McVan Instruments PTY LTD
A.C.N. 007 283 963

BWD604 MINI-LAB
Ver 2
MAINTENANCE MANUAL

58 Geddes Street, PO Box 298, Mulgrave, Australia, 3170
Tel: (+61-3) 9561-2888, Fax: (+61-3) 9560-1164

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BWD604 MINI-LAB (Ver 2) MAINTENANCE MANUAL

Important Notice

SAFETY INFORMATION

In this handbook and on the instrument panels may be found statements or symbols calling attention to a safety requirement or feature.

Symbols and statements used include the following:

	DANGER - HIGH VOLTAGE
	CAUTION
DANGER	To alert of possible danger to either operator or equipment that may be present during the described procedure.
WARNING	To alert operator that damage may occur to equipment under test if certain precautions as detailed are not followed.

Do not use this instrument in an explosive environment.

Do not remove the covers of the instrument unless you are qualified and experienced in servicing this class of instrument. Lethal voltages are present within the instrument.

This instrument must be grounded via the ground (earth) wire in the power cord, or by means of the ground terminal on the back panel if present. Loss of the safety ground will make conductive parts capable of rendering an electric shock and make operation of the instrument unreliable.

Always ensure the power cord is an approved type and in good condition and connected to a properly wired power outlet.

Use only the fuse type and rating as specified on the back panel.

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OPERATION SECTION

1. *INTRODUCTION*

The model BWD604 MINI-LAB is a combination of eleven versatile instruments and facilities in a stylish compact cabinet. Each facility can be used independently or in conjunction with each other to further increase MINI-LAB capabilities in providing such unusual outputs as square waves in excess of 10MHz to less than 10 days.

All outputs and inputs are short circuit proof. All inputs and outputs can be shorted together except the Function Generator BNC output. If +15V is shorted to the +5V supply it will not cause an over-voltage greater than +6V.

MINI-LAB's high performance, stability, accuracy, versatility and compact format makes it the ideal instrument for laboratories, service centres, production lines and education. Applications range through digital and analog electronics, electrical, biomedical, mechanical, chemical or optical, and more.

1.1 Summary of BWD604 MINI-LAB features.

a. Sine, triangle, square, ramp, pulse Function Generator output from <0.1Hz to >20MHz with digital frequency readout. Output up to 20Vp-p open circuit from a 50Ω source with variable offset and may be AM or FM modulated.
b. Logarithmic and linear Ramp Generator can be switched to the Function Generator to provide up to 2 decades of sweep.
c. Power Amplifier or Bi-polar Power Supply. Power Supply is continuously variable ±15V at 1 amp output. Amplifier gain is adjustable from x1 to x100 with ±15V at 1 amp output with polarity selection and a direct switching to Function Generator output.
d. Variable +15V and - 15V, 1 Amp stabilised Power Supplies with floating common which can be taken up to ±100V.
e. Fixed +5V, 3 amp regulated Power Supply.
f. Frequency Counter with 4 digit readout and spanning less than 5Hz to greater than 30MHz.
g. Volt, Amp, Ohm Digital Meter with true rms AC voltage and current measurement. 3½ digit readout.
h. Counter / Function Generator decade divider, providing a square wave output with a division ratio of 1 to 10,000.

2. *SPECIFICATIONS*

All parameters are measured after the instrument has been on for 15 minutes at room temperature between 20° and 25°C. All measurements made with all other outputs not in use unless otherwise stated. Function Generator specifications are based on a 50Ω load unless otherwise stated.

2.1 Function Generator.

Waveforms:	Sine, Triangle, Square, Ramp or Pulse.
Frequency Range:	Less than 0.1Hz to greater than 20MHz. Each range covers over 2 decades.
Readout:	Direct, 4 digit 8mm LED display Accuracy ±1 count. Gating Period 1 sec.
Output Volts:	20V p-p open circuit max. 10V p-p into 50Ω, short circuit protected.
Attenuator:	10, 20 and 30dB switch selected and a continuously variable 20:1 control.
Level Stability:	**Square wave** ±1dB from 0.1 Hz to 20MHz. **Triangle wave** ±1dB from 0.1Hz to 10MHz. **Sine wave** ±1dB from 0.1Hz to 20MHz.
Output Offset:	Output is normally centred about ground. A rotary control applies a continuously variable ±10V offset voltage to the output waveform into an open circuit load or ±5V into 50Ω.
Sync Output:	0 to +2.8V min. from 2.5kΩ source in quadrature to the main output.
Symmetry:	**Fixed:** Within ±2% from 0.1Hz to 20MHz. **Variable:** Selection of + or - continuously variable symmetry over 30% to 70% typical.
Sine Distortion:	<2.0% 5Hz to 500kHz increasing to <3% at 1MHz. Typically 1.5% 10Hz to 20kHz.
Rise and Fall Time:	(Square or pulse) <15nsec.
Triangle Linearity:	Better than 99% from 0.1 Hz to 1MHz.
Frequency Modulation:	Function Generator can be swept ±70% typically on each range by a ±10V external input or the internal sweep generator.
Modulation Input:	91kΩ and 33pF nominal.
Response:	Frequency, DC to >1MHz. Linearity better than 2%. ±10V gives ±70% change typical.

2.2 Log - Linear Sweep Generator.

Switch selection of LOG, EXT or LINEAR ramp voltages. Maximum span of sweep generator will sweep over 2 decades of each range of the Function Generator. Any portion of each range can be swept depending on the setting of the vernier and sweep amplitude control.

Linear Ramp:	100msec to >5 seconds, continuously variable.
Log Ramp:	200msec to >5 seconds, continuously variable.
Gate Output:	0 to +6V pulse during the reset period - can be used to trigger an oscilloscope and blank the return trace. Source impedance 10 kΩ.

2.3 Amplitude Modulator (or Balanced Modulator).

Amplitude modulation of all Function Generator waveforms from 0 to 95% modulation.

Modulation Frequency:	DC to 5MHz.
Input Impedance:	100kΩ and 33pF nominal.
Output Level:	Sine wave, unmodulated 10V p-p O/C, 5V p-p into 50Ω. Response ±2% to 1MHz, ±5% 1MHz to 10MHz. Modulation voltage ±2.0V for 95% modulation. When modulation signal is superimposed on approximately -1.5V then output will be balanced modulated.

2.4 Frequency Counter.

Digital counter can be switched from displaying Function Generator frequency to the frequency of an external signal input via the BNC connector. Function Generator remains fully operational when counter is used externally.

Display:	4 digit 8mm LED with over range indication.
Frequency Range:	<5Hz to >30MHz 10kHz, 100kHz, 1MHz, 10MHz, >30MHz. (5 ranges)
Resolution:	1Hz, 10Hz, 100Hz, 1kHz, 10kHz. (respectively)
Sensitivity:	200mV p-p, 100Hz to 12MHz increasing to 500mV p-p at 30MHz and 2V at 5Hz.
Input:	1MHz and 20pF approx. Max input 250V DC or p-p AC. Input diode protected.
Gate Period:	1 second fixed.
Count accuracy:	±1 count.

2.5 Decade Frequency Divider.

Signals applied to counter input are available divided down in decade steps and converted to a square wave output.

Division Ratios:	1 to 10,000 in 5 decade steps	
Max Input Frequency:	/1	500kHz
	/10	5MHz
	/100, /1000 and /10,000	>30MHz.
Output:	0 to +5V from 4.7kΩ source impedance.	

2.6 Clock Output.

Frequency:	1 Hertz square wave, accuracy <0.01%.
Output:	0 to +5V from 4.7kΩ source impedance.

2.7 Power Amplifier/Bi-polar Power Supply (Switch Selection).

2.7.1 Amplifier

Voltage Gain:	x1 to x100 continuously variable.
Polarity:	Switch selection of normal or inverted output.
Input Selection:	Switch selection of Function Generator output or an External source.
External Input:	100kΩ and 10pF nominal
Output Volts:	±15V into 15Ω
Output Current:	±1Amp with constant current overload.

	Gain: **x1**	**x20**	**x100**
Bandwidth: (-3dB)	All at ±15V output swing		
Bandwidth into 50Ω	DC-350kHz	DC-200kHz	DC-50kHz
Bandwidth into 15Ω	DC-250kHz	DC-150kHz	DC-35kHz
Rise Time into 50Ω	1usec	2.5usec	10usec
Output Impedance:	<0.1Ω	<0.2Ω	<1Ω
Hum and Noise O/C input:	1mV p-p	5mV p-p	<30mV p-p
Distortion:	All at ±15V output swing		
Distortion into 50Ω	<0.5%	<4%	N/A DC-100kHz
Distortion into 15Ω	<0.2%	<1.5%	<2% DC-10kHz
Distortion into 15Ω	<1%	<2%	<6.5% DC-30kHz

2.7.2 Power Supply

Output Volts:	Continuously variable from +15V to -15V.
Output Current:	0 to 1Amp maximum with constant current overload.
Output Impedance:	<0.05Ω.
Hum and Noise:	<5mV p-p at full output when Function Generator frequency is set to less than 100kHz.

2.8 -15V To 0 To +15V Isolated Power Supply.

Output Volts:	-15V to 0V and 0V to +15V with a common isolated 0V rail. Either output or the 0V terminal may be grounded or taken to a maximum of ±100V DC to ground.
Output Current:	1 Amp from each supply with constant current overload.
Output Impedance:	<0.01Ω for ±10% line change. <0.1Ω for 0 to full load change.
Hum and Noise:	<5mV p-p at full load when Function Generator frequency is set to less than 100kHz.

2.9 5V, 3A Fixed Supply.

Output Volts:	+5 Volts ± 0.25V
Output Current:	0 to 3 Amp. (Line voltage 210V/105V min) 0 to 2.5Amps. (Line voltage 200V/100V min). Output is protected against overload and over-voltage from any other BWD604 power supply.
Output Impedance:	<0.1Ω
Hum and Noise:	<10mV p-p at full output

2.10 Digital Volt, Ohm, Amp, Meter.

Display:	3½ digit, 8mm LED with over range indication.

2.10.1 DC Voltmeter

Ranges:	200mV, 2V, 20V, 200V, 500V (5 ranges)
Resolution:	100uV, 1mV, 10mV, 100mV, 1V (respectively)
Polarity:	+ or - with automatic indication
Accuracy:	<1% ±1 count
Input:	10MΩ
Common Mode Voltage:	±500V Maximum

2.10.2 AC Voltmeter

Ranges:	200mV, 2V, 20V, 200V, 350V rms (5 ranges)
Resolution:	100uV, 1mV, 10mV, 100mV, 1V rms (respectively)
Reading:	True rms with max 3-1 peak to trough waveforms
Accuracy:	<3% ±1 count, 5Hz to 5kHz
Bandwidth:	3Hz to 100kHz on 200mV range
	3Hz to 50kHz on 2V range
	3Hz to 10kHz on 20V range
	3Hz to 5kHz on 200 and 350V range

2.10.3 Ohmmeter

Ranges:	200Ω, 2kΩ, 20kΩ, 200kΩ, 2MΩ (5 ranges)
Resolution:	100mΩ, 1Ω, 10Ω, 100Ω, 1000Ω (respectively)
Accuracy:	<1% ±1 count

2.10.4 DC Ammeter

Ranges:	200uA, 2mA, 20mA, 200mA, 2A (5 ranges)
Resolution:	100nA, 1uA, 10uA, 100uA, 1mA (respectively)
Accuracy:	<1% ±1 count

2.10.5 AC Ammeter

Ranges:	200uA, 2mA, 20mA, 200mA, 2A rms (5 ranges)
Resolution:	100nA, 1uA, 10uA, 100uA, 1mA (respectively)
Reading:	True rms with max 3-1 peak to trough waveforms
Accuracy:	<3% ±1 count
Frequency:	5Hz to 1kHz on all ranges
Protection:	2 amp quick blow fuse and diodes.

2.11 Interconnection Facilities.

Push pull waveforms are available from Function Generator and Power Amplifier switched to the inverted mode. Bandwidth DC to 400kHz into an open circuit or 50Ω termination
All power supplies can be used separately or interconnected to provide the following range of voltage/current capabilities.

1. 0 to +15V 1A, -15V to 0 1A, 0 to ±15V 1A, and 5V at 3A.
2. 0 to ±15V 1A, 0 to + or - 30V 1A, and 5V at 3A.
3. 0 to ±45V 1A, and 5V at 3A
4. -10V to +5V and +5V to +20V at 1A, 0 to ±15V at 1A and 5V at 2A.
5. Interconnection of 1Hz square wave or the f/N output to Power Amplifier produces a 0 to > +15V or 0 to > -15V 1A square wave.
6. When the 1 second clock pulse is connected to the counter, the f/N output can be selected from 1 sec to 10,000 seconds
7. When the Function Generator output is connected to the counter input, the f/N output extends down to >10 days.
8. The ±15V Power Supply can be remotely programmed from -15V to +15V at 1Amp by an external voltage applied to the amplifier input. Control voltage is from ±150mV to ±15V depending on gain setting.

2.12 General.

Power Requirements:	100 to 132V or 200 to 265V, 50 - 60Hz. Range selection on rear panel. 150VA max.
Environmental Specifications:	
	<u>Operating:</u> Specifications are met within the prescribed input voltage range from +5° to 45°C and humidity from 0 to 95% RH.
	<u>Storage:</u> -40°C to +75°C non-operating
Safety Standards:	Instrument closely conforms to IEC348 recommendations. All components in the input power circuits including the power transformer are UL, CSA and VDE approved.
Dimensions:	328mm wide x 175mm high x 240mm deep, including knobs, feet, heat sinks etc.
Weight:	6kg, 7kg packed.
Additional products:	A range of oscilloscopes are available from McVan Instruments to use in conjunction with your BWD604 MINI-LAB. Please contact your supplier or direct to the factory for further details.
Ordering Code:	BWD604 MINI-LAB. Includes operating manual, power cord (Australia and New Zealand only) and meter leads.
Optional Accessories:	BNC to BNC cables 1 meter long. P32 1:1 and 10:1 probe (for frequency counter input). Meter leads - red and black. Maintenance Handbook. Operation Handbook. Power cord (Australia and New Zealand only)

All specifications subject to change without notice.

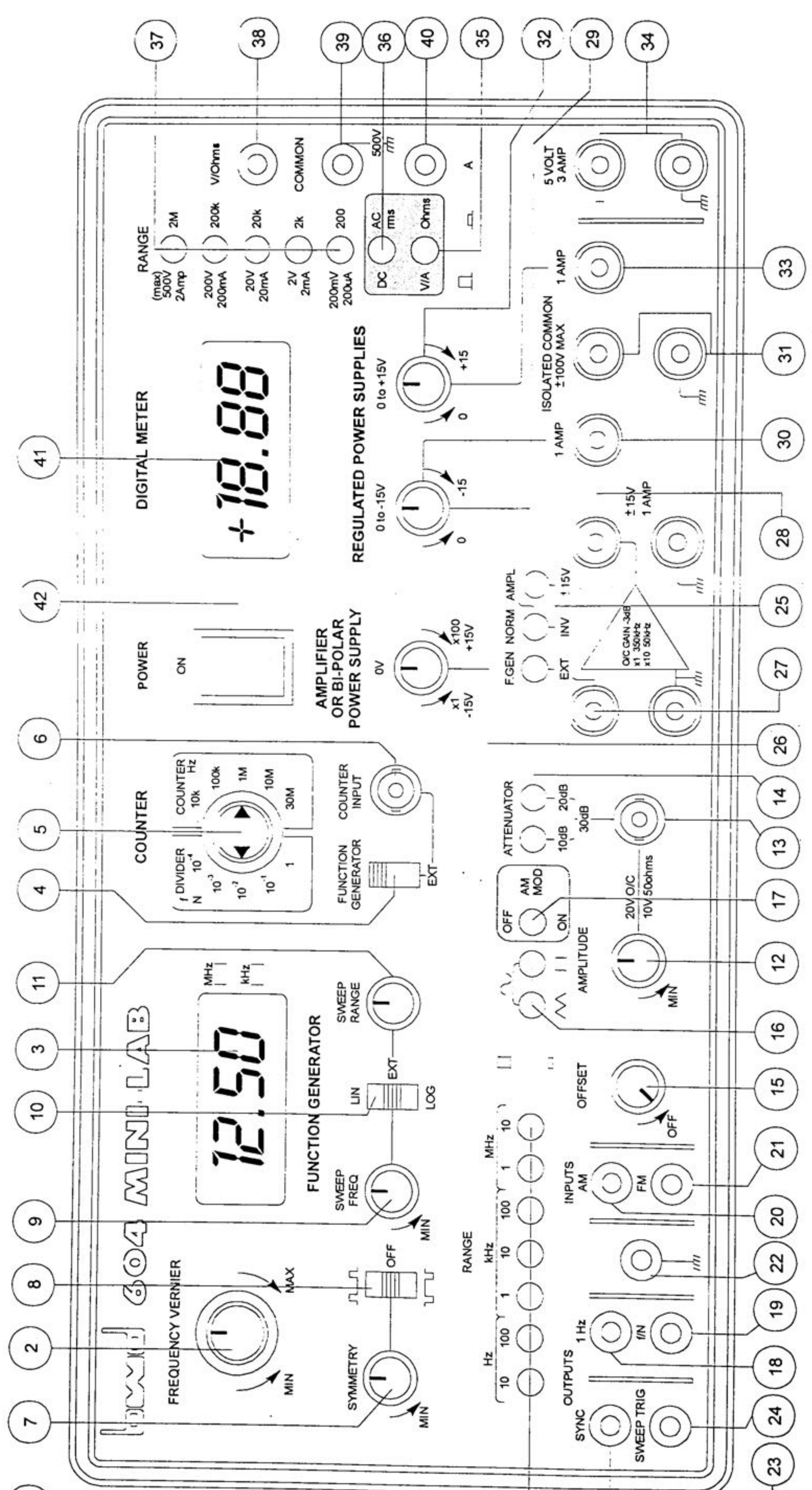


Fig 3.1 – Schematic Layout of BWD604V2

3. *CONTROLS AND THEIR FUNCTIONS*

The front panel is divided into the following six sections:

1. Function Generator and Ramp Generator.
2. Frequency Counter.
3. Power Amplifier/Bi-polar Power Supply.
4. 0 to + and - 15V Power Supply.
5. 5V, 3amp Power Supply.
6. Digital Meter.

Refer also to figure 3.1 for a schematic layout of the front panel..

3.1 Function Generator.

1. Range switch. The desired frequency range is selected by depressing the correct button.
2. Frequency Vernier multi-turn control. Uncalibrated control covers over 2 decades of frequency on each range.
3. Digital readout. When switch 4 is up, the readout will display the output frequency of the waveform present at the Function Generator BNC output socket. The range switch 1 automatically selects the readout in kHz or MHz.
4. Counter source switch. In the up position readout is as described in 3. In the down position the counter displays the frequency applied to the BNC input socket 6. The counter range switch 5 selects the correct frequency range for the externally applied frequency. Frequency overload will cause the display to flash on and off.
5. Counter Range and Frequency Divider switch. This switch controls two functions.
   As a counter range switch it enables the most appropriate range to be selected to suit the applied input frequency. The maximum frequency that can be counted without overload is marked on each step.
   NOTE: A higher input frequency than the counter will accommodate will cause it to indicate overload by flashing on and off but this does not affect the divider facility.
6. Counter input socket (BNC). Input socket for frequency counter or frequency divider.
7. Symmetry Vernier control. Fully counter clockwise the waveform remains symmetrical, as it is turned one side of the waveform will be extended.
8. Symmetry Selector switch. In the centre position, the Function Generator output waveforms are symmetrical. When pushed UP or DOWN, the rising or falling waveform symmetry can be adjusted by the Symmetry Vernier control.
9. Sweep Frequency control. Counter-clockwise the ramp selected by the LIN-EXT-LOG switch is at the slowest speed and fastest when fully clockwise.
10. LIN-EXT-LOG switch. In the centre position external signals applied to the FM input will frequency modulate the Function Generator output. A +ve voltage will increase the frequency, and a -ve voltage will decrease it.
    When LIN is selected a linear sawtooth waveform will sweep the frequency. The minimum frequency is with the Sweep Range control fully counter clockwise and the range increases as the Sweep Range control is turned clockwise. The rate of the sweep is controlled by the Sweep Frequency control.
    When LOG is selected the operation is the same as for linear except the sweep waveform is logarithmic.
11. Sweep Range control. Sets the high frequency limit of the sweep width as described for the LIN-EXT-LOG switch. Note that as the sweep width is reduced the sweep repetition rate increases.

12. Amplitude control. Adjusts the output voltage over a 20:1 amplitude range. Output impedance is not affected by the level control.
13. Frequency Generator output socket (BNC). Output socket for Function Generator waveforms.
14. Attenuator switches 10 and 20dB. Independent switches to select output levels. When both are depressed output is reduced 30dB. The level control 12 provides a further 26dB of attenuation making a total of 56dB , i.e. an approx 600:1 range in output level control.
15. Offset control. Fully counter-clockwise and switched off, the output waveform will be centred about ground. When the control is turned, the position of the output waveform about ground is adjustable over ±10V open circuit, or ±5V into 50Ω.
16. Waveform Selector switches. Both switches out, output waveform is sinusoidal. Left hand switch only pressed in, output waveform is triangular. Right hand switch only pressed, only waveform is rectangular. (See Fig 4.1)
17. AM switch. In the OUT position waveform is normal, when IN the output amplitude is reduced to 50% and signals applied to the AM socket (input 100kΩ and 30pF) will control the amplitude of the output waveform.
    Note: Distortion, linearity and rise time specifications do not apply to amplitude modulated waveforms.
18. 1Hz clock output socket. A +5V one second square wave is available from a 4700Ω source impedance.
19. f/N socket. Output at this socket is the waveform applied to Frequency Input socket, divided down by the decade ratio selected by the Frequency Divider switch. The output is a square wave for any division ratio and a clipped off version of the input waveform in the /1 position. +5V output from a 4700Ω source impedance.
20. AM socket. Signals applied to this socket will amplitude modulate the Function Generator waveforms when the AM selector switch is depressed. A positive voltage will increase amplitude, a negative voltage will decrease it. Approximately 3V p-p is required to provide 100% amplitude modulation. Input impedance is 100kΩ and 30pF nominally.
21. FM socket. Signals applied to this socket will modulate or change the frequency when the LIN-EXT-LOG switch is in the centre EXT position. A positive voltage will increase the frequency, a negative voltage will decrease it.
22. ⏚ socket. Ground terminal for input or output waveforms.
23. SYNC socket. A positive going signal of 0 to 2.8V min. from a 2500Ω source. The signal is 90° out of phase to the main output waveform.
24. RAMP gate pulse. A positive going 0 to +6V pulse from a 10,000Ω source is available during the return sweep period of the internal ramp to provide an oscilloscope trigger and CRT blanking pulse.

3.2 Power Amplifier/Bipolar Power Supply.

25. Selector switches. With all switches out the Function Generator output is connected to the amplifier. With the Gain/Voltage control fully counter clockwise the same amplitude signal will appear at the Amplifier output terminals as is present at the Function Generator BNC output socket. When the INT-EXT button is pressed, external signals can be applied to the amplifier via the Amplifier Input terminals. The centre button inverts the output providing for example the Function Generator with a push pull output.
    The R.H. switch changes the circuit from a power amplifier to a Bi-Polar Power Supply when it is engaged the Gain/Voltage control adjusts the output voltage from -15V to +15V.
26. Gain/Voltage control. When the Power Amplifier is selected this control adjusts the gain from x1 to x100. When the Bi-Polar power supply is selected it adjusts the output voltage from -15V to +15V. The power amplifier can be used as a voltage programmed power supply over

the range -15V to +15V. The gain control adjusts the programming voltage from ±15V at minimum gain to ±150mV at maximum gain.

27. Amplifier Input terminals. Input connections to power amplifier. Input is 100kΩ and 20pF nominally.
28. Amplifier output terminals. Output terminals for Power Amplifier or Bi-Polar power supply as selected by the Selector switches.
29. 0 to -15V Control. Adjusts the negative half of the isolated power supply from 0 to -15V at 1 amp.
30. 0 to -15V terminal. Output connection for -ve power supply.
31. 0 and Ground terminals. When the two terminals are linked the + and - outputs are voltages are with respect to ground. With the 0V terminal isolated, it or the positive or negative terminals can be connected to any other supply up to ±100V with respect to ground.
32. 0 to +15V control. Adjusts the positive half of the isolated power supply from 0 to +15V max at 1 amp.
33. 0 to +15V terminal. Output connection for positive power supply.
34. 5V, 3Amp Output terminals.

3.3 Digital Meter.

35. V/A-Ω Selector switch. Volts or Amps can be measured in the out position. Ohms are measured in the in (Ω) position.
36. DC-AC selector. DC Volts or amps are selected in the out position and AC Volts or amps (true rms) in the in position.
37. Range switches. Push buttons to select the voltage, current or ohms ranges.
38. V or Ω input socket. AC and DC voltages or ohms are applied to this input socket.
39. Common socket. Input for the low impedance side of all measurements. Socket is isolated from ground and may be taken to a maximum of + or - 500V DC from ground.
40. Amps socket. Input for AC or DC current measurement.
41. Digital Meter readout. 3½ digit readout with + or - indication for DC volts or amps. Polarity indication is automatic and a 1 on the MSD and the remaining digits blanked indicates overload.
42. Power ON-OFF. Illuminated rocker switch, switches both active and neutral input AC lines to the power transformer.

3.4 Rear Panel. (See Fig 3.2)

43. Line Voltage selector switch. In the down position, 200 to 264V AC is selected. In the up position 100 to 132V is selected. Input frequency is 50 to 60Hz for either range.
44. Fuse. Line fuse is in the active line. Rating and size are detailed on the rear panel label.
45. IEC Power line socket. 240V 6A rating socket. <u>The power cord must contain a safety ground lead which connects the to centre pin of the socket</u>. Any suitable and approved 3 core power lead can be used with the BWD604 MINI-LAB that fits the IEC input socket.

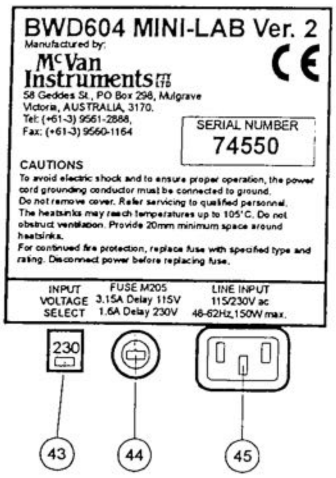


Fig 3.2
Rear Panel Arrangement

4. *OPERATION*

The purpose of this section is to outline the use of each separate function of the Model 604 MINI-LAB.

Throughout this section and the following section, drawings of the front panel and its controls are used to describe settings of switches and knobs.

1. Where a push button switch is shown filled in that button should be pushed in. All other buttons should be out.
2. The position of knobs is shown by a marker on the centre of the knob. The control should be turned so that the marker points in the same direction and setting as the drawing.
3. Where no marker appears on the drawing on a particular knob, the position of that control has no effect on the operation under discussion.

Check that the mains power selector switch on the rear panel is set correctly for the supply to which the instrument will be connected. Check the fuse rating corresponds to the information on the rear panel. The 3 pin plug may now be inserted into the correct power receptacle and power applied by switching the front panel ON/OFF switch to on.

4.1 Operation of the Function Generator. (See Fig 4.1)

With the controls set as indicated, the three waveforms shown on the right of the panel are available at the output socket depending on which selector buttons are engaged.

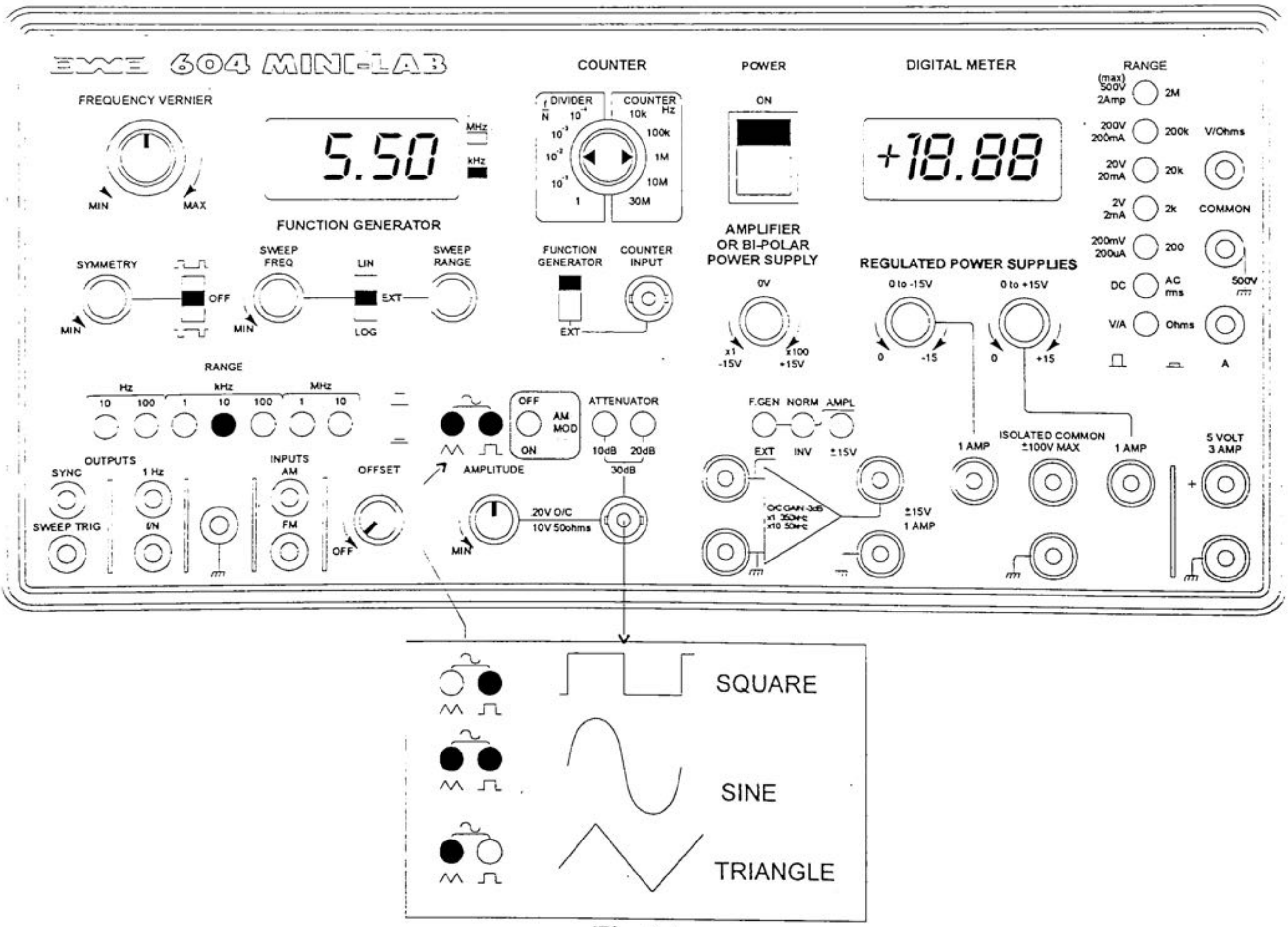


Fig 4.1

The frequency will be approximately 5kHz. The Frequency Vernier control enables the frequency to be set from <100Hz to > 12kHz on this range. This is displayed on the digital readout when the Counter selector switch is in the up position.

Output amplitude is set by the Amplitude control and the attenuator switches from approx 30mV to 20V p-p O/C. A sync pulse is available at the Sync socket.

4.1.1 Offset. (See Fig 4.2)

The output waveform can be offset up to ±10V with respect to the normally centred position. To offset a waveform, turn the Offset control clockwise out of its switched position. In the centre position of the control no offset is applied to the output waveform. Turn it counter-clockwise and the waveform will be offset negatively, the opposite occurs when it is turned clockwise.

NOTE: The maximum output from the Function Generator is ±10V, so to make full use of the offset range the waveform amplitude must be reduced to half or less. At frequencies up to 100kHz offset voltages up to ±45V can be obtained via the Power Amplifier and isolated Power Supply.

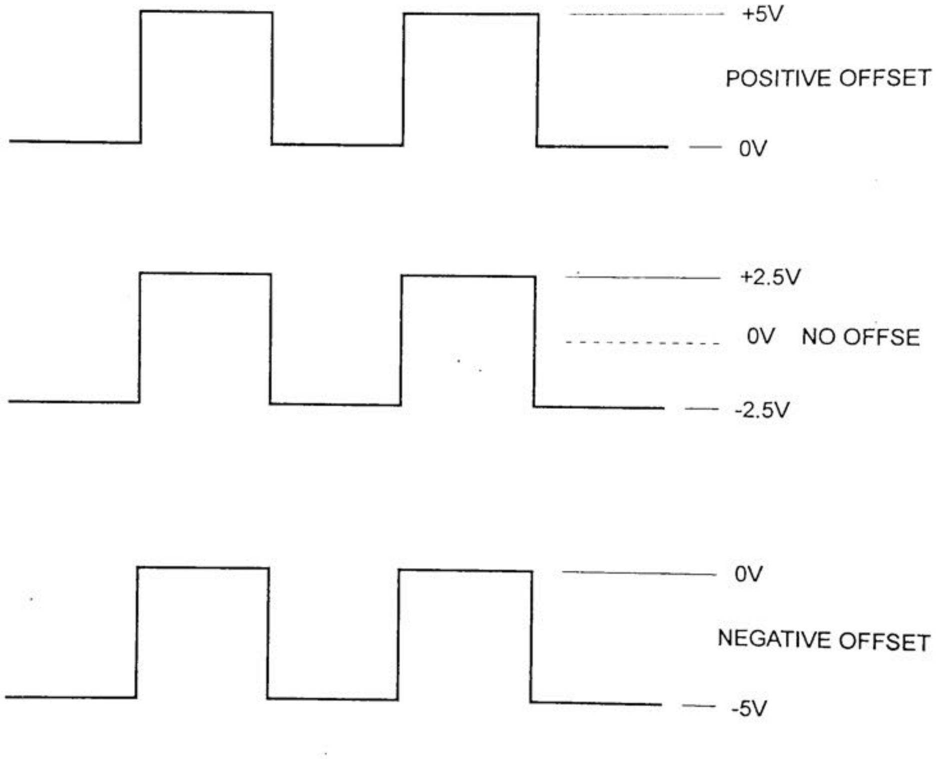


Fig 4.2

4.1.2 Variable Symmetry. (See Fig 4.3)

If the Symmetry switch is pushed up from its centre position the output waveform symmetry can be varied by the Symmetry control.

The change in symmetry is achieved by increasing the time duration of alternate half cycles. The overall effect is to decrease the frequency as the symmetry ratio changes from 1:1 to either 2.3:1 or 1:2.3. The start of a cycle of the square waveform coincides with the peaks of the sine and triangle waveforms. The Symmetry control works on all three output waveforms as shown below. Frequency of the asymmetrical waveform will be shown on the digital frequency display.

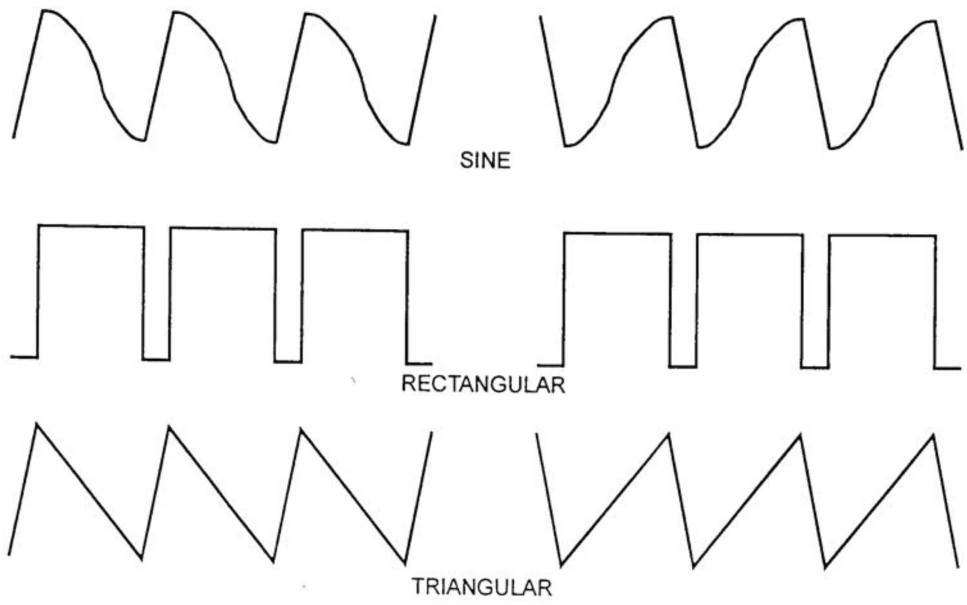


Fig 4.3

4.1.3 Sweep Output. (See Fig 4.4)

Setting the controls as shown in Fig 4.4 enables the frequency of the generator to be swept over the selected frequency range. The sweep width is adjusted by the Sweep Range control running low frequency to high frequency as the control is turned clockwise. Sweep can be selected to be linear or logarithmic.

The sweep starts at the lowest frequency, with the highest frequency set by the Sweep Range control.

The sweep ramp gate pulse available at the Sweep Trig socket can be connected to ext trigger input or the CH 2 input of an oscilloscope to lock the time base to the swept frequency.

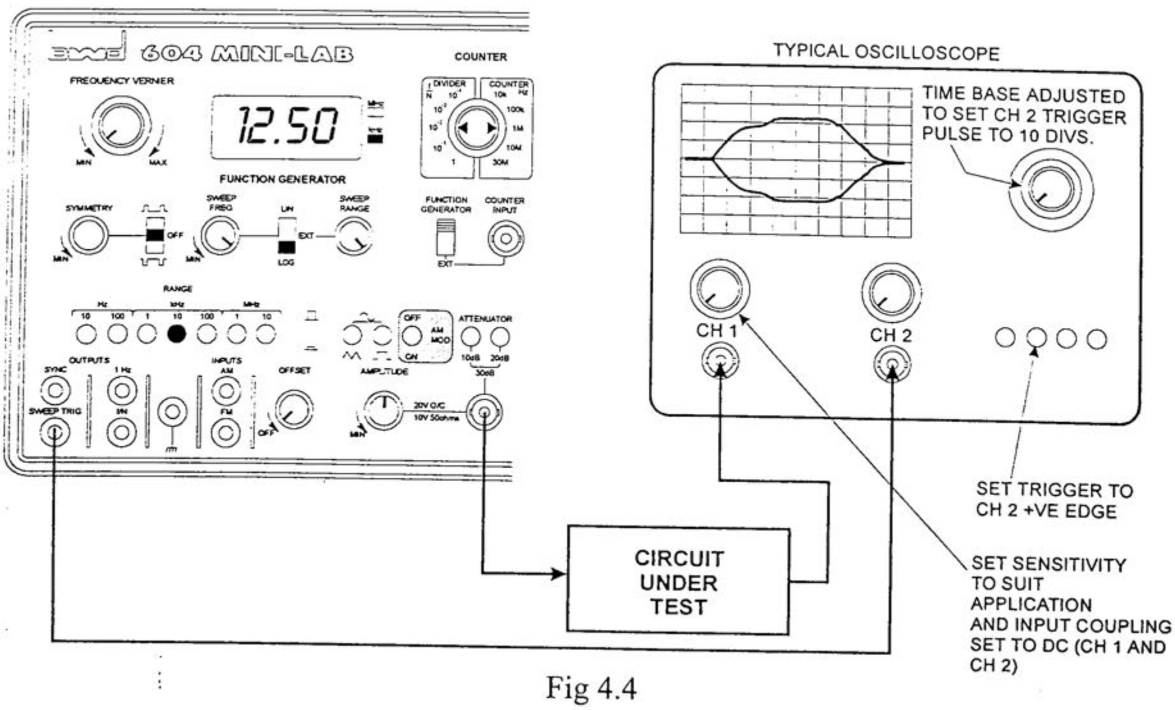


Fig 4.4

4.1.4 Frequency Modulation.

The Function Generator can be frequency modulated over any part of each range by signals applied to the FM input socket when the Log-Ext-Lin switch is set to EXT.

Each range can be swept by a ±10V input. This enables the output frequency to be set remotely by a DC voltage. A signal swinging symmetrically about ground will modulate the output above and below the centre frequency set by the Frequency Vernier. Modulation is linear, e.g. if the frequency is set to 5kHz, ±2.8V will modulate the output from 4kHz to 6kHz approximately. Any output waveform can be frequency modulated.

4.1.5 Amplitude Modulation.

When the AM MOD button is selected the Function Generator output amplitude is reduced to half. Signals from DC to >1MHz applied to the AM socket will amplitude modulate the generator output. Approx 4V p-p is required for 95% modulation. All the output waveforms can be amplitude modulated. The AM facility can be used as a remote output level control. Approximately -2V will reduce the output to zero whilst +2V will increase it to maximum.

NOTES:
1. As some distortion occurs in the AM modulator the AM button should not be engaged unless the facility is required.
2. Both FM and AM can be applied to the output signal simultaneously.
3. Balanced modulation can be obtained by adding DC bias of approximately -1.5V to the modulation signal.

4.2 Operation of the Digital Counter.

When the Function Generator (4) slide switch is pushed down to the EXT counter position, the Function Generator remains fully operative but the counter is now available for external measurements. As the counter gate time is constant at 1 second the input frequency is divided down from /1 to /10,000 depending on the counter range setting.

The maximum input frequency is indicated for each range. If the frequency is too high for the range selected the display will flash on and off, increasing in frequency with the degree of overload.

Too low an input level or too low a frequency for the range selected will result in a zero or varying display. As the input to the counter is 1MΩ and 20pF in parallel, a standard 1:1/10:1 oscilloscope probe such as a type P32 available from McVan Instruments can be used to connect to circuits under test. The counter will accommodate a wide variety of waveform shapes from sine to pulse.

4.3 Frequency Divider. (See Fig 4.5)

The output of the counter divider circuits is buffered and brought out at the front panel f/N socket. The output at /1 is a squared off version or pulse at the input frequency. From /10 to /10,000 output is a square wave with equal mark-space ratio, irrespective of the input waveform. With a pulse or square wave input the frequency can extend down to any frequency subject to a minimum input of 200mV p-p.

If the 1 second clock output is connected across to the counter input, a square wave output down to 10,000 sec or 2.777 hours is available. If the Function Generator output is connected to the counter input (with the selector switch set to Counter), then square waves with repetition rates continuously variable to greater than 10 days can be obtained.

If the f/N output is connected to the Power Amplifier, its output can be used to operate relays, small DC motors etc. to control experiments, testing sequences and similar functions. A pulse instead of a square wave output is available by connecting the f/N output to the Amplifier via a capacitor. The value of the capacitor will control the pulse width.

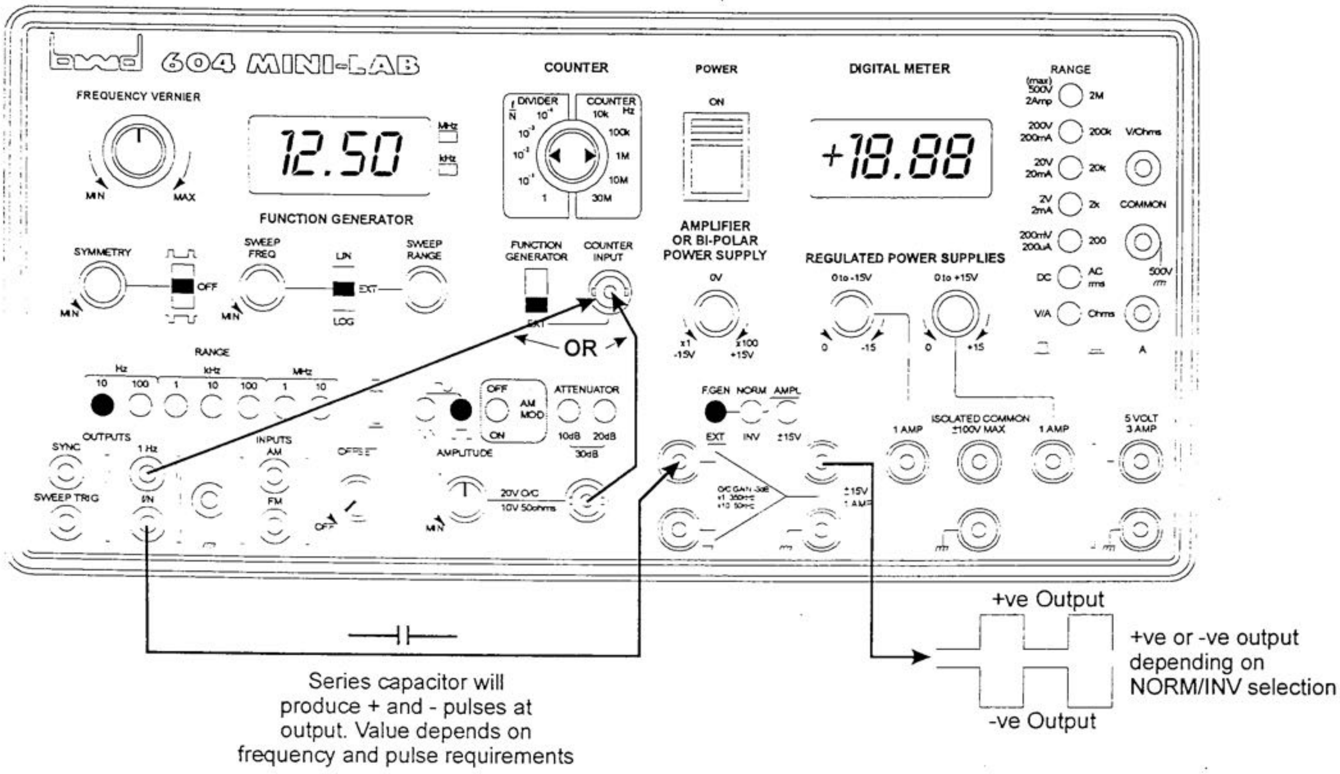


Fig 4.5

4.4 Power Amplifier.

When the three selector buttons that control the Ampl/Power Supply are all out and the gain control is fully counter-clockwise, the Amplifier output will be the same as the Function Generator (subject to upper frequency limits - see specifications). If the N/INV button is pressed the Amplifier output will be inverted providing a push-pull output with the Function Generator for applications requiring a balanced drive.

Rotating the gain control clockwise will increase the output amplitude to at least ±15V into a 15Ω load.

If offset is applied to the Function Generator output it will correspondingly offset the Power Amplifier output.

When the left hand button FG/EXT is pressed, the Function Generator is disconnected from the Power Amplifier and signals applied to the input terminals can now be amplified from x1 to x100

NOTE: It is recommended that input signals to the Power Amplifier are limited to 200kHz when operated at full load to minimise heat rise in the power output stage.

4.5 Bi-Polar Power Supply.

When the AMPL/±15V button is pressed, the amplifier input is disconnected the variable control now adjusts the output continuously from -15V to +15V with a maximum current output of 1 Amp.

Constant current overload operates to limit maximum short circuit current to approximately 1.2 Amps.

4.6 Isolated + and - 15V 1 Amp Supplies.

These isolated dc power supplies can be used on many ways. With the common 0V line linked to the ground terminal directly beneath it, each output may be adjusted separately from 0 to either + or - 15V with a maximum current of 1 Amp. Constant current overload limits the short circuit current to 1.2 Amps.

With the 0V line disconnected, either the positive or negative terminal can be grounded to supply either + or - 0 to 30V at 1 Amp. The 0V terminal can also be used as an output providing for example 0, +12V and +24V.

If one of the terminals is connected to the Bi-Polar Power Supply/ Power Amplifier output terminals, then the supply will float on whatever output is set at the P.S./AMPL output terminal. e.g. if the negative terminal is connected the up to +45V at 1Amp is available at the + terminal and conversely 0 to -45V is available if the positive terminal is connected to the P.S./AMPL output.

If the P.S./AMPL is switched to Power Amplifier then waveforms from either the Function Generator or an external source can be offset by the isolated power supply at frequencies to >10kHz.

Other voltage ranges are available when the supplies are connected to the +5V supply. e.g. when the + or - terminals are connected to +5V up to +35 at 1Amp and +5V at 2Amps, or -10V to +5V and +5V to +20V are available respectively.

4.7 Fixed +5V, 3Amp Supply.

This supply is stabilised to +5V within ±0.25V. It relies on the regulator to shut down under current or thermal overload conditions. A positive over-voltage clamp prevents the output from exceeding +6V if one of the higher voltage supplies set to >+5V is connected across it. This helps to protect any digital circuits connected to the +5V supply. It as also protected against reversed voltages being connected across it.

WARNING

A short circuit across the fixed +5V supply will shutdown the Function Generator Display/Counter Display for the duration of the short circuit.

4.8 Digital Meter (See Fig 4.6).

This completely isolated facility provides voltage, current or ohms measurements. The top 5 push buttons on the right hand side of the panel select the ranges whilst the voltage/current selector is at the bottom with the AC/DC selector above it. All AC measurements are true rms with trough to crest ratios up to 3:1.

Separate input sockets are provided for the voltage and current measurements with a central COMMON terminal isolated to withstand ±500V or 350V rms minimum to ground.

If the applied input overloads the selected range the display will blank out other than the first digit and the ± indicators on voltage or current measurements. To restore the reading select a higher range.

For maximum accuracy always use the highest sensitivity range possible without overload.

When measuring Ohms, the maximum voltage applied across the component under test is +5V via a 2kΩ resistor on the lowest 200Ω range. When measuring with the high resistance ranges, do not hold the component leads as skin resistance can affect the resistance reading.

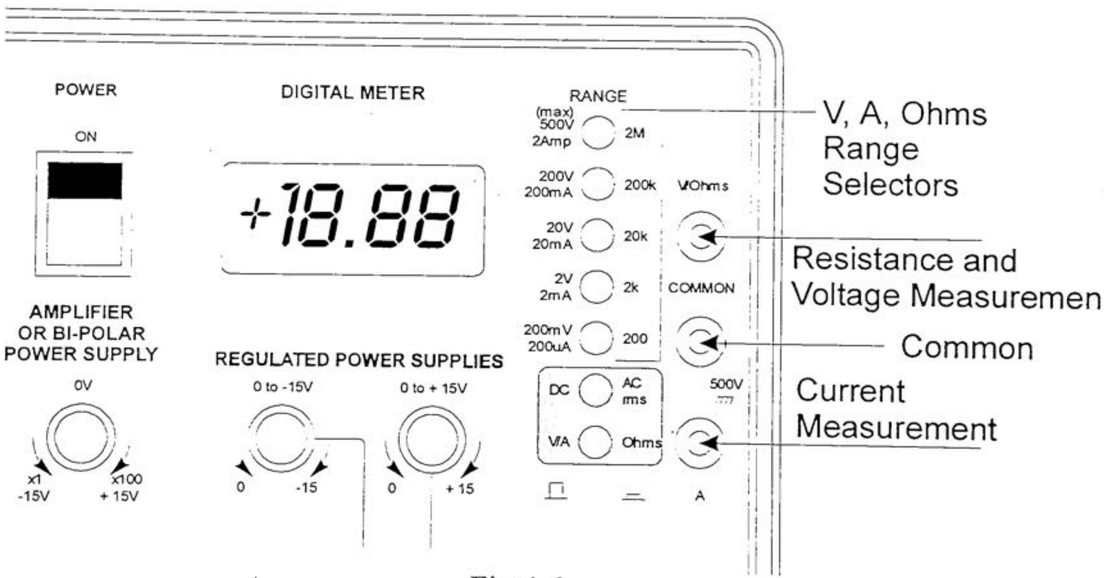


Fig 4.6

604 MINILAB (Ver. 2)
MAINTENANCE SECTION

5. *CIRCUIT DESCRIPTION*

5.1 Power Sources.

Refer to drawings 3409 and 3395. The transformer T150 supplies all circuits from its four secondary windings. The regulated ±15V, ±6V and the unregulated ±25V supplies are obtained from one winding supply. All circuits are referred to ground except the 5V rail that has its own secondary winding and rectifiers. The isolated ±15V supply has another independent secondary. The fourth secondary is a high insulation 8V winding for the digital voltmeter.

The transformer primary is in two halves enabling it to be connected in series or parallel, by the rear panel switch S151, for 115V or 230V operation. The front panel power switch S150 switches both input lines and incorporated an in-built neon indicator to show when the MINI-LAB is switched on. The fuse F150 is in the active line in series with a NTC resistor R163. The NTC resistor is used to reduce current surges when the instrument is switched on.

5.1.1 Power Supplies

Refer to drawing 3395. The fixed internal ±15V supplies are derived from an 18Vac secondary that is full wave rectified by BR1 bridge rectifier. The bridge rectifier supplies an unregulated +25V (nominal) to C61 filter capacitor and the +15V regulator (U1), as well -25V (nominal) is supplied to C63 and the -15V regulator (U3).
The +15V and –15V rails are adjusted by RV150 and RV151 respectively. Diodes D1, D2, D3, D4 protect the supplies from reverse biasing during turn ON/OFF operations, or under fault conditions.

The ±6V supplies are derived from the ±15V supplies by the two regulators U2 (+6V supply) and U4 (-6V supply). The ± 6V supplies are set by the trimming potentiometers RV21 (+6v) and RV21 (-6V).

The isolated ±15V variable supplies located on the main board are derived from a 18Vac isolated winding that is full wave rectified by BR2. The bridge BR2 supplies a +25Vdc (nominal) to C64 and -25Vdc (nominal) to C65 relative to the ISO COMMON line.

To enable each supply to be controlled from 0V, the auxiliary ± 1.25V rails are provided by regulators U7 and U8. The positive supply control potentiometer RV161 is returned to the -1.25V rail whilst RV162 negative supply control is returned to the +1.25V rail.

The maximum output voltage obtainable for the +ve supply is set by RV160 and the maximum -ve supply output voltage is set by RV163.

The output of both the isolated power supplies (+ and -) is current limited to provide a maximum current of approximately 1.2Amps. The voltage drop across R12 (R13) is applied between the base and emitter of Q1 (Q3). When this exceeds 0.6V, Q1 (Q3) conducts and current flows through R16 (R22) pulling Q2 (Q4) into conduction. As the emitter of Q2 (Q4) is returned to the -1.25V (+1.25V) auxiliary rail it will pull down the control input of U5 (U6) regulator thus allowing the respective power supply output voltage to operate down to zero.

Diodes D14, D15, D16 and D17 protect the regulators against reverse or over voltage at the output terminals.

5.1.2 +5V, 3Amp fixed supply.

The diodes D12 and D13 full wave rectify the 8Vac. The rectified DC voltage is filtered by capacitor C62 to reduce ripple. The regulator U18 has its output voltage set by resistors R116, R115 and R117. The output capacitor C68 is across the front panel terminals.

Over voltage and reverse voltage protection transistor Q22 is supplied with base current if the output rail is taken above +5.3V. If this occurs due to a fault in U18 or to an externally applied voltage, Q22 conducts and pulls the rail down to a maximum of +5.6V to protect externally connected signals to the +5V rail.

5.2 Function Generator

Refer to Fig 5.1 and drawing 3392. The Function Generator circuit design uses a the High Frequency Waveform Generator MAX038 integrated circuit (U13) to provide the triangle, sawtooth, sine, square and pulse waveforms. The MAXIM 038 and other associated high frequency circuits are located on the main pcb whilst the control circuits are located on the front panel pcb.

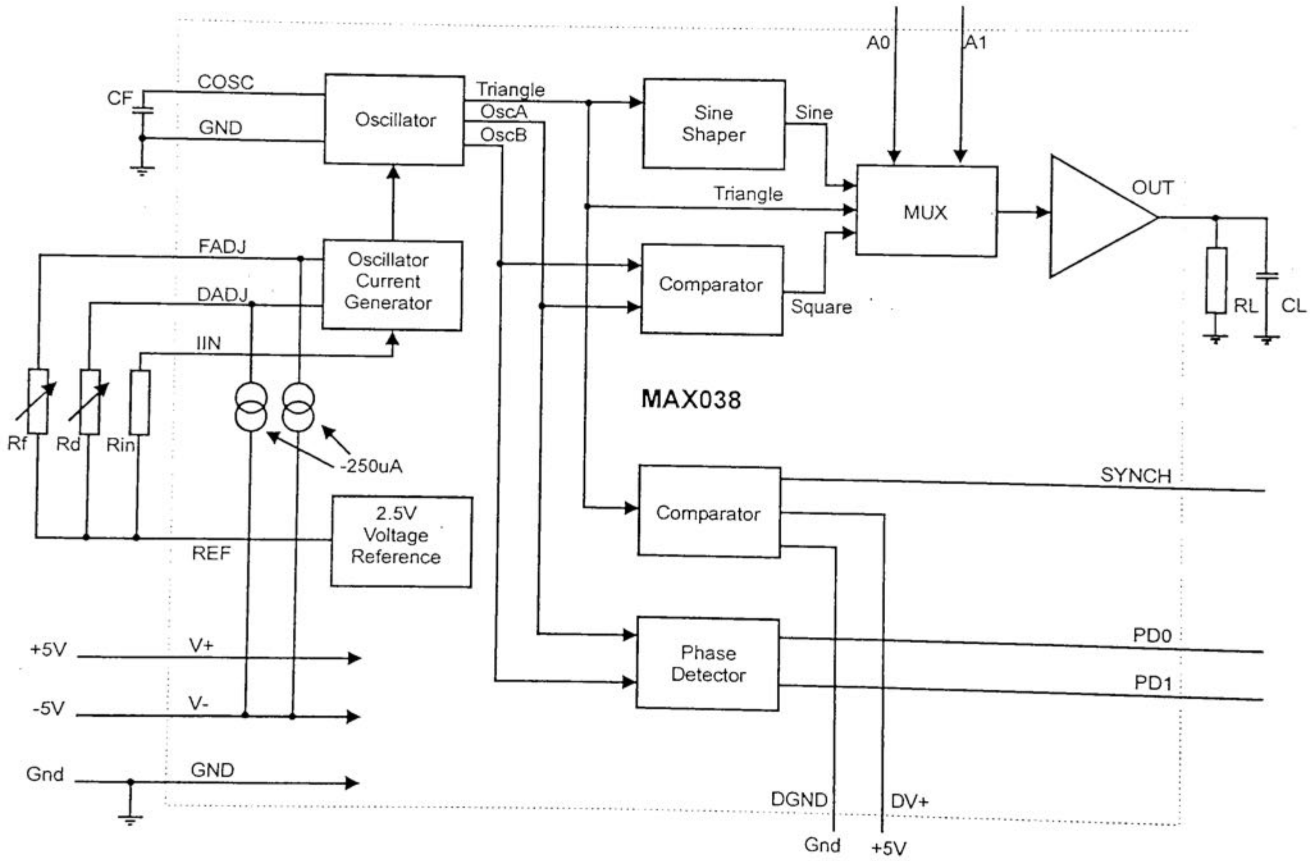


Fig 5.1 Function Generator Block Diagram and Basic Operating Circuit

5.2.1 Description of the MAX038 Waveform Generator.

The MAX038 is a flexible function generator integrated circuit that produces low distortion sine, triangle, sawtooth, square or pulse waveforms over the frequency range of less than 0.1HZ to more than 20MHz.

The Frequency and the Duty Cycle of the oscillator are independently controlled by programming the current, voltage or resistance of the internal oscillator current generator via FADJ, DADJ and IIN.

The desired output wave is selected under logic control by setting the appropriate code at the A0 and A1 inputs of the MAX038.

A SYNC output is provided for the triggering of external circuits.

The MAX038 is operated from a separate ±5V power supply derived from the ±15V main PCB supply. The ± 5V supply regulators are located near to the MAX038 and are decoupled (L1, L2, L3, L4) so as to reduce interference being fed back, via the supply rails, into any of the other BWD604 circuits..

The MAX038 oscillator is a relaxation type that operates by alternatively charging and discharging a capacitor, CF, with constant currents, simultaneously producing a triangle wave and a square wave. The charging and the discharging current is controlled by the current flowing into the IIN input. An internal closed loop amplifier forces IIN to virtual ground, with an input offset voltage of less than ±2mV. The generated charging and discharging currents can be modulated by the voltages applied to FADJ and DADJ. The output frequency is inversely proportional to capacitor CF.

The current into IIN is varied via multi-turn potentiometer RV202 (FREQUENCY) from greater than 2 μA to less than 750μ A. The IIN variation results in more than two decades of frequency change for any selected value of CF.

Applying ± 2.4V to the FADJ input changes the nominal frequency (at VFADJ=0V) by ± 70%: This procedure is used for implementing the frequency modulation mode of operation, refer section 5.2.4.

The Duty cycle (the percentage of time that the output waveform is positive) can be controlled from 10% to 90% by applying ± 2.3V to the DADJ input. This voltage changes the CF charging and discharging current ratio while maintaining nearly constant frequency.

The internal stable 2.5V reference voltage REF, allows simple determination of IIN,FADJ, or DADJ with fixed resistors and permits adjustable operation when potentiometers are connected from each of these inputs to REF, FADJ, and/or DADJ can be grounded, producing the nominal frequency with a 50% duty cycle.

A sine shaping circuit converts the oscillator triangle wave into a low distortion sine wave with constant amplitude. The triangle, square and sine waves are fed into a multiplexer the output of which is controlled by two logic level inputs A0 and A1.

The selected waveform is fed from the output of the multiplexer into an output amplifier that produces a constant 2Vpp amplitude (±1V), regardless of wave shape or frequency.

The triangle wave is also sent to an internal comparator that produces a SYNC waveform that can be used to synchronise external circuits.

The MAX038 generates two other phase-quadrature square waves that in conjunction with a phase detector generate PDI and PDO. This section of the MAX038 has not been made available to users of the BWD604 Ver2.

5.2.2 Waveform Selection

The output waveform is determined by the logic levels on the internal MUX address lines A0 and A1. The address lines levels are set by the positions of SW1 and SW2 push button switches as tabled below:

SW1	SW2	A0	A1	Waveform
OUT	OUT	x	1	SINE WAVE
OUT	IN	0	0	SQUARE WAVE
IN	OUT	1	0	TRIANGLE

Where X= don't care, 1 = +5V, 0= 0V

Switching of the waveform can be done at any time regardless of the phase or amplitude of the output. Waveform switching will occur within 0.3μs, followed by a possible small transient in the output waveform for up to 0.5μs.

5.2.3 Waveform Timing

The output frequency is determined by the current injected into the IIN pin of the MAX038, the value of the COSC (refer fig 5.1) capacitance to ground and the voltage on the FADJ pin.

When VFADJ = 0V, the fundamental output frequency (Fo) and period interval (To) is given by the formula:

Fo(MHz)=IIN (μA) / CF(pF)   (1)

To (μs) = CF (pF) / IIN (μA)   (2)

Where IIN = current injected into IIN input

CF = capacitance connected to COSC and GND consisting of CV1, C31 and either
C20 selected by SW4b or,
C21 selected by SW5b or,
C28 selected by SW6b or,
C32 selected by SW7b or,
C38 selected by SW8b or,
C39 selected by SW9b or,
C42 selected by SW10b.

The IIN input is driven with a voltage source (U12B) in series with a resistor R33. The formula for the oscillator frequency (Fo) and the period interval (To) is:

Fo(MHz) = VIN / (R33 x CF(pF)   (3)

$$To\ (\mu s) = CF\ (pF) \times R33 / VIN \qquad (4)$$

The output frequency is a direct function of the voltage as shown in the above equations and sweeping the voltage modulates the frequency.

The voltage into the buffer amplifier U12B is derived from either the front panel FREQUENCY potentiometer RV201 or from the LIN/LOG sweep generator. The mode of operation is selected by S202 (LIN/EXT/LOG)

In the EXT position the voltage is derived from RV201 that is connected between VREF and ground. This signal is fed to the input of the unity gain amplifier U12B whilst in either the LIN or the LOG mode the selected sweep generator output is fed into the unity gain buffer amplifier U12B

5.2.4 Frequency Modulation

The output frequency is modulated via the FADJ input. The FADJ input is connected to the unity gain buffer amplifier U12A. The input of U12A connected to the S202 switch buffer amplifier output (U11B), that is located on the front panel pcb.

The external FM mode of operation is selected with the LIN/EXT/LOG switch S202 in the EXT position. The ± 10V FM input is attenuated and then over-voltage protected prior to being connected to the S202 switch.

The fundamental frequency is set by the FREQUENCY potentiometer with the modulating input is at ZERO volts.

When the FM Input voltage is varied ±10.0Volts the output frequency will vary from 1.7 times down to 0.3 times the fundamental frequency (value when the voltage VFADJ equals zero volts).

The % deviation is directly related to the Voltage VFADJ

$$Dx\ (\%) = -VFADJ \times G/0.0343 \qquad (5)$$

where G = Instrument constant

Dx = Deviation in %

5.2.5 Symmetry Circuit

The voltage on DADJ controls the waveform duty cycle, defined as the percentage of time that the output waveform is positive.

In the Symmetry OFF position of S201, VDADJ = 0V and the duty cycle is 50% ± 2% prior to factory fine tuning.

The DADJ has a 250µA constant current sink to -5V and to reduce the effect of this current sink on the temperature coefficient of the MAX038 a unity gain amplifier output (U11B) is used as the voltage source.

The amplifier is connected to the wiper of RV1 that provides an adjustable ±mV dc voltage to enable the exact symmetry to be obtained and at the same time providing minimum distortion.

When the symmetry switch S201 is set to either non symmetrical modes of operation a +2.5V or -2.5V voltage is applied to the variable Symmetry potentiometer (RV202) the wiper of which is fed to the buffer amplifier (U11B) that is in turn connected to the DADJ input.

The duty cycle can be varied over the range 30% to 70% typically with minimal effect on the output frequency.

5.2.6 LOG-LIN Ramp

Refer also to drawing 3397. This circuit produces a variable frequency and variable amplitude linear or logarithmic ramp and a negative going pulse equal to the length of the reset time. When switched to linear Q203 acts as a constant current sink which discharges C201 linearly.

Transistors Q201 and Q202 reset C201 to zero (fully charged) when the voltage across C201 reaches +6.5V. To ensure the full charge on C201, the negative pull down across R201, 202 and 203 turns on Q200 which in turn pulls the base of Q203 positively, disconnecting it from discharging C201. When Q201 and 202 have pulled C201 down to +0.2V no current is available to keep then latched so they return to an open circuit state. R201, 202 and 203 return to normal, Q200 is cut off permitting the divider R208 and 209 to return to normal, Q203 conducts and the next cycle commences.

The output voltage across C201 is coupled through Q204 emitter follower to RV204 Sweep Range control and thence to S202B selector switch.

In the Log mode with S202A pushed down, positive feedback from Q204 collector allows C201 to be discharged exponentially to produce a logarithmic shaped ramp. All other functions remain the same except Q200 no longer affects the circuit as the logarithmic feedback collector circuit of Q204 reduces discharge current from C201 to zero during the return excursion.

5.2.7 Amplitude Modulator.

U14 is an amplifier with a continuously variable gain. The carrier input is applied to pins 3 and 6 whilst the modulation signal is connected to pin 2. The AM input is passed through a divider R51 and R52 to another divider chain R51, RV7, R54 and R39 connected between + and -15V. the voltage at the base of Q5 emitter follower is set by RV7 to bring the output level at pin 6 of U5 to 50% of the normal output level. Q5 base-emitter temperature variation compensates for the temperature variations of an internal diode on pin 2 of U14.

The balanced output of U14 is directly connected to U15 wide band amplifier that feeds S3B selector switch. Modulation distortion is adjusted by RV8 whilst RV9 centres the output signal. When AM is not selected S3A applies a DC voltage to the amplifier to bias it out of operation.

5.2.8 Function Generator Output Amplifier

Refer to Fig 5.2 and drawing 3396. This comprises a low frequency DC coupled amplifier and an AC high frequency amplifier. The HF amplifier comprises Q6, Q 7, Q8, Q9, Q10 and Q11. The DC amplifier is U16 op-amp. In the simplified schematic assume both input and output voltages are zero. If the input goes positive, current through R56 will cause the voltage at point A which is a virtual earth to rise. This will cause the base voltage of Q7 and 9 to rise increasing the current through Q7 and decreasing it in Q9 resulting in the voltage at point B and the output going negative. This negative fall is fed back to point A by the current through R76. The output signal will fall by the ratio of R56 to R76 = approx. x15, which sets the gain of the amplifier.

U18 op-amp biases the AC coupled amplifier and provides the DC and low frequency gain. Input to amplifier Q8 is taken from point A and its output drives Q9 and 7 emitters via R71 and R70 to provide good DC stability through the high open loop gain of the circuit. Emitter followers Q8 and 6 provide high frequency drive for Q9 and 7 whilst Q11 and 10 emitter followers provide the high current to drive the 50Ω output load.

Diodes D8 and D7 compensate for Q11 and Q10 base emitter voltage drops. RV11 centres the output voltage swing whilst RV12 OFFSET control supplies additional current via R60 to the junction at A when it is switched into circuit by S11, unbalancing the amplifier resulting in an offset output. R78, R79 and R80 in parallel set the output impedance of the amplifier to 50Ω.

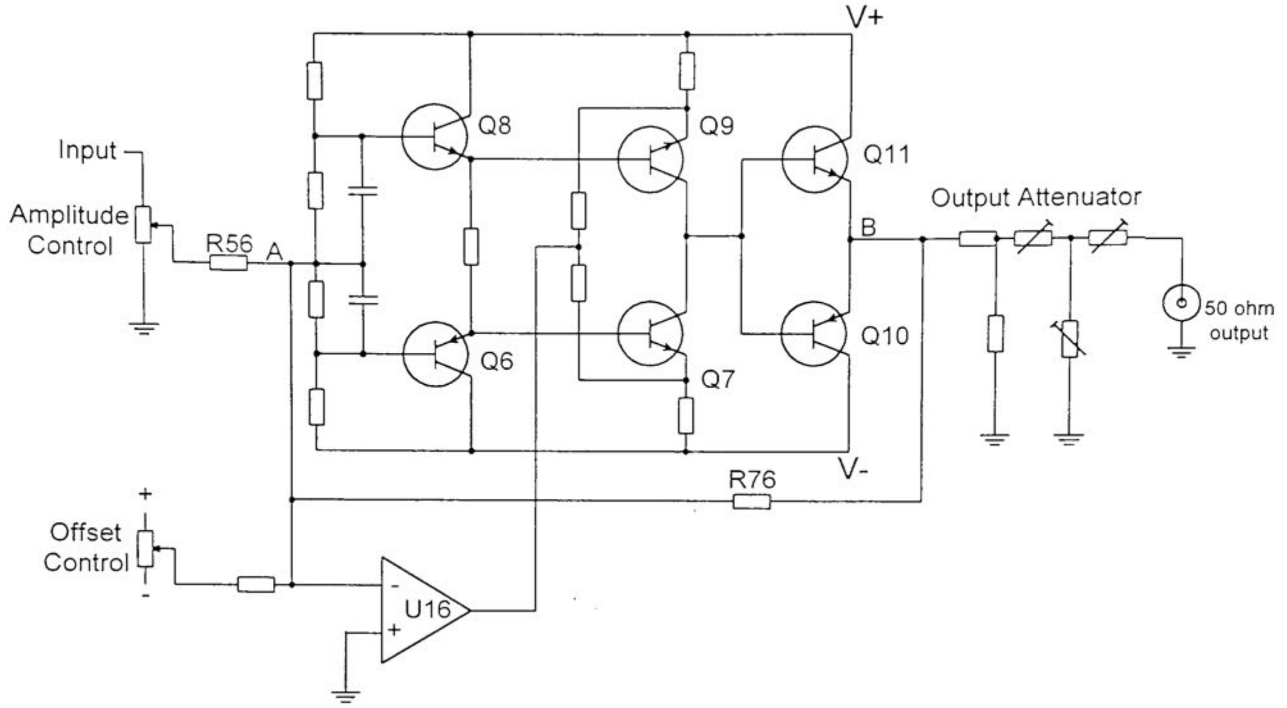


Fig 5.2 Function Generator Output Amplifier and Attenuator

5.2.9 Output Attenuator.

Two constant impedance T networks of 10 and 20dB attenuation may be switched independently or in series to provide 30dB attenuation. In conjunction with the variable control a 0 to >50dB range is available reducing the open circuit output from 20V to approx 63mV.

5.3 Power Amplifier / Bi-polar Power Supply

Refer to Fig 5.3 and drawing 3398.

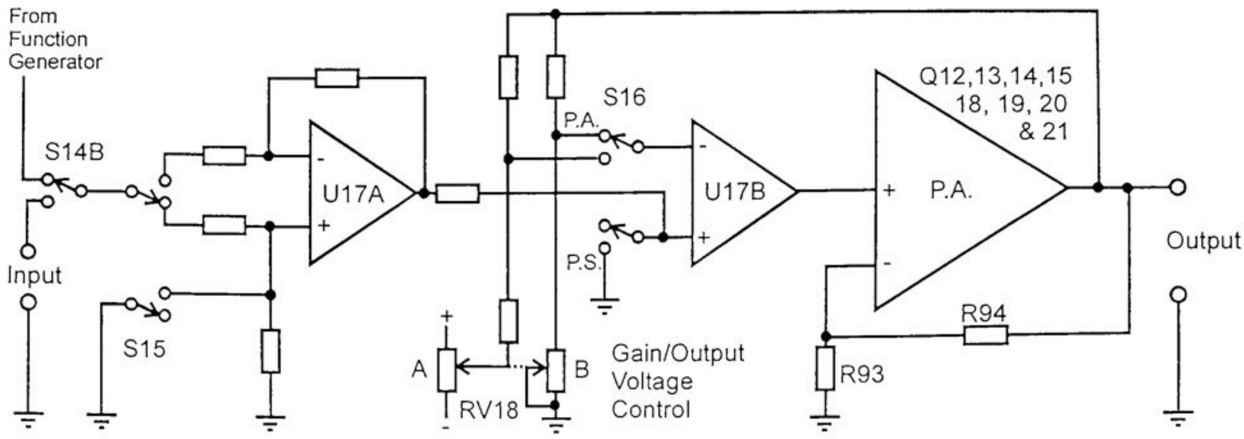


Fig 5.3 Power Amplifier/Bi-polar Power Supply Block Schematic

This circuit consists of U17A and U17B amplifiers driving a power amplifier Q12 to Q21 with negative feedback in both amplifier and power supply modes.

5.3.1 Power amplifier mode.

Input signals to the amplifier are selected by S14B from either the function generator output via R108 or from the front panel terminals. When external signals are selected the function generator signal is signal is grounded by S14A to minimise feed through. S15A NORM or INV selector feeds the signal via R109 and R108 attenuator in the NORM position to pin 3 of U17A or via R110 to U17A inverting input at pin 2 in the INV position. Both NORM and INV inputs are a constant 100kΩ input impedance.

S16 selects either the amplifier or power supply facilities. When Amplifier is selected, the input signal from U17A via R104 is connected to the non-inverting input of U17B pin 5 by S16B whilst S16A selects the overall negative feedback. This is taken via R107 and RV15 to the gain control RV18B and RV16 to ground. Variation of RV18B from min to max varies the negative feedback over a 100:1 range. Unity gain is set by RV15 and x100 gain by RV16. RV17 supplies a DC centring voltage to the output at x100 gain.

After amplification by U17B the signal is applied symmetrically to the push pull output amplifier by divider R102, Q16, Q17, RV19, R96 and R93. Q14 and Q12 amplifiers drive the complementary output stage as the signals developed across R91 and R100 collector loads are connected directly across the base - emitter junction of Q15 and Q18.

Negative feedback is applied around the power amplifier stage by R94 which feeds back the output signal to the common emitter resistor of Q14 and Q21, R93. The ratio of R93 and R94 sets the gain of the power amplifier to approx x2.4. This gain enables U17B with an output swing of ±12V to drive the power stage over its full output swing. High frequency response at x1 gain is adjusted by CV4 for best square wave response.

5.3.2 Power Supply Mode

The change over to Bi-Polar Power Supply is affected by S16 which selects another feedback divider and grounds the non-inverting input of U17B. R112 and R111 divider together with R113 is connected to RV18A front panel control which is placed across the ±15V rails. In the center position R113 has zero volts applied to it, so pins 5 and 6 of U17B will both be at zero also the output at pin 7 and via the power amplifier the output terminal.

When RV18A is moved clockwise from the centre, a negative voltage will be applied via R113 to inverting input pin 6. This will cause the output at pin 7 to go positive and via the power amplifier stage the output terminal J4 will also rise positively. The feed back resistors R112 and R111 will now apply a positive voltage to pin 6 equal and opposite to the negative voltage applied via R113. This will bring the voltage at pin 6 back to zero and the circuit to a quiescent state. When RV18A is turned counter clockwise the output falls negatively countering the positive voltage applied to R113 from RV18A.

Any variation at the output due to a load change will be fed back to pin 6 to bring the output back to its original value. C59 stabilises the loop gain of the circuit by rolling off the high frequency response.

5.4 Frequency Counter.

This circuit uses a 1 second crystal controlled clock to gate the counter IC U228 which in turn drives the 4 LED displays. The input frequency to be counted is selected by S220 from either the function generator output via R73 or from external signals applied to J220 input BNC connector and the amplifier consisting of Q220 to Q223.

The frequency to be counted is passed to U228 counter via U220A buffer, R234 and selector gate U223 when frequency is below 10kHz. Frequencies above 10kHz which would overload the counter display are divided down in decades by U221 and U222 dual decade dividers. The output of each divider is then taken to U223 a 1 of 8 selector, 5 of which are used. The gate enabled in U223 is determined by range switches S4-10 when the function generator is selected or S221 when external signals are to be counted. S220 effects the change over, S220B selects the signal applied to U220A, whilst S220C applies +5V or 0V to the selector pin 1 of U224 to enable the input voltages from the function generator when it is HI and from S221 when it is LO.

If the function generator is selected by S220, pins 3, 6, 10, and 13 are connected to the corresponding output pins 4, 7, 9, and 12 of U224. On the three lowest frequency ranges all inputs are held LO by S4 to S7, and the control inputs of U223 are also held LO via the U225A and U225B OR gates. This connects input pin 13 to output pin 3 and by direct connection to the counter input pin 8 of U228.

When the 4th range is selected, S7 connects pin 3 of U224 to +5V, pin 4 follows and via U225A gate takes pin 11 of U223 HI. This disconnects pin 13 and connects pin 14 of U223 to pin 3 output and the counter IC. In a similar manner as each frequency range is selected the control inputs of U223 are taken HI or LO selecting the appropriate divider output for that frequency range.

When S220 is pushed down to select the external counter input, S221 connections to U224 are activated to select the ranges whilst the function generator connections to pins 3, 6, 10, and 13 are disabled.

U228 counter is gated on for 1 second then reset for the next count period. A 32.768 kHz crystal controlled oscillator in U226 is divided down 2^{14} and then by 2^2 in U229 to generate a 1 second square wave at pin 1. This is differentiated by C332 and R237 before buffering by U227B gate. Its output is taken to pin 9 of the counter U228 to terminate the count period. The signal is also coupled into U227C gate and then to gate U227D and pin 14 of U228 where it resets the LED driver gates. This initiates the next counting period. The reset time is approx 5μsec long but as the minimum length of each count signal is 100μsec it has no effect the counting accuracy.

In the event of a signal higher than 10kHz being fed into the counter, a positive pulse will be generated at pin 1 when the counter overflows. This pulse is applied to a mono-stable circuit consisting of gates U227E and F and associated components. The positive pulse into U227E produces a LO at the output and a HI at F output on pin 8. This is communicated back to E input via C236 and R241, which hold E input HI for approx 0.5 sec as C236 discharges through R240 and R241 until the input falls past the hysteresis level of U227E, its output rises and the output at F falls. This has the effect of turning off the display for 0.5 sec. The action will be repeated if the signal continues to overflow the counter causing it to blink on and off.

The decimal point displays are switched by U220C, U220D and U220E gates from the same lines that select the division ratio in U223. The kHz - MHz LED's are also selected by the line to pin 9 of U223. Via U220F gate it turns on the MHz LED on the top two ranges and the kHz LED on the other ranges.

5.5 Counter Amplifier.

Signal applied to J220 front panel BNC connector is coupled to the input FET Q220 via limiting resistor R221 and parallel capacitor C221. Over voltage signals are clipped by diodes D220 and 221. Signals developed across R222 drain load are amplified by Q221 and fed back to the FET source resulting in a wide bandwidth low output impedance to feed Q222 and Q223 emitter coupled amplifier. The signal developed across R226 collector load is taken to S220B selector switch. S220A shorts out R226 when the function generator is selected.

5.6 Clock and other Output Waveforms.

The 1 second clock is taken via U229B connected as a buffer stage to R236 and then to the front panel output socket. The signals applied to the U220 counter are also available externally at the f/N socket via U220B inverting buffer followed by R235 limiting resistor.

5.7 Digital Meter. (See Fig 5.4)

This completely floating circuit is powered by an isolated winding on the power transformer T150. The AC is rectified by D300 bridge, filtered by C300 and regulated at +5V by U300. The negative -5V supply is supplied by an internal oscillator when a MAX 139 IC is fitted (U303) or by diode D301 followed by C318, R319 and zener diode D302 to regulate it if an ICL 7137 IC is fitted.

U303 is a complete digital meter requiring only an external reference input and a 3½ digit LED display, DIS300-303. When S300 is switched to V, or A, the input signal is applied to pin 36 and the LO input to pin 35. The reference voltage is obtained from the +5V rail via R318 and RV301 reference setting potentiometer.

The Voltage input signal is applied to a 10MΩ divider R301 and 302. Input range switches S302 to 306 select the input voltage in decade steps. S302 remains only as a fixed 100Ω resistor in series with S301 on the voltage ranges. The selected input voltage is taken via S302 to S301A AC-DC switch. If DC is selected S301B connects the voltage via S300C to pin 31 of U303 through an input filter R314 and C311.

When a current is applied between the Amp input and COM the current passes through S301E and S302 A-D as selected by the range switches. The voltage developed across the selected resistor(s) is then is then passed through R301 A-D as selected by the range switch in use, to S302, S301A and B when DC is selected and S300C to the input filter R314 and C311 to pin 31. In the event of a current greater than 2 Amps flowing through the input, the internal fuse will blow to protect the circuit and diodes D303 and D304 conduct and limit the current through the divider resistors.

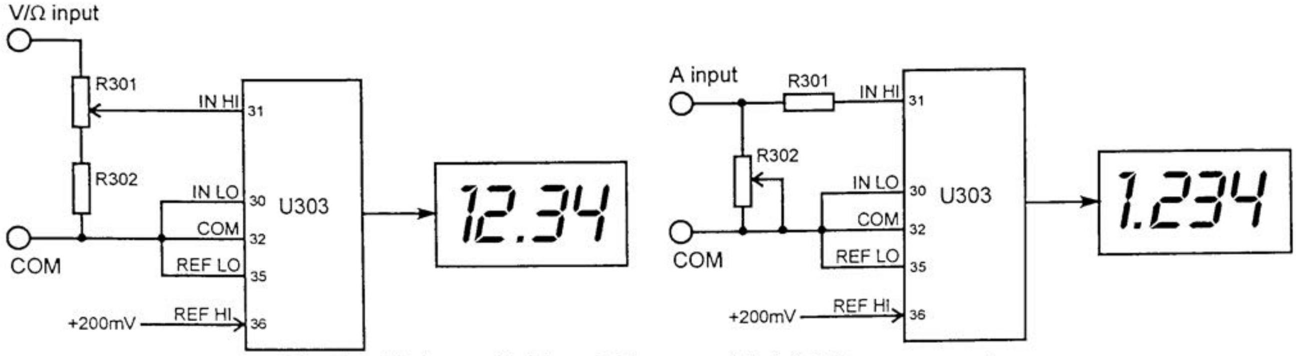


Fig 5.4 Voltage (left) and Current (right) Measurement.

5.7.1 AC Measurements.

When S301 selects AC the voltage to be measured is taken through C306 coupling capacitor and R307 voltage limiter to U302, an AC rms to DC converter. Diodes D305 and D306 protect the input against over voltage. The DC output of U302 is taken through S301B to S300C and then as before to pin 31 via R314.

5.7.2 Ohms Measurement.

When S300 is changed to Ω the entire configuration changes – see fig 5.5. The meter now compares the voltage developed across an unknown resistor with a voltage developed across a selected part of R301A to E. The measuring voltage is supplied from the +5V rail via R304 to the reference input pin 36 and to R301 via R303 - the latter replaces R302 to complete the 10MΩ divider R301. The reference LO input on pin 35 is connected to the input HI pin 31 via S300A, S300C and S300D switches.

The common connection remains connected to pins 30 and 32, the input LO and Common of U303.

When an external resistor is placed across the Ω input and COM, current flowing through R301 develops a voltage which is applied between the input Ref HI and LO of U303 whilst the voltage developed across R ext. is applied to pins 31 and 30, the measurement input. If the voltage across pins 30 and 31 is equal to that across 35 and 36 then the resistor values are equal and a full scale reading will be displayed. As the voltage across a resistor is directly proportional to its resistance the displayed voltage reading will equal the value of the unknown external resistor.

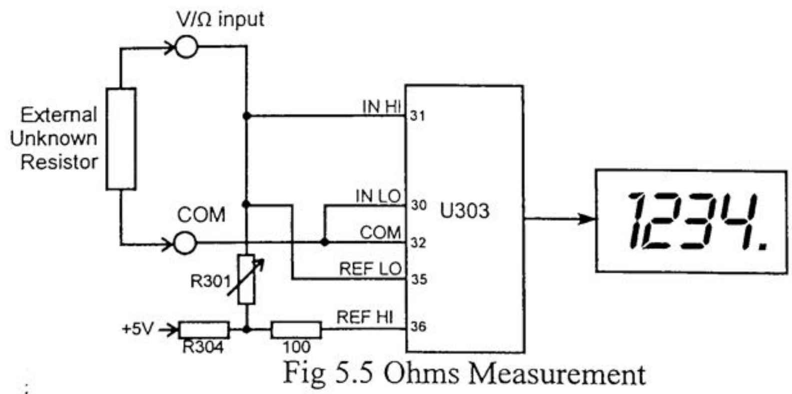


Fig 5.5 Ohms Measurement

6. ALIGNMENT PROCEDURE

The adjustments necessary to align a MINI-LAB are described on the following pages. It is necessary to remove the cover to perform the tests. Follow the procedure in section 7 of this manual for cover removal. The order of adjustments described follows a sequence so that each adjustment will not affect a previous adjustment. Orientation references (LHS, RHS etc.) are based on you facing the instrument's front panel.

Alignment should be made after the instrument has warmed up for 15 minutes and the ambient temperature should be between +20°C and +30°C to ensure the performance figures can be met over the specified temperature range.

6.1 Test Equipment Required.

Item	Specification	Application
DVM, 0-750V, 0-5amps	AC and DC volts and amps, accuracy < 0.25%	Power supply and DVM calibration
Oscilloscope and probes	DC – 50MHz bandwidth. 1mV to 10V/div sensitivity	Alignment of Function Generator, Amplifier and Power Supplies.
Digital Frequency Counter	10Hz to 50MHz range	Function Generator and Counter calibration.
Sine Wave Analyser	5Hz to 560KHz range, 0.01 to 10% THD	Function Generator and Power Amplifier distortion
15Ω, 10W load	Non-inductive	Power Amplifier response

Normal servicing tools including a low capacity insulated screwdriver.

Refer to PCB layouts to locate the components referred to. Component designations on PCB489 (main PCB – Fig 6.1) have numerical suffixes from 1 to 199, PCB488 (counter PCB – refer Fig 6.2) have suffixes from 200 to 299. PCB486 and PCB487 (DVM PCBs – refer Fig 6.3) have component suffixes from 300 to 399.

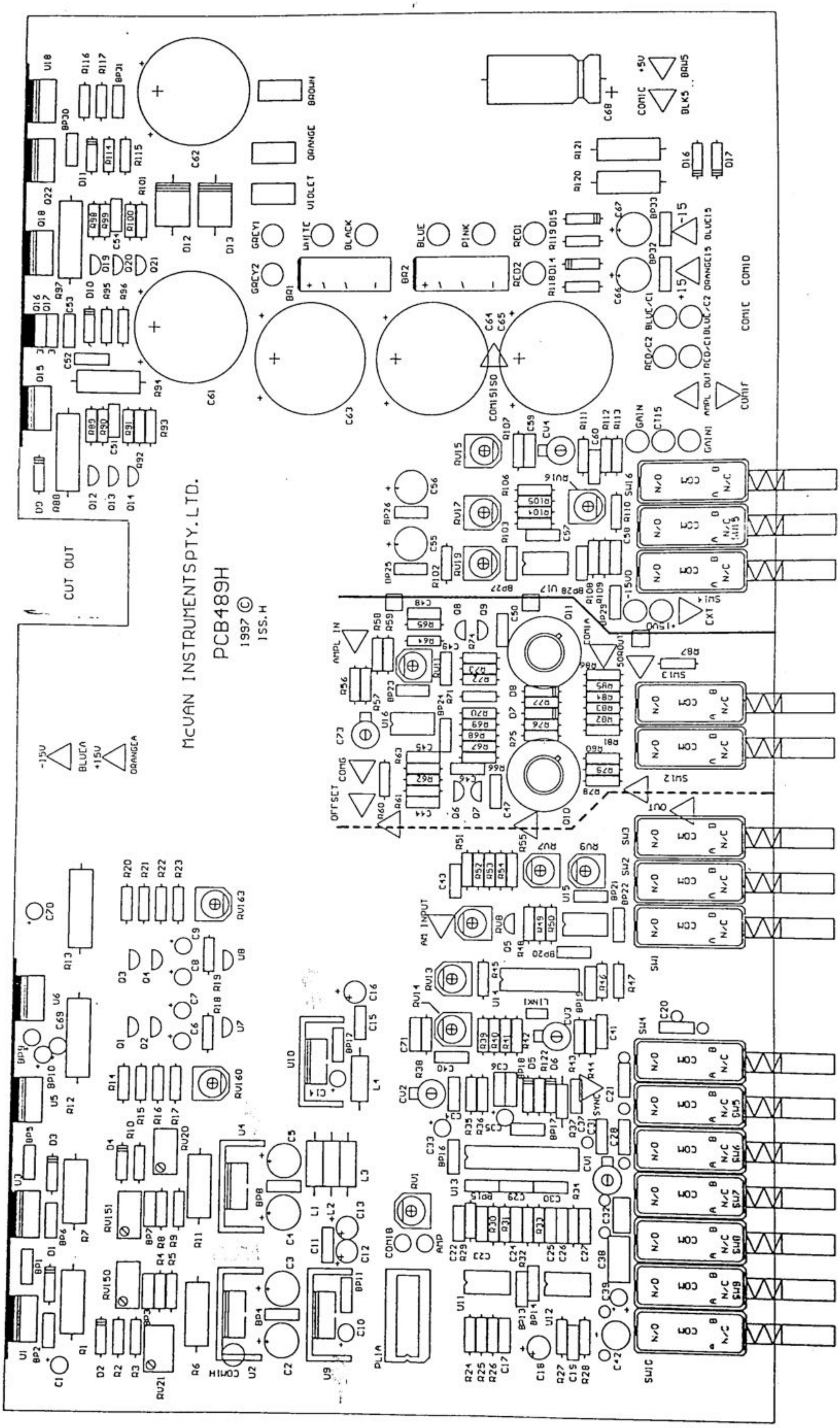
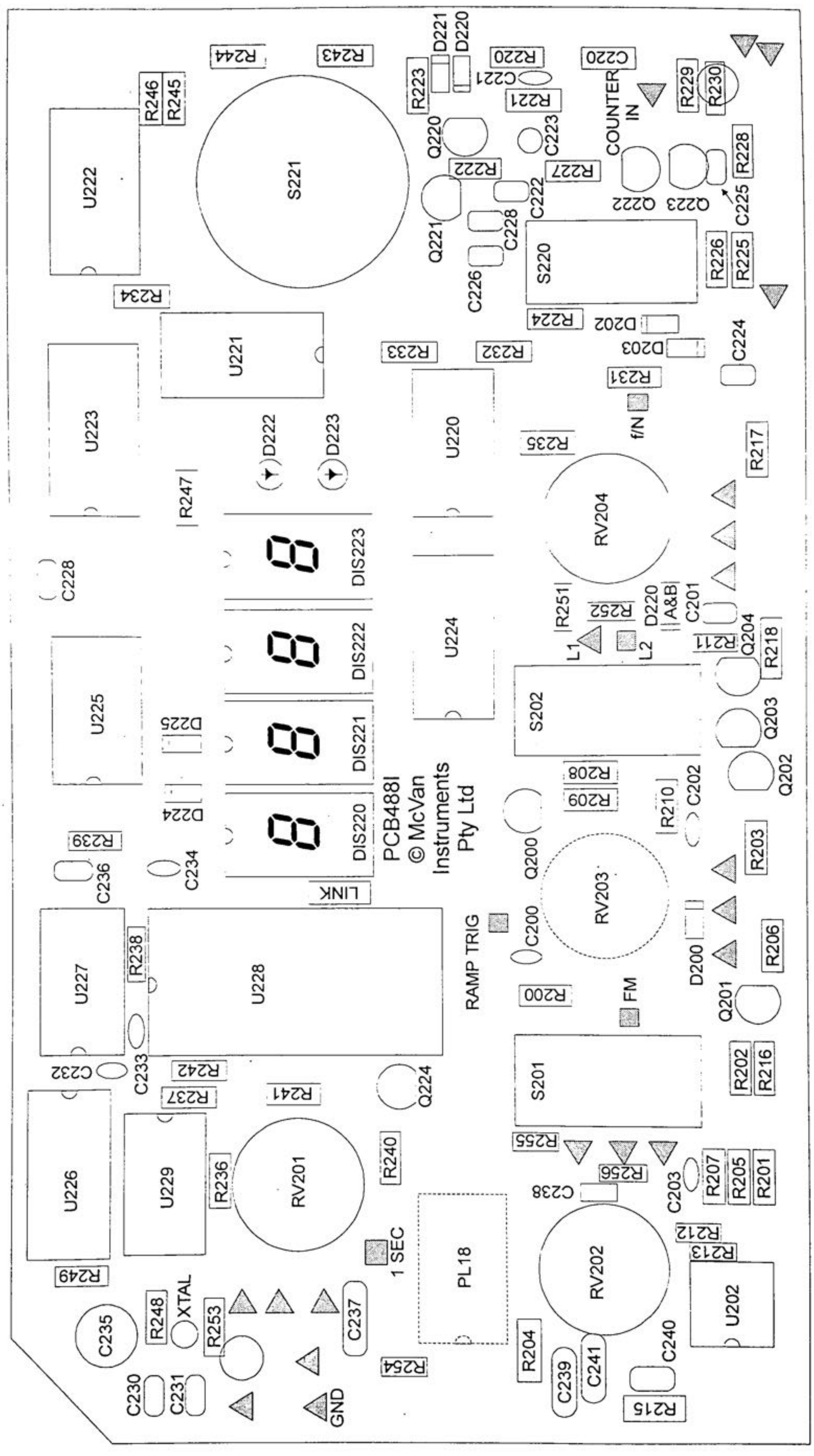


Fig 6.1 – PCB489 Main PCB Layout showing Component Designations.



Components in DASHED outline are fitted on the underside of the PCB.

Fig 6.2 – PCB488 Counter PCB Layout and Component Designations.

6.2 Internal Power Supply Adjustments

6.2.1 ±15Volt power supplies.

RV150 and RV151 ±15V adjustments on PCB489 are set first as they are used throughout the instrument and will affect calibration and performance of all sections (other than the DVM) if they are incorrect.

+15V supply.
Connect the DVM between chassis and +15V LHS end of R1, set RV150 for +15.0V ±0.1V.

-15V supply
Connect the DVM between chassis and -15V RHS end of R7, set RV151 for -15.0V ±0.1V.

6.2.2 ±6V power supplies.

+6V supply
Connect the DVM between chassis and +6V, RHS end of R6, set RV21 for +6.00V ±0.1V.

-6V supply
Connect the DVM between chassis and +6V, LHS end of R11, set RV20 for -6.00V±0.1V.

6.2.3 ±5V power supplies.

+5V supply
Connect the DVM between chassis and +5V, LHS top pin of U300 on the MINI-LAB DMM PCB. The voltage indicated should be between +4.75V and +5.25V.

-5V supply
Connect the DVM between chassis and -5V, LHS top end of C302 on the MINI-LAB DMM PCB. The voltage indicated should be between -4.00V and -5.00V.

6.3 Function Generator Alignment.

6.3.1 Amplifier Centring adjustment and OFFSET Control adjustment range check

Select square wave output and frequency of approx 1kHz. Turn the front panel Amplitude control to minimum and press in the 10 and 20dB attenuator buttons. Ensure the Offset control is fully counter clockwise in the off position. Connect an oscilloscope to the output BNC, set sensitivity to 50mV/div, DC coupled and position trace to centre of screen. Reduce oscilloscope sensitivity to 0.2V/div, release 10 and 20 dB buttons, if trace moves re-centre display with RV11. The output amplifier DC offset preset is now set for ZERO volts.

Select Function Generator DC OFFSET CONTROL to ON and check range of operation is ± 5V as dial is turned from fully CCW to fully CW. Turn the DC OFFSET Control to the OFF position after completing the range check.

6.3.2 Triangle Wave Amplitude Adjustment.

With 10 and 20dB attenuator buttons out, output Amplitude to maximum (CW) select square wave output. Connect oscilloscope set to 5V/div, DC coupled to output BNC, center display vertically on the oscilloscope display. Press triangle button, adjust RV14 (near centre of main pcb) to make the triangle amplitude 10.4Vpp into 50Ω termination

6.3.3 Waveform Symmetry.

Select square wave, 1kHz range, turn frequency Vernier for 1kHz.

Set oscilloscope to +ve normal (non-Auto) trigger, then adjust time base until one waveform occupies precisely 10 divisions. Adjust RV1 to bring negative step of the square wave to exactly center screen.

6.3.4 Max Frequency Calibration.

Select 10MHz range. Turn frequency Vernier to maximum (CW). Adjust CV1 for reading of 21.00MHz on the Function Generator Display.

6.3.5 Sine Wave Distortion Check

Connect a Distortion Analyser meter to the Function Generator output. Set the level on the meter and then switch to distortion, select a range where the reading is approx centre scale. Now adjust RV1 for minimum distortion reading on the Distortion Analyser meter. It should be possible to get the distortion down to approx 1.5% distortion over the range 10Hz to 20kHz and <2% up to 500kHz.

Finally reconnect the oscilloscope to the output and reset RV5 and RV6 for centering and amplitude if necessary.

6.4 Amplitude Modulator.

Select maximum output and sine wave, 1MHz frequency on 1MHz range. Centre waveform on oscilloscope, press AM button. Waveform should remain centred and be half amplitude of normal display. Adjust RV9 to centre waveform and RV7 to set half amplitude. Apply a 1kHz, 4V pk-pk sine wave to the AM terminal. Trigger the monitoring oscilloscope to the 1kHz modulating waveform. Set modulation amplitude to just below that of maximum modulation. Adjust RV8 for symmetrical modulation. Re-centre display with RV9. Depth of modulation should remain constant over the entire frequency range and practically constant over a DC to 1MHz modulation range. Release the AM button.

6.5 Power Amplifier.

Connect the oscilloscope to the Function Generator output BNC socket, leave all three push buttons out so that the Function Generator is connected to the amplifier. Set the Function Generator to 1kHz sine wave and full output. Turn POWER AMPLIFIER gain control to x1.

Monitor Function Generator output at the BNC socket, then move oscilloscope probe to POWER AMPLIFIER output terminals. Adjust RV15 to set level equal to FUNCTION GENERATOR output, press NORM-INV button to check amplitude is similar.

Turn POWER AMPLIFIER gain control fully clockwise, reduce FUNCTION GENERATOR output to display the same amplitude on the screen. If trace has moved up or down, re-centre with RV17. Monitor output of Function Generator, set to 200mV p-p, i.e 4 div deflection at 50mV/div. Now connect oscilloscope to POWER AMPLIFIER output terminals and set attenuator to 5V/div, then adjust RV16 for 4 div deflection. Re-centre with RV17 if necessary.

To set response, reduce gain to x1 N/INV to NORM and change output to square wave. Increase FUNCTION GENERATOR output to max, set frequency at 10kHz. Connect oscilloscope across output terminals of POWER AMPLIFIER using a 10:1 probe. Place a 15Ω 10w non-inductive load across the output terminals. Adjust C41 for optimum square wave shape.

NOTE. Overshoot may be different on + or - edges of square wave, adjust for optimum on minimum overshoot corner.

No adjustments are required for the Bi-Polar Power Supply.

6.6 Positive Variable Regulated Power Supply.

Connect a DVM between white and red output terminals, set DVM to 20V range. Turn 0 to +15V control fully clockwise, set RV160 for +15.3V.

6.7 Negative Variable Regulated Power Supply.

Connect DVM between blue and white output terminals, set DVM to 20V range. Turn 0 to -15V control fully clockwise, then set RV163 for -15.3V.

NOTE: The MINI-LAB Digital Meter can be used for power supply alignment if previously calibrated.

6.8 Digital Meter.

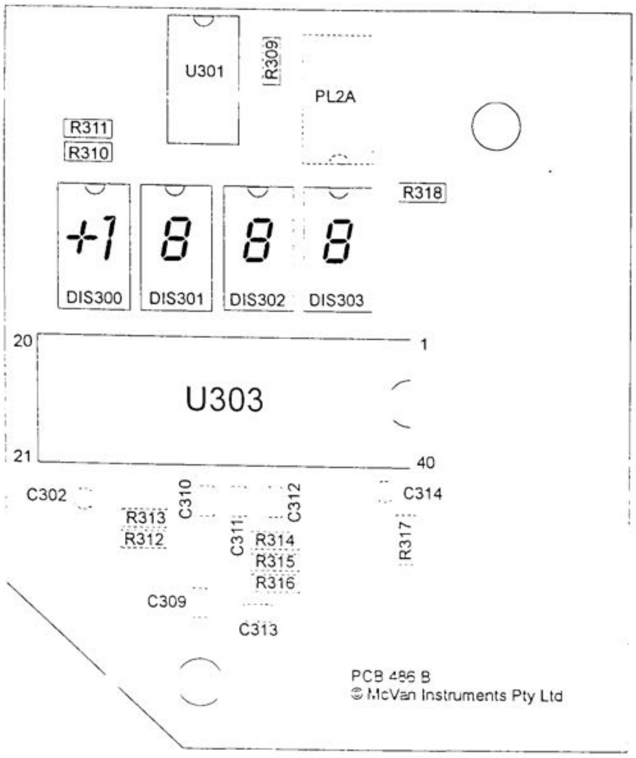
Refer to Fig 6.3. Switch to DC Volts and 200mV range. Connect a known precision voltage between the red and blue (V and COM) input sockets and set input to 190mV DC. Adjust RV301 until DVM reads 190mV.

Alternatively, connect a variable voltage to the red and blue input sockets, then connect in parallel a DVM with an accuracy of better than 0.25%. Set the voltage to approx 190mV, adjust RV301 until the MINI-LAB DVM reads the same as the external DVM.

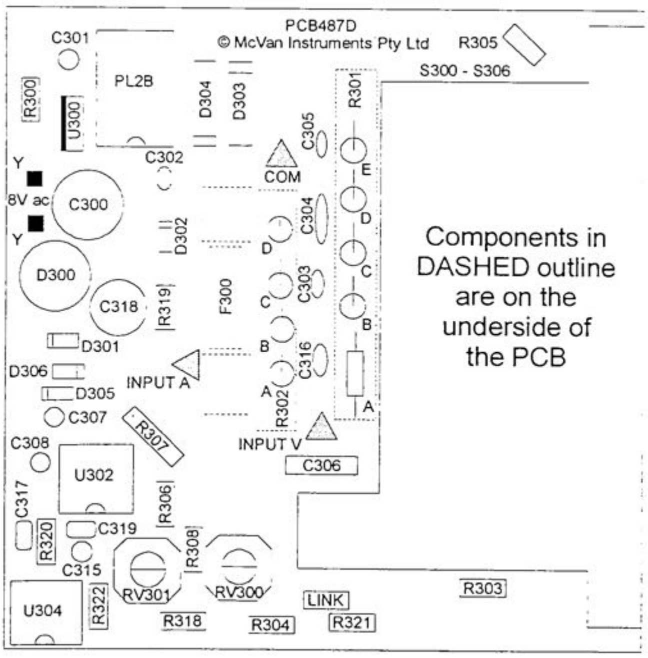
6.8.1 AC Centring Adjustment.

Place a short circuit across the red and blue sockets. Select AC rms and 200mV. Adjust RV300 (nearest front panel) for zero reading. NOTE: with short circuit removed some reading due to pick up will be present on the display. This will be eliminated when meter leads are connected to a circuit.

All adjustments are now complete.



Components in DASHED outline are on the underside of the PCB



Components in DASHED outline are on the underside of the PCB

Fig 6.3 – PCB486 and PCB487 DVM Layout and Component Designations

7. MAINTENANCE

7.1 Introduction.

To increase the life of your instrument, several simple precautions should be undertaken regularly. If the instrument is only used intermittently, or in a dusty atmosphere, it should be kept covered with a dust cover when not in use.

Dust and dirt should be cleaned from the panel and controls, using a 1% solution of a mild detergent. Do not wet the instrument, otherwise the liquid may penetrate inside the cover or controls.

7.2 Maintenance Tools.

No special tools are required to service a MINI-LAB. All screws are standard slotted or cross head, all knob fixing screws are 3mm Allen grub screws. De-soldering or soldering requires only normal electronic service tools.

7.3 Removing the Cover

> **WARNING**
>
> To avoid electric shock, disconnect the instrument from the power input source before removing the cover or replacing any component or assembly.

To remove the cover, perform the following steps;

a) Disconnect the power cord from the rear of the instrument and from the power source.

b) Stand the instrument face up on the heat sinks. Remove the four screws holding the feet and two holding the handle end covers, then slide the cover down. With the cover resting on the bench, lift the MINI-LAB clear of the cover by holding the side edges of the front panel.

c) When replacing the cover, follow the reverse procedure. Make sure the cover fits evenly all around the panel trim. Tip gently onto the top and fit the feet taking care to fit the flat washers between the feet and cover.

d) Stand the instrument on its feet and replace the handle.

7.4 Removal of Heat Sinks and Power Semiconductors.

To remove a device from the heatsink carefully de-solder the device from the PCB using a solder sucker and solder wick. Undo the screw holding the device onto the heatsink Remove the cap screw and shakeproof washer and carefully remove the device from the heatsink

ENSURE THAT THE DEVICE IS CORRECTLY DE-SOLDERED SO AS TO AVOID DAMAGE TO THE PLATED THROUGH HOLE PADS AND TRACKS.

Lift the regulator/transistor carefully off the heat sink making sure the insulating washer and thermal conductive insulation is not damaged. When replacing the regulator or transistor ensure both the heat sink and device being replaced is clean. Then coat both of them with a heat sink paste, position the thermal conductive insulation (mica washer or sil-pad) on the heat sink then take the device with the insulating bush and locate the bush through the thermal conductive insulation and into the heat sink hole. Fit the screw and washer and tighten down.

NOTE: Use only a mica washer for insulation as other insulators have a higher thermal conductivity for the 5Volt regulator U18

7.5 Removal of DVM Assembly.

Remove three wires plugged onto the front panel V, COMM and Ω sockets. Disconnect the two yellow wires from the transformer. Press in the bottom three push buttons, V/A, DC and 200mV then remove the screws holding the top of the PCB's to pillars. Tip the DVM PCB's back, press the bottom push button in with a plastic rod then lift the assembly out.

To replace the DVM push in the bottom three push buttons, then slide the assembly down with the top tilted back until the slots at the bottom of the PCB slide over the two screws projecting from front panel pillars. With a plastic rod push in the bottom push button up to its stop, then tip the assembly upright helping the push buttons clear the panel holes if necessary with the plastic rod.

Reconnect the two yellow transformer leads and the three front panel wires, the colours correspond to the input socket colours.

7.6 Removal of Counter PCB.

Remove the knobs on the front panel related to the counter PCB, then unplug the two leads on the back of the right hand end. Unplug the plug at the top end of the ribbon cable and remove two screws at the left hand end of the PCB. Finally remove the nut holding the range switch to the front panel, and pull the board away from the front panel. If the PCB is to be removed completely from the frame, disconnect the four wires plugged into the front of the board noting their location for when the board is replaced.

To replace the counter board reverse the above procedure making sure the wires to the front of the board are in their correct places and that they do not interfere with any of the controls and are clear of the display. Remember to pass the counter input wire from the BNC socket through the hole in the PCB whilst refitting.

7.7 Interconnecting Ribbon Cables and Wires.

Care must be taken when removing interconnecting ribbon cables or individual wires to ensure that they are refitted back in the same place. Remove individual wire plugs carefully otherwise the socket may become loose on the pin. If thus occurs they can be retightened by gently squeezing the socket when removed from its mating pin.

7.8 Replacing Electronic Components.

Transistors, FET's and integrated circuits should not be replaced unless they are faulty. If removed from the circuit board during fault finding and found OK, return them to their original locations. Replacement or relocating them may affect the adjustment of the instrument. When a semi-conductor is replaced, check the performance of any circuit that may be affected.

Replacement components should be of the original type or a direct replacement. Most ICs are fitted in sockets for easy replacement during servicing, make sure they are replaced correctly oriented.

7.9 Internal Cleaning.

Completely disconnect the MINI-LAB from power and external circuits. Remove the cover.

Clean off dust with dry low pressure air. Remove any remaining dirt with a brush or a cloth, dampened with a solution of mild detergent and water. A cotton bud can be used to clean narrow spaces on circuit boards. Ensure all circuits are dry before replacing the cover and reapplying power.

8. *FAULT FINDING*

8.1 Circuit Diagrams.

These are located on pages at the rear of this manual. Division of circuitry on different boards is indicated by dotted lines encompassing each circuit.

8.2 Procedure.

The following procedures check simple problems. The initial steps verify correct control settings, operations and adjustments. If the trouble is more extensive use the circuit description and circuit diagrams to locate the fault. When corrected, check against the specification or align the circuit as in section 6.

8.3 Check Control Settings.

Incorrect control settings can give a false indication of failure. Refer to either section 3 and 4 of this manual if there is a query use or operation of any control.

8.4 Check Equipment connected to the MINI-LAB.

Ensure that instruments or equipment connected to the MINI-LAB are not causing an apparent fault condition. e.g. highly inductive loads on Power Amplifier output causing ringing on the output, or an intermittent or open circuit probe connected to the counter. Faulty BNC to BNC 50Ω cables with open or shorted signal or ground leads are a major source of trouble.

8.5 Visual Check.

Check for broken wire connections, ribbon connectors partially unplugged, damaged components, ICs not fully inserted in sockets, damaged circuit boards, or other damaged parts.

WARNING

To avoid electric shock, disconnect the instrument from the power line source before visually inspecting the PCB's and other internal parts.

8.6 Performance Check against Specification.

Check the performance of either those circuits where trouble appears to exists, or the entire instrument if necessary. Re-align the repaired section as described in section 6.

WARNING

Dangerous voltages exist on the AC input circuits in this instrument. If it is operated with the cabinet removed, do not touch exposed connections or components, unless you are certain of the voltages in the vicinity.

8.7 Check Power Supply Circuits.

Because the MINI-LAB instrument is transformer operated with normal rectified supplies, it can be run up slowly with a variable voltage transformer. This enables power circuits to be operated at low voltages when checking for faulty circuits. Also as the transformer secondaries are plugged into the PCB each secondary can be disconnected to assist in isolating a faulty circuit.

If all leads from the transformer except the grey, black and white wires are removed from the PCB, only the internal ±15V and ±6V rails will be left operative. Be sure not to short out any leads removed from the transformer.

NOTE: The function generator digital display is taken from the 5V rail, therefore orange, violet and brown leads must also be plugged in for this facility to work.

If the fault is not located by DC measurements, use an oscilloscope to verify circuit performance.

NOTE: Most waveforms are affected by switch or control positions, so ensure these settings are taken into account when examining a circuits performance.

8.8 Circuit Repair and Adjustment.

Once the defective part is located, replace it with an identical part or one that is equal to or better in specification and similar in size. After replacing the component the repaired circuit should be checked for performance against the specification. As the ±15V and ±6V power supplies affect every circuit except the DVM and isolated ±15V power supplies, the entire instrument should be checked after work on any part of these circuits.

WARNING

To avoid electric shock, always disconnect the instrument from the power line before removing or replacing components.

8.9 Special Parts.

In addition to the standard electronic components, some special parts are used in this instrument. These parts are manufactured or selected by McVan Instruments to meet special requirements. All electrical and mechanical parts can be obtained from McVan Instruments or one of their distributors. Many of the parts can be obtained from a local source. Before purchasing a part from a source other than McVan Instruments or a distributor, check the component parts list for the correct rating, tolerance and description.

NOTE: Physical size and shape of a component may affect instrument performance particularly at high frequencies or power. Always use identical components unless it is known that a substitute will not degrade the instrument performance.

8.10 Ordering Replacement Parts.

It is essential when ordering parts to include the following information in your order:-

a) Instrument type (include modifications or options if applicable).
b) Instrument serial number.
c) A description of the part and the McVan Instrument part number or circuit designation.

8.11 Packaging for Shipment.

If the instrument is to be returned for servicing, attach a tag showing the name of a person and telephone/fax number to can be contacted, return address, the instrument's serial number, the nature of the service required and proof of purchase if repair is claimed under warranty.

Surround the instrument in plastic sheeting to protect its finish. Use the original packing if it is available or pack in a strong corrugated carton or wooden crate. Pack at least 8cm of foam or similar packaging around the instrument to firmly support it in the box.

9. *PARTS LIST & CIRCUIT SCHEMATICS*

9.1 Component Designations.

A	Assembly	H	Heater	RV	Variable resistor
B	Lamp	J	Jack	S	Switch
C	Capacitor	L	Indicator	T	Transformer
D	Diode	M	Meter	TH	Thermistor
DL	Delay line	P	Plug	VDR	Voltage dependent resistor
F	Fuse	Q	Transistor	R	Resistor

9.2 Abbreviations.

Amp	Ampere (A)
c	Carbon
CDS	Ceramic disc
CMC	Cer. multilayer capacitor
DPST	Double pole single throw
DPDT	Double pole double throw
elec	Electrolytic capacitor
FET	Field effect transistor
kHz	Kilohertz = 1000 Hz
kohm	Kilo-ohms = 1000 Ω
Lin	Linear
Log	Logarithmic
m	milli = 0.001
MHz	MHz = 1,000,000Hz
MF	Metal film
mA	Milliampere = 0.001Amps
MΩ	Megohm = 1,000,000ohms
mfr	Manufacturer
MO	Metal oxide
MHT	Polyester capacitor
MPC	Metalised polyester cap.
Ne	Neon
NPO	Zero temperature coefficient
ns	Nanosecond = 0.000,000,001sec
p	Peak
pF	Pico Farad = 10^{-12}F
preset	Internal preset
PYE	Polyester
pot	Potentiometer
PCB	Printed circuit board
PIV	Peak inverse voltage
PYS	Polystyrene
p-p	Peak to peak
rot	Rotary
rms	Root mean square
RV	Variable pot
si	Silicon
tol	Tolerance
trim	Trimmer
Ta	Tantalum
V	Volts
var	Variable
W	Watt
ww	Wire wound

9.3 Parts List

Pages follow on immediately.

9.4 Circuit Schematics

Pages follow on immediately after the Parts List.

9.3 BWD604 V2 Parts List

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
Component Designator = BP						
BP 1	100n	50V	20.0%		CMC	CPC104P5000
BP 2	100n	50V	20.0%		CMC	CPC104P5000
BP 3	100n	50V	20.0%		CMC	CPC104P5000
BP 4	100n	50V	20.0%		CMC	CPC104P5000
BP 5	100n	50V	20.0%		CMC	CPC104P5000
BP 6	100n	100V	5.0%		MKT	CPP104P1013[illegible]
BP 7	100n	50V	20.0%		CMC	CPC104P5000
BP 8	100n	50V	20.0%		CMC	CPC104P5000
BP 9	10u	35V			TANTALUM	CPT100U3505
BP 10	10u	35V			TANTALUM	CPT100U3505
BP 11	100n	50V	20.0%		CMC	CPC104P5000
BP 12	100n	50V	20.0%		CMC	CPC104P5000
BP 13	100n	50V	20.0%		CMC	CPC104P5000
BP 14	100n	50V	20.0%		CMC	CPC104P5000
BP 15	100n	100V	5.0%		MKT	CPP104P1013[illegible]
BP 16	1n	50V	10.0%		CDS	CPC102P5004
BP 17	1u	50V			CMC	CPC105P5000
BP 18	1n	50V	10.0%		CDS	CPC102P5004
BP 19	100n	50V	20.0%		CMC	CPC104P5000
BP 20	100n	50V	20.0%		CMC	CPC104P5000
BP 21	100n	50V	20.0%		CMC	CPC104P5000
BP 22	100n	50V	20.0%		CMC	CPC104P5000
BP 23	100n	50V	20.0%		CMC	CPC104P5000
BP 24	100n	50V	20.0%		CMC	CPC104P5000
BP 25	100n	50V	20.0%		CMC	CPC104P5000
BP 26	100n	50V	20.0%		CMC	CPC104P5000
BP 27	100n	50V	20.0%		CMC	CPC104P5000
BP 28	100n	50V	20.0%		CMC	CPC104P5000
BP 29	100n	50V	20.0%		CMC	CPC104P5000
BP 30	100n	50V	20.0%		CMC	CPC104P5000
BP 31	100n	50V	20.0%		CMC	CPC104P5000
BP 32	100n	50V	20.0%		CMC	CPC104P5000
BP 33	100n	50V	20.0%		CMC	CPC104P5000
Component Designator = BR						
BR 1	RS402L			BRIDGE RECT.		RECRS402L
BR 2	RS402L			BRIDGE RECT.		RECRS402L
Component Designator = C						
C 1	100u	25V			ELECTRO	CPE101U2506
C 2	100u	25V			ELECTRO	CPE101U2506
C 3	100u	25V			ELECTRO	CPE101U2506
C 4	4u7	25V	20.0%		TANT	CPT475P25057
C 5	100u	25V			ELECTRO	CPE101U2506
C 6	4u7	35V	20.0%		TANT	CPT475P35057
C 7	1u	35V	20.0%		TANT	CPT105P35057
C 8	1u	35V	20.0%		TANT	CPT105P35057
C 9	1u	35V	20.0%		TANT	CPT105P35057
C 10	10u	25V			TANTALUM	CPT100U2505
C 11	10n	50V	20.0%		CMC	CPC103P6300
C 12	10u	25V			TANTALUM	CPT100U2505
C 13	10u	25V			TANTALUM	CPT100U2505
C 14	10u	25V			TANTALUM	CPT100U2505
C 15	10n	50V	20.0%		CMC	CPC103P6300
C 16	10u	25V			TANTALUM	CPT100U2505
C 17	100n	100V	5.0%		MKT	CPP104P10139
C 18	10u	25V			TANTALUM	CPT100U2505
C 19	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 21	470P	100V	5.0%	N220	CDS	CPC471P1013
C 22	100n	50V	20.0%		CMC	CPC104P5000
C 23	100n	50V	20.0%		CMC	CPC104P5000

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
C 24	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 25				NOT FITTED		CPE1O5P6306
C 26	100n	50V	20.0%		CMC	CPC104P5000
C 27	100n	50V	20.0%		CMC	CPC104P5000
C 28	4n7	50V	10.0%		MKS2	CPP472P50049
C 31	2p2	50V	10.0%	NPO	CDS	CPC229P5003
C 32	47n	50V	10.0%		MKS2	CPP473P50049
C 33	1u	35V			TANTALUM	CPT105P35057
C 34					NOT FITTED	
C 35	1u	35V			TANTALUM	CPT105P35057
C 36					NOT FITTED	
C 37					NOT FITTED	
C 38	470n	50V	10.0%		MKS2	CPP474P50049
C 39	4u7	35V			TANTALUM	CPT475P35057
C 40	100n	100V	5.0%		MKT	CPP104P10139
C 41	100n	100V	5.0%		MKT	CPP104P10139
C 42	47u	16V			ELECTRO	CPE470U1606
C 43	22p	100V	5.0%	NPO	CDS	CPC220P1013
C 44	10n	50V	20.0%		CDS	CPC103P5000
C 45	10n	50V	20.0%		CDS	CPC103P5000
C 46	10n	50V	20.0%		CDS	CPC103P5000
C 47	100n	50V	20.0%		CMC	CPC104P5000
C 47 B	22n	50V	5.0%		CDS	CPC223P5003
C 48	10n	50V	20.0%		CDS	CPC103P5000
C 49	10n	50V	20.0%		CDS	CPC103P5000
C 50	100n	50V	20.0%		CMC	CPC104P5000
C 50 B	22n	50V	5.0%		CDS	CPC223P5003
C 51	100n	100V	5.0%		MKT	CPP104P10139
C 52	680p	100V	5.0%	N220	CDS	CPC681P1013
C 53	100n	100V	5.0%		MKT	CPP104P10139
C 54	100n	100V	5.0%		MKT	CPP104P10139
C 55	100u	25V			ELECTRO	CPE101U2506
C 56	100u	25V			ELECTRO	CPE101U2506
C 57	6p8	500V	5.0%	NPO	CDS	CPC689P5013
C 58	10p	500V	5.0%	NPO	CDS	CPC100P5014
C 59	22p	100V		NPO	CDS	CPC220P1013
C 60	470p	100V	10.0%	N220	CDS	CPC471P1013
C 61	6800u	35V			ELECTRO	CPE682U3506
C 62	15000u	16V			ELECTRO	CPE153U1506
C 63	6800u	35V			ELECTRO	CPE682U35O6
C 64	6800u	35V			ELECTRO	CPE682U3506
C 65	6800u	35V			ELECTRO	CPE682U3506
C 66	100u	25V			ELECTRO	CPE101U2506
C 67	100u	25V			ELECTRO	CPE101U2506
C 68	470u	16V			ELECTRO	CPE471U1606
C 69	10u	25V			TANTALUM	CPT100U2505
C 70	10u	25V			TANTALUM	CPT100U2505
C 71					NOT FITTED	
C 200	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 201	10u	25V	20.0%		TANT	CPT100U25O5
C 202	68p	100V	5.0%	NPO	CDS	CPC680P1013
C 203	82p	100V	5.0%	NPO	CDS	CPC820P1013
C 220	100n	50V	20.0%		CMC	CPC104P5000
C 221	220p	500V	5.0%		CDS	CPC221P5015
C 222	100n	50V	20.0%		CMC	CPC104P5000
C 223	2u2	35V	20.0%		TANT	CPT225P35057
C 224	100n	50V	20.0%		CMC	CPC104P5000
C 225	2u2	35V	20.0%		TANT	CPT225P35057
C 226	2u2	35V	20.0%		TANT	CPT225P35057
C 227	100n	50V	20.0%		CMC	CPC104P5000
C 228	100n	50V	20.0%		CMC	CPC104P5000
C 229	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 230	27p	100V	5.0%	NPO	CDS	CPC270P1013

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
C 231	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 232	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 233	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 234	100p	100V	5.0%	NPO	CDS	CPC101P1012
C 235	220u	10V			ELECTRO	CPE221U1006
C 236	100n	50V	20.0%		CMC	CPC104P5000
C 237	1u	50V			CMC	CPC105P5000
C 238	100n	50V	20.0%		CMC	CPC104P5000
C 239	1u	50V			CMC	CPC105P5000
C 240	1u	50V			CMC	CPC105P5000
C 241	1u	50V			CMC	CPC105P5000
C 300	470u	10V			ELECTRO	CPE471U1006
C 301	10u	16V	20.0%		TANT	CPT100U16057
C 302	10u	16V	20.0%		TANT	CPT100U16057
C 303	10p	500V	5.0%		CDS	CPC100P5014
C 304	470p	160V	5.0%		PYS	CPS471P16139
C 305	4n88	100V	10.0%		PYE	CPP472P10189
C 306	47n	630V	10.0%		PYE	CPP473P63189
C 307	33u	10V	20.0%		TANT	CPT330U10057
C 308	10u	16V	20.0%		TANT	CPT100U16057
C 309	47n	100V	10.0%		PYE	CPP473P10189
C 310	220n	50V	20.0%		CMC	CPC224P5000
C 311	100n	100V	10.0%		MKS	CPP104P10149
C 312	100n	100V	10.0%		MKS	CPP104P10149
C 313	100n	100V	10.0%		MKS	CPP104P10149
C 314	1u	35V	20.0%		TANT	CPT105P35057
C 315	2u2	35V	20.0%		TANT	CPT225P35057
C 316	11.2p	500V	10.0%	N750	5p6 + 5p6 CDS	CPC569P5013
C 317	10u	16V	20.0%		TANT	CPT100U16057
C 318	10u	16V	20.0%		TANT	CPT100U16057
C 319	10p	500V	5.0%		CDS	CPC100P5014

Component Designator = CV

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
CV 1	2-27p				TRIMMER	CVM270P2517
CV 2					NOT FITTED	
CV 3	1-5p				TRIMMER	CVM509P2517
CV 4	2-27p				TRIMMER	CVM270P2517

Component Designator = D

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
D 1	1N4004			RECTIFIER		DIO4004
D 2	1N4004			RECTIFIER		DIO4004
D 3	1N4004			RECTIFIER		DIO4004
D 4	1N4004			RECTIFIER		DIO4004
D 5	1N4148			DIODE		DIO4148
D 6	1N4148			DIODE		DIO4148
D 7	1N4148			DIODE		DIO4148
D 8	1N4148			DIODE		DIO4148
D 9	1N4004			RECTIFIER		DIO4004
D 10	1N4004			RECTIFIER		DIO4004
D 11	BZX79/C5V6			ZENER		DZE7956
D 12	6A20			RECTIFIER		DIO6A20
D 13	6A20			RECTIFIER		DIO6A20
D 14	1N4004			RECTIFIER		DIO4004
D 15	1N4004			RECTIFIER		DIO4004
D 16	1N4004			RECTIFIER		DIO4004
D 17	1N4004			RECTIFIER		DIO4004
D 200	1N4148			DIODE		DIO4148
D 201	1N4148			DIODE		DIO4148
D 202	1N4148			DIODE		DIO4148
D 203	1N4148			DIODE		DIO4148
D 204 A	BZX79 C5V6			ZENER		DZE7956
D 204 B	BZX79 C5V6			ZENER		DZE7956
D 220	1N4148			DIODE		DIO4148
D 221	1N4148			DIODE		DIO4148

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
D 222	ESBR5501			LED RED		DLE5501
D 223	ESBR5501			LED RED		DLE5501
D 224	1N4148			DIODE		DIO4148
D 225	1N4148			DIODE		DIO4148
D 300	W04			BRIDGE RECT.		RECW04
D 301	1N4004			RECTIFIER		DIO4004
D 302	BZX79/C5V1			ZENER		DZE7951
D 303	FR406			RECTIFIER		DIO305
D 304	FR406			RECTIFIER		DIO305
D 305	1N3595			DIODE		DIO3595
D 306	1N3595			DIODE		DIO3595

Component Designator = DIS

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
DIS 220	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021
DIS 221	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021
DIS 222	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021
DIS 223	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021
DIS 300	ELS311AHR			DISPLAY	1.5 DIGIT, 7 SEGMENT DISPLAY	DIS311A
DIS 301	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021
DIS 302	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021
DIS 303	LTS312AHR			DISPLAY	1 DIGIT, 7 SEGMENT DISPLAY	DIS3021

Component Designator = F

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
F 150	1.6A 250V M205 FUSE			FUSE		FUS3111

Component Designator = L

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
L 1	10uH FIXED INDUCTOR			INDUCTOR		TFM910UH
L 2	10uH FIXED INDUCTOR			INDUCTOR		TFM910UH
L 3	10uH FIXED INDUCTOR			INDUCTOR		TFM910UH
L 4	10uH FIXED INDUCTOR			INDUCTOR		TFM910UH

Component Designator = MISC

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
MISC	SKIRTED KNOB 6.3mm SHAFT (1/4")					K22-405C-1544
MISC	DVM TEST LEAD SET (RED/BLACK)					PRO0140
MISC	USER (OPERATOR) HANDBOOK					HBK604
MISC	FUSE HOLDER					FHD205104
MISC	HANDLE					MHD17467A
MISC	HANDLE END COVER					MHD27445A
MISC	RUBBER FOOT					MFT350120
MISC	MAINS INLET SOCKET					CON051950
MISC	SHORT PUSH BUTTON					MKN110405
MISC	SMALL KNOB 4mm SHAFT					K20-405C-1544
MISC	SMALL KNOB 6.3mm SHAFT (1/4")					K20-405C-1544
MISC	POWER CORD					CBL165553
MISC	LONG PUSH BUTTON					MKN111007

Component Designator = PCB

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
PCB 486 B	PCB				DVM DISPLAY	PCB486B
PCB 487 D	PCB				DVM ATTEN & RMS	PCB487D
PCB 488 I	PCB				COUNTER PCB	PCB488I
PCB 489 H	PCB				MAIN BOARD	PCB489H

Component Designator = Q

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
Q 1	PN200			PNP		TRS20001
Q 2	PN100			NPN		TRS10001
Q 3	PN100			NPN		TRS10001
Q 4	PN200			PNP		TRS20001
Q 5	PN200			PNP		TRS20001

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
Q 6	PN5771			PNP		TRS42581
Q 7	MPS6544			NPN		TRS65443
Q 8	PN5770			NPN		TRS57701
Q 9	BF450			PNP		TRS45002
Q 10	2N2905A			PNP		TRS2905A
Q 11	2N2219A			NPN		TRS2219A
Q 12	PN200			PNP		TRS20001
Q 13	PN100			NPN		TRS10001
Q 14	PN100			NPN		TRS10001
Q 15	MJE2955T			PNP		TRS29550T
Q 16	BD139			NPN		TRS13902
Q 17	BD139			NPN		TRS13902
Q 18	MJE3055T			NPN		TRS30553T
Q 19	PN100			NPN		TRS10001
Q 20	PN200			PNP		TRS20001
Q 21	PN200			PNP		TRS20001
Q 22	MJE3055T			NPN		TRS30553T
Q 200	PN200			PNP		TRS20001
Q 201	PN100			NPN		TRS10001
Q 202	PN200			PNP		TRS20001
Q 203	PN200			PNP		TRS20001
Q 204	PN100			NPN		TRS10001
Q 220	2N5458			FET		TRS54581
Q 221	2N4258			PNP		TRS42581
Q 222	PN5770			NPN		TRS57701
Q 223	PN5770			NPN		TRS57701
Q 224	PN100			NPN		TRS10001

Component Designator = R

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
R 1	220	1w	5.0%	MF		RES221230
R 2	2k2	0.25w	5.0%	MF		RES222210
R 3	220	0.25w	5.0%	MF		RES221210
R 4	10	0.25w	5.0%	MF		RES100210
R 5	330	0.25w	5.0%	MF		RES331210
R 6	390	1w	5.0%	MF		RES391230
R 7	220	1w	5.0%	MF		RES221230
R 8	10	0.25w	5.0%	MF		RES100210
R 9	330	0.25w	5.0%	MF		RES331210
R 10	1k5	0.25w	5.0%	MF		RES152210
R 11	390	1w	5.0%	MF		RES391230
R 12	0R47	3w	5.0%	MF		RES478041
R 13	0R47	3w	5.0%	MF		RES478041
R 14	1k0	0.25w	5.0%	MF		RES102210
R 15	4k7	0.25w	5.0%	MF		RES472210
R 16	1k0	0.25w	5.0%	MF		RES102210
R 17	620	0.25w	5.0%	MF		RES621210
R 18	330	0.25w	5.0%	MF		RES331210
R 19	330	0.25w	5.0%	MF		RES331210
R 20	1k0	0.25w	5.0%	MF		RES102210
R 21	4k7	0.25w	5.0%	MF		RES472210
R 22	1k0	0.25w	5.0%	MF		RES102210
R 23	620	0.25w	5.0%	MF		RES621210
R 24	100k	0.25w	5.0%	MF		RES104210
R 25	100k	0.25w	5.0%	MF		RES104210
R 26	330k	0.25w	5.0%	MF		RES334210
R 27	100k	0.25w	5.0%	MF		RES104210
R 28	12k	0.25w	5.0%	MF		RES123210
R 29	330k	0.25w	5.0%	MF		RES334210
R 30	0R	0.25w	5.0%	MF		RES000210
R 31	1M	0.25w	5.0%	MF		RES105210
R 32	100	0.25w	5.0%	MF		RES101210
R 33	3k6	0.25w	5.0%	MF		RES362210
R 34	2k2	0.25w	5.0%	MF		RES222210
R 35				NOT FITTED		

Cct Ref		Value	Rating	Tol'	Type	Details	McVan Part No
R 36					NOT FITTED		
R 37		2k2	0.25w	5.0%	MF		RES222210
R 38		47R	0.25w	5.0%	MF		RES470210
R 39		560	0.25w	5.0%	MF		RES561210
R 40		680	0.25w	5.0%	MF		RES681210
R 41		22k	0.25w	5.0%	MF		RES223210
R 42		2k7	0.25w	5.0%	MF		RES272210
R 43		330	0.25w	5.0%	MF		RES331210
R 44		330	0.25w	5.0%	MF		RES331210
R 45		1k0	0.25w	5.0%	MF		RES102210
R 46		1k0	0.25w	5.0%	MF		RES102210
R 47		4k7	0.25w	5.0%	MF		RES472210
R 48		6k8	0.25w	5.0%	MF		RES682210
R 49		22k	0.25w	5.0%	MF		RES223210
R 50		1k0	0.25w	5.0%	MF		RES102210
R 51		100k	0.25w	5.0%	MF		RES104210
R 52		15k	0.25w	5.0%	MF		RES153210
R 53		24k	0.25w	1.0%	MF		RES243110
R 54		3k0	0.25w	5.0%	MF		RES302110
R 55		20k	0.25w	1.0%	MF		RES203110
R 56		287	0.25w	1.0%	MF		REP2871100
R 57		4k7	0.25w	5.0%	MF		RES472210
R 58		470k	0.25w	5.0%	MF		RES474210
R 59		470k	0.25w	5.0%	MF		RES474210
R 60		6k8	0.25w	5.0%	MF		RES682210
R 61		100	0.25w	5.0%	MF		RES101210
R 62		910	0.25w	5.0%	MF		RES911210
R 63		12k	0.25w	5.0%	MF		RES123210
R 64		910	0.25w	5.0%	MF		RES911210
R 65		100	0.25w	5.0%	MF		RES101210
R 66		3R3	0.25w	5.0%	MF		RES339210
R 66	B	33	0.25w	5.0%	MF		RES330210
R 67		8k2	0.25w	5.0%	MF		RES822210
R 68		10	0.25w	5.0%	MF		RES100210
R 69		120	0.25w	5.0%	MF		RES121210
R 70		1k8	0.25w	5.0%	MF		RES182210
R 71		1k8	0.25w	5.0%	MF		RES182210
R 72		120	0.25w	5.0%	MF		RES121210
R 73		10	0.25w	5.0%	MF		RES100210
R 74		3R3	0.25w	5.0%	MF		RES339210
R 74	B	33	0.25w	5.0%	MF		RES330210
R 75		10	0.25w	5.0%	MF		RES100210
R 76		4k7	0.25w	5.0%	MF		RES472210
R 77		10	0.25w	5.0%	MF		RES100210
R 78		150	0.25w	5.0%	MF		RES151210
R 79		150	0.25w	5.0%	MF		RES151210
R 80		150	0.25w	5.0%	MF		RES151210
R 81		34R8	0.25w	1.0%	MF		REP3480110
R 82		26R1	0.25w	1.0%	MF		REP2610110
R 83		26R1	0.25w	1.0%	MF		REP2610110
R 84		41R2	0.25w	1.0%	MF		REP4120110
R 85		41R2	0.25w	1.0%	MF		REP4120110
R 86		10	0.25w	5.0%	MF		RES100210
R 87		3k3	0.25w	5.0%	MF		RES332210
R 88		0R47	3w	5.0%	MF		RES478041
R 89		1k0	0.25w	5.0%	MF		RES102210
R 90		10k	0.25w	5.0%	MF		RES103210
R 91		220	0.25w	5.0%	MF		RES221210
R 92		22	0.25w	5.0%	MF		RES220210
R 93		180	0.25w	5.0%	MF		RES181210
R 94		680	1W	5.0%	MF		RES681230
R 95		39	0.25w	5.0%	MF		RES390210
R 96		10k	0.25w	5.0%	MF		RES103210

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
R 97	0R47	3w	5.0%	MF		RES478041
R 98	1k0	0.25w	5.0%	MF		RES102210
R 99	10k	0.25w	5.0%	MF		RES103210
R 100	220	0.25w	5.0%	MF		RES221210
R 101	22	0.25w	5.0%	MF		RES220210
R 102	10k	0.25w	5.0%	MF		RES103210
R 103	47k	0.25w	5.0%	MF		RES473210
R 104	10k	0.25w	5.0%	MF		RES103210
R 105	22k	0.25w	5.0%	MF		RES223210
R 106	150k	0.25w	5.0%	MF	SELECTED	RES153210
R 107	9k1	0.25w	5.0%	MF		RES912210
R 108	31k6	0.25w	1.0%	MF		REP3163110
R 109	68k	0.25w	5.0%	MF		RES683210
R 110	100k	0.25w	5.0%	MF		RES104210
R 111	3k0	0.25w	1.0%	MF		RES302110
R 112	100k	0.25w	1.0%	MF		RES104110
R 113	100k	0.25w	1.0%	MF		RES104110
R 114	330	0.25w	5.0%	MF		RES331210
R 115	240	0.25w	5.0%	MF		RES241210
R 116	1k2	0.25w	5.0%	MF		RES122210
R 117	1k8	0.25w	5.0%	MF		RES182210
R 118	6k8	0.25w	5.0%	MF		RES682210
R 119	6k8	0.25w	5.0%	MF		RES682210
R 120	560	1w	5.0%	MF		RES561210
R 121	560	1w	5.0%	MF		RES561210
R 122	220	0.25w	5.0%	MF		RES221210
R 140	270	0.25w	5.0%	MF		RES271210
R 163	33	1w	20.0%	NTC		RMX33023
R 175	18	0.25w	5.0%	MF		RES180210
R 200	10k	0.25w	5.0%	MF		RES103210
R 201	1k0	0.25w	5.0%	MF		RES102210
R 202	20k	0.25w	5.0%	MF		RES203210
R 203	15k	0.25w	5.0%	MF		RES153210
R 204	510	0.25w	5.0%	MF		RES511210
R 205	2k4	0.25w	5.0%	MF		RES242210
R 206	100	0.25w	5.0%	MF		RES104210
R 207	12k	0.25w	5.0%	MF		RES123210
R 208	2k4	0.25w	5.0%	MF		RES242210
R 209	8k2	0.25w	5.0%	MF		RES822210
R 210	56k	0.25w	5.0%	MF		RES563210
R 211	43k	0.25w	5.0%	MF		REP433210
R 212	120k	0.125W	5.0%	MF		RES124200
R 213	100k	0.125W	5.0%	MF		RES104200
R 214	140k	0.25w	5.0%	MF		RES144210
R 215	82k	0.25w	5.0%	MF		RES823210
R 216	6k8	0.25w	5.0%	MF		RES682210
R 217	100	0.25w	5.0%	MF		RES101210
R 218	33M	0.5w	5.0%	MF		RES336220
R 219	1M5	0.25w	5.0%	MF		RES155210
R 220	1M	0.25w	5.0%	MF		RES104210
R 221	470k	0.25w	5.0%	MF		RES474210
R 222	820	0.25w	5.0%	MF		RES821210
R 223	510	0.25w	5.0%	MF		RES511210
R 224	10	0.25w	5.0%	MF		RES100210
R 225	100	0.25w	5.0%	MF		RES101210
R 226	470	0.25w	5.0%	MF		RES471210
R 227	2k2	0.25w	5.0%	MF		RES222210
R 228	1k1	0.25w	5.0%	MF		RES112210
R 229	2k2	0.25w	5.0%	MF		RES222210
R 230	100	0.25w	5.0%	MF		RES101210
R 231	22	0.25w	5.0%	MF		RES220210
R 232	470k	0.25w	5.0%	MF		RES474210
R 233	620k	0.25w	5.0%	MF		RES624210

Cct Ref		Value	Rating	Tol'	Type	Details	McVan Part No
R 234		4k7	0.25w	5.0%	MF		RES472210
R 235		4k7	0.25w	5.0%	MF		RES472210
R 236		4k7	0.25w	5.0%	MF		RES472210
R 237		33k	0.25w	5.0%	MF		RES333210
R 238		33k	0.25w	5.0%	MF		RES333210
R 239		33k	0.25w	5.0%	MF		RES333210
R 240		1M	0.25w	5.0%	MF		RES105210
R 241		10k	0.25w	5.0%	MF		RES103210
R 242		6k8	0.25w	5.0%	MF		RES682210
R 243		100k	0.25w	5.0%	MF		RES104210
R 244		100k	0.25w	5.0%	MF		RES104210
R 245		100k	0.25w	5.0%	MF		RES104210
R 246		100k	0.25w	5.0%	MF		RES104210
R 247		510	0.25w	5.0%	MF		RES511210
R 248		33k	0.25w	5.0%	MF		RES333210
R 249		10M	0.25w	5.0%	MF		RES106210
R 250		100	0.25w	5.0%	MF		RES101210
R 251		56k	0.25w	5.0%	MF		RES563210
R 252		100k	0.25w	5.0%	MF		RES104210
R 253		56	0.25w	5.0%	MF		RES560210
R 254		100	0.25w	5.0%	MF		RES101210
R 255		5k6	0.125W	5.0%	MF		RES562200
R 256		10	0.125W	5.0%	MF		RES100201
R 300		270	0.25w	5.0%	MF		RES271210
R 301	A	9M	0.5w	0.5%	MF		RES905620
R 301	B	900k	0.25w	0.5%	MF		RES904610
R 301	C	90k	0.25w	0.5%	MF		RES903410
R 301	D	9k0	0.25w	0.5%	MF		RES902610
R 301	E	900	0.25w	0.5%	MF		RES901610
R 302	A	90	0.25w	0.5%	MF		RES900610
R 302	B	9	0.25w	0.5%	MF		RES909610
R 302	C	0R9	0.5w	0.5%	MF		RES908620
R 302	D	0R01	2w	0.5%	MF		RES108640
R 303		100	0.25w	5.0%	MF		RES101210
R 304		2k2	0.25w	5.0%	MF		RES222210
R 305		560	0.25w	5.0%	MF		RES561210
R 306		100k	0.25w	5.0%	MF		RES104210
R 307		47k	0.25w	5.0%	MF		RES473210
R 308		33M	0.5w	5.0%	MF		RES336220
R 309		56k	0.25w	5.0%	MF		RES563210
R 310		270	0.25w	5.0%	MF		RES271210
R 311		270	0.25w	5.0%	MF		RES271210
R 312		750	0.25w	5.0%	MF		RES751210
R 313		1M	0.25w	5.0%	MF		RES105210
R 314		1M	0.25w	5.0%	MF		RES105210
R 315		1M	0.25w	5.0%	MF		RES105210
R 316		1M	0.25w	5.0%	MF		RES105210
R 317		120k	0.25w	5.0%	MF		RES124210
R 318		200k	0.25w	5.0%	MF		RES204110
R 319		4k7	0.25w	5.0%	MF		RES472210
R 320		2M2	0.25w	5.0%	MF		RES225210
R 321		2k2	0.25w	5.0%	MF		RES222210
R 322		3k3	0.25w	5.0%	MF		RES332210

Component Designator = RV

Cct Ref	Value	Type	McVan Part No
RV 1	100k	CER PRESET	POT310415
RV 2		NOT USED	
RV 3		NOT USED	
RV 4		NOT USED	
RV 5		NOT USED	
RV 6		NOT USED	
RV 7	1k	CER PRESET	POT310215
RV 8	50k	CER PRESET	POT350315
RV 9	50k	CER PRESET	POT350315

Cct Ref		Value	Rating	Tol'	Type	Details	McVan Part No
RV 10		500			LIN CARBON		POT150111
RV 11		50k			CER PRESET		POT350315
RV 12		10k			LIN CARBON & SPDT SWITCH (S11)		POT110314
RV 13					NOT USED		
RV 14		100			CER PRESET		POT310115
RV 15		10k			CER PRESET		POT310315
RV 16		200			CER PRESET		POT320115
RV 17		50k			CER PRESET		POT350315
RV 18	A	10k			LIN CARBON TANDEM		POT1103121
RV 18	B	10k			LIN CARBON CONTROL		
RV 19		100			CER PRESET		POT310115
RV 20		100			CER PRESET MULTITURN		POT310117
RV 21		100			CER PRESET MULTITURN		POT310117
RV 150		500			CER PRESET MULTITURN		POT350117
RV 151		500			CER PRESET MULTITURN		POT350117
RV 152					NOT USED		
RV 160		500			CER PRESET		POT350115
RV 161		10k			LIN CARBON		POT1103111
RV 162		10k			LIN CARBON		POT1103111
RV 163		500			CER PRESET		POT350115
RV 201		10k			LIN CARBON 5:1 SLOW MOTION		POT1103151
RV 202		10k			LIN CARBON		POT1103111
RV 203		250k			LIN CARBON		POT1224113
RV 204		10k			LIN CARBON		POT1103111
RV 300		50k			CER PRESET		POT350315
RV 301		2k			CER PRESET		POT320215

Component Designator = S

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
S 1					Part of 8 module push button assembly	SWH204
S 2					Part of 8 module push button assembly	SWH204
S 3					Part of 8 module push button assembly	SWH204
S 4					Part of 7 module push button assembly	SWH187
S 5					Part of 7 module push button assembly	SWH187
S 6					Part of 7 module push button assembly	SWH187
S 7					Part of 7 module push button assembly	SWH187
S 8					Part of 7 module push button assembly	SWH187
S 9					Part of 7 module push button assembly	SWH187
S 10					Part of 7 module push button assembly	SWH187
S 11	ON REAR OF RV12					
S 12					Part of 8 module push button assembly	SWH204
S 13					Part of 8 module push button assembly	SWH204
S 14					Part of 8 module push button assembly	SWH204
S 15					Part of 8 module push button assembly	SWH204
S 16					Part of 8 module push button assembly	SWH204
S 150	POWER ON/OFF					SWH8221MRR
S 151	MAINS VOLTAGE RANGE					SWH20212

Cct Ref	Value	Rating	Tol'	Type	Details	McVan Part No
S 201	SYMMETRY SELECTOR					SWH4301
S 202	LIN-LOG SWEEP SELECTOR					SWH4301
S 220	FUNCTION GENERATOR-COUNTER SELECTOR					SWH6200
S 221	COUNTER RANGE					SWH1055
S 300					Part of 7 module push button assembly	SWH205
S 301					Part of 7 module push button assembly	SWH205
S 302					Part of 7 module push button assembly	SWH205
S 303					Part of 7 module push button assembly	SWH205
S 304					Part of 7 module push button assembly	SWH205
S 305					Part of 7 module push button assembly	SWH205
S 306					Part of 7 module push button assembly	SWH205

Component Designator = T

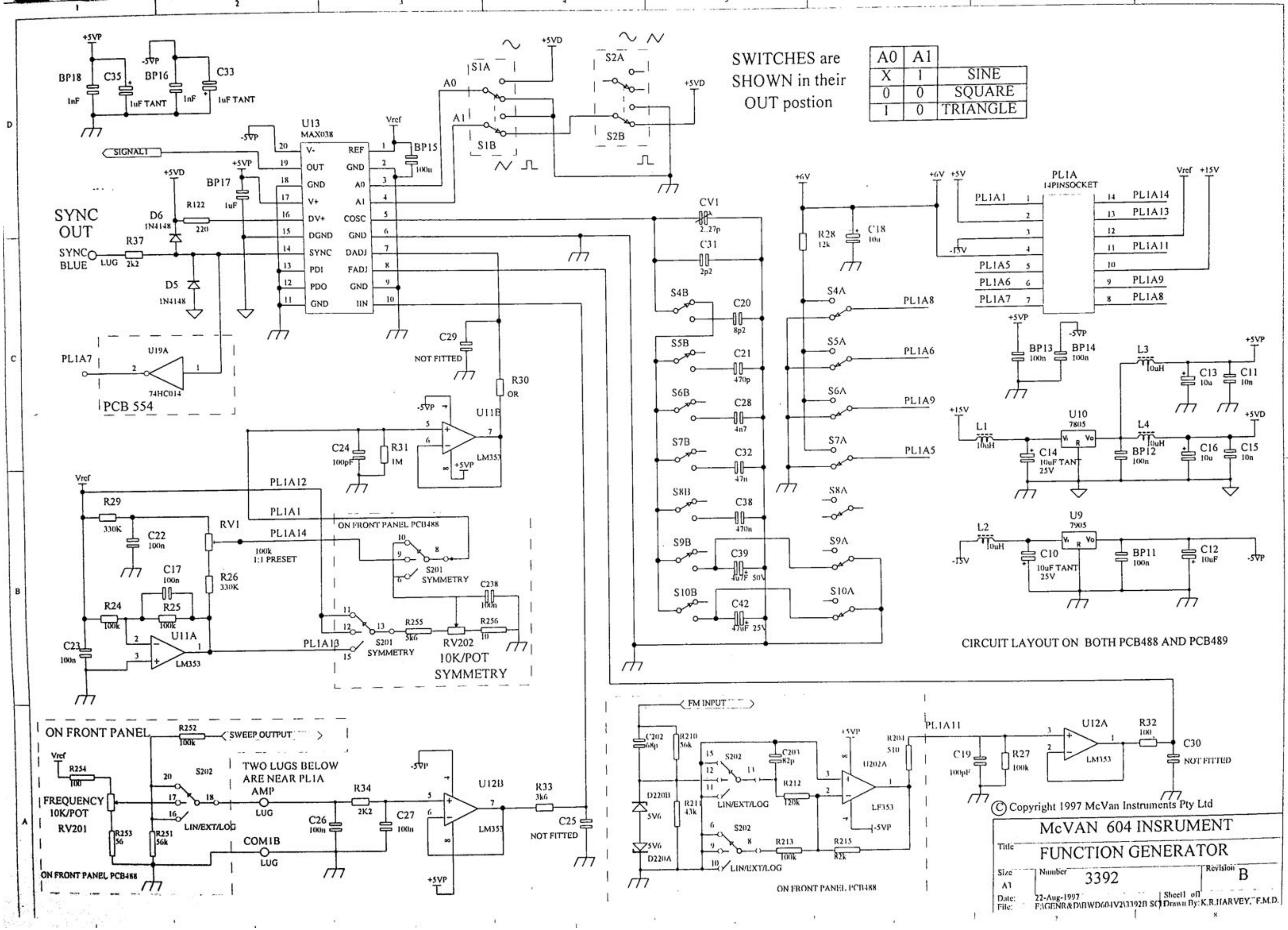
T 150	POWER TRANSFORMER					TFM2524

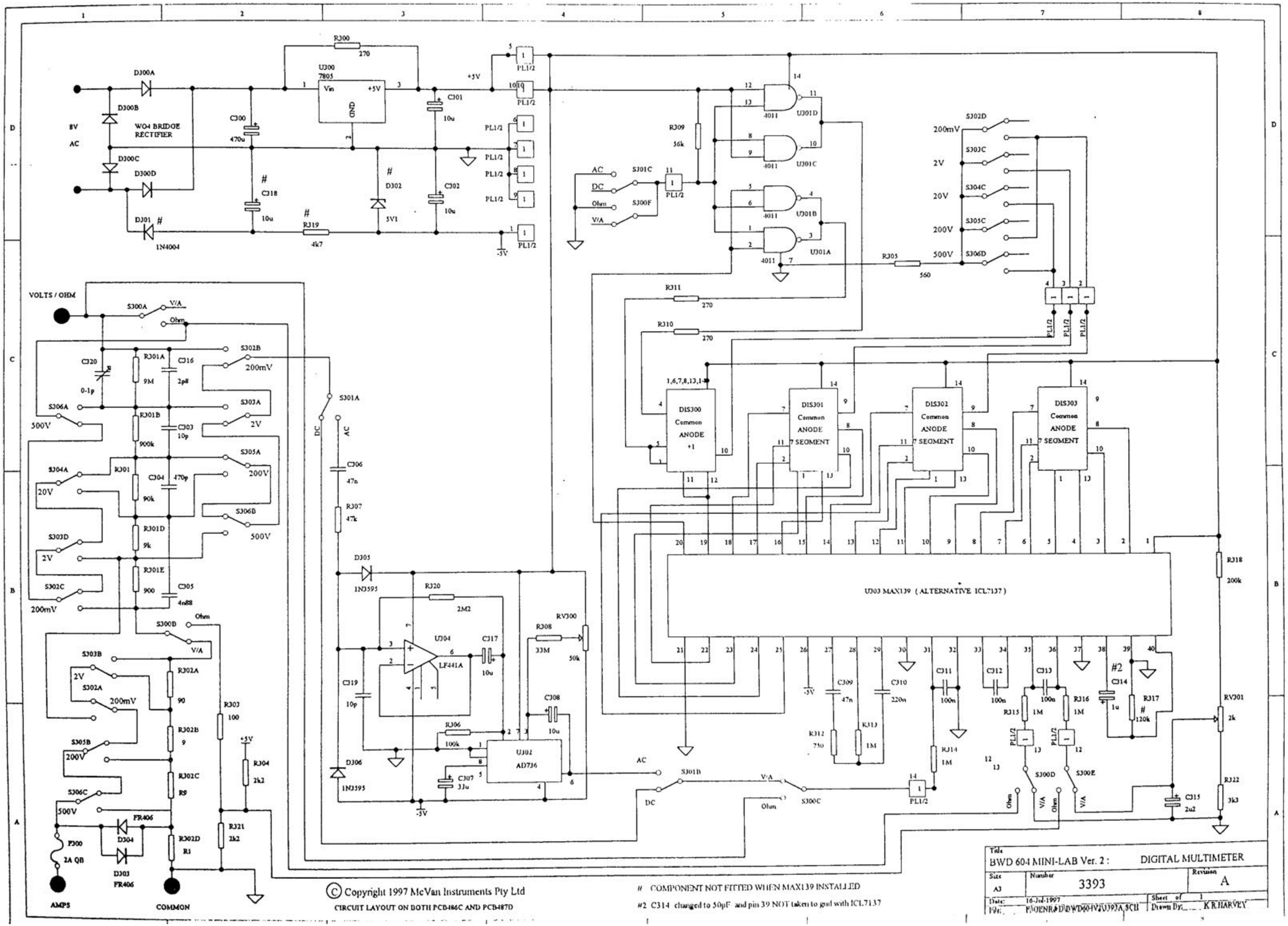
Component Designator = U

U 1	LM317			POS. REG.		REG317T
U 2	7805			POS. REG.		REG7805
U 3	7912			NEG. REG.		REG7912
U 4	7905			NEG. REG		REG7905
U 5	LM317			POS. REG		REG317T
U 6	LM337			NEG. REG.		REG337T
U 7	LM317L			POS. REG.		REG317L
U 8	LM337L			NEG. REG.		REG337L
U 9	LM7905			NEG. REG		REG7905
U 10	LM7805			POS. REG.		REG7805
U 11	LM353			DUAL OP-AMP		ICC353
U 12	LM353			DUAL OP-AMP		ICC353
U 13	MAX038			WAVEFORM GENERATOR		ICC038
U 14	MC1445			MODULATOR		ICC1445
U 15	LM6361			OP-AMP		ICC6361
U 16	LM351			OP-AMP		ICC351
U 17	LM353			DUAL OP-AMP		ICC353
U 18	LM350T			POS. REG.		REG350T
U 19	74HC14			HEX INVERTER	SMD	SICC74HC14D
U 202	LM353			DUAL OP-AMP		ICC353
U 220	74HC14			HEX INVERTER		ICC74HC14
U 221	74HC390			DUAL COUNTER		ICC74HC390
U 222	74HC390			DUAL COUNTER		ICC74HC390
U 223	4051			SELECTOR		ICC4051
U 224	74HC257			SELECTOR		ICC74HC257
U 225	74HC32			QUAD OR GATE		ICC74HC32
U 226	4060			OSC. DIVDER		ICC4060
U 227	74C14			HEX INVERTER		ICC74C14
U 228	ICM7217IPI			COUNTER		ICC72171P
U 229	4013			DUAL D BI-STABLE		ICC4013
U 300	7805			POS. REG.		REG7805
U 301	4011B			QUAD NAND GATE		ICC4011
U 302	AD736			RMS CONVERTER		ICC736
U 303	MAX 139			DVM		ICCMAX139
U 304	LF441			OP-AMP		ICC441

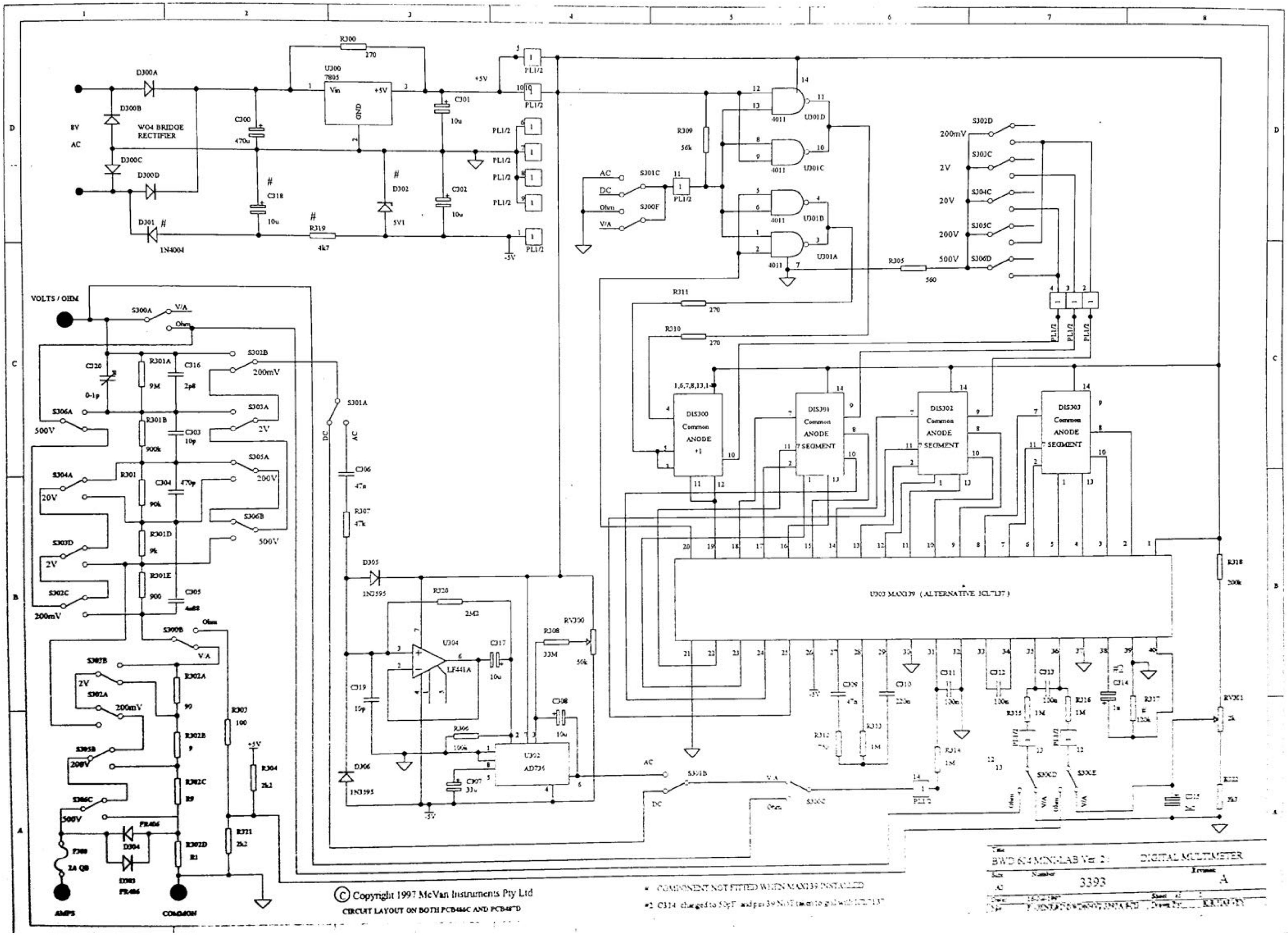
9.4 Circuit Schematics

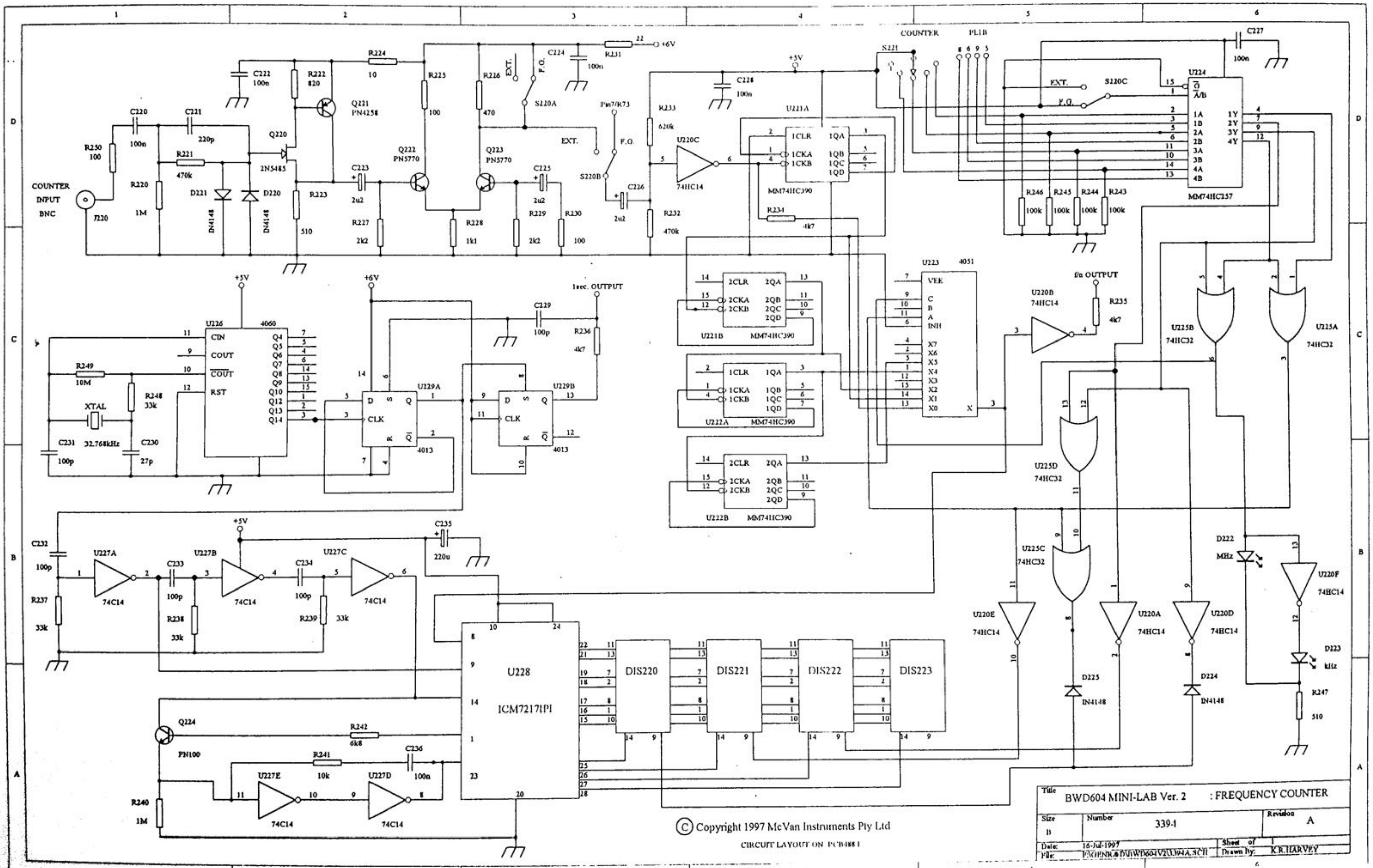
Drawing No.	Description	Size
3392	Function Generator	A4
3393	Digital Multimeter (DVM)	A4
3394	Frequency Counter	A4
3395	Power Supplies	A4
3396	Amplitude Modulator Waveform Amplifier	A4
3397	Log/Lin Sweep Circuit	A4
3398	Power Amplifier/Variable Power Supply	A4
3409	AC power Input and Transformer	A4

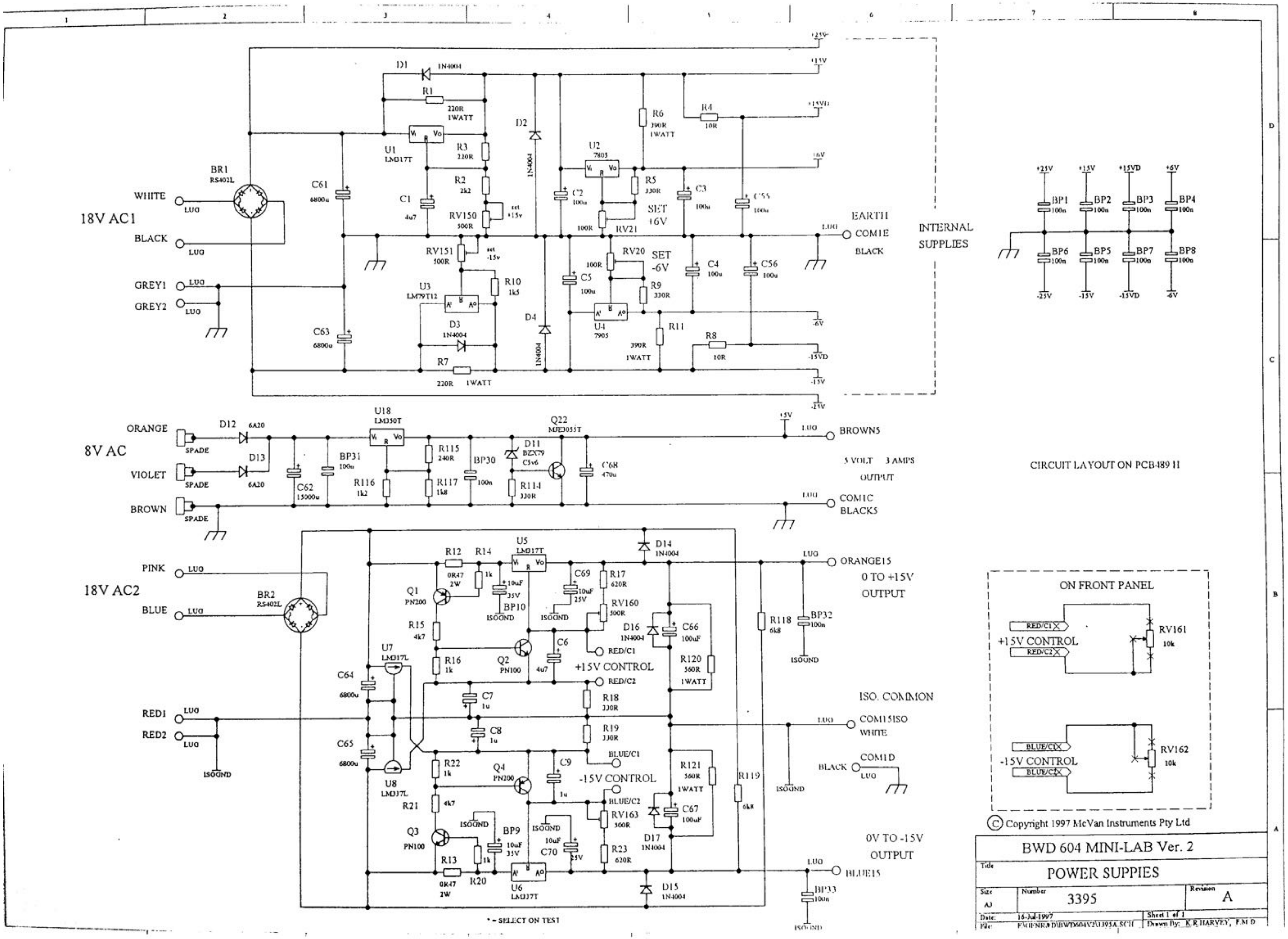

SWITCHES are SHOWN in their OUT postion
A0 A1
X 1 SINE
0 0 SQUARE
1 0 TRIANGLE
SYNC OUT
PCB 554
ON FRONT PANEL PCB488
10K/POT SYMMETRY
ON FRONT PANEL
TWO LUGS BELOW ARE NEAR PL1A
FREQUENCY 10K/POT RV201
ON FRONT PANEL PCB488
CIRCUIT LAYOUT ON BOTH PCB488 AND PCB489
FM INPUT
SWEEP OUTPUT
ON FRONT PANEL PCB488
© Copyright 1997 McVan Instruments Pty Ltd
McVAN 604 INSRUMENT
FUNCTION GENERATOR
Title
Size A1
Number 3392
Revision B
Date: 22-Aug-1997
Drawn By: K.R.HARVEY, F.M.D.

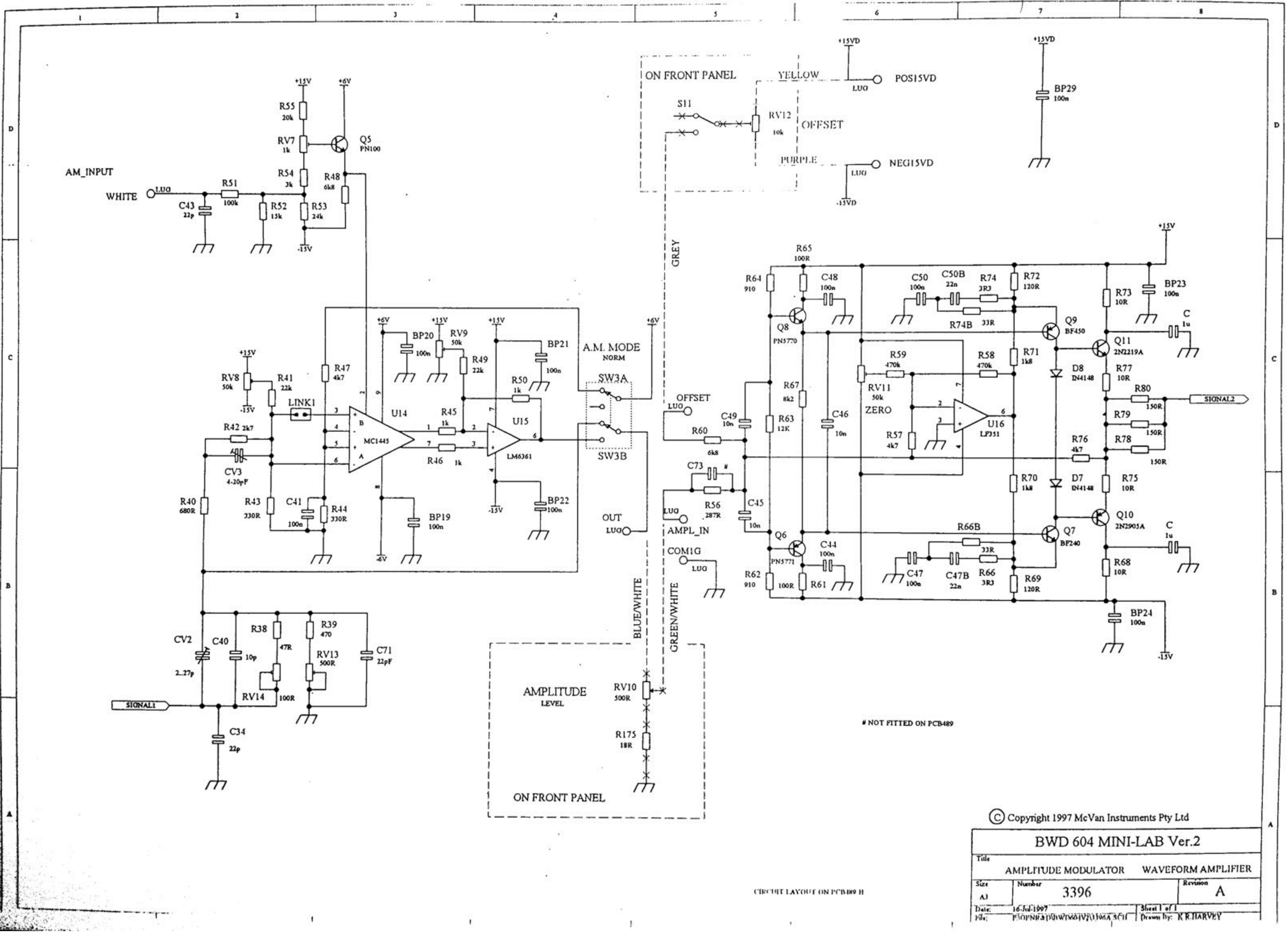


U303 MAX139 (ALTERNATIVE ICL7137)
© Copyright 1997 McVan Instruments Pty Ltd
CIRCUIT LAYOUT ON BOTH PCB486C AND PCB487D
COMPONENT NOT FITTED WHEN MAX139 INSTALLED
#2 C314 changed to 50pF and pin 39 NOT taken to gnd with ICL7137
Title
BWD 604 MINI-LAB Ver. 2 : DIGITAL MULTIMETER
Size A3
Number 3393
Revision A
Date: 16-Jul-1997
Sheet 1
Drawn By: K.R.HARVEY

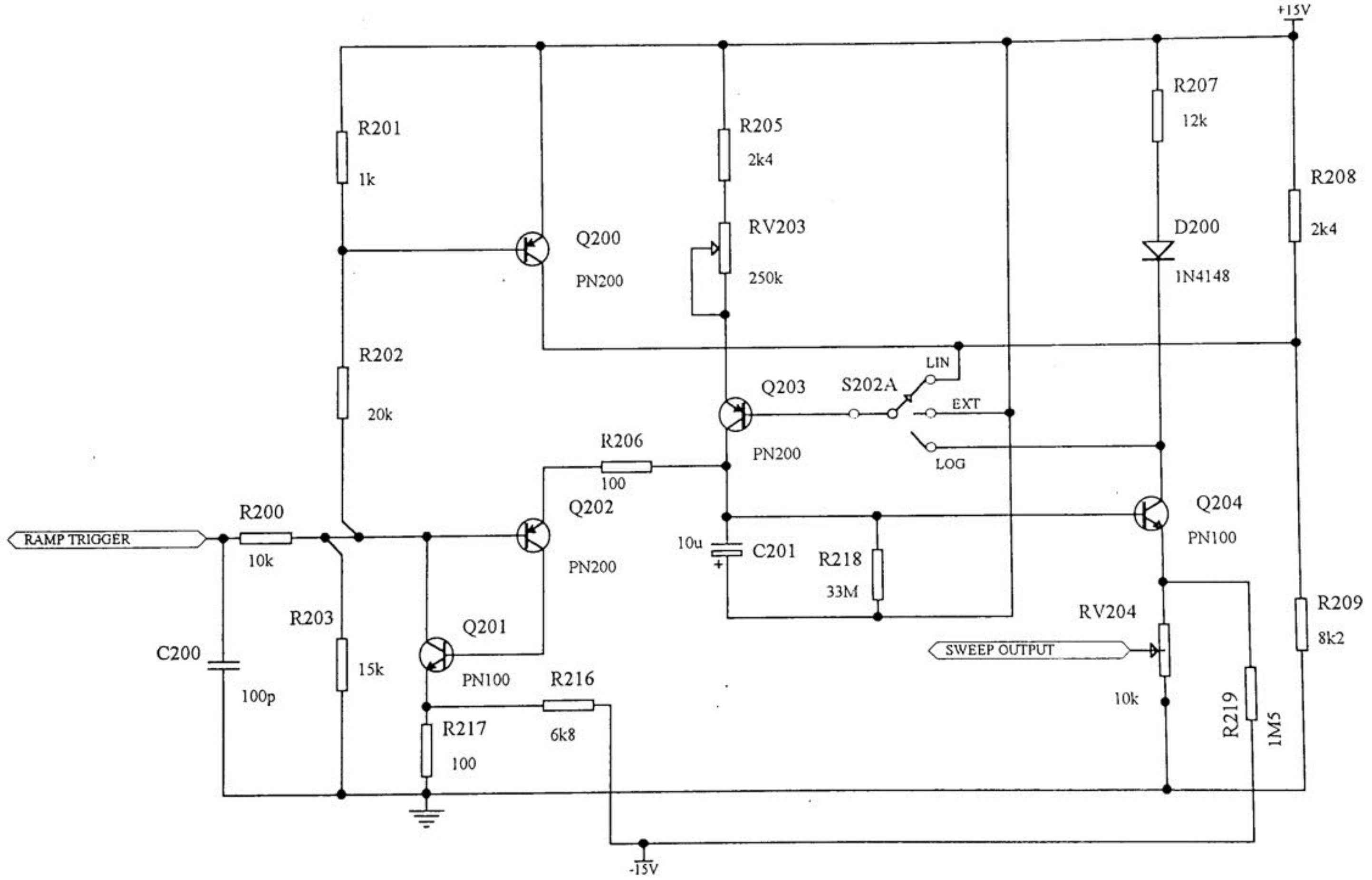

BWD 604 MINI-LAB Ver 2
DIGITAL MULTIMETER
3393
A
U303 MAX139 (ALTERNATIVE ICL7137)
* COMPONENT NOT FITTED WHEN MAX139 INSTALLED
© Copyright 1997 McVan Instruments Pty Ltd
CIRCUIT LAYOUT ON BOTH PCB486C AND PCB487D
VOLTS / OHM
AMPS
COMMON
W04 BRIDGE RECTIFIER


COUNTER INPUT BNC
J220
R250 100
C220 100n
C221 220p
R220 1M
R221 470k
D221 1N4148
D220 1N4148
Q220 2N5485
C222 100n
R222 820
Q221 PN4258
R224 10
R223 510
C223 2u2
R227 2k2
Q222 PN5770
R225 100
R228 1k1
Q223 PN5770
R226 470
C225 2u2
R229 2k2
R230 100
EXT.
F.O.
S220A
C224 100n
R231 22
+6V
Pin7/R73
S220B
C226 2u2
R233 620k
R232 470k
C228 100n
+5V
U220C 74HC14
U221A MM74HC390
R234 4k7
U221B MM74HC390
U222A MM74HC390
U222B MM74HC390
COUNTER
S221
PL1B
S220C
U224 MM74HC257
C227 100n
R246 100k
R245 100k
R244 100k
R243 100k
U223 4051
U220B 74HC14
fin OUTPUT
R235 4k7
U225A 74HC32
U225B 74HC32
U225C 74HC32
U225D 74HC32
U220A 74HC14
U220D 74HC14
U220E 74HC14
U220F 74HC14
D222 MHz
D223 kHz
R247 510
D224 1N4148
D225 1N4148
U226 4060
R249 10M
R248 33k
XTAL 32.768kHz
C231 100p
C230 27p
U229A 4013
U229B 4013
1sec. OUTPUT
C229 100p
R236 4k7
C232 100p
R237 33k
U227A 74C14
C233 100p
R238 33k
U227B 74C14
C234 100p
R239 33k
U227C 74C14
C235 220u
U228 ICM7217IPI
DIS220
DIS221
DIS222
DIS223
Q224 PN100
R242 6k8
R241 10k
C236 100n
U227E 74C14
U227D 74C14
R240 1M
© Copyright 1997 McVan Instruments Pty Ltd
CIRCUIT LAYOUT ON PCB488 I
Title BWD604 MINI-LAB Ver. 2 : FREQUENCY COUNTER
Size B
Number 339-I
Revision A
Date: 16-Jul-1997
Sheet of
Drawn By: K.R.HARVEY


18V AC1
WHITE
BLACK
GREY1
GREY2
8V AC
ORANGE
VIOLET
BROWN
18V AC2
PINK
BLUE
RED1
RED2
INTERNAL SUPPLIES
EARTH COM1E BLACK
BROWN5
5 VOLT 3 AMPS OUTPUT
COM1C BLACK5
ORANGE15
0 TO +15V OUTPUT
+15V CONTROL
-15V CONTROL
ISO. COMMON
COM15ISO WHITE
BLACK COM1D
0V TO -15V OUTPUT
BLUE15
* = SELECT ON TEST
CIRCUIT LAYOUT ON PCB-189 II
ON FRONT PANEL
RV161 10k
RV162 10k
© Copyright 1997 McVan Instruments Pty Ltd
BWD 604 MINI-LAB Ver. 2
Title
POWER SUPPIES
Size A3
Number 3395
Revision A
Date: 16-Jul-1997
Sheet 1 of 1
Drawn By: K.R.HARVEY, F.M.D

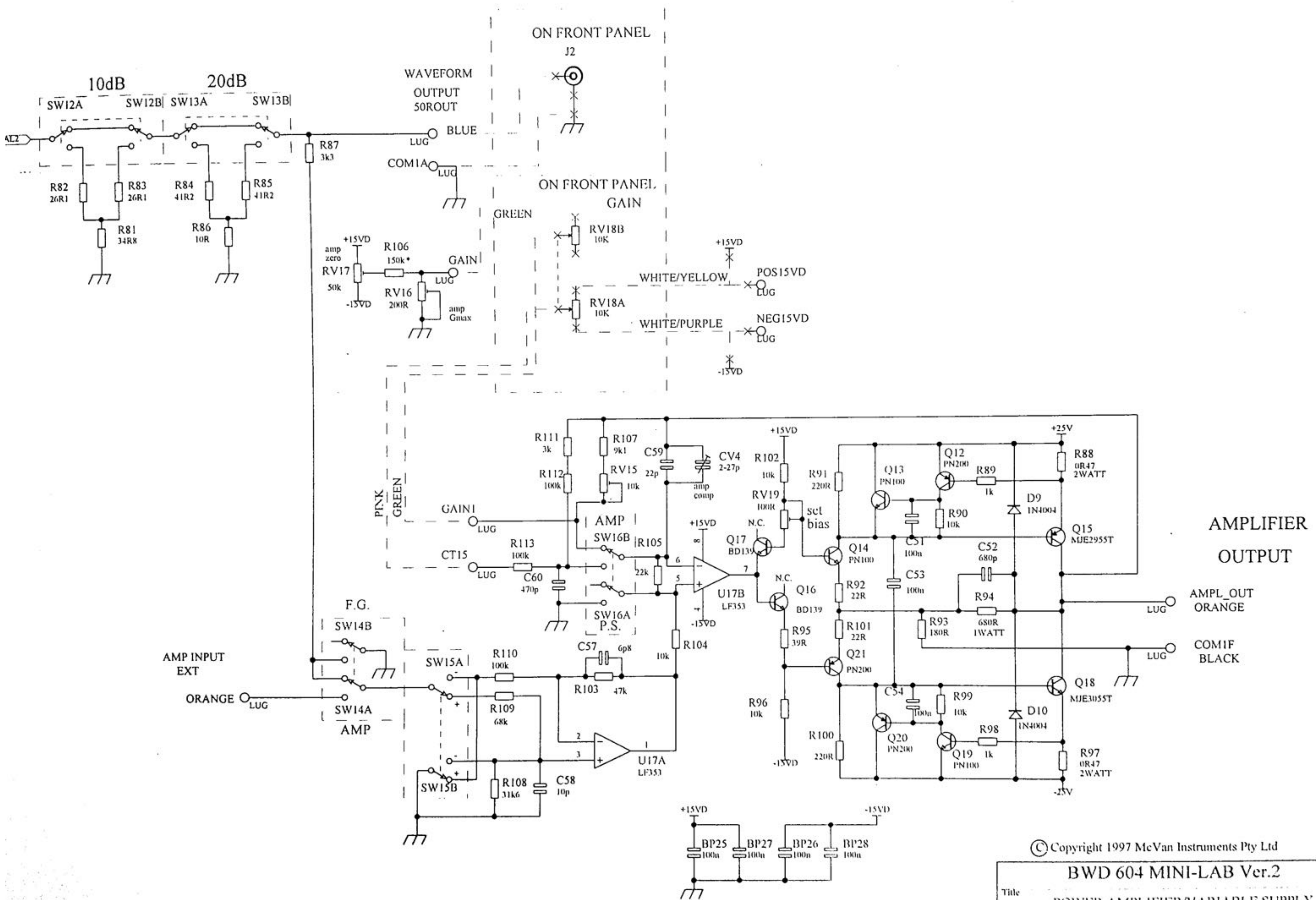


AM_INPUT
WHITE
ON FRONT PANEL
OFFSET
YELLOW
PURPLE
GREY
POS15VD
NEG15VD
A.M. MODE
NORM
SW3A
SW3B
OUT
OFFSET
AMPL_IN
COM1G
BLUE/WHITE
GREEN/WHITE
AMPLITUDE
LEVEL
ON FRONT PANEL
ZERO
SIGNAL1
SIGNAL2
MC1445
LM6361
LF351
NOT FITTED ON PCB489
CIRCUIT LAYOUT ON PCB489 H
© Copyright 1997 McVan Instruments Pty Ltd
BWD 604 MINI-LAB Ver.2
AMPLITUDE MODULATOR WAVEFORM AMPLIFIER
Number 3396
Revision A
Size A3
Date: 16-Jul-1997
Sheet 1 of 1
Drawn by: K R HARVEY



Circuit Layout on PCB 488

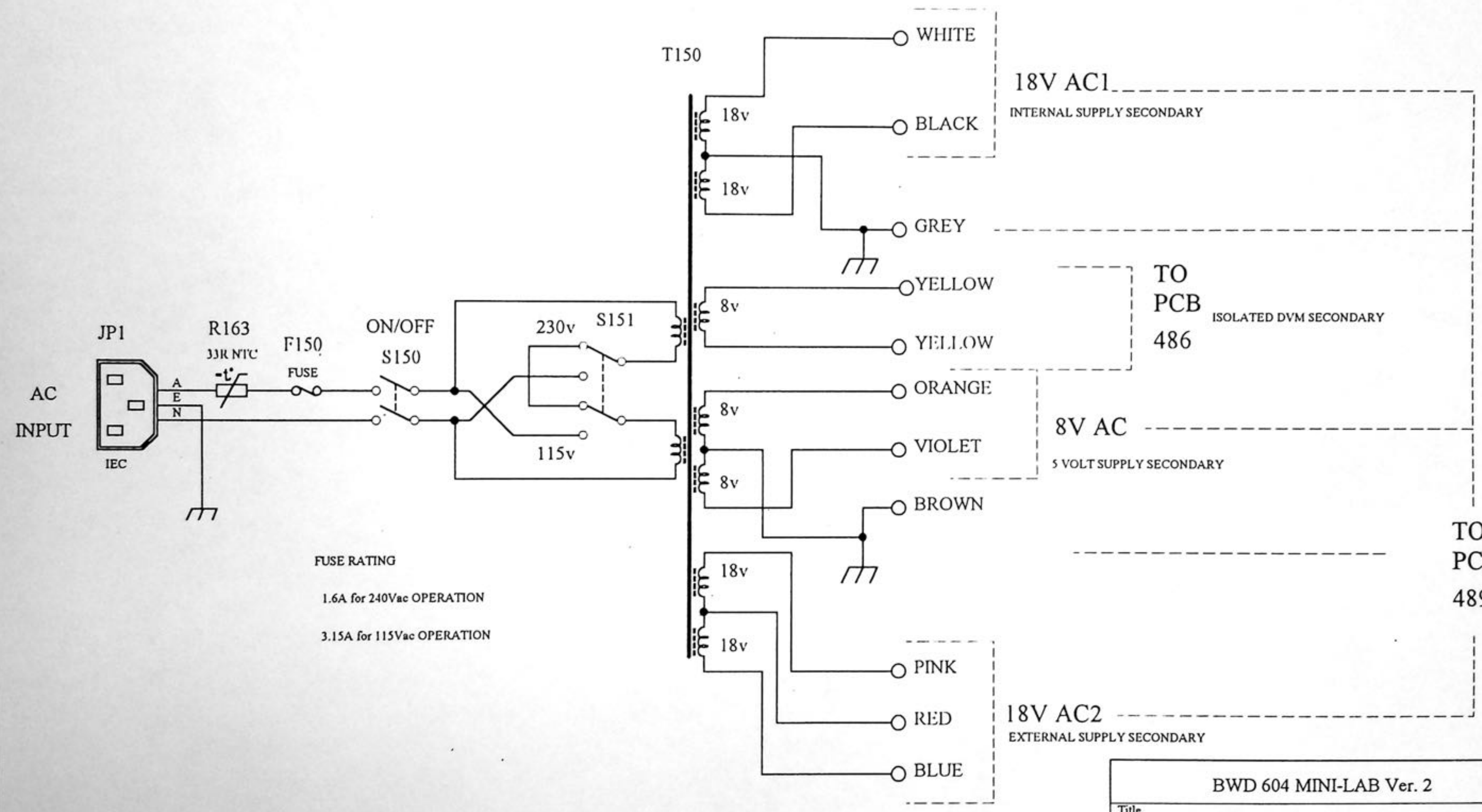
Title: BWD604 MINI-LAB Ver. 2 LOG / LIN SWEEP CIRCUIT		
Size: A4	Number: 3397	Revision: A
Date: 16-Jul-1997	Sheet of	
File: F:\GENR&D\BWD604V2\3397A.SCH	Drawn By: K.R.HARVEY	



* Selected on Testing and Calibration

Circuit Layout on PCB 489 II

Title	BWD 604 MINI-LAB Ver.2
	POWER AMPLIFIER/VARIABLE SUPPLY
Size A3	Number 3398 — Revision B
Date: 22-Aug-1997	Sheet of
File: E:\GENR&D\BWD604V2\3398II.SCH	Drawn By: K R HARVEY/ F.M.D.



BWD 604 MINI-LAB Ver. 2			
Title: 240V & TRANS. AC INPUT			
Size: A4	Number: 3409		Revision: A
Date: 16-Jul-1997		Sheet of 1	
File: F:\GENR&D\BWD604V2\3409A.SCH		Drawn By: K.R.HARVEY, F.M.D	