Signal Strength Meter for TheNet X-1J Release 2

This file contains a description of the S-meter extensions necessary for TheNet X- 1J to display received signal strength.

The software assumes that there is a signal strength meter available that produces a voltage proportional to the logarithm of the input signal strength. If there is no such output available from the receiver, it is often possible to add such a function to it.

If there is such a meter output, the ADC expects an input voltage in the range 0 to 3V. It is not necessary for the voltage to be referenced to zero for no signal, as the software can compensate for this. It must not exceed the ADC reference voltage (3V).

If there is no such meter output, then one may be created by adding a second IF to the receiver. If a device such as the MC3356 or MC3362 is used, it has a logarithmic Received Signal Strength Indicator (RSSI) output of surprising accuracy. The first prototype I built had a deviation from linearity of less than 1dB over the main part of its range, with a kink at low signal levels and compression at the high end. If you can print out the Word for Windows version of this file, a graph of the calibration data is appended to the file. If not, the raw data is contained in the file 'smeter.csv' in comma separated spread sheet format. The next one built had 2 dB variation in its linearity over the operating range.

The prototype circuit is contained in the Word for Windows version of this file. It consists of an FET input buffer (so that the receiver is not unduly loaded) followed by a low pass filter. The filter has a cut-off of 1 MHz. This is connected to the IF input of the receiver chip, and the output of the RSSI taken from pin 14.

The circuit is also shown in the file 'smeter.ljt'. This is an HP PCL printout file. Copy it (a binary file with the '/B' switch if using DOS COPY) to an HP Laserjet or compatible printer.

You must consider the circuit as a design idea that will need to be modified for your radio. My prototype was fitted to the 455 KHz IF signal from the second conversion mixer, and the low pass was needed as there was a significant component of the 10.245 MHz second conversion oscillator in the signal. The IF strip of the MC3356 will operate from 200 KHz to 50 MHz, so without the low pass it can be driven by a 10.7 or 21.4 MHz IF. What is important is that the signal is taken after the main receiver selectivity, usually its crystal filter, and before any limiting IF amplifier stages. It is also important that the signal levels are correct, so that a signal that is just detectable on the receiver just starts to increase the DC output of the RSSI. It may be necessary to adjust the signal level, for example by adding an amplifier stage before the MC3356 input.

Note that there are many devices with RSSI outputs - use any of them that are handy but remember you need one with an accurate and large range. The operational range of the MC3356 is between 50 and 60 dB, and I am told that more modern cellular radio IFs have up to 90 dB range !.

To calibrate the meter, you need a known signal, for example a signal generator of known output, and a switched attenuator with at least 5dB steps and preferably 2 dB steps. Connect a DC voltmeter to the output of the MC3356, and connect the signal generator to the receiver input operating frequency (144.625 for the prototype) via the attenuator. The signal should be increased in 2 dB steps and the voltage noted for each step. The results need to be plotted as a graph. In calibrating the prototype, slight errors were noted in the calibration of the switched attenuator. These need to be subtracted out from the data.

On the graph, draw a straight line through the curve as a 'best fit' ignoring the end of range effects of noise floor, hysteresis or overload. Where the line crosses the noise floor, note the DC voltage and dBm level at this point. Calculate the slope of the curve in units of dB per volt. You should then have the following data items :

- The noise floor DC reading
- The slope of the best fit calibration curve
- The dBm point that corresponds to the crossover of the noise floor and the best fit calibration line.

The dB multiplier is calculated as :

dB_multiplier = X . Vref / V

where X dB change in input caused V volts DC change (i.e. the slope of the best fit line from the graph), and Vref is the ADC reference voltage.

The data are input as follows :

The signal strength meter noise floor is entered as an integer in the range 0 to 255 (hopefully a small number about 50 ish) calculated from the DC noise floor reading from the graph (V) and the ADC reference voltage (Vref) as

256 * V / Vref

The dBm meter display format multiplier is entered as calculated above from the graph. In my prototype, 54 dB change caused 2V DC change in output with a 3V reference voltage, so the multiplier was 81.

The dBm noise floor is entered at a positive integer corresponding to the complement of the dBm zero point from the graph. For example, 0.65 V DC was the noise floor reading for my prototype and the calibration line crossed this noise floor level at a dBm reading of -113 dBm. The dBm noise floor is entered at 113 (i.e. drop the '-').

The S meter multiplier is set by trial and error depending on your perception of what constitutes an S9 signal !. Alternatively, it is set to the dB_multiplier divided by the number of dB per S point, so in the previous example, if you want 4 dB per S point, set it to 20. Note that there are several 'standards' for the number of dB per S point, all vociferously defended and justified. It is better to use the dBm scale.

The output of the RSSI needs to be connected to the ADC in the TNC. The easiest way to do this is to use the squelch line in the standard TNC2 5 pin DIN connector (pin 5). This signal is frequently unused in nodes. The RSSI output is connected to pin 5 in the radio, and in the TNC the signal is disconnected from the squelch circuits and connected instead to channel 2 of the ADC (one of the unused pads on the ADC). In TNCs such as the BSX2, the squelch signal is connected into the TNC circuits via a diode that forms a logical AND gate with the modem DCD. The easiest way to disconnect pin 5 from these circuits is to lift one end of that diode.

The lead from radio to TNC must be reasonably short as the output impedance of the RSSI is not low. If problems are found, an op-amp buffer may need to be added to give a low impedance drive.

When exploring the innards of radios looking for suitable tap point, a degree of care and ingenuity will be needed. Finding one with about the right signal level, prior to a limiter, after the main bandpass filter and without undue loading on the radio circuits is not always easy.

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Example Node heard list showing dBm format

IPNET:G8KBB-5}

Callsign	Pkts	Port	Time	Dev.	dBm	Type
G8KBB-2	1129	1	0:0:0			Node TCP/IP
FELIX	869	0	0:0:6	5.7	-79	
G0JVU-2	4285	0	0:0:40	5.9	-78	Node TCP/IP
G7MNS	368	0	0:1:17	4.1	-89	
G8STW-5	6227	0	0:4:54	5.0	-102	TCP/IP
G1YRE	61	0	0:5:27	6.2	-82	
GB7MXM	326	0	0:7:6	5.8	-78	
FB1ICL	1	0	0:13:40	6.9	-104	
G0TMH-5	1	0	0:13:57	6.1	-107	TCP/IP
G0OEY-5	2288	0	0:14:10	6.1	-93	Node TCP/IP
G1DVU-5	1	0	0:18:39	7.6	-107	TCP/IP
G8HUE	90	0	0:21:50	5.5	-92	
G7BKO	1	0	2:0:14	7.0	-96	
G4ZEK-14	13	0	3:39:22	5.7	-79	
G0NJA	29	0	4:8:54	6.6	-91	
G7JVE-5	259	0	5:23:33	4.3	-105	TCP/IP
G8INE	5	0	8:11:28	6.3	-112	
G4IZC-5	69	0	8:26:29	6.8	-112	TCP/IP