Deviation Meter For TheNet X-1J

1. INTRODUCTION

The deviation meter is actually a peak audio level meter. It is the first of a series of applications built into TheNet X-series firmware that makes use of an Analogue to Digital Converter (ADC). The ADC can be (optionally) added quite simply to a TNC2.

This paper describes the circuit, its configuration and its operation, but there is a separate set of files that describes the deviation meter in more detail, containing the artwork, netlist etc. If you can't find the archive of this set of files (originally named X1JDEV.ZIP), contact G0JVU.

2. CIRCUIT OVERVIEW

The basic structure of the circuit is shown below :

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The audio input is amplified and converted to a DC peak representation. This voltage is read by the ADC, which has a range of 0 .. 3 volts, and converted into an 8 bit binary value in the range 0 .. 255.

The software is configured to read the ADC at the end of each valid packet. A packet is considered valid if its CRC is correct. As soon as a valid CRC is detected, the ADC is instructed to start converting on the deviation meter channel, this conversion taking 30 microseconds. Just before the formatted frame is linked into the chain of pending received frames, the ADC is read and the value stored with the frame.

The reading therefore corresponds to the peak audio level at the end of a packet. If there are no non linear elements between the receiver's discriminator and the meter input, this will correspond fairly accurately to the peak deviation.

Care must be taken over its interpretation. It does not measure independently the two tone levels - it is assumed that whatever local standards that relate to pre-emphasis (i.e. use it or not) have been implemented. If used for 9600 baud FSK operation, this is not a problem.

The meter will give the wrong answer on the following conditions :

- A badly distorted audio signal
- Badly off frequency
- Incorrect adherence to local pre-emphasis standards if used for AFSK
- A noisy signal

3. SOFTWARE

As explained in section 2, the deviation meter is activated on receipt of a valid packet. The software interrupt routine, upon detecting a valid CRC, whether the deviation meter is installed or not, whether it is enabled or not, will instantly write the 'start channel conversion' command to the ADC (I/O address 0x20) as soon as the interrupt is serviced. It will therefore also be signalled when other errors such as framing or invalid CRCs are detected.

If the CRC is correct, then about 50 to 100 microseconds later, the Z80 will read the ADC and will store the corresponding value with the packet. Again, this happens whether or not the function is enabled (it is quicker to do it than to test whether to do it or not !).

The value received is transferred to the internal heard list format without conversion. It is still therefore the 8 bit count (0 to 255).

When a user displays the heard list, the deviation meter parameter (as set with the METER command) is used to control the display. If disabled, the deviation details are not displayed in the heard list. If it is enabled, then the 8 bit count value is multiplied by the multiplier value to give a deviation reading in hertz. This is displayed as kilohertz in the heard list. If the multiplier setting is '1' it will have a full scale range of 0.2 KHz (not very useful). If set to 10, it will have a full scale range of 2.5 KHz. If set to 255, it will display up to 64 KHz. A typical setting will therefore be in the range 15 to 30, depending on the analogue setting. The objective is to set it such that the maximum possible audio level from the receiver, given its filters, corresponds to just under the 3 volt maximum input to the ADC.

The deviation is displayed to a resolution of 100 Hz, but it should not be assumed to be this accurate.

Small fluctuations in the reading can be expected.

Finally, to guard against an unnoticed overrange, the display in the heard list will precede the deviation reading by a chevron ('>') if the value read from the ADC is 254 or 255.

4. Detailed Circuit Description.

All of the signals necessary for this circuit are found on the Z80 CPU chip located on the TNC motherboard, with the exception of a -5V power supply, and the audio signal to be measured.

We therefore decided to base the circuit around the Z80 CPU. We knew from experience that people are reluctant to attack the insides of their TNCs' with a hot soldering iron, and settled on the socket idea as the least intrusive way of gaining access to the required signals.

The circuit was designed with the radio ham junk box in mind, with the only "specialist part" required being the ADC itself.

The input is first amplified (x10) by U2A a quarter part of the LM324 quad op-amp. This circuit is also a precision half-wave rectifier, which is used to reduce the effect of D1's voltage offset. A more linear response is obtained with this configuration. The output is smoothed by C2, and then R3 provides a user adjustable control for the DC representation of the received audio level into the ADC.

The second part of the quad op-amp (U2B) provides a low impedance voltage reference drive for the ADC. R6 should be adjusted such that the DC level on pin 8 (VREF) on the ADC is equal to 3.0 V.

The address decode for the ADC is performed by 2 parts of the 74HC00 (U3). The ADC is mapped to the I/O address 0x20 and is selected by the X-1J software when required.

The other three (customisable) ADC channels will be available for use in later releases, for such items as temperature sensors, pressure sensors, or whatever comes to mind that will be of interest to users etc. There are also two spare op-amps within the LM324 for use with these 'customisable inputs'. Any input signal should be conditioned to provide a 0V...3V full scale signal into the ADC .

4.1 Parts List

QTY	REF	PART
2	C1, C3	1 µF @ 10V
1	C4	0.1 µF (de coupling capacitor)
1	C2	22 µF @ 10V
1	R1	10K
2	R5,R7	1K
1	R4	1K8
2	R3,R6	10K Miniature Potentiometers
1	R2	100K
2	D1,D3	IN4148
1	D2	2V7 Zener (250mW)
1	U1	ADC0844 (National Semiconductor) *
1	U2	LM324
1	U3	74HC00
1	JP1	3 pin HEADER
1	40PIN	40PIN WIRE WRAP SOCKET

1		**PCB**
1	**X-1J**	**SOFTWARE!**

***** The ADC0844 is a four channel ADC available from most large mail-order companies. At the time of the X1J release (August '93), I have had some concern over the price of the device. When originally selected the device was available for approx. £8 in the UK. In the last two months it has risen to £18! It may be cheaper direct from outlets within the USA.

5. Construction

PCB's, PCB patterns, and component locations will be available from G0JVU / G8KBB starting in September, 1993. The PCB will be single sided and approx. 3 inches by 2 ½ inches.

However the circuit is not complex and for the more adventurous a small circuit can be built up (without the need for a 40 pin socket) and then wired to the solder side of the TNC motherboard. In fact the original prototype built on veroboard measured 1 inch by 2½ inches.

The 40 pin socket on the DEV PCB is intended to be a wire wrap type, soldered to the DEV unit PCB with long legs extending down, cropped so that the PCB can be "plugged" into the 40 pin Z80 socket on the TNC motherboard. The previously removed Z80 CPU is then re-inserted in the socket on the DEV PCB.

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If your TNC's Z80 is not socketed, you may like to consider adding one now! Otherwise you will need to work out some other way of getting the necessary signals to the DEV board. I suggest fitting a "tin-plate" folded pin socket, as the wire wrap sockets will locate into them. Turned pin sockets present extreme difficulty in mating with the square section wire wrap sockets.

If there is not enough clearance in the TNC box for the extra PCB, you could consider using a header plug, with the necessary signals being transferred to the DEV board , mounted elsewhere, via a short cable.

There are three other connections that need to be made from the DEV PCB to the TNC motherboard:

JP1 Pin 1	Cable shield for audio signal (Earth)
JP1 Pin 2	Audio input from rig (5pin DIN inside TNC)
JP1 Pin 3	-5V (from TNC motherboard)

Solder in the components in the usual way, taking care not to make any solder bridges to the tracks running in-between the IC pads. Ensure the chips, and polarised components are the right way around, and take the usual ESD precautions. There are four wire links needed on the PCB to complete the single-sided circuit.

6. Alignment

There are four adjustable controls that will need to be set-up for correct operation.

1) Radio's audio drive signal into the TNC. (Volume control).
2) The deviation signal level control (R3).
3) The reference voltage for the ADC. (R6)
4) The METER parameter within X-1J.

The best set-up sequence (todate) is:-

a) Adjust R6 on the DEV board to give 3.0V input into pin 8 of the ADC.
b) Attach an oscilloscope (if available) to pin 1 of the LM324. Turn the rig's squelch control such that the squelch noise is driving the input of the DEV circuit. Adjust the rig's audio drive signal into the DEV circuit so that the output of the op-amp is just clipping the power rails. This will be seen as a 10V peak to peak signal.
c) Adjust R3 to give the maximum DC signal into pin 3 of the ADC. This should be 3V maximum.

Note: The function of R3 is to scale the input voltage into the ADC. The maximum signal available from the circuit is approx. 3V which corresponds to the full range of the ADC. A 3V input into the ADC will enable the circuit to present the widest possible range of values to the X-1J software. However significant "unexplained" variations in the reported deviation (MHEARD list) can be reduced by lowering the input voltage to the ADC. If you do need to adjust this voltage, then you will also have to adjust the METER parameter within the X-1J software again.

d) The "METER" parameter within X-1J gives the final adjustment to the circuit. Converting the received binary number into a meaningful deviation in KHz.
In practice with the unit operating as described above, a value of 47 was found to provide a true representation of the displayed deviation to the measured deviation. To ensure an accurate measurement is given to the user, you will need to calibrate the function using a signal with a known deviation!

As you can see from the above set up procedure. If you change the setting of the volume on the rig afterwards, all will be lost! It is preferable to take the audio from before the audio amplifier sections of the receiver (ideally direct from the discriminator) and to adjust the parameters or op-amp gain accordingly.

7. Contacts.

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