	A4
R306	33000-042	A2
R307	N/F	A2
R308	33000-038	A2
R309	33000-042	A3
R310	33000-021	A6
R311	33000-037	A5

REF.	PtNo	GRID
R312	33000-034	A5
R313	33000-008	A3
R314	33000-037	A6
R315	N/F	A1
R316	N/F	A2
R317	33000-042	A2
R318	33000-042	A3
R320	33000-028	A4
R321	33000-042	A4
R322	33000-025	A9
R323	33000-044	A9
R324	33000-004	B2
R325	33000-042	A2
R326	33000-041	B2
R327	33000-008	B3
R328	33000-008	A4
R329	33000-044	A9
R330	33000-042	B2
R331	33000-037	B2
R332	33000-042	B2
R333	33000-044	B5
R334	33000-044	B5
R335	33000-037	B3
R336	33000-044	B5

REF.	PtNo	GRID
R337	33000-028	B5
R338	33000-037	B1
R339	33000-037	B2
R340	33000-037	B5
R341	33000-041	B2
R342	33000-042	B2
R343	33000-004	B2
R344	33000-037	B2
R345	33000-031	B2
R346	33000-042	B3
R347	33000-042	B3
R348	33000-037	B3
R349	33000-037	B3
R350	33000-037	B3
R351	33000-037	B3
R352	33000-004	B4
R353	33000-042	B4
R354	N/F	B9
R355	33000-040	B9
R356	33000-031	B9
R357	33000-038	B9
R358	33000-037	B9
R360	33000-044	B9
R361	33000-037	B1
R362	33000-037	B2

REF.	PtNo	GRID
R363	33000-037	B2
R364	33000-028	B2
R365	33000-042	B4
R366	33000-042	B4
R367	33000-028	B2
R368	33000-037	C7
R369	33000-044	C2
R370	33000-030	C5
R371	33000-038	C5
R372	33000-037	C6
R373	33000-037	C5
R374	33000-037	C5
R375	33000-037	C5
R376	33000-044	C5
R377	33000-041	C5
R378	33000-031	C5
R379	33000-037	C6
R380	33000-008	C6
R381	33000-028	C8
R382	33000-037	C1
R383	33000-037	C2
R384	33000-037	C2
R385	33000-037	C2
R386	33000-031	C5
R387	33000-008	C6

REF.	PtNo	GRID
R388	33000-008	C6
R389	33000-037	C8
R390	33000-042	C6
R391	33000-040	C7
R392	33000-044	C8
R393	33000-037	C2
R394	33000-037	C2
R395	33000-008	C8
R396	33000-030	C8
R397	33000-031	C5
R398	33000-031	C5
R399	33000-040	C5
R400	33000-044	C8
R401	33000-031	C5
R402	33000-031	C5
R403	33000-036	C5
R404	33000-042	C8
R405	33000-037	C8
R406	33000-037	C8
R407	33000-034	C8
R408	33000-037	D6
R409	33000-031	D7
R410	33000-037	D7
R411	33000-031	D6
R412	33000-031	D7

REF.	PtNo	GRID
R413	33000-044	D8
R414	33000-039	D2
R415	33000-031	D6
R416	33000-031	D7
R417	33000-028	D1
R418	33000-028	D2
R419	33000-028	D2
R420	33000-008	D5
R421	33000-037	D1
R422	33000-037	D2
R423	33000-044	D5
R424	33000-031	D6
R425	33000-037	D6
R426	33000-037	D6
R427	33000-039	D4
R428	33000-040	D6
R429	33000-037	D6
R430	33000-028	D5
R431	33000-035	D5
R432	33000-035	D5
R433	33000-037	D5
R434	33000-034	D5
R700	N/F	A8
R701	N/F	A8
R702	N/F	A8

REF.	PtNo	GRID
R703	N/F	B8
R704	N/F	B8
R705	N/F	B8
R706	N/F	B8
R707	N/F	B8
R708	N/F	B7
R709	N/F	B8
R710	N/F	B7
R711	N/F	B8
R712	N/F	B7
R713	N/F	B8
R714	N/F	C8
TR1	N/F	E2
TR3	31000-016	E5
TR4	N/F	E2
TR5	31000-001	E4
TR6	31000-016	E4
TR7	31000-004	F5
TR8	31000-004	F4
TR9	31000-001	F7
TR10	31000-004	F8
TR11	31000-001	F9
TR12	31000-004	F7
TR13	31000-004	F9
TR14	31000-001	F9

REF.	PtNo	GRID
TR15	31000-001	F6
TR16	31000-001	F7
TR17	31000-004	G6
TR18	31000-001	G7
TR19	N/F	G10
TR20	31000-001	G3
TR21	31000-001	G3
TR22	31000-004	G10
TR24	31000-004	G10
TR26	31000-001	H4
TR27	31000-004	H4
TR28	31000-004	H4
TR29	N/F	H3
TR30	N/F	H3
TR300	31000-004	A4
TR301	31000-004	A4
TR302	31000-001	A4
TR303	31000-001	A6
TR304	31000-016	B2
TR306	31000-004	C6
TR308	31000-004	C6
TR311	31000-004	D6
TR700	N/F	B8
TR701	N/F	B8
XL300	35000-006	C2

REF.	PtNo	GRID
ZD3	31000-014	H7
BC1	5131-385	D3
BC2	5131-385	D7
D40	31000-002	E4
R204	33000-037	E4

6430-788 FITTING LIST (BMM80 SERIES)

REF.	PtNo	GRID
C1	32000-023	E4
C4	32000-023	E5
C5	32000-023	E8
C6	32000-029	E8
C7	32000-025	E9
C8	N/F	E2
C9	32000-028	E6
C10	32000-027	E7
C11	32000-029	E4
C12	32000-029	E5
C13	32000-004	E6
C15	32000-029	E5
C16	32000-029	F7
C17	32000-030	F3
C18	32000-004	F4
C19	32000-028	F8
C20	32000-004	F7
C21	32000-029	F6
C22	32000-004	F7
C23	32000-004	F8
C24	32000-025	F9
C25	32000-029	F3
C26	32000-029	F6
C27	32000-025	F8
C28	32000-029	F6

REF.	PtNo	GRID
C29	32000-028	F8
C30	32000-028	F9
C31	32000-029	F3
C32	32000-004	F3
C33	32000-029	F6
C34	32000-030	F3
C35	32000-027	F6
C36	32000-004	F7
C37	32000-029	F9
C38	32000-023	G6
C39	32000-029	G8
C40	32000-031	G3
C41	32000-004	G7
C43	32000-028	G3
C45	32000-029	G3
C46	32000-029	G3
C47	N/F	H2
C48	32000-027	H7
C51	32000-029	H8
C300	N/F	A1
C314	32000-030	A6
C315	32000-004	A2
C316	32000-004	A5
C317	32000-004	A6
C318	32000-028	A2

REF.	PtNo	GRID
C319	32000-029	A9
C320	32000-025	A9
C321	32000-029	B4
C322	32000-025	B6
C323	32000-029	B2
C324	32000-025	B9
C325	32000-004	B5
C326	32000-004	B4
C327	32000-004	B5
C328	32000-004	B4
C329	32000-004	B4
C330	32000-025	B9
C331	32000-025	B3
C332	32000-029	B3
C333	32000-023	B6
C335	32000-031	C2
C336	32000-031	C2
C337	32000-027	C5
C339	32000-004	C2
C340	32000-028	D5
C341	32000-004	D8
C342	32000-004	D3
C343	32000-004	D8
C344	32000-023	C9
C345	32000-023	C9

REF.	PtNo	GRID
C346	32000-028	D4
C347	N/F	D5
C700	N/F	B7
C701	N/F	A8
C702	N/F	B8
C703	N/F	B8
C704	N/F	B8
C705	N/F	B8
C706	N/F	B8
C707	N/F	B8
D1	N/F	E2
D2	N/F	E2
D5	N/F	E2
D6	31000-002	E3
D7	31000-002	F3
D8	31000-002	F8
D9	31000-002	F3
D10	31000-002	F3
D11	31000-002	F8
D12	31000-002	F8
D13	31000-002	F7
D14	31000-002	F8
D15	31000-002	F3
D16	31000-002	F3
D17	31000-002	G3

REF.	PtNo	GRID
D18	31000-002	G3
D20	31000-002	G3
D21	31000-002	G3
D23	31000-002	G3
D26	31000-002	H2
D27	31000-002	G7
D28	31000-002	H2
D33	31000-002	H7
D34	31000-002	H9
D35	31000-002	H9
D38	31000-002	H4
D39	N/F	H4
D300	31000-002	A5
D301	31000-002	A5
D302	N/F	A2
D303	31000-002	A5
D304	31000-002	A5
D305	31000-002	A5
D306	31000-002	A5
D307	31000-002	A6
D308	31000-002	A9
D309	31000-002	A9
D312	31000-002	B9
D316	31000-002	B5
D317	31000-002	B5

REF.	PtNo	GRID
D318	31000-002	B5
D324	31000-002	C6
D327	31000-002	C6
D328	31000-002	D8
D329	31000-002	C8
D333	31000-002	D5
D334	31000-002	D6
D335	31000-002	C8
D336	31000-002	C9
D337	31000-002	C9
D339	31000-002	D8
D340	31000-002	D8
D341	31000-002	D5
D700	N/F	B8
D701	N/F	B7
D702	N/F	B8
D703	N/F	B8
D705	N/F	B7
FS2	35000-005	H8
IC1	N/F	E2
IC2	30000-103	E5
IC3	30000-101	E6
IC4	31000-028	F7
IC5	30000-024	E9
IC6	30000-009	F4

REF.	PtNo	GRID
IC7	30000-066	F6
IC8	30000-104	F7
IC9	31000-028	F8
IC10	30000-101	E9
IC11	30000-104	F3
IC12	30000-024	G2
IC15	30000-104	H2
IC16	30000-024	H3
IC300	30000-104	A2
IC301	30000-007	A3
IC302	30000-066	A4
IC303	30000-105	A5
IC304	30000-106	A9
IC305	30000-066	B2
IC306	306139-082	C3
IC307	31000-028	C5
IC308	30000-102	C1
IC309	30000-101	C3
IC310	30000-024	C5
IC311	30000-024	C6
IC312	30000-024	D7
IC313	30000-066	C7
IC314	30000-101	D4
IC700	N/F	B7
IC701	N/F	B8

REF.	PtNo	GRID
IC702	N/F	B8
R1	33000-031	E2
R2	N/F	E2
R3	N/F	E2
R4	N/F	E2
R5	N/F	E2
R6	N/F	E2
R7	N/F	E2
R8	N/F	E2
R9	33000-031	E2
R10	33000-036	E9
R11	33000-037	E9
R12	33000-037	E2
R13	N/F	E2
R14	33000-036	E9
R15	33000-034	E9
R16	33000-004	E9
R17	N/F	E9
R18	N/F	E2
R20	33000-031	E9
R21	33000-030	E9
R22	N/F	E9
R23	N/F	E2
R24	33000-028	E3
R25	33000-039	E6

REF.	PtNo	GRID
R26	33000-037	E5
R27	33000-034	E7
R28	33000-030	E7
R29	33000-037	E7
R30	33000-037	E7
R31	33000-031	E9
R32	33000-031	E9
R33	N/F	E2
R34	N/F	E2
R35	33000-037	E4
R36	33000-037	E4
R37	33000-028	E5
R38	N/F	E5
R39	33000-036	E5
R40	33000-006	E5
R41	33000-004	E7
R42	33000-037	E8
R43	33000-028	E8
R44	33000-037	E4
R45	33000-037	E4
R46	N/F	E5
R47	33000-037	E9
R48	33000-031	F4
R49	33000-028	F4
R50	33000-028	F4

REF.	PtNo	GRID
R51	33000-037	F4
R52	33000-025	F4
R53	33000-028	F5
R54	33000-004	F7
R55	33000-006	F7
R56	33000-042	F8
R57	33000-042	F8
R58	33000-042	F8
R59	33000-034	F9
R60	33000-034	F9
R61	33000-031	F2
R62	33000-044	F8
R63	33000-042	F8
R64	N/F	F9
R65	33000-037	F4
R66	33000-004	F7
R67	33000-031	F8
R68	33000-028	F9
R69	33000-005	F3
R70	33000-034	F4
R71	33000-037	F7
R72	33000-031	F3
R73	N/F	F5
R74	33000-037	F7
R75	33000-037	F8

REF.	PtNo	GRID
R76	33000-037	F8
R77	33000-037	F8
R78	33000-037	F8
R79	33000-037	F8
R80	33000-031	F8
R81	N/F	F6
R82	33000-037	F7
R83	33000-004	F7
R84	33000-034	E4
R85	33000-028	F5
R86	33000-037	F5
R87	33000-037	F5
R88	33000-043	F6
R89	33000-041	F6
R90	33000-028	F6
R91	33000-004	F7
R92	33000-037	F8
R93	33000-031	F3
R94	33000-004	F7
R95	33000-037	F7
R96	33000-031	F3
R97	33000-008	F3
R98	33000-028	F5
R99	33000-028	F5
R100	33000-041	F5

REF.	PtNo	GRID
R101	33000-037	F5
R102	33000-043	F5
R103	33000-039	F5
R104	33000-041	F6
R105	N/F	F6
R106	33000-036	F6
R107	33000-038	F6
R108	33000-031	F7
R109	33000-037	F8
R110	33000-039	F8
R111	33000-044	F9
R112	33000-005	F9
R113	33000-031	F7
R114	33000-041	F8
R115	N/F	F5
R116	33000-037	F7
R117	33000-031	F7
R118	33000-031	F8
R119	33000-031	F8
R120	33000-042	F8
R121	33000-042	F8
R122	33000-004	F9
R124	33000-037	F7
R125	33000-037	F7
R126	33000-037	F7

REF.	PtNo	GRID
R127	33000-031	F7
R128	33000-037	F9
R129	33000-031	F9
R130	33000-031	F9
R131	33000-042	F6
R132	33000-042	F6
R133	33000-031	F7
R134	33000-037	F8
R135	33000-044	F3
R136	33000-031	F7
R137	33000-031	F7
R138	33000-028	F9
R139	33000-042	F9
R140	33000-006	F9
R141	33000-006	F9
R142	33000-004	F9
R143	33000-044	F3
R144	33000-042	F6
R146	33000-004	G6
R147	33000-008	F7
R148	N/F	F9
R149	33000-044	G7
R151	33000-008	G6
R152	33000-006	G7
R153	33000-008	G7

REF.	PtNo	GRID
R154	N/F	G9
R156	33000-004	G6
R157	33000-004	G7
R158	33000-037	G9
R162	33000-038	G3
R163	33000-028	G3
R165	33000-014	G9
R166	N/F	G9
R167	33000-031	G3
R168	33000-040	G3
R169	33000-040	G3
R170	33000-031	G3
R171	33000-042	G3
R172	34000-009	G4
R173	33000-044	G2
R174	33000-042	G3
R176	33000-042	H2
R177	33000-042	H2
R182	33000-004	H7
R183	33000-042	H7
R184	33000-037	H8
R185	33000-037	H7
R186	33000-037	H2
R188	33000-038	H3
R189	N/F	H9

REF.	PtNo	GRID
R190	N/F	H9
R191	N/F	H9
R192	33000-031	H3
R193	33000-031	H3
R195	33000-036	H2
R196	33000-038	H2
R197	33000-034	H4
R198	33000-034	H4
R199	33000-034	H4
R200	N/F	H4
R201	33000-031	F4
R202	33000-035	E9
R203	33000-035	E9
R300	33000-028	A4
R301	33000-028	A4
R302	33000-028	A4
R303	33000-028	A4
R304	33000-031	A4
R305	33000-034	A4
R306	33000-042	A2
R307	N/F	A2
R308	33000-038	A2
R309	33000-042	A3
R310	33000-021	A6
R311	33000-037	A5

REF.	PtNo	GRID
R312	33000-034	A5
R313	33000-008	A3
R314	33000-037	A6
R315	N/F	A1
R316	N/F	A2
R317	33000-042	A2
R318	33000-042	A3
R320	33000-028	A4
R321	33000-042	A4
R322	33000-025	A9
R323	33000-044	A9
R324	33000-004	B2
R325	33000-042	A2
R326	33000-041	B2
R327	33000-008	B3
R328	33000-008	A4
R329	33000-044	A9
R330	33000-042	B2
R331	33000-037	B2
R332	33000-042	B2
R333	33000-044	B5
R334	33000-044	B5
R335	33000-037	B3
R336	33000-044	B5

REF.	PtNo	GRID
R337	33000-028	B5
R338	33000-037	B1
R339	33000-037	B2
R340	33000-037	B5
R341	33000-041	B2
R342	33000-042	B2
R343	33000-004	B2
R344	33000-037	B2
R345	33000-031	B2
R346	33000-042	B3
R347	33000-042	B3
R348	33000-037	B3
R349	33000-037	B3
R350	33000-037	B3
R351	33000-037	B3
R352	33000-004	B4
R353	33000-042	B4
R354	N/F	B9
R355	33000-040	B9
R356	33000-031	B9
R357	33000-038	B9
R358	33000-037	B9
R360	33000-044	B9
R361	33000-037	B1
R362	33000-037	B2

REF.	PtNo	GRID
R363	33000-037	B2
R364	33000-028	B2
R365	33000-042	B4
R366	33000-042	B4
R367	33000-028	B2
R368	33000-037	C7
R369	33000-044	C2
R370	33000-037	C5
R371	33000-038	C5
R372	33000-037	C6
R373	33000-037	C5
R374	33000-037	C5
R375	33000-037	C5
R376	33000-044	C5
R377	33000-041	C5
R378	33000-031	C5
R379	33000-037	C6
R380	33000-008	C6
R381	33000-028	C8
R382	33000-037	C1
R383	33000-037	C2
R384	33000-037	C2
R385	33000-037	C2
R386	33000-031	C5
R387	33000-008	C6

REF.	PtNo	GRID
R388	33000-008	C6
R389	33000-037	C6
R390	33000-042	C6
R391	33000-040	C7
R392	33000-044	C8
R393	33000-037	C2
R394	33000-037	C2
R395	33000-008	C6
R396	33000-030	C8
R397	33000-031	C5
R398	33000-031	C5
R399	33000-040	C5
R400	33000-044	C8
R401	33000-031	C5
R402	33000-031	C5
R403	33000-036	C5
R404	33000-042	C6
R405	33000-037	C6
R406	33000-037	C6
R407	33000-034	C8
R408	33000-037	D6
R409	33000-031	D7
R410	33000-037	D7
R411	33000-031	D6
R412	33000-031	D7

REF.	PtNo	GRID
R413	33000-044	D8
R414	33000-039	D2
R415	33000-031	D6
R416	33000-031	D7
R417	33000-028	D1
R418	33000-028	D2
R419	33000-028	D2
R420	33000-008	D5
R421	33000-037	D1
R422	33000-037	D2
R423	33000-044	D5
R424	33000-031	D6
R425	33000-037	D6
R426	33000-037	D6
R427	33000-039	D4
R428	33000-040	D6
R429	33000-037	D6
R430	33000-028	D5
R431	33000-035	D5
R432	33000-035	D5
R433	33000-037	D5
R434	33000-034	D5
R700	N/F	A8
R701	N/F	A8
R702	N/F	A8

REF.	PtNo	GRID
R703	N/F	B8
R704	N/F	B8
R705	N/F	B8
R706	N/F	B8
R707	N/F	B8
R708	N/F	B7
R709	N/F	B8
R710	N/F	B7
R711	N/F	B8
R712	N/F	B7
R713	N/F	B8
R714	N/F	C8
TR1	N/F	E2
TR3	31000-016	E5
TR4	N/F	E2
TR5	31000-001	E4
TR6	31000-016	E4
TR7	31000-004	F5
TR8	31000-004	F4
TR9	31000-001	F7
TR10	31000-004	F8
TR11	31000-001	F9
TR12	31000-004	F7
TR13	31000-004	F9
TR14	31000-001	F9

REF.	PtNo	GRID
TR15	31000-001	F6
TR16	31000-001	F7
TR17	31000-004	G6
TR18	31000-001	G7
TR19	N/F	G10
TR20	31000-001	G3
TR21	31000-001	G3
TR22	31000-004	G10
TR24	31000-004	G10
TR26	31000-001	H4
TR27	31000-004	H4
TR28	N/F	H4
TR29	N/F	H3
TR30	N/F	H3
TR300	31000-004	A4
TR301	31000-004	A4
TR302	31000-001	A4
TR303	31000-001	A6
TR304	31000-016	B2
TR306	31000-004	C6
TR308	31000-004	C6
TR311	31000-004	D6
TR700	N/F	B6
TR701	N/F	B8
XL300	35000-006	C2

REF.	PtNo	GRID
ZD3	31000-014	H7
BC1	5131-385	D3
BC2	5131-385	D7
D40	31000-002	E4
R204	33000-037	E4

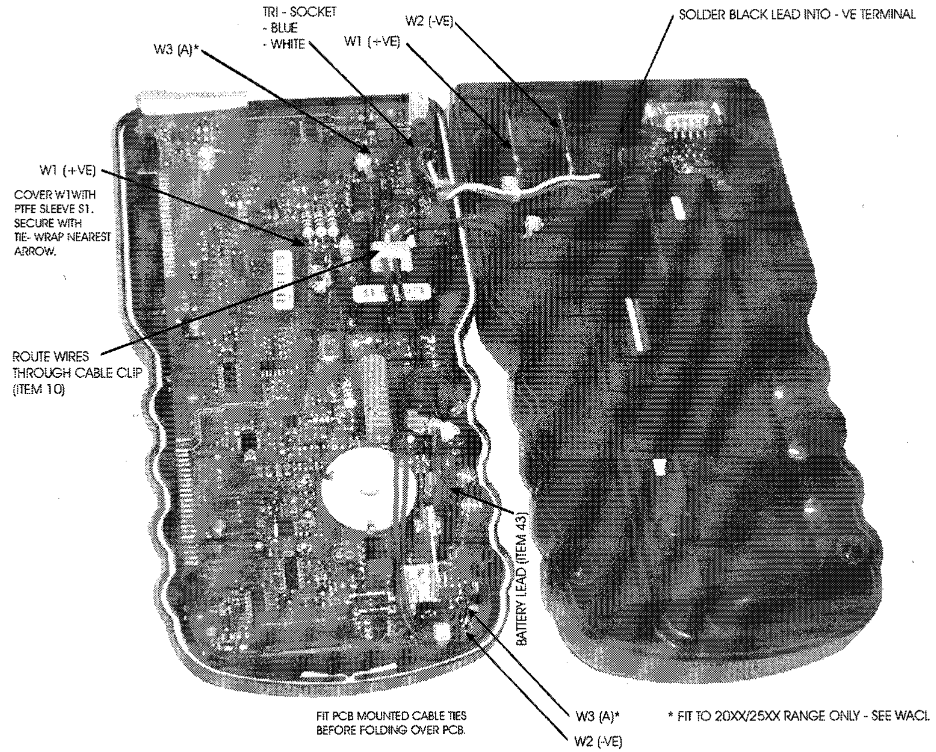
Appendix 13 Assembly Drwaings

AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent CT17 9EN, U.K.

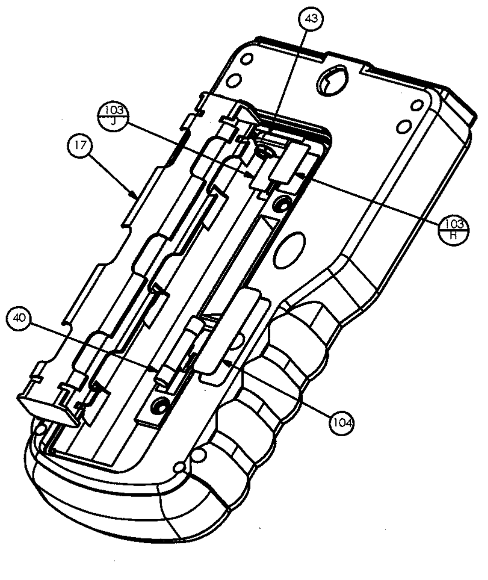
INSTRUMENT ASSEMBLIES

1st Used On: BMM RANGE

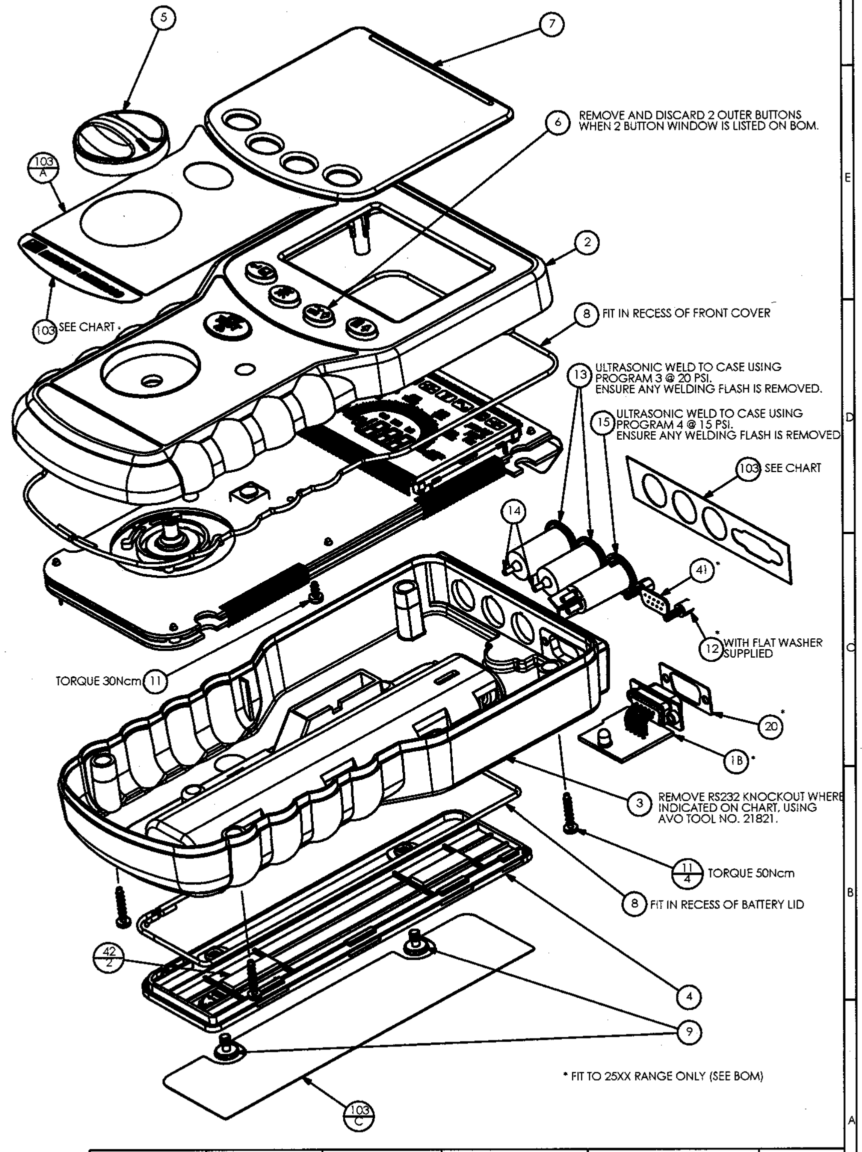
Part No.: 6410-974-976 | Scale:- 1:1 | Sheet 1 of 2



* FIT TO 20XX/25XX RANGE ONLY - SEE WACI.

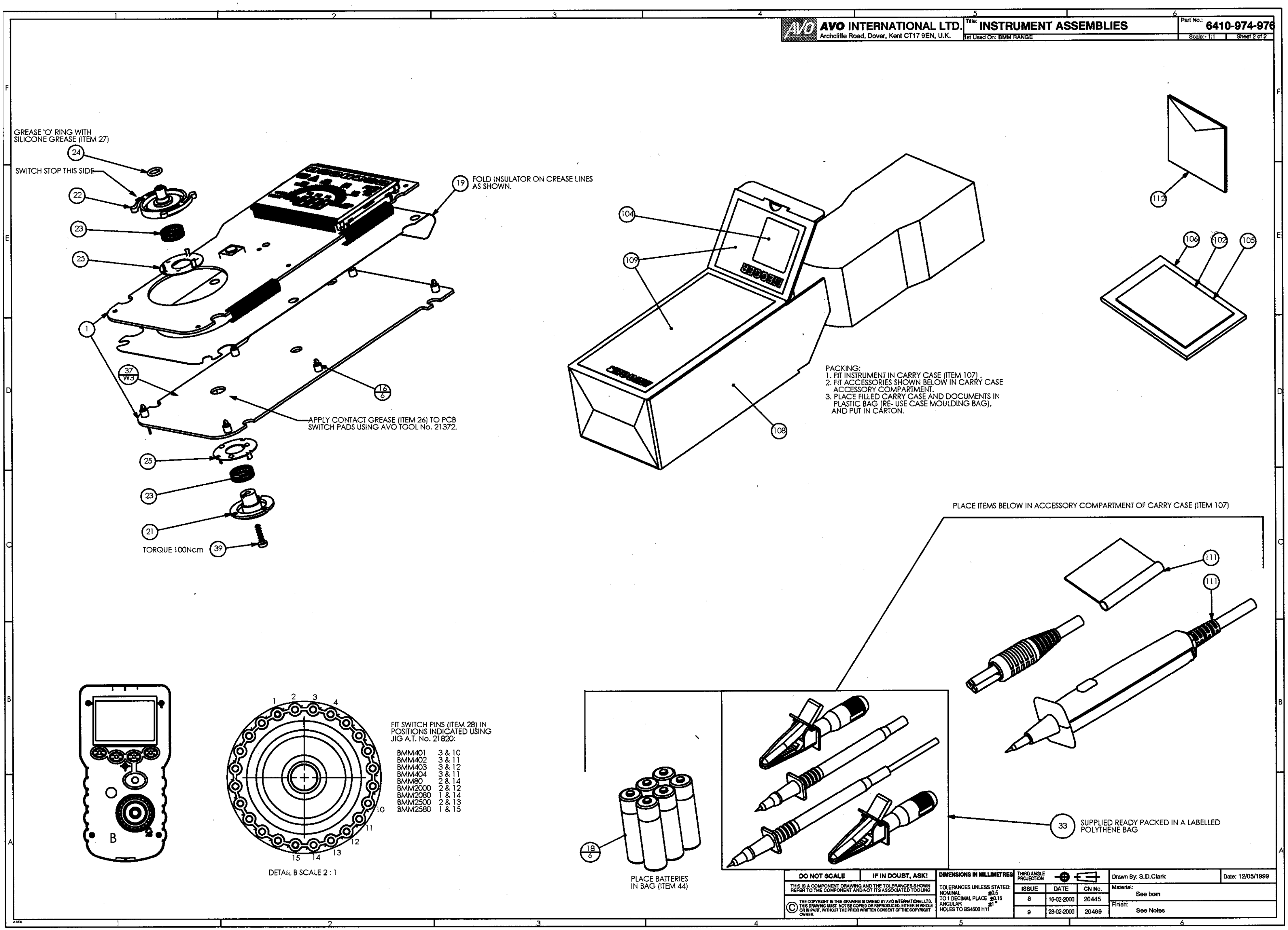


INSTRUMENT	INSTR. NO.	PLANNING BILL	LABEL VARIANTS	KNOCKOUT REMOVED
BMM80	6111-382	6410-974	B,H.	NO
BMM80 RS	6111-417		C,H.	NO
BMM80 FDD	6111-463		B,H.	NO
BMM80 SIP	6111-464		B,H.	NO
BMM80 FNS	6111-465		B,H.	NO
BMM80 EFG (FARNELL)	6111-497		B,H	NO
BMM80 EFG	6111-478		B,H.	NO
BMM2000	6111-383	6410-975	B,H.	NO
BMM2000 RS	6111-418		C,H.	NO
BMM2000 FDD	6111-466		B,H.	NO
BMM2000 SIP	6111-467		B,H.	NO
BMM2000 FNS	6111-468		B,H.	NO
BMM2000 EFG	6111-479		B,H.	NO
BMM2000 EFG (FARNELL)	6111-975		B,H.	NO
BMM2080	6111-384		B,H.	NO
BMM2080 RS	6111-419		C,H.	NO
BMM2080 FDD	6111-469		B,H.	NO
BMM2080 SIP	6111-470		B,H.	NO
BMM2080 FNS	6111-471		B,H.	NO
BMM2080 EFG	6111-480		B,H.	NO
BMM2500	6111-385	6410-976	B,G.	YES
BMM2500 RS	6111-420		C,G.	YES
BMM2500 FDD	6111-472		B,G.	YES
BMM2500 SIP	6111-473		B,G.	YES
BMM2500 FNS	6111-474		B,G.	YES
BMM2500 EFG	6111-487		B,G.	YES
BMM2580	6111-386		B,G.	YES
BMM2580 RS	6111-421		C,G.	YES
BMM2580 FDD	6111-475		B,G.	YES
BMM2580 SIP	6111-476		B,G.	YES
BMM2580 FNS	6111-477		B,G.	YES
BMM2580 EFG	6111-488		B,G.	YES



* FIT TO 25XX RANGE ONLY (SEE BOM)

DO NOT SCALE	IF IN DOUBT, ASK!	DIMENSIONS IN MILLIMETRES	THIRD ANGLE PROJECTION			Drawn By: S.D.Clark	Date: 10/05/1999
THIS IS A COMPONENT DRAWING AND THE TOLERANCES SHOWN REFER TO THE COMPONENT AND NOT ITS ASSOCIATED TOOLING		TOLERANCES UNLESS STATED: NOMINAL ±0.5 TO 1 DECIMAL PLACE ±0.15 ANGULAR ±1° HOLES TO BS4500 H11	ISSUE	DATE	CN No.	Material: See bom	
© THE COPYRIGHT IN THIS DRAWING IS OWNED BY AVO INTERNATIONAL LTD. THIS DRAWING MUST NOT BE COPIED OR REPRODUCED EITHER IN WHOLE OR IN PART, WITHOUT THE PRIOR WRITTEN CONSENT OF THE COPYRIGHT OWNER.			8	16-02-2000	20455	Finish: See Notes	
			9	28-02-2000	20469		


AVO INTERNATIONAL LTD.
Archcliffe Road, Dover, Kent CT17 9EN, U.K.
Title: INSTRUMENT ASSEMBLIES
1st Used On: BMM RANGE
Part No.: 6410-974-976
Scale:- 1:1
Sheet 2 of 2
GREASE 'O' RING WITH SILICONE GREASE (ITEM 27)
SWITCH STOP THIS SIDE
FOLD INSULATOR ON CREASE LINES AS SHOWN.
APPLY CONTACT GREASE (ITEM 26) TO PCB SWITCH PADS USING AVO TOOL No. 21372.
TORQUE 100Ncm
PACKING:
1. FIT INSTRUMENT IN CARRY CASE (ITEM 107).
2. FIT ACCESSORIES SHOWN BELOW IN CARRY CASE ACCESSORY COMPARTMENT.
3. PLACE FILLED CARRY CASE AND DOCUMENTS IN PLASTIC BAG (RE- USE CASE MOULDING BAG), AND PUT IN CARTON.
PLACE ITEMS BELOW IN ACCESSORY COMPARTMENT OF CARRY CASE (ITEM 107)
FIT SWITCH PINS (ITEM 28) IN POSITIONS INDICATED USING JIG A.T. No. 21820:
BMM401 3 & 10
BMM402 3 & 11
BMM403 3 & 12
BMM404 3 & 11
BMM80 2 & 14
BMM2000 2 & 12
BMM2080 1 & 14
BMM2500 2 & 13
BMM2580 1 & 15
DETAIL B SCALE 2 : 1
PLACE BATTERIES IN BAG (ITEM 44)
SUPPLIED READY PACKED IN A LABELLED POLYTHENE BAG
DO NOT SCALE
IF IN DOUBT, ASK!
DIMENSIONS IN MILLIMETRES
THIRD ANGLE PROJECTION
TOLERANCES UNLESS STATED:
Drawn By: S.D.Clark
Date: 12/05/1999
Material: See bom
Finish: See Notes
ISSUE DATE CN No.
8 16-02-2000 20445
9 28-02-2000 20469

Appendix 14 BOM 's /Part numbers

Parent	6430-794	BMM2500 SERIES PCB ASSY		
Level	Part Number	Component	U/M	Reqd
1	6132-032	BMM2500 PCB KIT	EA	1
2	25418-217	FUSE CLIP 6.3mm 15A PCB 102071	EA	2
2	21816-536	SCREW M3x6 PAN HD POZI BR.NP.	EA	1
2	21810-603	NUT M3 FULL BRASS N.P	EA	1
2	21813-304	WASHER M3 CRINKLE BER.Cu	EA	1
2	20000-308	TRANSISTOR, ZVP3306A	EA	3
2	20000-471	IC OP-AMP TLC271ACP	EA	2
2	25925-010	WIRE LINK INSULATED	EA	1
2	25950-039	FUSE-500mA 440V 10kA 32mm	EA	1
2	25960-096	PLUG "D" 9 WAY RIGHT ANGLED	EA	1
2	25975-107	SWITCH PUSH TACTILE SPNO PCB	EA	1
2	25980-057	RELAY SPDT 380 VAC 8A JS5-K**	EA	2
2	25980-059	RELAY 2PC/0 2- 5Vdc LATCHING	EA	1
2	26837-066	RES:750K MG 5% 0.5W VR37	EA	4
2	26837-130	RES"10M0 MG 1% 0.5W VR37	EA	4
2	26900-025	RES;100R0 MF 1% 0.25W MFR4	EA	1
2	26900-134	RES:470K0 MF 1% 0.25W MFR4	EA	1
2	26900-161	RES,24K0 MF 1% 0.25W MFR4	EA	2
2	26970-084	CAP TANT'- 10uF 10Vac 10%	EA	2
2	26970-087	CAP FILM-- 47nF 1500Vdc 20%	EA	1
2	26970-109	CAP ELEC"220uF 16Vdc 20%	EA	2
2	26970-137	CAP FILM-'220nF 63Vdc 5%	EA	1
2	27889-636	CAPACITOR 4.7uF 63Vdc 10%	EA	1
2	27889-827	CAP FILM-'100nF 63Vdc 10%	EA	13
2	27889-956	CAP ELEC'- 47uF 16Vdc 20%	EA	1
2	27889-996	CAP FILM' 1.0uF 50Vdc 10% 5R	EA	1
2	27920-011	TRANSDUCER ELECTRO-MAGNETIC	EA	1
2	27960-041	FET P CHANNEL POWER RFD8P05	EA	2
2	28433-801	DIODE,1N4148 SILICON	EA	2
2	28863-082	DIODE,1N4007 1A-1000V	EA	11
2	28863-160	DIODE,1A 1000V BA159	EA	2
2	28900-099	VOLT. REGULATOR 5 VOLT	EA	1
2	28920-039	LED HIGH BRIGHTNESS 3600 MCD	EA	2
2	28920-064	DIODE,1500V FAST RECOV. BY448	EA	1
2	28920-065	ZENER 5.0W 5%'18V 1N5355B	EA	1
2	28940-037	TRANSISTOR MTP3055E	EA	1
2	6131-767	TX ASSY BM200/1/4 BM400s	EA	1
2	6180-418	BACKLIGHT BMM/LCB	EA	1
2	6280-326	LCD BMM SERIES	EA	1
2	25960-045	HEADER, 36-WAY	EA	0.25
2	10005-240	KAPTON DISC 30mm DIA	EA	1
2	26837-177	RES 0R5 WW 5% W21	EA	1
2	26900-286	RES 3R3 MF. 1% 0.25W MFR4	EA	1
2	26970-126	CAP ELEC"100uF 6Vdc 20%	EA	2
2	27900-049	INDUCTOR 33uH LINE FILTER	EA	2
2	5131-377	HEATSINK (TRANSISTOR)	EA	1
2	28940-028	TRANSISTOR, PNP, TIP32A	EA	1
2	26837-189	RES'4M7 MF.1% 0.6W MRS25	EA	1

1	**6430-790**	**BMM2500 SERIES SM ASSY**	**EA**	**1**
2	5440-254	BMM MAIN/DISPLAY PCB	EA	1
2	30000-007	IC ADC 12BIT 3 STATE BINARY OP	EA	1
2	30000-009	IC NOR GATE QUAD 2 INPUT SO14	EA	1
2	30000-024	IC ANOLOG SWITCH 3x2IN-PT 4053	EA	6
2	30000-066	IC ANALOG SWITCH 2P4W 4052	EA	4
2	30000-088	IC DRIVER/RECR.X 2 LTC1383CS	EA	1
2	30000-101	IC DECODER ADDRESSABLE 74HC259	EA	4
2	30000-102	IC EEPROM 8Kx8 24C64 SO8	EA	1
2	30000-103	IC CONVERTER +5to-5V MAX860CUA	EA	1
2	30000-104	IC OP-AMP X2 TL062CPWLE TSSOP8	EA	6
2	30000-105	IC MONOSTABLE X2 74HC123 TSSOP	EA	1
2	30000-106	IC OP-AMP CMOS 8xSOIC ICL7611	EA	1
2	31000-001	TRANSISTOR -NPN- DRG 6180-396	EA	14
2	31000-004	TRANSISTOR -PNP- DRG 6180-395	EA	17
2	31000-016	TRANSISTOR N-TYPE ENCH. FET	EA	3
2	31000-023	IC REGULATOR MW LT1121CS8-5	EA	1
2	31000-028	IC COMPARATOR X4 LM339 TSSOP14	EA	3
2	32000-004	CAP SMD CER- 100nF 10% 1206	EA	22
2	32000-022	CAP SMD TANT'- 10uF 20% 7343	EA	1
2	32000-023	CAP SMD ELEC 10uF 16V 0405	EA	8
2	32000-025	CAP SMD CER- 10nF 10% 0603	EA	8
2	32000-027	CAP SMD CER. 1nF 10% 0603	EA	5
2	32000-028	CAP SMD CER 330pF 10% 0603	EA	8
2	32000-029	CAP SMD CER- 100nF -20+80%0603	EA	22
2	32000-030	CAP SMD CER 100pF 5% 0603	EA	3
2	32000-031	CAP SMD CER 33pF 5% 0603	EA	3
2	32000-032	CAP SMD CER 10pF 5% 0603	EA	2
2	33000-004	RES SM. 30K 2% 1/8W (S/M)	EA	17
2	33000-005	RES SM. 10M 10% 1/8W (S/M)	EA	2
2	33000-006	RES SM. 3K 2% 1/8W (S/M)	EA	6
2	33000-008	RES SM. 300K 2% 1/8W (S/M)	EA	15
2	33000-013	RES SM. 100R 2% 1/8W (S/M)	EA	6
2	33000-021	RES SM. 10R 5% 0.125W (S/M)	EA	3
2	33000-025	RES SM. 3M3 2% 0.125W (S/M)	EA	2
2	33000-030	RES SM. 330R 1% 0.063W	EA	6
2	33000-034	RES SM. 3K3 1% 0.063W	EA	15
2	33000-036	RES SM. 6K8 1% 0.063W	EA	5
2	33000-037	RES SM. 10K 1% 0.063W	EA	82
2	33000-038	RES SM. 22K 1% 0.063W	EA	9
2	33000-040	RES SM. 47K 1% 0.063W	EA	6
2	33000-041	RES SM. 68K 1% 0.063W	EA	7
2	33000-042	RES SM. 100K 1% 0.063W	EA	34
2	33000-043	RES SM. 330K 1% 0.063W	EA	2
2	33000-044	RES SM. 1M 1% 0.063W	EA	18
2	34000-009	POT SMD 1M 25% 0.15W 4mmSQ	EA	1
2	35000-006	CRYSTAL SMD 8MHZ 32SMX	EA	1
2	6139-142	BMM400/2000/2500 uP PROGRAMMED	EA	1
3	30000-070	IC uP MICROPROCESSOR H8/3837	EA	1
3	5172-536	LABEL FOR E-PROMS	EA	1
4	17570-035	LABEL YELLOW S/ADH 31.8 x 9.5	EA	1
3	17565-559	LABEL STATIC WARNING (SYMBOL)	EA	1

2	5173-579	PCB BAR CODE LABEL	EA	1
3	25995-013	LABEL(CUSTOM) 6,35X24mm	EA	1
2	33000-014	RES SM. 1R 5% 1/8W (S/M)	EA	1
2	35000-005	FUSE, 1.25A RESETTABLE SMD	EA	1
2	33000-039	RES SM. 33K 1% 0.063W	EA	5
2	5131-374	CONNECTOR 25 WAY (UNFORMED)	EA	2
2	33000-035	RES SM. 4K7 1% 0.063W	EA	4
2	31000-002	DIODE,SM. LL4148 (S/M)	EA	58
2	33000-028	RES SM. 33R 1% 0.063W	EA	26
2	31000-014	ZENER SM. 33V 5% 0.5W	EA	1
2	33000-031	RES SM. 1K 1% 0.063W	EA	42
1	5173-579	PCB BAR CODE LABEL	EA	1
2	25995-013	LABEL(CUSTOM) 6,35X24mm	EA	0

The above table of components is the BOM for the BMM2580 , this includes all components that are present on the BMM80/BMM2000/BMM2080/BMM2500 and BMM2580 range of instruments. All instruments use the same basic board with components added or subtracted as required.

The components required to build up a finished instrument are contained in the following table , all parts required by the BMM80/BMM2000/BMM2080/BMM2500 and BMM2580 range of instruments are present in the BOM's.

Parent	6410-976		BMM2500 SERIES PLANNING BILL		
Level	**Bubb**	**Component**		**U/M**	**Reqd**
1	1	6430-794	BMM2500 SERIES PCB ASSY	EA	1
2		6132-032	BMM2500 PCB KIT	EA	1
2		5173-579	PCB BAR CODE LABEL	EA	1
3	1	25995-013	LABEL(CUSTOM) 6,35X24mm	EA	1
1	2	5410-298	FRONT COVER	EA	1
1	3	5410-299	REAR COVER BMM	EA	1
1	4	5410-301	BATTERY COVER	EA	1
1	5	5310-410	RANGE KNOB	EA	1
1	6	5210-426	KEYPAD BMM2500	EA	1
1	7	5110-503	WINDOW (4 BUTTON)	EA	1
1	8	18760-010	CORD SILICON SPONGE 2mm DIA.	MS	1.03
1	9	5151-533	CAPTIVE SCREW	EA	2
1	10	25945-033	CABLE CLIP SELF ADHESIVE	EA	1
1	11	21264-229	SCREW PLASTITE No4 .25" PAN Hd	EA	1
1	12	22420-053	SCREWLOCK ASSY(EA=2)	EA	1
1	13	5210-411	TERMINAL SOCKET,GREY x2**	EA	2
1	14	25965-099	SOCKET 4mm DIA.	EA	2
1	15	6280-310	FIXED SOCKET ASSY (BM80/2)	EA	1
2	1	5210-402	PLUG BODY	EA	
2	2	5152-273	PLUG CONTACT	EA	
1	16	22420-056	SPACER 4LG SNAP FIT NYLON	EA	6
1	17	22410-006	BATTERY HOLDER 6xAA C/W	EA	1
1	18	25511-841	BATTERY, 1.5V, DURACELL MN1500	EA	6
1	19	5140-928	INSULATOR BMM	EA	1
2	1	18900-043	POLYESTER SHT 406x305x0.175mm	EA	0.3333
1	20	5140-927	GASKET - RS232 FLANGE	EA	1
1	21	5210-361	SWITCH BOTTOM **	EA	1
1	22	5310-357	INDEX SPIDER/SWITCH TOP**	EA	1
1	23	5160-324	SPRING (ROTARY SWITCH)	EA	2
1	24	24126-123	O RING 8mm I/D 1.5mm SECTION	EA	1
1	25	5131-339	CONTACT DISC	EA	2
1	26	17685-002	CONTACT GREASE 35ML SYRINGE	ML	0.06
1	27	17641-672	GREASE SILICONE BASED MS44	GM	
1	28	21128-008	PIN SPRING DOWEL 2x8mm	EA	2
1	29	25274-417	CABLE TIE 100x2.5mm T18R	EA	7
1	33	8101-063	CROC CLIP BLACK(96)(IEC 1010)	EA	1
1	34	8101-064	CROC CLIP RED (96)	EA	1
1	35	8101-065	LEAD BLACK with CAP(96)	EA	1
1	36	8101-066	LEAD RED with CAP(96)	EA	1
1	37	6140-336	WACL BMM2000/2500	EA	1
2	1	13489-195	WIRE 1/0.6 PVC RED THK TYP 3	MS	0.57
2	2	18274-733	SLEEVING PTFE 2mm NAT.	MS	0.035
1	38	6111-442	DOWNLOAD MANAGER S/WARE CDROM	EA	1
1	39	21264-227	SCREW PLASTITE No4 .5" PAN Hd	EA	5
1	40	25950-039	FUSE-500mA 440V 10kA 32mm	EA	1
1	41	5140-929	GASKET - RS232 INTERNAL	EA	1
1	42	5140-930	FOAM STRIP 25x8x3	EA	2
1	43	6180-410	BATTERY CONNECTOR (PP3)	EA	1
1	44	9000-015	PLASTIC BAG 3" X 3.25 SEALEASI	EA	1

Parent	6410-974		BMM80 SERIES PLANNING BILL		
Level	Bubb	Component		U/M	Reqd
1	1	6430-792	BMM80 PCB ASSY	EA	1
2		6132-030	BMM80 PCB KIT	EA	1
2		5173-579	PCB BAR CODE LABEL	EA	1
3	1	25995-013	LABEL(CUSTOM) 6,35X24mm	EA	1
1	2	5410-298	FRONT COVER	EA	1
1	3	5410-299	REAR COVER BMM	EA	1
1	4	5410-301	BATTERY COVER	EA	1
1	5	5310-410	RANGE KNOB	EA	1
1	6	5210-425	KEYPAD BMM80/400/2000	EA	1
1	7	5110-502	WINDOW (2 BUTTON)	EA	1
1	8	18760-010	CORD SILICON SPONGE 2mm DIA.	MS	1.03
1	9	5151-533	CAPTIVE SCREW	EA	2
1	10	25945-033	CABLE CLIP SELF ADHESIVE	EA	1
1	11	21264-229	SCREW PLASTITE No4 .25" PAN Hd	EA	1
1	13	5210-411	TERMINAL SOCKET,GREY x2**	EA	2
1	14	25965-099	SOCKET 4mm DIA.	EA	2
1	15	6280-310	FIXED SOCKET ASSY (BM80/2)	EA	1
2	1	5210-402	PLUG BODY	EA	
2	2	5152-273	PLUG CONTACT	EA	
1	16	22420-056	SPACER 4LG SNAP FIT NYLON	EA	6
1	17	22410-006	BATTERY HOLDER 6xAA C/W	EA	1
1	18	25511-841	BATTERY, 1.5V, DURACELL MN1500	EA	6
1	19	5140-928	INSULATOR BMM	EA	1
2	1	18900-043	POLYESTER SHT 406x305x0.175mm	EA	0.3333
1	21	5210-361	SWITCH BOTTOM **	EA	1
1	22	5310-357	INDEX SPIDER/SWITCH TOP**	EA	1
1	23	5160-324	SPRING (ROTARY SWITCH)	EA	2
1	24	24126-123	O RING 8mm I/D 1.5mm SECTION	EA	1
1	25	5131-339	CONTACT DISC	EA	2
1	26	17685-002	CONTACT GREASE 35ML SYRINGE	ML	0.06
1	27	17641-672	GREASE SILICONE BASED MS44	GM	
1	28	21128-008	PIN SPRING DOWEL 2x8mm	EA	2
1	29	25274-417	CABLE TIE 100x2.5mm T18R	EA	6
1	33	8101-063	CROC CLIP BLACK(96)(IEC 1010)	EA	1
1	34	8101-064	CROC CLIP RED (96)	EA	1
1	35	8101-065	LEAD BLACK with CAP(96)	EA	1
1	36	8101-066	LEAD RED with CAP(96)	EA	1
1	37	6140-339	WACL BMM80	EA	1
2	1	13489-195	WIRE 1/0.6 PVC RED THK TYP 3	MS	0.36
2	2	18274-733	SLEEVING PTFE 2mm NAT.	MS	0.035
1	39	21264-227	SCREW PLASTITE No4 .5" PAN Hd	EA	5
1	40	25950-039	FUSE-500mA 440V 10kA 32mm	EA	1
1	42	5140-930	FOAM STRIP 25x8x3	EA	2
1	43	6180-410	BATTERY CONNECTOR (PP3)	EA	1
1	44	9000-015	PLASTIC BAG 3" X 3.25 SEALEASI	EA	1

Appendix 15 Downloading to computer (BMM2500's)

Download to a computer

Data will be downloaded in the order in which the tests were carried out. Download is requested by sending ASCII 'S' <CR> to the instrument, which (if it is in the RCL position) will go into remote mode and then transmit the serial number. An 'N' <CR> sequence will obtain the next line of code as detailed below. Sending 'X' <CR> or the user pressing any of the instrument keys will abort the download.

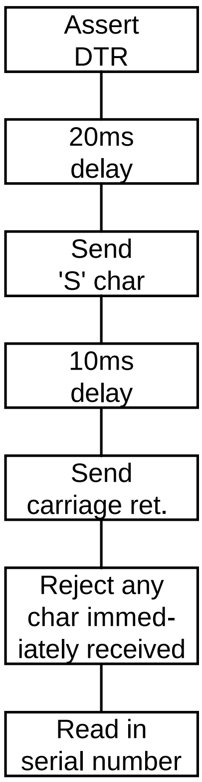
Hardware

The BMM uses an internal optically-isolated serial link. The PC side of the link generates its own supply by utilising the DTR PC output line. Therefore, this must be permanently asserted (i.e. positive voltage) during communication. To allow the supply to be generated, a delay of approximately 20ms should occur between DTR being asserted and the first character being sent by the PC.

As no handshaking is used over the serial link it is recommended that there is a delay of, say, 10ms between each character sent. This also allows the internal supply to recover between characters.

A characteristic of the internal optical link used is that each time a character is transmitted to the BMM a spurious character may be reflected back on the receive line. This can be accommodated by ignoring the receive line whilst transmitting a message and rejecting any character received immediately after the message is complete. The BMM makes an allowance for this by delaying each line of information sent by approximately 5ms.

To clarify, to put the BMM into download mode the following steps would be undertaken by the PC :-



Note that there can be up to a 200ms delay between the instrument receiving the carriage return and the transmission of the serial number.

Output Format

This section describes the format used for stored result data when it is retrieved via the RS232 port.

The format will be 9600 baud, 2 stop bits, 1 start bit, no parity.
The coded information is in the format developed for the BM80/400, i.e.

"<identifier>","<text before number>",<value>,"<units>"<CR><LF>

The first field is a unique identifier giving the test type.
The second field gives any text before the result, i.e. >, <, (blank), or -. This field may also be used to give information on the test type.
The third field gives the result as a numeric value.
The fourth field gives the units.

Serial Number

Information

<serial number>

The first line downloaded will always be the serial number and is sent when the instrument goes into remote mode (i.e. after receiving S<CR>).

Format

"BMM25XX yyy...yyy"<CR><LF>

where yyy...yyy is an identifier unique to the instrument.

The total number of characters within the quotes can be up to 20.

NB the instrument name may be five to nine characters depending on the variant. It is always separated from the serial number by a space.

Distribution Board Number

Information

<distribution board number>

Format

"DB","",distribution board number,""<CR><LF>

where distribution board number is in the range 1 - 99

The distribution board number is downloaded in sequence and all results subsequently downloaded relate to that distribution board. Subsequent distribution board numbers will be downloaded each time a new number is chosen.
Note that a distribution board number does not have to be selected by the user, so it is possible to have results that do not relate to any distribution board.

Circuit Number

Information

<circuit number>

The first line of each test result downloaded is always the circuit number.

Format

"C","",circuit number,""<CR><LF>

where circuit number is in the range 1 to 99

Circuit 14 is used in the examples below.

In the examples below, the <CR><LF> characters at the end of each line have been omitted for clarity.

Insulation (2 results)
Information

<connection, test voltage, resistance, leakage current>

Format (resistance)

"Fpz","x",value,"unit"
where
p = 1 for 1000V
p = 2 for 500V
p = 3 for 250V
p = 4 for 100V
p = 5 for 50V
z = LE, NE, LN or LL
x = (blank) or >
unit = M or G

Format (leakage current)

"LC","x",value,"unit"
where
LC = Leakage Current
x = (blank), -,> or <
unit = u

Example

"C","",14,""	Circuit 14
"F5LN","",103,"M"	Insulation LN 103M Test Voltage 50 V
"LC","",0.533,"u"	Leakage Current 0.533 uA

Continuity (1 result)
Information

<connection, resistance>

Format

"RAz","x",value,"unit"
where
RA = Resistance result
z = r1 for an R1 measurement
z = r2 for an R2 measurement
z = r1r2 for an R1 + R2 measurement
z = rr1 for a ring R1 measurement
z = rr2 for a ring R2 measurement
z = rrn for a ring Rn measurement
x = (blank), - or >
unit = R

Example

"C","",14,""	Circuit 14
"RAr1r2","",0.05,"R"	Continuity R1 + R2 0.05 R

Data-logging /Real-time transmission information.

This section describes the format used for logged data when it is retrieved via the RS232 port.

The same format is used for real-time transmission of results when in 'calibrate' mode. (This is not available to the end customer). The data is sent to the instrument's battery compartment interface, so that test equipment such as the functional tester can be semi-automated. Results are made available every 2 seconds.

Logging Interval

Information
<logging interval>

The first line downloaded is always the logging interval.
This is sent once only per set of logged results.
(During real-time result transmission, the logging interval does not apply, and is therefore not sent)..

Format
"LOGI","",interval,""<CR><LF>
where interval is in the range 10 to 1990

In the desciption below, the <CR><LF> characters at the end of each line have been omitted for clarity.

Test result data (one kind only in any logging session)

Insulation (2 results)

Format (resistance)
"Inp","x",value,"unit"
where
"In" = insulation
p = 1 for 1000V
p = 2 for 500V
p = 3 for 250V
p = 4 for 100V
p = 5 for 50V
x = (blank), or >
unit = M, or G

Format (leakage current)
"LC","x",value,"unit”
where
LC = Leakage Current
x = (blank), -, > or <
unit = u

Volts / millivolts (2 results)

Note that the frequency result is set to zero if the input is dc, or if the input is ac, but below the threshold for frequency measurement.

Format (voltage)
"Vo","x",value,"unit”
where
Vo = volts
x = (blank), -, > or <
unit = (blank), or m

Format (frequency)

"Fr","x",value,"unit"
where
Fr = Frequency
x = (blank), >, or <
unit = (blank)

Continuity (1 result)

Format

"Co","x",value,"unit"
where
Co = continuity
x = (blank), - or >
unit = (blank)

Kilohms (1 result)

Format

"Ki","x",value,"unit"
where
Ki = kilohms
x = (blank), - or >
unit = k, or M

Capacitance (1 result)

Format

"Ca","x",value,"unit"
where
Ca = capacitance
x = (blank), >, or <
unit = n, or u

milliamps (2 results)

Note that the frequency result is set to zero if the input is dc, or if the input is ac, but below the threshold for frequency measurement.

Format (current)

"Cu","x",value,"unit"
where
Cu = current
x = (blank), -, or >
unit = m

Format (frequency)

"Fr","x",value,"unit"
where
Fr = Frequency
x = (blank), >, or <
unit = (blank)

End Message

Information

<end message>

Format

"C","-",1,""

Appendix 16 Display Messages

1. Messages seen in recall mode - general

Message	Description
'rcl'	Recall mode selected
'cor'	Stored data is corrupted
'Prn'	Printing in progress
'dEL'	Ready to delete stored test results (flashed briefly) confirms that results have been deleted
'Clr'	Ready to clear stored user-variables: (flashed briefly) confirms that variables have been cleared
'Pdt'	Printer delay time setup
'X.Y'	Printer delay time is X.Y seconds
'Log'	Data logging set-up
'on'	Data logging status
'off'	Data logging status
'Int'	Data logging interval time setup
'PQRS'	Data logging interval time is PQRS seconds
'd--'	No distribution board number selected
'dxy'	Currently selected distribution board no.
'Lng'	Language set-up
'1'	Language '1' currently selected
'2'	Language '2' currently selected
'Std'	(flashed briefly) logging status, logging interval, language selection , printer delay or distribution board no. has been stored

2. Messages seen in recall mode - result recall and print modes

Message	Description
'rcl'	Recall mode selected
'Prn'	Printing in progress
'cxy'	Circuit number of currently selected result
'dxy'	Distribution board number
(result)	Actual result data
'l-E'	Line-earth connection for ins result
'l-n'	Line-neutral connection for ins result
'l-l'	Line-line (3-phase) connection ins
'n-E'	Neutral-earth connection for ins result
'50V' – '1000V'	Test voltage for ins result
'r12'	r1-r2 type connection for continuity result
'r1'	r1 type connection for continuity result
'r2'	r2 type connection for continuity result
'rr1'	rr1 type connection for continuity result
'rr2'	rr2 type connection for continuity result
'rrn'	rrn type connection for continuity result

3. Messages seen during result storage

Message	Description
(result)	test complete, results can be stored
'l-E'	line-earth connection for ins result
'l-n'	line-neutral connection for ins result
'l-l'	line-line (3-phase) connection for ins
'n-E'	Neutral-earth connection for ins result
'r12'	r1-r2 type connection for continuity result
'r1'	r1 type connection for continuity result
'r2'	r2 type connection for continuity result
'rr1'	rr1 type connection for continuity result
'rr2'	rr2 type connection for continuity result
'rrn'	rrn type connection for continuity result
'cxy'	Circuit number of currently selected result
'Full'	Result storage area full
'Std'	(flashed briefly) result has been stored

4. Other messages during normal testing mode

Message	Description
'---'	mV or mA - frequency result not displayed
	since input is below trigger value
'---'	RCL – stored data being validated
'---'	uF - change of load detected
'-dc'	insulation test prohibited, a negative dc voltage is present
'>XYV'	insulation test prohibited, terminal voltage exceeds XY volts, (XY = 25 or 55)
'>25V'	mA test prohibited, terminal voltage exceeds 25 volts
'>500mA'	mA test terminated, input exceeds 500mA
'EXY'	Error occurred, 2 digit identifying code displayed
'off'	Instrument is about to autoshutdown

5. Messages seen in download mode

Message	Description
'rcl'	ready for download mode
'dld'	download mode entered, BMM ready to send results
'SU'	set-up mode entered
'Lng'	Language load mode entered, BMM ready to receive language data

6. Messages seen during data logging

Message	Description
'Log'	confirm/cancel logging message
'on'	confirm data logging status
'off'	confirm data logging status
'Full'	result storage area full

7. Messages seen at other times

Message	Description
‘-‘	switch position selected is invalid
'CAL'	(flashed briefly at start-up) calibrate mode
'tES'	(flashed briefly at start-up) test mode
'unc'	(flashed briefly at start-up) uncalibrate mode
'bpE'	(flashed briefly at start-up) bypass EEPROM mode
'diA'	(flashed briefly) diagnostic mode, diagnostics switch position selected
'Fxy'	Diagnostic mode, error occurred, 2 digit identifying code displayed

Appendix 17 Pinout Tables

MICROCONTROLLER PORT CONNECTIONS(A4 PCB)

PORT PIN	PIN NO.	NAME	I/O	COMMENTS
PORT1				
1.0	80	KEYS-	O	
1.1	81	BUZZER	O	TIMER FL OUTPUT
1.2	82	SPARE	O	TIMER FH OUTPUT
1.3	83	FREQ/V DETECT B-	I	TIMER G INTERRUPT
1.4	84	DIODES-	O	
1.5	85	AD STATUS	I	IRQ1- INTERRUPT
1.6	86	TEST	I	IRQ2- INTERRUPT
1.7	87	PULSE MEAS	I	IRQ3- INTERRUPT
PORT2				
2.0	14	CONTACT DETECT-	I	
2.1	15	SCL/AD CE-	O	
2.2	16	SDA	I/O	
2.3	17	BACKLIGHT ON	O	
2.4	18	LATCH 4 ENABLE-	O	
2.5	19	LATCH 3 ENABLE-	O	
2.6	20	LATCH 2 ENABLE-	O	
2.7	21	LATCH 1 ENABLE-	O	
PORT3				
3.0	22	D(0)	I/O	
3.1	23	D(1)	I/O	
3.2	24	D(2)	I/O	
3.3	25	D(3)	I/O	
3.4	26	D(4)	I	
3.5	27	D(5)	I	
3.6	28	D(6)	I	
3.7	29	D(7)	I	
PORT4				
4.0	88	OFF	O	
4.1	89	SERIAL IN	I	SERIAL INPUT
4.2	90	SERIAL OUT	O	SERIAL OUTPUT
4.3	91	V DETECT A-	I	IRQ0- INTERRUPT
PORT5 - PORT9				
LCD DRIVERS				
PORTA				
A.0	35	COMMMON 1	O	LCD DRIVER
A.1	34	COMMMON 2	O	LCD DRIVER
A.2	33	COMMMON 3	O	LCD DRIVER
A.3	32	WATCHDOG	O	(COMMON 4)
PORTB				
B.0	93	SWITCH A	I	A/D I/P
B.1	94	SWITCH B	I	A/D I/P
B.2	95	BATT/2	I	A/D I/P
B.3	96	POSTERM MONITOR1	I	A/D I/P
B.4	97	POSTERM MONITOR2	I	A/D I/P
B.5	98	I SOURCE MONITOR	I	A/D I/P
B.6	99	2.5V CHECK	I	A/D I/P
B.7	100	-5V CHECK	I	A/D I/P
PORTC				
C.0	101	SPARE I/P	I	(A/D) I/P
C.1	102	SPARE I/P	I	(A/D) I/P
C.2	103	SPARE I/P	I	(A/D) I/P
C.3	104	SPARE I/P	I	(A/D) I/P

A/D CONVERTER INTERNAL 8-BIT – (A4 PCB)

CHANNEL No.	NAME	DESCRIPTION
CHANNEL 0	SWITCH A	ROTARY SWITCH MIDDLE RING
CHANNEL 1	SWITCH B	ROTARY SWITCH INNER RING
CHANNEL 2	BATT/2	BATTERY CHECK
CHANNEL 3	POSTERM MONITOR1	INPUT INVERTER O/P MEASUREMENT
CHANNEL 4	POSTERM MONITOR2	INPUT AMPLIFIER O/P MEASUREMENT
CHANNEL 5	I SOURCE MONITOR	CURRENT SOURCE AMPLIFIER O/P
CHANNEL 6	2.5V REF	SELF-CHECK 2.5V REFERENCE
CHANNEL 7	-5V CHECK	SELF-CHECK -5V GENERATOR
CHANNEL 8	UNUSED	0V
CHANNEL 9	UNUSED	0V
CHANNEL 10	UNUSED	0V
CHANNEL 11	UNUSED	0V

LATCH OUTPUTS (A4 PCB)

BIT	PIN	LATCH 1 (IC3)	LATCH 2 (IC10)	LATCH 3 (IC314)	LATCH 4 (IC309)
0	4	HV INV RLY-	NEG TERM CTRL 1	2K TRIGGER	LBEN-
1	5	HV ON	NEG TERM CTRL 2	DISCHARGE	HBEN-
2	6	INS V SEL 1	I CTRL(0)	VOLTS TEST	AD RUN
3	7	INS V SEL 2	I CTRL(1)	FREQ SOURCE SEL	AD REF SEL 1
4	9	INS 50V	I CTRL(2)	MV TEST	AD REF SEL 2
5	10	IOC DISCONNECT	PULSE SOURCE SEL	(SPARE)	AD REF REDUCE
6	11	MA TEST-	INS I MEAS-	(SPARE)	AD INPUT SEL 1
7	12	AUX POWER OFF	(SPARE)	(SPARE)	AD INPUT SEL 2