

PCB 75020

9.1 Introduction

The meter driver circuit card comprises two separate circuits:

- the log law converter to provide the appropriate switching selection and characteristics for the normal and expanded logarithmic scales,
- the ballistics circuit to correct the ballistics of the meter movement and to provide an output for A to D conversion to allow the data to be sent out over the interface bus.

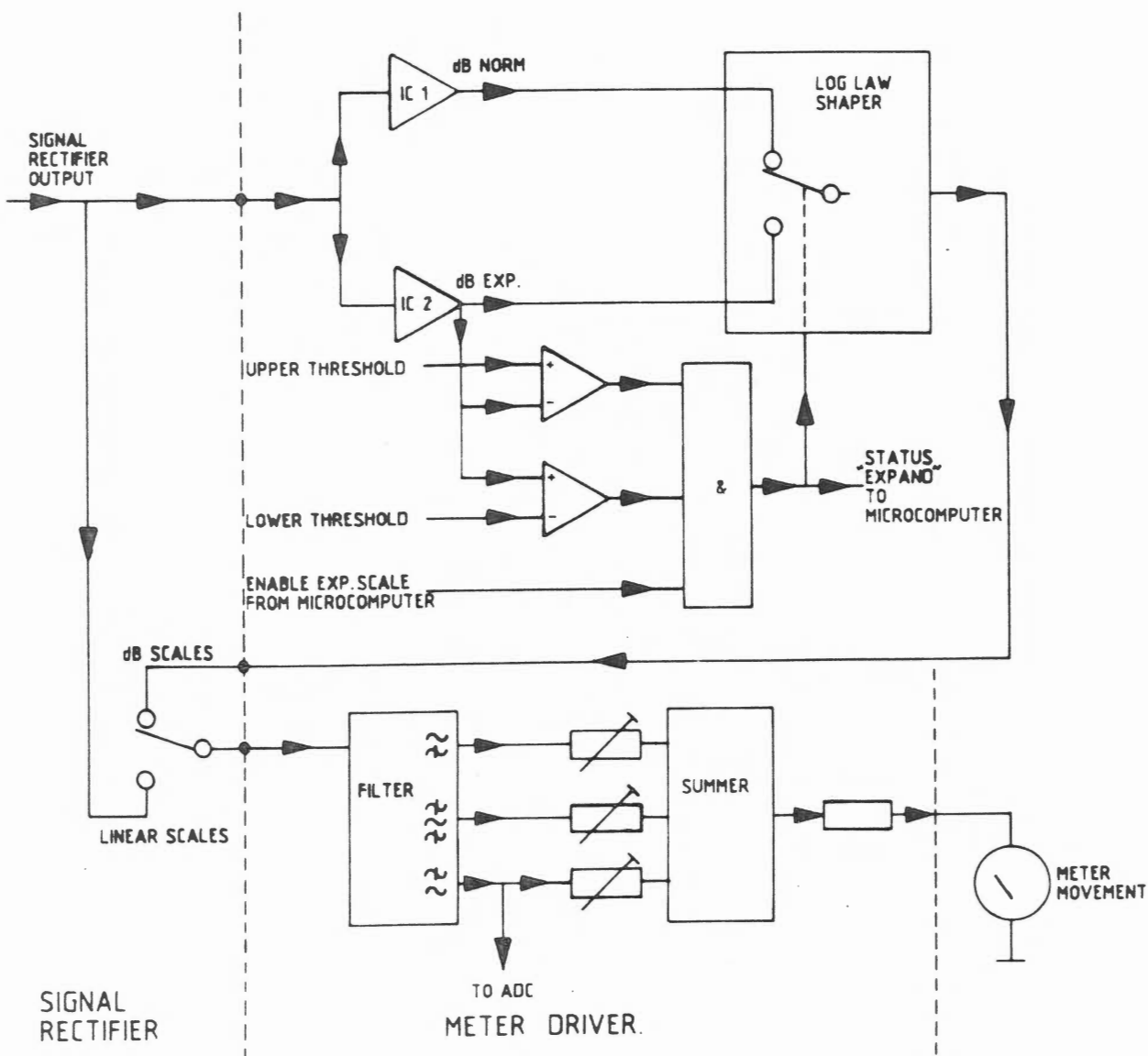


Figure 9.1.1 Block Diagram

9.1.1 Log shaping circuit

A quasi-logarithmic characteristic is achieved by a piecewise linear approximation technique, in which eight transistors are progressively switched on. As the collector loads of the eight transistors are in the feedback-path of an op amp, an increase in signal reduces the overall load resistance in the feedback circuit to shape the amplifier logarithmic response.

To obtain the two different characteristics required for the normal and expanded scales, two sets of load feedback resistors are provided, the appropriate set being selected by analogue switches, the unused set being disabled by transistors, under the control of the normal/expand switching logic.

9.1.2 dB Normal and dB Expanded scales

Both logarithmic scales are centred on the same input level, 0 dB. The "dB NORM" scale is calibrated from -12 dB to +12 dB in 1 dB steps to facilitate measurements of filters, equalisers and similar equipment. The "dB EXP" scale is calibrated from -1.5 dB to +1.5 dB in 0.1 dB steps to enable fast and highly accurate measurements of level deviations.

Either scale may be manually selected by depressing the appropriate front-panel pushbutton. However, the dB EXP will be overridden by automatic switching to the dB NORM scale by means of a comparator circuit if the signal deviates by more than ± 1.8 dB from the centre 0. The dB NORM scale LED in the meter movement flashes to indicate this transition. The expanded scale selection is restored if the signal level returns to within ± 1.5 dB of the centre 0.

9.1.3 Meter Ballistics Circuit

Low-inertia, light-weight meter movements, designed to respond rapidly to programme peaks are often inherently delicate. The MJS401D has been designed around a robust accurate instrument that achieves the necessary fast response with a unique meter "kick-start" action, by incorporating a state-variable filter in the meter ballistic circuit. The outputs of the low-pass, band-pass and high-pass sections are suitably combined to give the required fast response to the meter movement at 2 V f.s.d.

The low-pass output is fed to the ADC at 10 V f.s.d., possessing the ballistics of an ideal PPM movement.

9.2 Circuit Description

9.2.1 Input Signal Conditioning

The "to log amp" output from the rectifier card is routed simultaneously to two op amps. IC1 responds to the dB normal scale signal, and IC2 responds to the expanded input range by providing a high gain output above a fixed input threshold level.

The gain of the IC1 stage is fixed at about 1.25 by means of R1, R2 and VR1.

IC9d inverts the incoming signal at nominally unity gain. IC2 inverts this signal again, with a gain of about 10.5, set by R4, R7 and VR3. A substantial offset is applied via R5, R6 and VR2. The result is a positive-going voltage at IC2 which is 0 V for a reading of -2 dB, and 10 V for +2 dB. Zener diode D11 clamps IC2's output at -0.6 V or +15 V for input voltages outside this range.

9.2.2 dB Normal Scale

When the dB normal scale is selected, the logic low input signal on IC6b/7 gives a logic low output on pin 1. This in turn is applied to the gate of FET TR10, causing it to turn off. IC6a is connected as an inverter, and therefore has a logic 1 at its output, pin 2. This is applied to TR11, causing it to conduct and ground the junction of R8 and all the expanded scale feedback resistors. The logic 1 is also fed to IC7a/13, turning it on and connecting the junction of R3 and all the dB normal scale feedback resistors to IC4/3. This is normally the non-inverting input, but because the transistors TR2 to TR9 in the feedback path invert, the overall effect is of an inverting amplifier.

Therefore, R3 is the input resistor of an amplifier that has TR1 and the diode-selected transistor load as feedback resistance, dependent on signal value, to determine the gain slope of the characteristic. As the signal increases, more transistor loads are paralleled into the feedback circuit, thereby flattening the response as the signal amplitude increases to give the familiar logarithmic characteristic.

The log law input on SKT2/8 is routed to the non-inverting input pin 3 of the buffer amplifier IC1. The stage gain of x1.25 approx. is set by the feedback preset VR1 (NORMAL).

The positive output signal on IC1/6 (TP3) provides the input signal to the log-shaping circuit IC4, TR1, TR2 to TR9, and the associated components.

The emitters of the law-shaping transistor circuits TR2 to TR9 are connected to a -7.613 V reference line derived via IC3 from a bandgap reference diode, D10. The diodes D2 to D8 in the base circuits of the transistors are progressively activated as the signal amplitude on the intermediate output of IC4/8 increases. The output at pin 8 is used rather than pin 6, because the IC is only required to sink current, not to source it. The output at pin 8 has very little drive capability, therefore satisfying the requirement not to source much current. Transistor TR1 is added in order to restore sufficient sink capability.

The offset of the stage is nulled by VR20 and frequency compensation is

effected by capacitor C9. The compensation capacitor is much more than would normally be expected for an IC of this type, because of the high gain of transistors TR2 to TR9 in the feedback path.

The output of IC4 is clamped to the -7.613 V line by diode D1 and conducts for signals greater than a diode drop above this value.

The conduction of TR1 determines the feedback load selected. For example, in response to a low input signal (below -12 dB) from IC4, the output to the base of TR1 approaches the -18 V supply on its collector. Consequently, this PNP emitter-follower conducts heavily and the -18 V on its collector is routed via emitter resistor R50 to pass current through the entire diode chain D2 to D8 in the bases of TR2 to TR9 to hold off all these transistors.

At -12 dB, TR1 is slightly less conductive, which means that the voltage on D2 anode becomes sufficient (as D2 becomes less conductive) to turn on TR2. This occurs at approximately -7 V on the base of TR2. R17 and VR5 provide a feedback path to the inverting input of IC4 to set the -12 dB gain.

As the signal amplitude increases, TR1 becomes less conductive. Its emitter potential becomes less negative and more diodes turn off; consequently, more shaping transistors conduct, their collector resistor values determining the slope. Finally, at +14 dB, TR1 is almost off (0.3 mA approx.) and all diodes are blocked, which allows all the transistors (TR2 to TR9) to conduct.

Presets VR5 to VR12 set the meter outputs as indicated from -12 dB to +14 dB for the normal log law scale.

9.2.3 Expanded scale threshold comparators

These comparators provide for automatic changeover to dB normal scale if the signal exceeds ± 1.8 dB around centre 0. Conversely, they switch from dB normal to dB expanded scale if the signal returns to within 1.5 dB of centre 0.

IC6 is a quad comparator with NPN open-collector outputs. Sections b, c and d are wire-ANDed together so that the expanded scale can only be selected if three conditions are all satisfied:

- (i) the expanded scale has been selected, thus IC6b is off;
- (ii) the input signal voltage is above the minimum threshold, thus IC6d is off; and
- (iii) the input/signal is below the maximum threshold, thus IC6c is off.

The reference voltage across D10 is connected to the inverting input of IC6d and to the non-inverting input of IC6c. If, in expanded scale, the input signal to IC6d/11 drops below the reference on IC6d/10, then a low output on pin 13 turns off TR10 and, via IC6a, gives a high output to switch on IC7a,b and d and TR11, the conditions for dB normal scale.

Conversely, if in expanded scale, the input signal via R51 to IC6c/8 exceeds the reference on IC6c/9, then a zero output on pin 14 turns off TR10 and switches to dB normal scale.

The expanded scale is restored by the reverse comparator action if the signal

returns to within limits. A small amount of hysteresis is applied via R56 and R57 to prevent oscillation between expanded and normal scales.

9.2.4 dB Expanded Scale

The law-shaping for the dB expanded scale works in the same way as for the dB normal scale, but with different slopes within each segment of the piecewise linear curve.

9.2.5 Meter Ballistic Circuit

The input to the meter driver on SKT2/5 from the rectifier card is at a level of 2.000 V for 0 dB deflection on the meter in dB scales, or 77.5 % of FSD in linear scales.

The signal is applied via the voltage follower IC8a to the inverting input of amplifier IC8d. This stage has a gain of approximately four, adjustable by VR13, to give the 10 V full-scale output for the analogue-digital converter. The offset is adjusted by means of the potentiometer VR18 connected to the non-inverting input.

The output on IC8d/8 is fed via R59 to the inverting input of IC8b, the high-pass section of a state-variable filter comprising op amps IC8b, IC8c and IC9a. Op amp IC8b has unity gain and feeds the output via high-pass preset VR16 to the inverting summing input of the meter amplifier IC9b.

The high-pass output from IC8b/14 also provides the input for the first integrator section IC8c that provides the band-pass output across preset VR14. This output is routed via R69, R70 and R71 to the non-inverting input of the meter amplifier IC9b.

The band-pass output from IC8c/1 also provides the input for the second integrator IC9a. The output on IC9a/8 adds the low-pass characteristic via preset VR15 to the inverting input of IC9b.

This low-pass output on IC9a/8 is fed to the ADC on the microcomputer. It can also be fed to a chart recorder, for example.

The outputs of the state-variable filter are suitably combined by input resistors R69-R71 and R73-R76 to give the 2 V f.s.d. required by the meter.

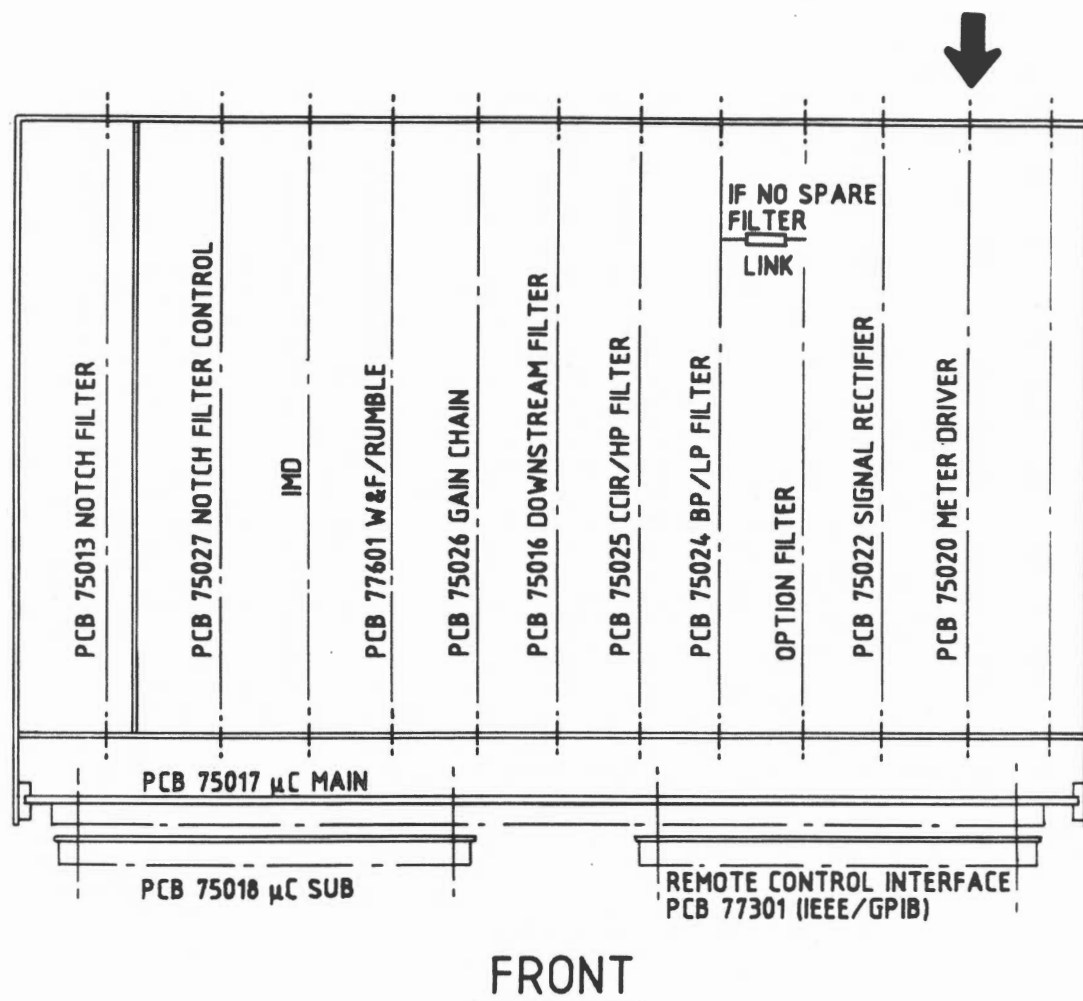
The output from IC9b/7 is inverted by the unity gain op amp IC9c, with VR19 providing offset correction. The output from IC9c/1 (TP7) is applied via R78 and SKT2/4 to the meter movement.

9.3 Removal/Replacement

Switch off the MJS401D and remove the mains lead.

Remove the four screws retaining the top cover. Pull the top cover straight up.

With the instrument facing you, the Meter Driver is installed in the 11th slot from the left in the main card frame. Verify by noting the printing on the motherboard.



MJS401D PCB Location Guide

Remove the card by grasping the top corners and gently pulling up.

Replacement is the opposite of removal. Carefully line up the connectors before pushing down and ensure the card is properly held within the guides.

Extender card PCB75030 may be used to facilitate repair and recalibration.

9.4 Fault Finding

9.4.1 General

Use extender card PCB 75030.

If linear scales are working correctly, but not dB scales, suspect the log law shaper or the input conditioning amplifiers, IC9d, IC1 (dB normal scale only) and IC2 (dB expanded scale only).

If no scales are working correctly, check that the A.C. signal is reaching the Signal Rectifier by observing the "SCOPE" signal, which should be at least 700 mV peak to peak for an input signal of 0 dBu at 1 kHz applied to the selected input of the input module, "LEVEL" function, 0 dB range.

If the signal is getting that far, put the Meter Driver on its extender and measure the D.C. voltage at SKT2/8. For the above conditions, this should be 2 V. In "VOLTS" scale, the same voltage should be present at SKT2/5. If this is correct, the fault is in the Meter Ballistics section of the Meter Driver. If not, the fault is in the Signal Rectifier. Refer to Section 13.

9.5 Calibration

9.5.1 General

Use extender card PCB 75030.

To perform this calibration you will need:

- (i) An A.C. voltage calibration source, of frequency about 1kHz (the exact frequency is not important), whose level is variable between 0 V and 4 V, with a level accuracy of better than 300 parts per million;
- (ii) A D.C. DVM of 4.5 digits resolution or better, and an accuracy of better than 300 parts per million;
- (iii) An oscilloscope (D.C. coupled) and probe.

If the A.C. voltage calibration source and/or DVM were calibrated more than 6 months ago, have them calibrated by a laboratory with traceable standards before using them to calibrate the MJS401D.

9.5.2 D.C. adjustments

Remove any input signal. Set VR20 to mid-track.

Adjust VR4 for exactly -7.613 V on TP1.

Adjust VR18 to produce exactly 0.00 V D.C. at TP6.

Adjust VR19 to produce 0.00 V D.C. at TP7.

Check D.C. conditions:

D10	cathode	+1.2 V	to	+1.32 V.
D2	anode	< -7.1 V.		
D8	cathode	< -11.5 V.		
TP4		+13 mV	to	-13 mV.

9.5.2 Meter Ballistics Calibration

VR14 and VR16 are factory preset to work with the meter supplied in the test set. They should not need adjustment unless the meter movement is replaced. The adjustment is not easy, and needs some practice. If you need to adjust them, you will need a function generator capable of generating square waves at about 0.5 Hz and about 2.5 V peak.

Apply the output of the function generator to the ballistics input of the extender card. Switch to "Ballistics". Adjust the function generator's level so that the meter reaches 95 % of full scale deflection after the initial oscillation. For this step it may be helpful to lower the frequency of the function generator.

Return to 0.5 Hz.

Adjust VR14 and VR16 to achieve settling after one only overshoot, which should be to 100 % of full scale deflection. The overshoot should be rapid. If the correct combination of settings is not made, a much slower overshoot or undershoot will be visible, either instead of or in addition to the correct

rapid response.

It is not easy to describe the adjustment in words. The most helpful hint is to make a small adjustment to one preset, then set the other to achieve the 5 % overshoot (i.e. from 95 % to 100 %). If the adjustment is still not correct (i.e. the lower frequency disturbance is still visible), make another adjustment similarly in the same direction. Noting whether the low frequency disturbance has got better or worse will indicate the direction to make further adjustments.

9.5.3 Meter Mechanical Zero

Short out meter movement terminals using a crocodile clip lead. Adjust Meter Mechanical Zero through front panel to the left-hand scale end.

9.5.4 Input Signal Calibration Check

Check System Gain

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	Off	RMS	Volts	---	0	0

Source Setup

Freq	Level dB	Volts	Connect to
1kHz		1.000	Input A

DVM to "TO LOG AMP" via 1 k Ω (so the capacitance of the meter does not cause the output stage of the Signal Rectifier to oscillate) - confirm exactly 2.581 volts. Otherwise adjust VR1 on Signal Rectifier board (Horizontal, half way down).

9.5.5 "Volts" Scale Calibration

Check Meter Driver Gain

DVM to TP6

Adjust VR13 for exactly 10.00 V D.C.

Set Meter Deflection Calibration

Source Setup

Freq	Level dB	Volts
1kHz		0.8000

Adjust VR15 for meter deflection "8" on 0 - 10 scale.

9.5.6 "dB NORM" Scale Calibration

Check Rectifier Output Calibration

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	Off	RMS	dB Norm	---	0	0

Source Setup

Freq	Level		DVM Reading
	dB	Volts	
1kHz	0	0.7750	2.000

DVM to "TO LOG AMP" on extender board via 1 k Ω - LEAVE IT THERE !

Check DVM reads between 1.998 and 2.002 V.

Source Setup

Freq	Level		DVM Reading
	dB	Volts	
1kHz	-8	0.3085	0.7962

Scope probe to TP8.

Adjust VR20 to just cause jump from -8.2 V to -7.6 V on scope. Ensure it is the correct jump - it is possible to adjust VR20 far enough to cause a jump between other voltages, and the calibration becomes impossible.

Source Setup

Freq	Level		DVM Reading
	dB	Volts	
1kHz	0	0.7750	2.000

Meter Centre Scale Adjustments

Set scope to D.C.

Scope Probe to TP5.

Adjust VR1 to just cause jump from -7.6 V to -7.0 V on scope.

Source Setup

Freq	Level		DVM Reading
	dB	Volts	
1kHz	-2	0.6456	1.589 V

Scope Probe to TP2.

Adjust VR2 for 0 mV on the scope.

dB NORM/dB EXP Centre Scale Calibration

Source Setup

Freq	Level		DVM Reading
	dB	Volts	
1kHz	0	0.7750	2.000 V

Switch repeatedly between "dB NORM" and "dB EXP" scales.

Adjust VR3 so that there is no movement of the meter pointer.

9.5.7 Log Converter Calibration

In the following set of adjustments, the same trimmers set up both "dB NORM" scale points and "dB EXP" scale points. Because of the inevitable gain errors between the two scales some compromise in actual meter readings may be required. The net result should still be well inside ± 0.05 dB on the expanded scale.

dB NORM Scale Calibration

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	Off	RMS	dB Norm	---	0	0

Source Setup

Freq	Level		DVM Reading	Adjust	To Read
	dB	Volts			
1kHz	-12	0.19467	0.5024	VR5	-12
	-8	0.3085	0.7962	VR6	-8
	-4	0.4890	1.2619	VR7	-4
	0	0.7750	2.000	VR8	0
	+4	1.2282	3.170	VR9	+4
	+8	1.9467	5.024	VR10	+8
	+12	3.085	7.962	VR11	+12
	+14	3.884	10.024	VR12	Right hand scale end

dB EXP SCALE

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	Off	RMS	dB Exp	---	0	0

Perform the following series of checks.

Confirm the setting, or adjust the stated variable resistor to halve the error.

Source Setup					
Freq	Level		DVM Reading	Adjust	To Read
	dB	Volts			
1kHz	-1.5	0.6521	1.6828	VR5	-1.5
	-1.0	0.6907	1.7825	VR6	-1.0
	-0.5	0.7316	1.8881	VR7	-0.5
	0	0.7750	2.0000	VR8	0
	+0.5	0.8209	2.1185	VR9	+0.5
	+1.0	0.8696	2.244	VR10	+1.0
	+1.5	0.9211	2.377	VR11	+1.5

