

PCB 77601

17.1 Introduction

This card contains all the circuitry to measure rumble, Wow & Flutter, and F.I.M., to a variety of international standards. On-board switches are provided to set up the board to the desired standards. Once the switches are set, the MJS401D automatically performs W & F or rumble measurements to the selected standard when the appropriate front panel buttons are pressed. All the measurement standards provided on the board may be selected under IEEE-488 bus control.

Figure 17.1.1 shows a block diagram of the wow and flutter/rumble card.

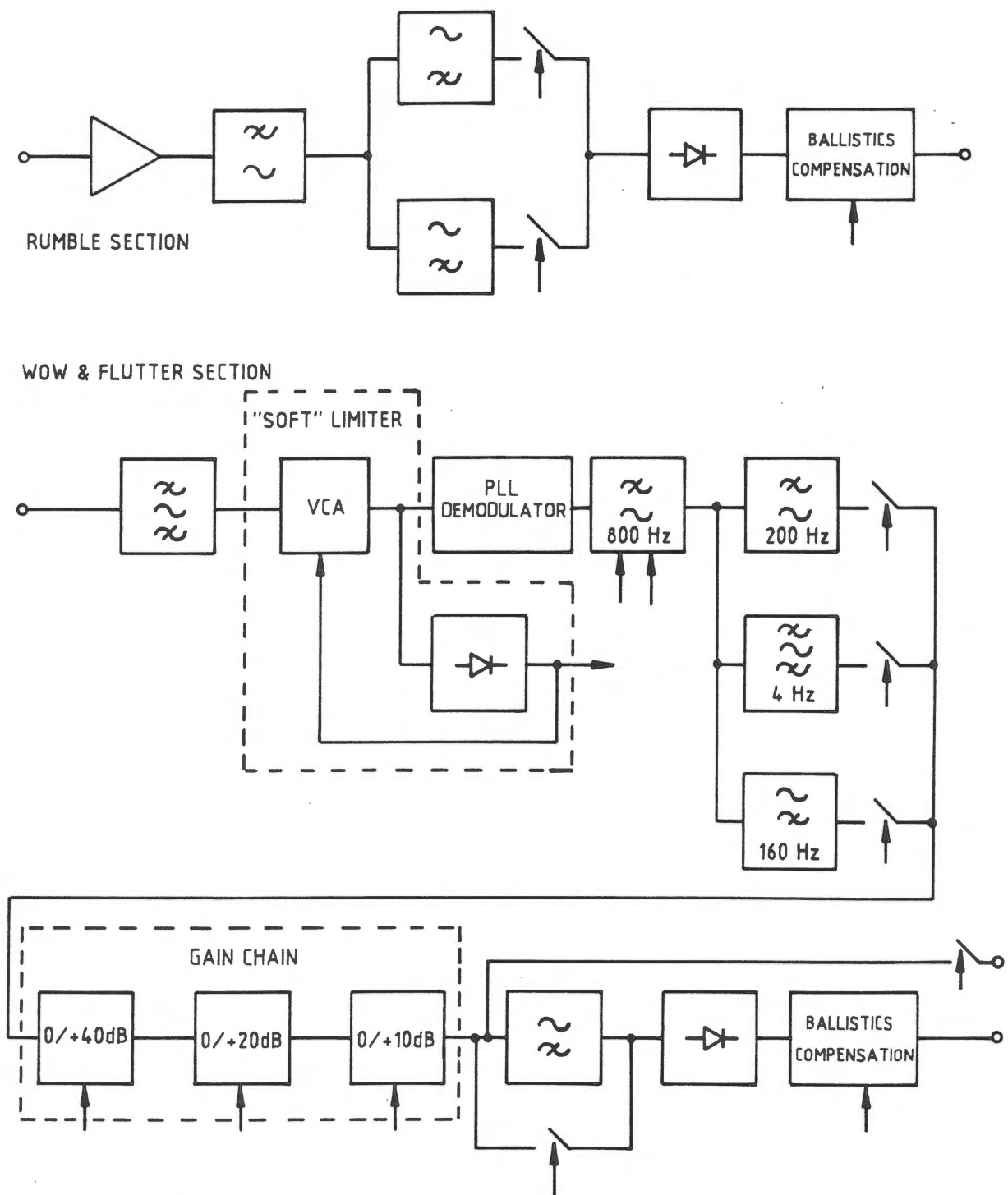


Figure 17.1.1 Wow and Flutter/Rumble Card - Block Diagram

17.2 Circuit Description - Rumble Measurement Section

17.2.1 Filtering

The rumble signal enters the card via PL1 pin 4 from the gain chain output, goes via voltage follower IC1/3,2,1, and is delivered via C1, R94 and VR1 to amplifier IC2/12,13,14. The gyrator IC2/10,9,8 and associated components serve to sharpen the low frequency (10 Hz) corner of the rumble measurement bandwidth, by slightly peaking amplifier IC2/12,13,14 response at 10 Hz. The low frequency response in the unweighted rumble mode is defined by C1, R1, VR1 and R2, with R94 providing a low frequency roll off limit of -14 dB at 2 Hz. Second order low pass filter IC2/3,2,1 provides the upper frequency limit of both weighted and unweighted rumble filter measurement, with a turnover frequency of 315 Hz. The output of IC2/3,2,1 feeds the unweighted rumble output (10 Hz-315 Hz) via C9, R14, and analogue switch IC3 to pin 2 of inverting amplifier IC4. IC2 output (pin 1) also feeds a high pass filter IC2/5,6,7, with a turnover frequency of 315 Hz, to provide a bandpass (weighted) rumble response at IC2/7. This is also fed to inverting amplifier IC4, via C10, R13, and analogue switch IC3.

The weighted/unweighted rumble filter selection is selected via IC3 pin 6 and 7, from binary-to-1-of-8 decoder IC12.

17.2.2 Signal Rectifier

IC4 output feeds a full wave signal rectifier, comprising R16, R17, D2 and IC4/5,6,7. Positive half cycles force IC4 output close to the negative rail, reverse biasing D2, therefore positive half cycles pass through R16 and R17 with no attenuation. Negative half cycles cause IC4 pin 7 to go positive, forward biasing D3 and effectively causing R16, R17, D2 and IC4/5,6,7 to act as an inverting amplifier for negative-going input half cycles. This arrangement produces a full wave rectified signal at the R17/D2 cathode junction. IC5 forms the active part of the low pass filter, with a choice of two CR networks, selected by analogue switch IC18. To simulate "VU Meter" type ballistics, IC18 pin 14 is "made" to pin 12, selecting network R95, R96, C57 and C58. With IC18 pin 14 made to pin 13, network R18, R19, C12 and C13 is selected to provide for BS 4852 requirements. The rumble output is fed via R20 to PL3 pin 6, and from there to the rumble multiplexed input on the signal rectifier card. D3 limits the output to +12 V maximum, and VR4 is adjusted to null the total offset due to IC4/3,2,1, IC4/5,6,7 and IC5.

17.3 Circuit Description - Wow & Flutter/F.I.M. Section

17.3.1 Input Signal Filtering

The 3 kHz or 3.15 kHz signal from the equipment under test is brought into the card via PL1 pin 3, direct from the input amplifier. C14-17, R21-24, IC1/5,6,7 and IC1/12,13,14 form a fourth order high pass filter with a turnover frequency of 2 kHz, in order to exclude any interference from any signal below 3 kHz. IC1/10,9,8, R25, R26, C18 and C19 form a second order low pass filter with a turnover frequency of 4 kHz, in order to filter out signals significantly above 3.15 kHz.

17.3.2 Signal Limiter

The signal from IC1 output (pin 8) is fed through C20 and R28 to the input of amplifier IC6/12,13,14. D4, R33, R90 and C24 form a half wave rectifier/-quasi-peak detector circuit to feed an increasing positive voltage to TR1 gate, as the a.c. voltage at IC6 pin 14 increases. This has the effect of reducing the dynamic resistance of TR1, increasing the signal attenuation of the attenuator R28/TR1 as the amplitude of the a.c. signal at IC6 pin 14 rises. This produces a signal amplitude stabilising circuit which provides an almost constant signal level of approximately 1 V peak at IC7/14 (via C23 and R32), for signal levels of -20 dBu to +40 dBu applied to the MJS401D's input. The MJS401D's input amplifiers are set to 40 dB attenuation with 20 dB gain when Wow and Flutter is selected. Voltage follower IC6/10,9,8 supplies a buffered version of the d.c. at TR1 gate for low input signal level detection.

17.3.3 Phase Locked Loop

IC7 is configured as a phase locked loop, whose own voltage controlled oscillator tracks the incoming signal frequency at pin 14. The d.c. control voltage to the internal V.C.O. is buffered internally by an NMOS source follower, and is taken from pin 10 on IC7 via VR3 and R43, to inverting amplifier IC9/5,6,7. The internal V.C.O. control voltage provides a voltage representation of the change of V.C.O. frequency required to track a change of input signal frequency. The varying voltage at pin 10 therefore represents the varying frequency (pitch) of the 3 kHz or 3.15 kHz signal from the unit under test. Wow and Flutter measurements are specified (approximately) as the ratio of the peak signal frequency variation to the test frequency, and specified as a percentage. The phase locked loop supplies a constant voltage/-Hz frequency change, so in order to keep the ratio of frequency deviation to centre frequency constant, IC3 shorts out R40 of the series resistors R39 and R40, which raises the value of volts/Hz at pin by 5% when 3.15 kHz test signal frequency is used instead of 3 kHz.

Raising the test frequency select control voltage to select 3.15 kHz (IC11 pin 2) also raises the voltage at IC7 pin 12 slightly, to increase IC7 oscillator frequency.

IC7 oscillator capacitor is C25, and the phase locked loop low pass filter comprises R35 and C26. The V.C.O. square wave output at pin 2 is taken to the MJS401D microcomputer board via C27 and PL3 pin 1, in order to perform drift measurement. IC8 supplies a regulated +15v to IC7.

The phase lock loop enable circuit comprises TR3, TR4, R41, D5 and D12. With the voltage at TR3 gate from IC11 pin 7 low, the P.L.L. is disabled. IC7

inhibit pin 5 is held by R41, and source follower TR4 cuts off the source current from IC7's source follower output (pin 10), by taking the voltage across R42 high, and reverse biasing D5. IC9/5,6,7 output (pin 7) is effectively a voltage follower whose output voltage is set by voltage divider R44 and R45 to approximately 6.5 V. This is similar to the voltage level at IC7/10 when IC7 is operating, and therefore provides a means of inhibiting IC7 without a large voltage transient appearing at IC9 pin 7 when the P.L.L. is enabled or inhibited.

VR3 is used to set the voltage excursion at IC9 pin 7 to a known value corresponding to a known frequency deviation. C29 forms a low pass filter to reduce the 6 kHz or 6.3 kHz content of the voltage at IC9 pin 7.

17.3.4 W & F Weighting Filters

IC9 pin 7 feeds the inputs of two alternative Wow and Flutter filters, plus an F.I.M. filter.

The "unweighted" Wow and Flutter filter comprises R47, R48, C30, C31, IC6/3, 2, 1 and R49, R50, C32, C33, IC9/13,12,14. This forms a fifth order low pass filter with a flat response to 800 Hz turnover frequency (the fifth section comprises R46/C29). The output of the 800 Hz low pass filter at IC9 pin 14 is taken to a weighting filter, comprising C35, C36, R52, R91, IC9/10,9,8 and C39, R55, R56, C40 with amplifier stage IC9/3,2,1 and resistors R57 and R58. This arrangement adds a weighting filter with a bandpass characteristic, to the Wow and Flutter voltage filtering chain. The bandpass filter has third order highpass and first order lowpass sections, peaking at unity gain at 4 Hz.

A further highpass second order filter for F.I.M. measurement, with turnover frequency of 159 Hz, is connected to IC9 output (pin 14). This comprises C37, C38, R53, R54, IC9/5,6,7, C42 and R60.

17.3.5 Weighting Filter Selection

Analogue switch IC10 selects one the outputs from the three filters described earlier, according to which output of IC12 (D, E or F) is low. The "unweighted" filter output (IC9/14) is a.c. coupled via C34 and filtered again by first order section R51, R100 and C60 (to give a turnover frequency of 200 Hz), and applied to IC10/4. The "unweighted" Wow and Flutter signal is selected by IC10/9 (D) going low. The output of the "weighted" W & F signal is coupled by C41 and R59 to IC10/15, and selected by a low logic level on IC12/10 (E). The output of the "F.I.M." filter (IC9/7) is coupled via C42 and R60 into IC10/14. It is selected by a "low" logic level on IC10/11 (F).

17.3.6 Wow and Flutter Gain Chain

The selected W & F or F.I.M. signal is fed by IC10 (pins 2, 5 and 12) to the inverting input of IC14. An output is taken to the MJS401D gain chain from IC14 output via RL1 for 'scope monitoring. Following IC14 are three identical gain stages, IC14/5,6,7, IC14/3,2,1, IC18/3,2,1, and the three sections of analogue switch IC15.

The feedback resistor R71 of IC14/5,6,7 has R72 switched in parallel with it by IC15/4 and 5. The value of the parallel pair R71 and R72 equals the value of R70, and thus the stage has unity gain. If the logic level on IC15/9 goes

high, R72 is effectively removed from the parallel combination of R72 and R71, and the stage gain increases from unity to +40 dB. Exactly the same mode of operation applies to the second and third stages, except that the second stage gain increases from 0 dB to +20 dB, and the third stage gain increases from 0 dB to +10 dB.

Thus the combined gain can be set between 0 dB and +70 dB gain in 10 dB steps by the combination of logic levels on IC15 control pins 9, 10 and 11. Only the range 0 dB to +40 dB is actually used.

The three IC15 logic control pins are driven by the MJS401D microcomputer via PL1 pins 6, 8 and 7 via and gate IC13. The gain is set at minimum unless IC11 pin 7 is high.

17.3.7 Wow & Flutter Rectifier

The output of the third stage in the gain chain, IC16/1, is coupled to the rectifier/peak detector circuit, IC17 and IC16/5,6,7, either directly or via C61. The high pass filter C61/R79 is required for N.A.B./J.I.S. standard measurements, having a turnover point of 0.5 Hz. For I.E.C. standard measurements, the high pass filter is not required, and C61 is bypassed by the opto-coupled F.E.T., IC20. This happens when current flows in the L.E.D. of IC20, due a logic high applied to TR5 gate, turning it on. The logic line starting at connector PL3 pin 2, from the MJS401D microcomputer, is taken high (+5 V) for I.E.C. standard measurements.

A unity gain inverting amplifier (IC16/5,6,7, R79 and R80) provides two equal amplitude but antiphase signals to peak detectors IC17, D9 and D10.

With the N.A.B. standard selected (PL3 pin 2 low), TR5 is off and IC18 pin 9 is high. The output from the peak detectors (D9, D10 cathodes) is taken from pin 4 to pin 3, and via potential divider and second order lowpass network R93, R88, R87, C59, R89 and C50, via pins 1 and 15 of IC18, to IC19 non-inverting input, pin 3. (IC18 pin 10 is also high.) Since TR2 is turned off, IC19 is a voltage follower, forming the active part of a second order lowpass filter.

The output of IC19 is taken to the "W & F" input of the signal rectifier card via R86 and PL1 pin 5, with D11 limiting the peak output voltage to 12 V.

With the I.E.C. standard selected, IC18 pin 9 is low (TR5 turned on) and the peak detectors' output routed to network R92, R82, R83 and C49, which forms a composite voltage divider and peak catching circuit. The output of the voltage divider is routed by IC18 pins 2 and 15 to IC19 non-inverting input. (IC18 pin 10 is low.) TR2 is turned on, and the resistors R84 and R85 set the gain of the output stage comprising R84, R85 and IC19.

17.3.8 Logic Control Circuitry

The on-board switches are set by the user, according to the measurement standards required for both rumble and W & F measurements. The switch settings are "polled" by the MJS401D microcomputer testing the logic level at PL3 pins 7 and 8. In the case of rumble measurements, the switch settings decide whether the I.E.C. or B.S. standard "ballistics" apply, and in the case of W & F measurement, switch settings determine 3 kHz or 3.15 kHz test tone frequency, and I.E.C. or N.A.B. "ballistics".

The connections to the microcomputer are used twice to set up the card, once with data from PL3 pin 2 and PL1 pins 6, 7 and 8 latched across by a strobe pulse on PL3 pin 4, and again directly.

The logic levels applied to the card via SKT1/6, 7 and 8 and SKT3/2, from the microcomputer, are used twice. The first time, a positive strobe pulse on SKT3/4 latches the data into quad "D"-type flip-flop IC11. Once this is done, the data on the four lines may be changed, and are used to set up the gains of amplifiers IC14, 15 and 16, and select I.E.C./N.A.B. standards for wow and flutter measurements.

The card function is defined by the latched (in IC11) versions of the data applied to SKT1/6, 7 and 8. The data is transferred to IC11 "Q" outputs, pins 7, 10 and 15 on the rising edge of the strobe pulse at IC11/9.

These outputs of IC11 are applied to decoder IC12 inputs, pins 3, 2 and 1. The decoded output of IC12 goes low to enable the appropriate function. The following table gives the selected card function:

<u>MSB</u>		<u>LSB</u>		IC12 Output Pin	Function Selected
SKT1/6	SKT1/8	SKT1/7	IC11/15		
IC11/7	IC11/10	IC11/15	IC12/3	IC12/2	IC12/1
0	0	0	15		Microcomputer reads SW1 2-5 via SKT3/7
0	0	1	14		Unweighted Rumble
0	1	0	13		Weighted Rumble
0	1	1	12		Microcomputer reads SW1 3-4 via SKT3/7
1	0	0	11		Unweighted wow and flutter
1	0	1	10		Weighted wow and flutter
1	1	0	9		FIM (Frequency Intermodulation Distortion)
1	1	1	7		Not used

All the wow and flutter and FIM functions are selected when the most significant bit of IC12 (pin 7) is high. This enables the phase-locked loop IC7 via TR3, enables the gain setting of IC14, 15 and 16, and enables RL1 via the NOT Q output, IC12/6. When the Rumble functions are selected, the MS bit is low, thus disabling the phase-locked loop and setting the wow and flutter gain chain to minimum gain.

The remaining logic level latched in IC11 is used to set the wow and flutter centre frequency at either 3.00 kHz or 3.15 kHz, and is taken to IC3/11 and R38 from IC11/2.

Once a wow and flutter or FIM function is selected (I11/7 high) the gain of the gain chain IC14-16 can be set by subsequent logic levels on SKT1/6, 7 and 8 via three of the AND gates within IC13. The logic levels set the wow and flutter signal by a combination of 40 dB, 20 dB and 10 dB steps as shown in the table below:

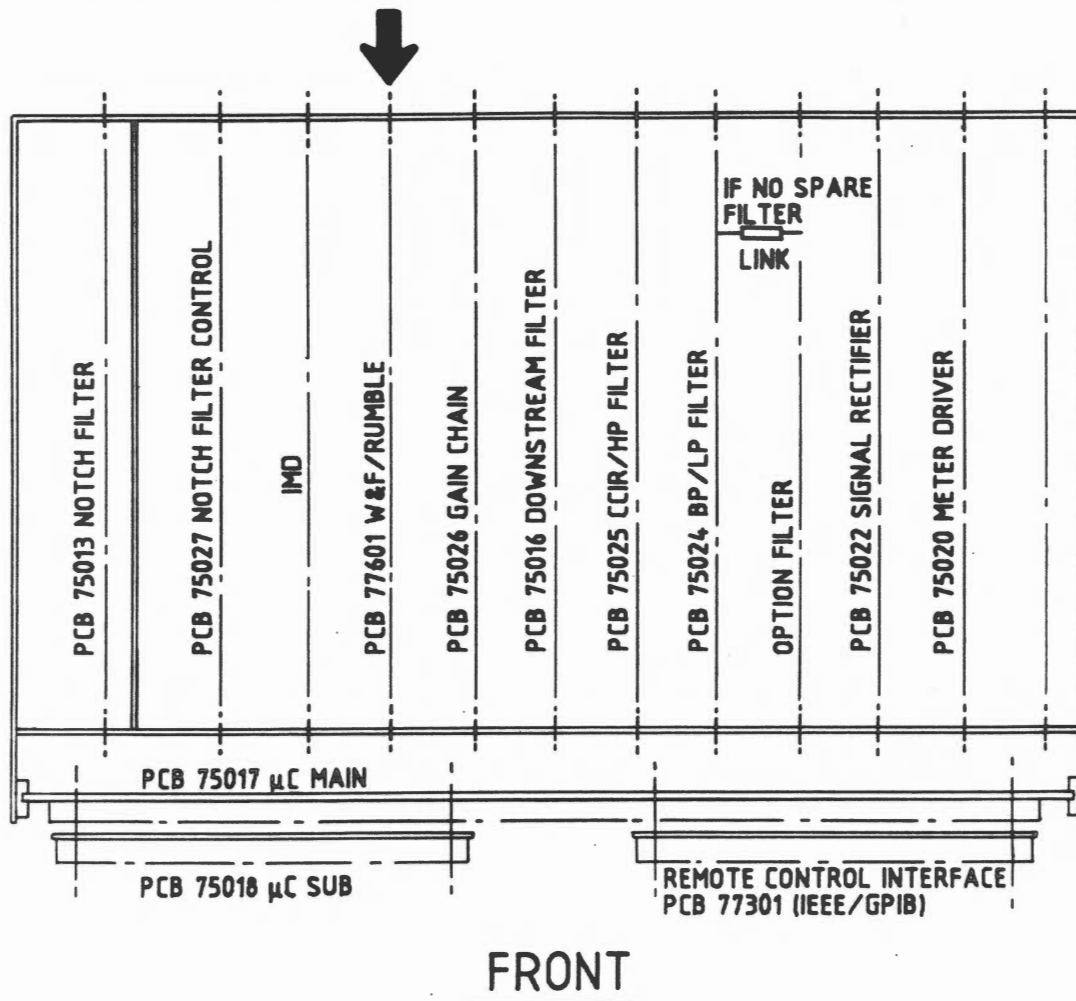
Range setting	Total gain	IC14/7, 6, 5	IC14/1, 2, 3	IC16/1, 2, 3
10 %	0 dB	0 dB	0 dB	0 dB
3 %	+10 dB	0 dB	0 dB	+10 dB
1 %	+20 dB	0 dB	+20 dB	0 dB
0.3 %	+30 dB	0 dB	+20 dB	+10 dB
0.1 %	+40 dB	+40 dB	0 dB	0 dB

17.4 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 Wow and Flutter/Rumble card is installed in the 3rd 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 75036 may be used to facilitate repair and calibration.

17.5 Fault Finding

17.5.1 No Output when Rumble Selected

Apply 315 Hz to the MJS401D input and trace it through IC1/1, IC2/14, IC2/1, and IC2/7 (in that order).

Check that one and only one of IC3 pins 9 and 10 is low. If not, suspect IC11 and IC12. If it is, check IC4/1. If no signal present, replace IC4. If signal present, check for full-wave rectified signal at D2 cathode, and the presence of a d.c. signal at D3 cathode, equivalent to the average of the rectified signal at D2 cathode. If the signal is not present, suspect the preceding circuitry.

17.5.2 Rumble Measurement Filter Characteristic Incorrect

Check that the appropriate filter characteristic has been selected, by checking IC3 logic levels. Low on IC3/9 = Unweighted rumble; low on IC3/10 = Weighted rumble.

17.5.3 Rumble Measurement Gain Incorrect

Check VR1 setting.

Check filter characteristic. The "Unweighted" filter has unity gain between 10 Hz and 315 Hz; the "Weighted" filter has unity gain at 315 Hz, falling at either side.

17.5.4 W&F Fault Finding - General

The aim of the wow and flutter measurement system is to measure the amount of frequency modulation of a signal at the chosen centre frequency. To test the system, then, it is necessary to generate a carrier signal of 3.15 kHz or 3.00 kHz, frequency-modulated at a rate between 0.1 Hz and 630 Hz. The level of the carrier should be at least 100 mV. The wow and flutter reading is proportional to the depth of frequency modulation of the carrier.

17.5.5 No Output when W&F Selected

Check SW1 settings. Check +5 V present on IC7/16. Check +5 V and -13 V supplies present on IC10. Check appropriate circuitry is enabled, especially that IC12/3 is high, when W&F is selected. Check logic levels at IC12 are correct to the table in the Circuit Description section. If not, check or replace IC11 and/or IC12.

Check correct functioning of input signal limiter. There should be approx. 1 V peak-peak sine wave present at TP2 for signal levels at the MJS401D input from 100 mV to 100 V RMS. If no signal present, or signal heavily distorted or low level, check IC1, IC6, TR1 and associated components.

Note that there is an attenuation of 20 dB introduced by the input module, so the signal appearing at the W&F card input will be 20 dB below that appearing at the MJS401D input.

Check operation of phase-locked loop IC7. There should be a square wave at the chosen centre frequency (3.00 kHz or 3.15 kHz) and 15 V peak-peak at

IC7/4.

Check for presence of W&F signal at IC7/10. This will be heavily contaminated by a sawtooth waveform at twice the centre frequency (6.00 kHz or 6.3 kHz). Follow the signal through the filters IC6 and IC9. Check IC10 pins 9 or 10 high (according to whether Weighted or Unweighted selected). Follow the signal through the gain chain (IC14, IC15, IC16), rectifier (IC16 and IC17), and filter IC19.

17.5.6 W&F Range or Gain Incorrect

Check for correct operation of circuit elements as described under "No Output" above.

Check logic levels of amplifier gain switches (IC14, 15, 16) against table given in the Circuit Description.

Check that the correct filter has been selected. Check that the response of the filter is approximately correct.

17.6 Calibration

17.6.1 Equipment Needed

Frequency-modulated signal generator, capable of generating a carrier frequency of 3.15 kHz or 3.00 kHz, frequency-modulated to a depth variable between 10 % and 0.1 %, at a modulation rate from 0.1 Hz to 800 Hz.

Alternatively, a function generator with a linear "sweep" or "VCO" input, and another function generator or very-low-frequency generator (0.1 Hz to 800 Hz) to frequency-modulate the first. Ensure that the "Sweep" or "VCO" input is D.C. coupled. If not, the low modulating frequencies will be attenuated, and incorrect calibration will result.

MJS401D with MD404B.

Digital voltmeter, 3 1/2 digits or better, with 200 mV and 20 V D.C. ranges.

Extender card PCB 75036.

17.6.2 Rumble Calibration

MJS401D Front Panel Setup

Input	Load	Function	Wtd/Unwtd	Rectifier	Scale	Dist'n	Coarse	Fine
A	On	Rumble	Weighted	---	dB Norm	---	0	0

There should be no input to the MJS401D. Connect the DVM to the "Rumble" output on the extender card, with the return on the "0 V" strap.

Adjust VR4 for 0 mV $\pm$ 10 mV.

MJS401D Front Panel Setup

Input	Load	Function	Wtd/Unwtd	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Level	---	---	dB Norm	---	0	0

Connect the MD404B output to the MJS401D input A. Set the MD404B for a reading of exactly 0 dBu at exactly 315 Hz.

MJS401D Front Panel Setup

Input	Load	Function	Wtd/Unwtd	Rectifier	Scale	Dist'n	Coarse	Fine
A	Off	Rumble	Weighted	---	dB Norm	---	0	0

Adjust VR1 for no change in meter reading.

The frequency response of the rumble system may now be checked. Weighted, the response should fall either side of 315 Hz, being -15 dB at 100 Hz and 1 kHz, and -27 dB at 50 Hz and 2 kHz. Unweighted, the response should be flat between 10 Hz and 315 Hz, falling to -14 dB at 2 Hz, -15 dB at 1 kHz and -27 dB at 2 kHz.

17.6.3 Wow and Flutter Calibration

Connect the MD404B output to input A of the MJS401D.

MJS401D Front Panel Setup

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

Measure the voltage at IC9 pin 14. Log the result.

Select the "W & F, Drift" function on the MJS401D. The display should show "-0.00% DRFT" or "+0.00% DRFT". Measure the voltage on IC9 pin 14 again. Adjust VR2 for the same value as previously logged.

Connect the output of the FM signal generator to input A of the MJS401D. Set the generator to give an output of about 1 V, sine wave, at 3.15 kHz (or 3.00 kHz if you normally use that centre frequency), frequency modulated at 4 Hz to a depth of 1.00 % peak (0.707 % RMS).

The display should show a drift reading of nearly 0, though the reading will not be constant. If the reading is nearly ± 5 %, the centre frequency DIL switch of the wow and flutter card is probably not set correctly.

MJS401D Front Panel Setup

Input	Load	Function	Filters	WTD/UNWTD	Scale	Dist'n	Coarse	Fine
A	Off	W & F	Off	WTD	dB Norm	1 %	0	0

Adjust VR3 for a reading of 1 % (if the IEC/DIN/BS/CCIR standard is selected) or 0.71 % (if the NAB/JIS standard is selected).

The frequency responses of the different characteristics may now be checked. In the following paragraphs, results are given in dB relative to the 4 Hz weighted value, which may be 1 % or 0.71 %, according to the rectifier characteristic selected on the wow and flutter card. Hence -3 dB is either 0.71 % or 0.5% respectively, etc.

Wow and flutter, weighted, to either rectifier characteristic, should be at a peak at 4 Hz, falling to -12 dB at 0.5 Hz and 63 Hz.

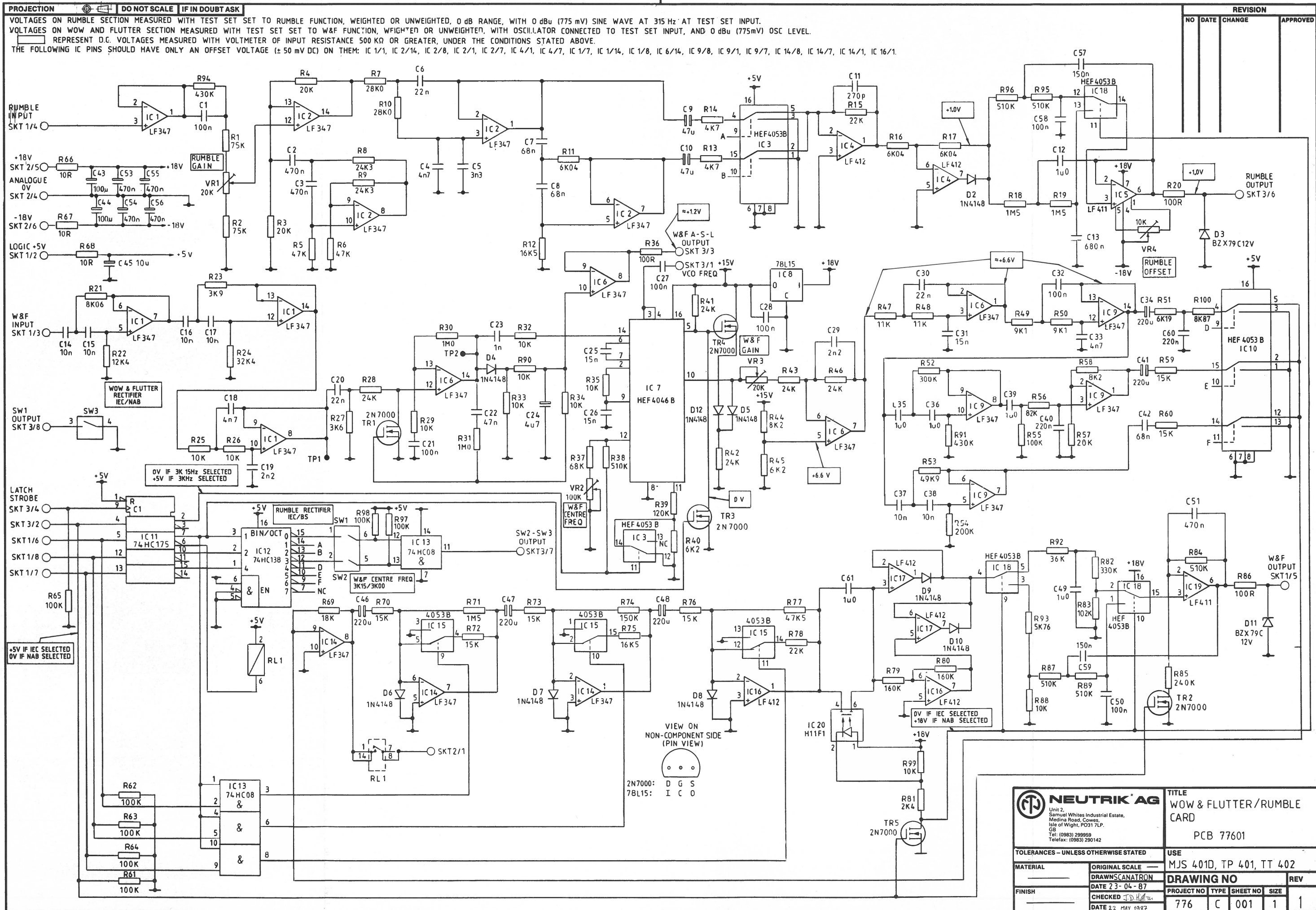
Wow and flutter, unweighted, to IEC/DIN/BS/CCIR, should be -3 dB at 200 Hz, and within -3 dB at 0.1 Hz. To NAB/JIS, it should be -3 dB at 200 Hz, and the peak reading at 0.5 Hz should be -3 dB.

FIM, if selectable on your MJS401D, should be -3 dB at 160 Hz and 800 Hz with respect to the value at 400 Hz. The reading at 400 Hz should be 1 % for a peak frequency deviation of ± 1 %, centred on 3 kHz.

FIM is not normally selectable from the front panel of the MJS401D. It can be made selectable by a simple change to one of the EPROMS. Contact your agent or dealer for details. It is always selectable over the IEEE-488 bus; the syntax is:

FIM
or Function FIM

See the IEEE-488 instruction manual (Part 3 of this manual) for fuller details of IEEE-488 control of the MJS401D and MD404B.



REVISION			
NO	DATE	CHANGE	APPROVED

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TITILE
WOW & FLUTTER/RUMBLE
CARD
PCB 77601

TOLERANCES - UNLESS OTHERWISE STATED
USE
MJS 401D, TP 401, TT 402

MATERIAL	ORIGINAL SCALE	DRAWING NO	REV
FINISH	DATE 23-04-87	PROJECT NO	TYPE
CHECKED	DATE 22 MAY 1987	776	C
		001	1

WORKING BYLINE W0617