

PCB 75016

6.1 Introduction

The downstream filter is a programmable filter with a centre or cut-off frequency determined by a 9-bit word received from the microcomputer. It is inserted in the MJS401D signal path after the "gain chain" and before the fixed filters.

Two filter modes are available, namely high-pass or band-pass, or the filter can be bypassed to give a flat response.

The downstream filter PCB also contains a four-phase rectifier which is used in the auto-set-level process for the THD+N function.

6.1.1 High-pass mode

The high-pass mode is selected whenever the MJS401D is in the total harmonic distortion and noise (THD+N) measurement function. In this operating mode the microcomputer tunes the notch filter to the centre frequency of the incoming signal, and also tunes the high-pass filter to 1.414 times the incoming signal frequency. The combined effect of the notch filter and the high-pass filter in the signal path results in a combined frequency response curve as shown in Fig. 6.1.1. The peak in the high-pass response just above the turnover point results overall in a flat pass-band response as low as the second harmonic of the incoming signal frequency. Furthermore, the filtering attenuates unwanted interference and noise below the incoming signal centre frequency.

The high-pass filter output signal level can be increased in one-eighth dB steps up to a maximum of seven-eighths dB under the control of three data bits from the microcomputer. This forms part of the post notch filter gain control system, together with the gain chain card, as part of the auto-set-level system for distortion measurements.

6.1.2 Band-pass mode

The band-pass mode is used only for the MJS401D "crosstalk" function.

It is often desirable to measure the amplitude of a signal at a particular frequency, which may be accompanied by noise or interference. To facilitate measurement, the state-variable filter used here is switched to operate as a band-pass filter with a centre frequency tuned by the microcomputer to equal that of a reference signal, either generated by the internal MD404B oscillator, or applied to the MJS401D oscillator connector if no MD404B is fitted. Response of the filter in bandpass mode is shown in Fig. 6.1.2.

6.1.3 Direct (bypass) mode

For MJS401D measurements other than THD or crosstalk, the signal is routed directly to the output buffer IC9, thus providing a flat frequency response.

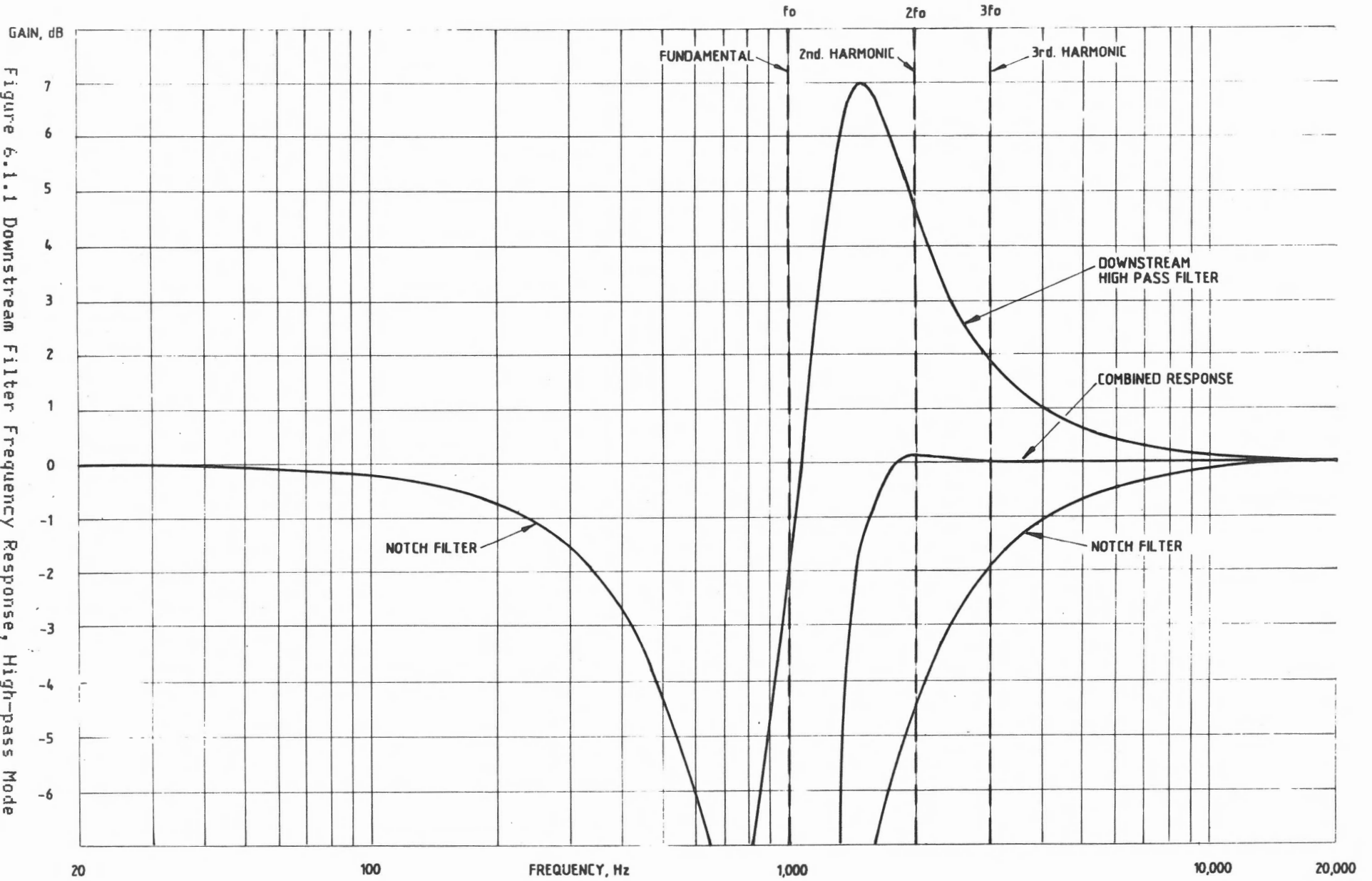
6.1.4 Auto set-level rectifier

This is an independent circuit block that takes the input and 90° phase-shifted equal amplitude signals from the notch filter and converts them to a four-phase rectified d.c. voltage. The d.c. voltage is fed to the microcomputer system analogue-to-digital converter to enable the microcomputer to control the gain chain and high-pass filter gain in order to perform auto set-level control.

6.1.5 Relay drivers

The card also contains the relay drive circuits for selecting the frequency decade switched capacitors in the filter feedback circuits.

Figure 6.1.1 Downstream Filter Frequency Response, High-pass Mode



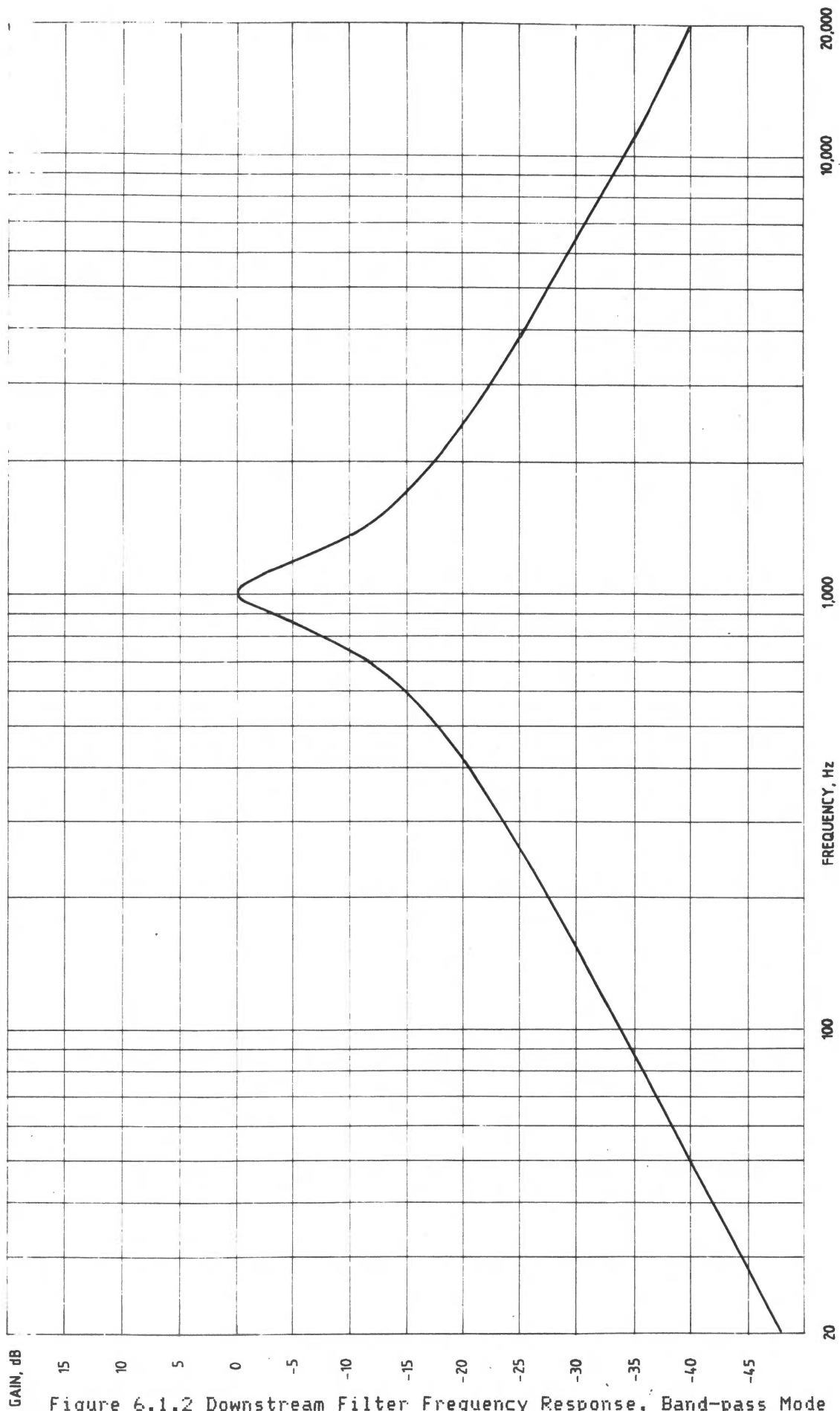


Figure 6.1.2 Downstream Filter Frequency Response, Band-pass Mode

6.2 Circuit Description

6.2.1 Principles of Operation - Filter Section

The filter consists of a state-variable circuit with variable gain, using four operational amplifiers (IC11, IC12, IC8 and IC10). This configuration is used here as a universal filter to provide both a high-pass output and a bandpass output.

The state variable filter gives HP, BP and LP filter outputs with independently controlled damping and frequency. A 4 op amp version allows all inverting amplifiers to be used, allowing electronic switching to be used for control at virtual earth inverting inputs.

The block diagram Fig. 6.2.1 shows the overall circuit configuration.

For a full treatment of state-variable filters refer to many published texts.

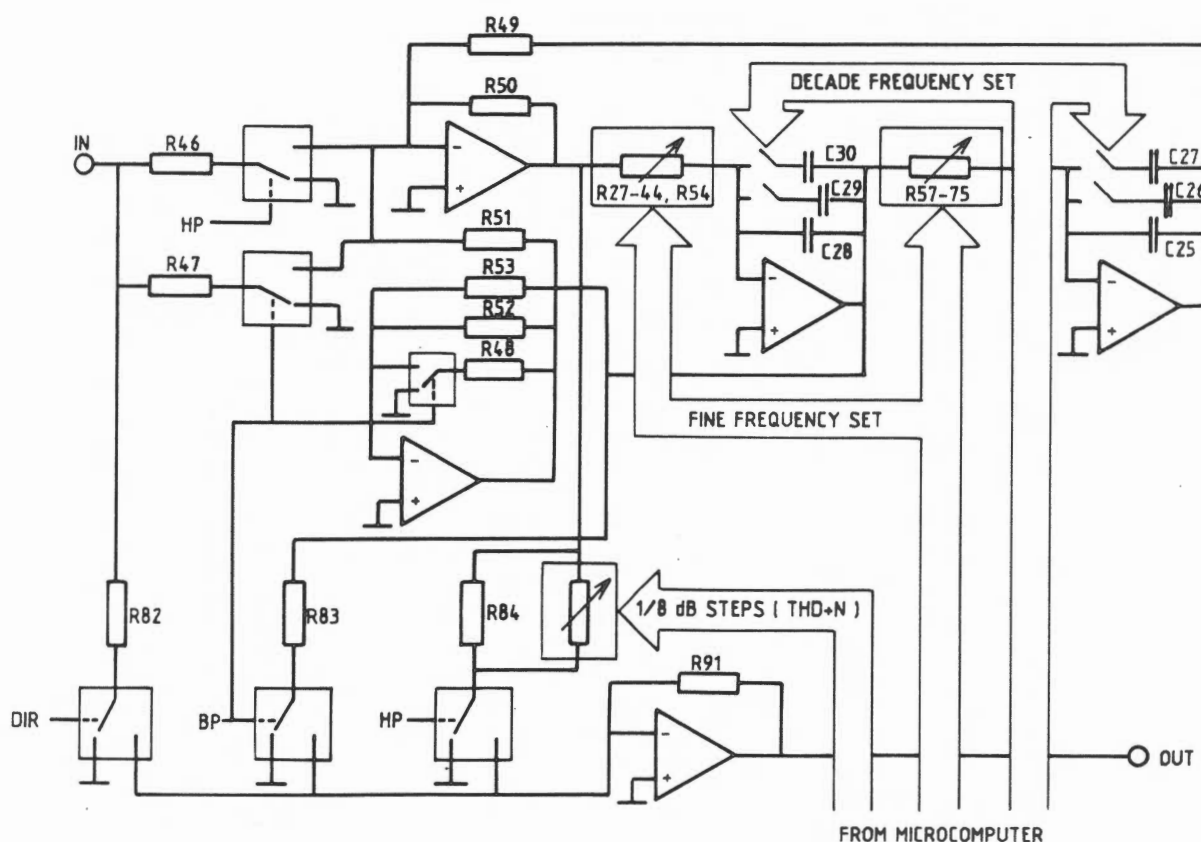


Figure 6.2.1 Block Diagram, Filter Section

6.2.2 High-pass Mode

Frequency tracking is provided by digital inputs D0 to D8 which are used to drive the analogue switches IC1 to IC6 to control the fine frequency-determining resistor chains in the inputs of IC8 and IC10.

The frequency decade is selected by digital inputs on SKT3/8 (200 Hz to 2 kHz) and SKT3/7 (20 Hz to 200 Hz). A logic high on one of these inputs causes either TR1 or TR2 to conduct to energise RLA or RLB respectively.

When the decade 200 Hz to 2 kHz is selected, relay contacts RLA/1 close to include capacitors C29 and C26 in the integrator feedback paths. Alternatively, when the decade 20 Hz to 200 Hz is selected, it switches in C30 and C27 by means of relay contacts RLB/2. In the highest decade range, 2 kHz to 20 kHz, only capacitors C28 and C25 are in circuit.

Op amps IC11, IC8, IC10 and IC12 form the state-variable filter.

Op amp IC12 provides a selected degree of damping over the pass band determined by the values of R52 and R53 (and R52//R48 in the band-pass mode).

The overall circuit path is as follows.

The signal input is fed via C1, R46 and the analogue switch IC14/4,3 to the inverting input of the unity gain summing stage IC11.

The high-pass output is derived from the IC11/6 output via R84, analogue switch IC13/15,1 and the unity-gain output amplifier IC9.

Overall unity gain is achieved by maintaining resistors R46, R49, R50 and R51 all at the same value.

The fine frequency change is obtained by identical variation of the two integrator input resistor chains controlled via the IC1 to IC6 analogue switches from the D0 to D8 inputs. The analogue switch driver inputs are active high via the pull-up resistors R1 to R9; i.e. the normal state for the D0 to D8 inputs is at logic low.

The turnover frequency is determined by the integrator capacitors and R54 (R75) in parallel with the effective resistance determined by the R-2R ladder combinations R28-R42 (R58-R72), R27-R44 (R57-R74).

The capacitance is changed in decades as shown in the table.

DECADE SELECTED (INPUT HIGH)	CIRCUIT ACTIVATED	INTEGRATING CAPACITORS		
		IN IC10	IN IC8	
2 kHz-20 kHz		C25	(C28)	300pF
200 Hz-2kHz	TR1, RLA	C25+C26	(C28+C29)	3nF
20 Hz to 200Hz	TR2, RLB	C25+C27	(C28+C30)	30.3nF

Three auto set level control inputs D0, D1, D2 applied on SKT2/3, SKT2/4 and SKT2/5 respectively, provide automatic control of the high-pass filter output attenuation via analogue switch IC7. The switch positions are shown for logic low on the driver control inputs; i.e. R85...R90 gives maximum attenuation across the high-pass filter output.

6.2.3 Band-pass Filter Mode

When selected, the band-pass filter gives the instrument a level measurement facility with automatically tuned second-order band-pass at a "Q" of 5.

Reference to the basic state-variable circuit of Fig. 6.2.3 will show that a

band-pass output is available at the output of the first integrator.

In this band-pass configuration, the input signal is applied to the inverting input of IC12. To give the necessary damping, IC12 gain is reduced by R48, connected in parallel with the fixed feedback resistor R52 by switch IC14/13,14.

For unity gain, the input resistor R47 is equal to feedback resistor R53.

Automatic fine and coarse frequency selection for the band-pass configuration is by means of IC1 to IC6 and relay drivers TR1 and TR2, as described for the high-pass filter.

6.2.4 Direct Mode

When the direct mode is selected, the filter circuits are bypassed and the input to the Downstream Filter card is applied via the unity gain output op amp to the card output socket.

A logic high on the direct function input SKT2/2 is applied to analogue switch IC13/9 driver input. This control signal removes the earth shunt and R82 is connected via analogue switch IC13/4,3 to the inverting input of IC9.

The input signal to the card on SK1/1 is thus routed via C1, R82, IC13/4,3 and IC9 to the output connector SKT4/8.

6.2.5 Auto Set Level Rectifier

Figure 6.2.2 shows the block diagram of the rectifier section.

Inverting op amps IC15 and IC16 half-wave rectify input signals that are applied from the notch filter input and the 90° phase-shifted output respectively.

Taking the input on SKT4/3:

- Each negative-going half-cycle of the signal to inverting input IC15/2 appears as a positive half-cycle on output pin 6. This is blocked by D3. The negative input half-cycle is admitted to IC17/2 via R99 to produce a positive output on IC17/1.
- Each positive-going half-cycle of the signal to inverting input IC15/2 appears as a negative half-cycle on output pin 6. Feedback diode D1 blocks it, but D3 passes it to produce a negative half-cycle on input IC17/2. This effectively cancels the input positive half-cycle through R99, providing a net negative input current to IC17/2, giving a positive output to IC17/1.

In this way, a negative going half-wave rectified signal is obtained and applied by resistor R104 inverting summing amplifier IC17.

The rectified output of the identical circuit IC16 is also mixed at IC17/2. This represents the 90° out-of-phase signal.

The outputs of these 2 rectifiers are summed with a direct version of the input signals in a 2:1 ratio set by the summing resistors R104, R105, R99, and R101. The resulting wave has minimal ripple at twice the frequency.

The composite rectified signal is inverted to give a positive output on IC17/1, the amplitude of which is set precisely by VR1.

The auto set level rectifier output is fed via the smoothing network R107, C8 and VR4 and voltage follower IC17 to provide an output on SKT1/7 for the analogue-to-digital converter.

VR4 is used to set the charge/discharge time constant comprising VR4, R107, and C8 to an exact value. This enables the microcomputer to predict the final value of the rectifier output at SKT1/7 by taking successive samples throughout the charge or discharge time of the VR4, R107, C8 time constant. The FAST DISCHARGE control line on SKT1/3 when taken HIGH places a near short circuit R109 across C8 to rapidly discharge C8. This can be triggered under software control when overload occurs on the A-D converter output.

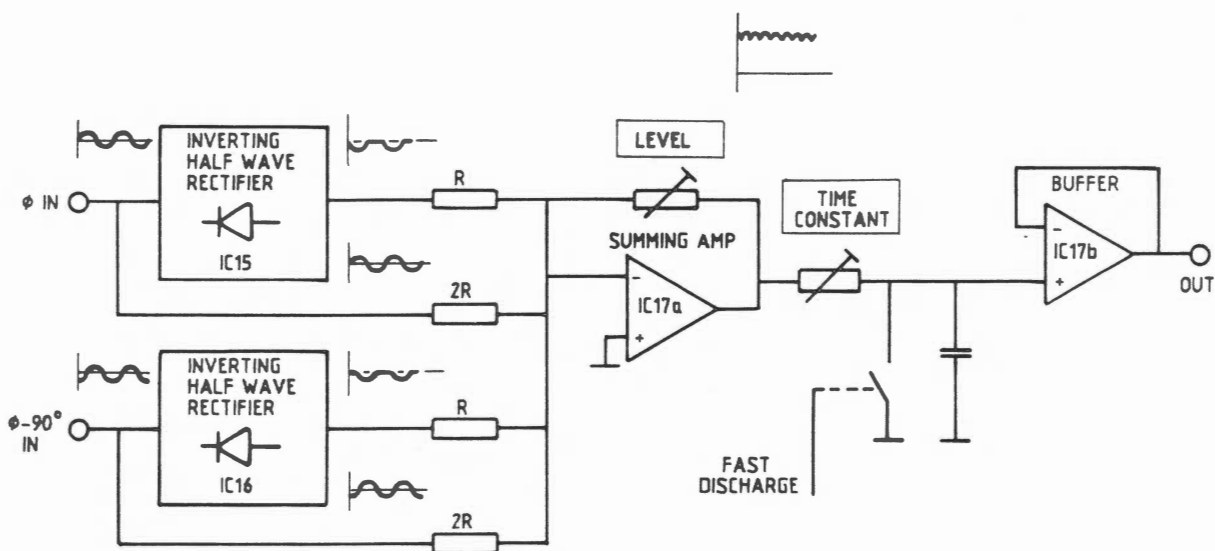


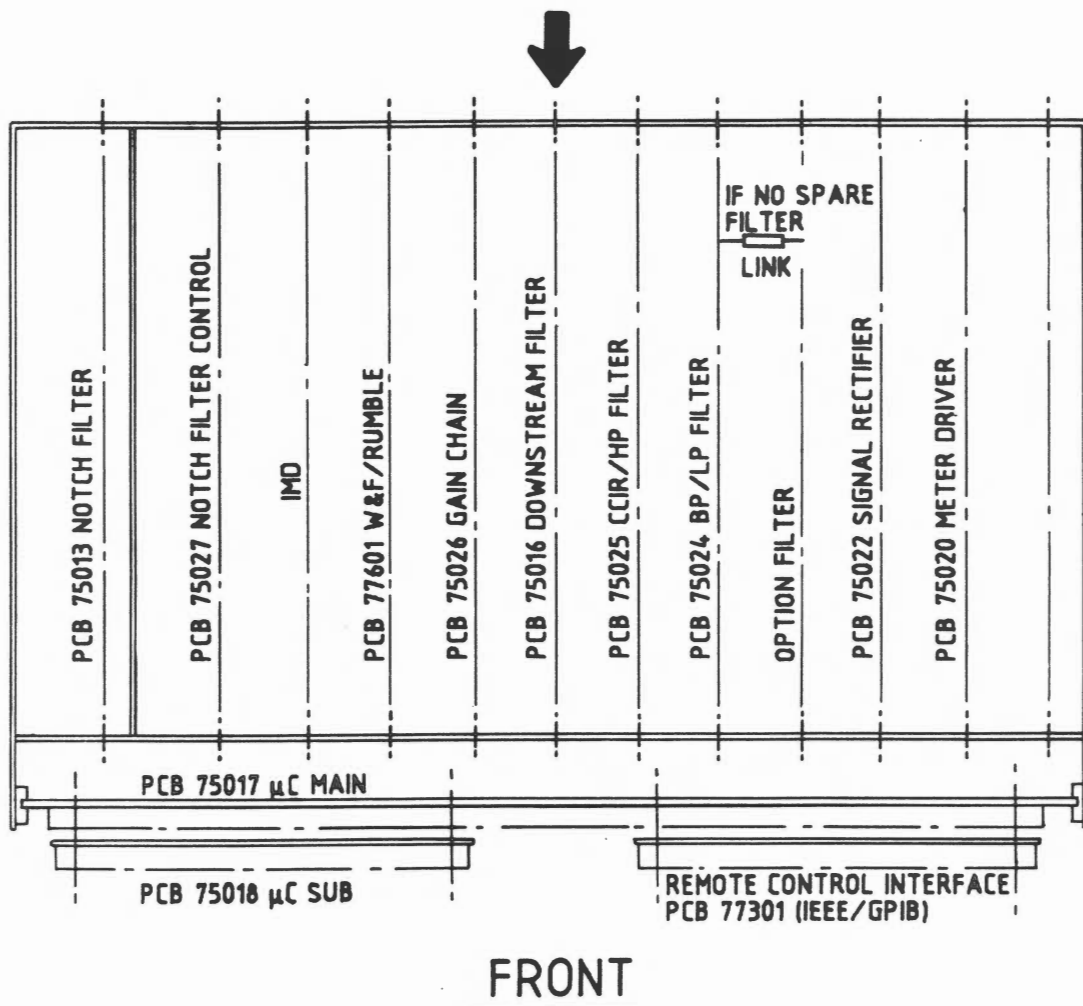
Figure 6.2.2 Block Diagram, Rectifier Section

6.3 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 Downstream Filter card is installed in the 6th 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 PCB 75029 may be used to facilitate repair and calibration.

6.4 Fault Finding

Use Extender Card PCB 75029.

6.4.1 Auto Set Level Gain

Auto Set Level is used within the THD+N and IMD functions to adjust the instrument gain to achieve a reference level for % DISTORTION and dB DISTORTION readings.

The setting of 1 dB and 10 dB steps takes place elsewhere in the system, while 1/8 dB step level changes are located on this PCB. See section 10 for detailed information.

If level steps are correct except for fractional dB steps, then this section is suspect.

The "AUTO SET LEVEL" indicator on the extender card shows the status of the microcomputer output lines controlling the 1/8th dB steps.

AUTO SET LEVEL DISPLAY								
DISPLAY	0	1	2	3	4	5	6	7
GAIN dB	0	1/8	2/8	3/8	4/8	5/8	6/8	7/8
SKT2/5 (D0)	L	H	L	H	L	H	L	H
SKT2/4 (D1)	L	L	H	H	L	L	H	H
SKT23 (D2)	L	L	L	L	H	H	H	H

To check out this system, set up as follows:

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	THD+N	30K	RMS	% Dist	As req'd	---	---

Set "% DIST" to give approximately centre scale reading.

Connect a sinewave source to Input A. A function generator is preferable for this application; distortion is what we are trying to measure.

Source Setting

Frequency	Level	Source Impedance
~1kHz	~0 dBu (0.775V)	Minimum

Using the extender card:-

Fine adjust the source to obtain "0" on the "Auto Set Level" display on the extender card.

Measure the AC voltage between filter O/P and audio ground.

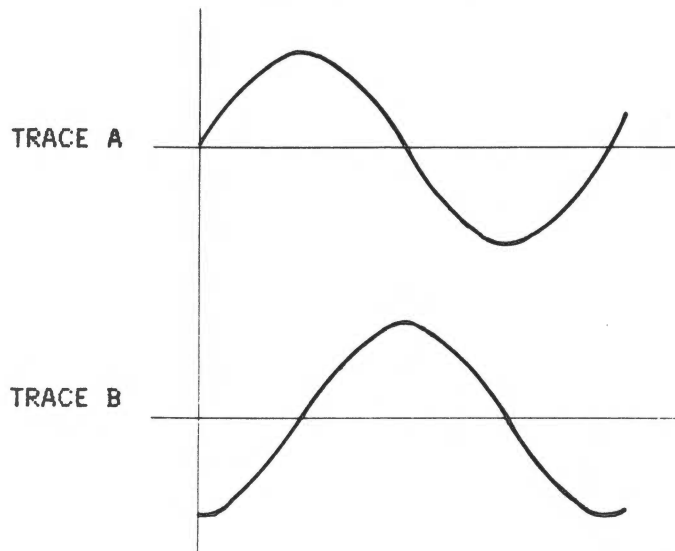
Now slowly decrease the oscillator output. The "Auto Set Level" display should step from the initial "0" through to "7" while the average measured voltage should not vary.

Failure of the display to step properly most likely indicates a fault in the

IC37 output latch on the microcomputer board, or the interconnections between microcomputer, motherboard and programmable filter PCB. Other less likely possibilities are the A.S.L rectifier (this board); or A/D converter in the microcomputer board.

6.4.2 Auto Set Level Rectifier

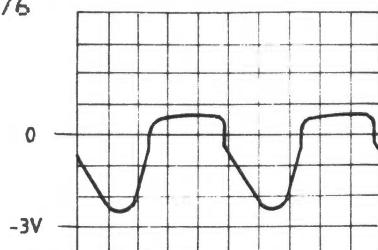
Using the setup described above, connect a dual beam 'scope to the extender board with trace A on the "RECTIFIER 0" input and trace B on the "RECTIFIER 0 - 90°" input. Examine the waveform shown on the 'scope which should be similar to that below, with trace B 1/4 wave behind trace A.



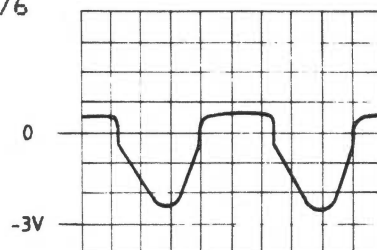
If this is not the case the fault is likely to be in the 90° phase shift section of the NOTCH FILTER CARD.

Other waveforms are shown below, triggered with respect to the "Rectifier Ø" input on the extender PCB.

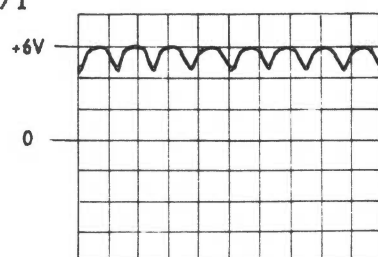
IC15/6



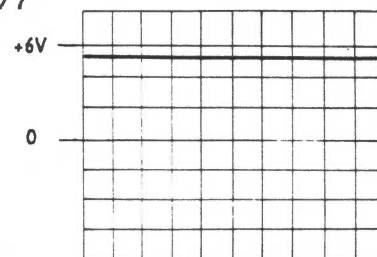
IC16/6



IC17/1



IC17/7



Voltage on IC17/7 = average of the voltage on IC17/1.

6.4.3 Function Selection

INSTRUMENT FUNCTION	DOWNSTREAM FILTER PCB FUNCTION		
	BP (SKT1/8)	HP (SKT2/1)	DIR (SKT3/7)
LEVEL	L	L	H
THD+N	L	H	L
IMD	L	L	H
X-TALK	H	L	L
READ OSC	L	L	H
W & F	L	L	H

The corresponding LED on the extender card will light indicating the above function is active (H).

Improper function selection indicates a failure of output latches or the microcomputer PCB on interconnections between the microcomputer, motherboard and Downstream Filter board.

If the function selection is correct, but board operation is incorrect, refer to the appropriate analogue switches on the Downstream Filter board.

6.4.4 Filter Frequency Tuning

Frequency tuning is controlled by the microcomputer system. The incoming frequency is measured, then appropriate output latches are set to select the correct decade and frequency within the decade.

First determine that the frequency display on the MJS401D is giving a sensible reading. If not, refer to the microcomputer section 3.

6.4.5 Decade Selection

Set up the instrument front panel and sinewave source as shown in Section 6.4.1 above.

On the extender card, the decimal point on the alphanumeric display labelled 200 Hz to 2 kHz should be lit. The others should be off. Ignore the rest of the display for the moment. Proceed as follows:-

Source Frequency	ALPHANUMERIC DISPLAY DECIMAL		
	2 kHz-20 kHz	200 Hz-2 kHz	20 Hz-200 Hz
100 Hz	OFF	OFF	ON
1 kHz	OFF	ON	OFF
10 kHz	ON	OFF	OFF

If these displays are correct then a decade tuning fault must lie in the circuits on the Downstream Filter card. Otherwise check the microcomputer output latches and connections through the motherboard.

6.4.6 Fine Frequency Selection

The 9 data lines D0 - D8 control frequency selection within a decade band. The status of these lines is displayed on the 3 alphanumeric displays as a hexadecimal value.

From left to right the displays show:-

D8	-	0 or 1
D4-7	-	0 to F
D0-3	-	0 to F

Thus, for example, if the display on the extender card were 1B3, the states of the tuning lines D0-D8 would be:-

DATA LINE	D8	D7	D6	D5	D4	D3	D2	D1	D0
LOGIC STATE	1	1	0	1	1	0	0	1	1
HEXADECIMAL	1	B				3			

Frequencies within the decade band are linearly related to the data line state. A small overlap between decades is provided.

In practice the frequency selection function can be easily checked out by sweeping an oscillator very slowly from the lowest frequency in the decade - readout 000 - to the highest - 1FF. Observe any missing states and backup the frequency if necessary to check them out.

Note all missing states carefully - then relate them to the appropriate data line(s).

If states are missing, failure of microcomputer output latches, or connections from the microcomputer through the motherboard to the Downstream Filter are indicated.

If all selection states are present, then set up as follows:-

MJS401D Front Panel Setup

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

Source Setting

Frequency	Level	Waveform
1 kHz	0 dB	Sine

Adjust the oscillator to give a reading of exactly "0 dB" on the MJS401D meter. Then slowly sweep from 20 Hz to 20 kHz. Readings should be within ± 0.5 dB. Note the display reading for any step which is in error, decode the control status lines, then inspect the circuitry involved. Please ensure that the error is in the measuring set and not the oscillator. To do this switch to "LEVEL" and compare readings.

6.5 Calibration

Check D.C. conditions:

Adjust VR2 and VR3 to approximately mid-track.

D10	cathode	>+17.5 V
D11	anode	<-17.5 V
D12	anode	-11.4 V to -12.6 V
D13	cathode	+5.25 V to +4.5 V
IC10	pin 6	+13 mV to -13 mV
Adjust VR2 for 0 mV on IC11 pin 6.		
Adjust VR3 for 0 mV on IC8 pin 6.		
IC9	pin 6	+13 mV to -13 mV
IC15	pin 6	+0.5 V to -0.5 V
IC16	pin 6	+0.5 V to -0.5 V
IC17	pin 1	+60 mV to -60 mV
IC17	pin 7	+70 mV to -70 mV

Note that the adjustments to VR2 and VR3 do not adjust the offset of the ICs they are directly connected to, but rather the offset of the IC before them. This is an effect of the tightly-coupled ring of the state variable filter.

6.5.1 Adjust Gain of Auto Set Level Rectifier

The purpose of the following is to create a perfect 1% Distortion source.

Use a signal mixer according to the drawings in Section 31, Appendix B.

Plug into test set input "A". Turn the signal mixer output level control fully up.

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	Off	RMS	dB Exp	1%	0	0

Plug a low distortion oscillator such as the MD404B into the "A" input of the Signal Mixer.

Calibrate oscillator "A" as follows:-

Source Setting

MJS401D READING		
ADJUST	LEVEL	FREQ
OSC "A"	0	1.0 kHz

Unplug oscillator "A". Plug in and calibrate oscillator "B" as follows:-

MJS401D Front Panel Setup

Input	Load	Function	Filters	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	Off	RMS	dB Exp	1%	-40	0

Source Setting

	<u>MJS401D READING</u>	
<u>ADJUST</u>	<u>LEVEL</u>	<u>FREQ</u>
OSC "B"	0 (-40)	2.0 kHz

Plug in oscillator "A" again. Leave both oscillators fixed and check the combined output as follows.

Source Setting

	<u>MJS401D READING</u>	
<u>ADJUST</u>	<u>LEVEL</u>	<u>FREQ</u>
OSC "B"	0	1.0 kHz

We now have a calibrated 1 % Distortion source.

Select "THD+N" function on the MJS401D front panel.

Adjust VR1 to obtain a reading of 10 (=1 %) on the MJS401D meter.

6.5.2 Adjust Rectifier Time Constant

The purpose of this adjustment is to set the RC time constant formed by VR4, R107 and C8. This time constant must be set to match the sampling time constant of the software reading the A.S.L A/D converter. The software contains an estimating algorithm which gives a best predicted level setting for the A.S.L gain. This occurs in the shortest time when matched with the rectifier time constant.

Get the MJS401D into diagnostics mode as follows:-

Turn off.

Depress and hold "Level" while turning on.

Depress "Level" again for Group 1.

Depress "Read Osc" for Test 5.

Depress "THD+N".

Input a sine source at about 0 dBu and 100 Hz into MJS401D input "A". Ensure that no source is plugged into "B" but the 600 ohm load is selected on "B".

Switch between input "A" and "B". Note the hexadecimal reading in the frequency display.

Adjust VR4 until the reading (value unimportant) reaches a final value fastest without overshooting.

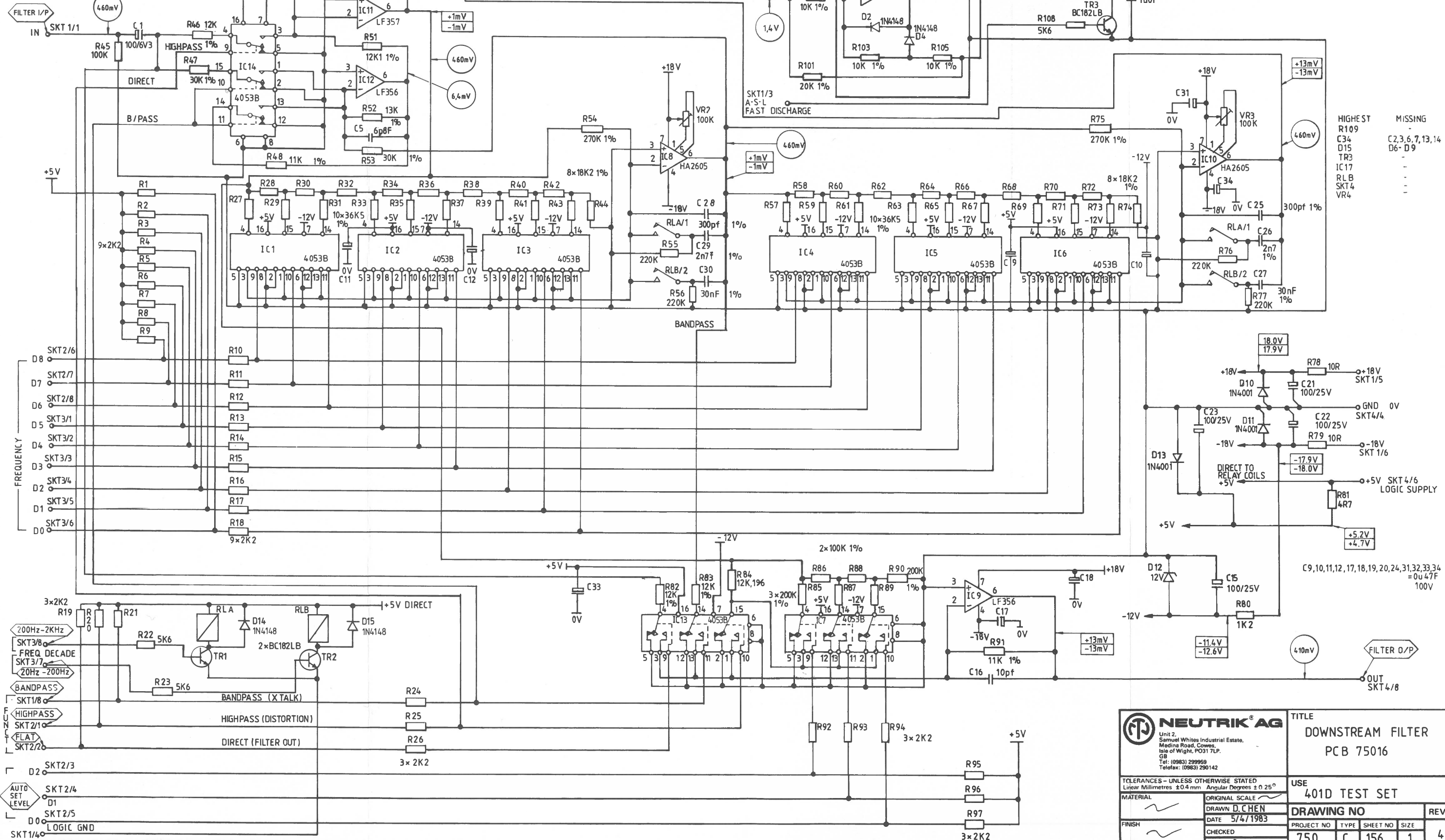
PROJECTION DO NOT SCALE IF IN DOUBT ASK

REPRESENTS A.C. VOLTAGES MEASURED WITH AN INPUT IMPEDANCE OF 10K OHMS OR GREATER. UNLESS OTHERWISE SPECIFIED THESE LEVELS CORRESPOND TO A 1KHz TONE AT A REFERENCE LEVEL OF +5dBu (1.38V) INTO A FULLY CALIBRATED TEST SET, "X-TALK" FUNCTION, 0dB RANGE

REPRESENTS D.C. VOLTAGES MEASURED WITH A VOLT-METER OF 20,000Ω/V OR GREATER. MAXIMUM DEFINED AS MOST POSITIVE VOLTAGE. UNLESS OTHERWISE SPECIFIED THESE VOLTAGES ARE WITH NO SIGNAL INPUT, "X-TALK" FUNCTION, 0dB RANGE

USE EXTENDER CARD PCB 75029

EXTENDER TEST POINT OR INDICATOR REFERENCE.



REVISION				
NO	DATE	CHANGE	APPROVED	
1	30/12/82	A-S-L RECTIFIER		
2	2/1/83	REWORKED		
3	25/8/85	REWORKED		
4	24/10/85	REWORKED		

HIGHEST MISSING
R109 C2,3,6,7,13,14
C34 D6-D9
D15
TR3
IC17
RLB
SKT4
VR4

C9,10,11,12,17,18,19,20,24,31,32,33,34
= 0u47F 100V

NEUTRIK AG
Unit 2, Samuel Whites Industrial Estate,
Medina Road, Cowes,
Isle of Wight, PO31 7LP,
GB
Tel: (0983) 299958
Telefax: (0983) 290142

TITLE
DOWNSTREAM FILTER
PCB 75016

TOLERANCES - UNLESS OTHERWISE STATED
Linear Millimetres ±0.4mm Angular Degrees ±0.25°
MATERIAL
FINISH

USE
401D TEST SET
DRAWING NO
PROJECT NO TYPE SHEET NO SIZE
750 C 156 1 4