Adding an S-meter to the Transceiver; improving the Tx audio

Juan H la Grange, ZS6SZ.

1. Introduction

The transceiver as described does not have an s-meter, which is a distinct disadvantage since radio amateurs regularly exchange Readability and Signal strength reports.

In addition, the original transceiver had a panel meter which indicated the VCO tuning voltage. With an external VFO implemented, this meter became redundant and thus available as an s-meter.

A description of the s-meter implemented is given below.

Feedback from other radio amateurs that the audio quality on Transmit was poor, led to a new microphone splitter design and mixer level adjustments, as also described below.

2. S-meter requirements

An s-meter should measure the input signal strength at the antenna of the receiver as follows, assuming that the input impedance is 50 ohm:

Microvolt rms input at the receiver antenna input	S-reading	Output of the LNAF, mVp-p, or input to the S-meter.
1,6	S-4	0,9
3,2	S-5	1,8
6,3	S-6	3,6
12,6	S-7	7,1
25,1	S-8	14,2
50,1	S-9	28,4
158	S-9 + 10 dB	89,4

Thus, a logarithmic / exponential measurement scale is required for easy readout.

The non-comprehensive set of values in the table and the third column is discussed below.

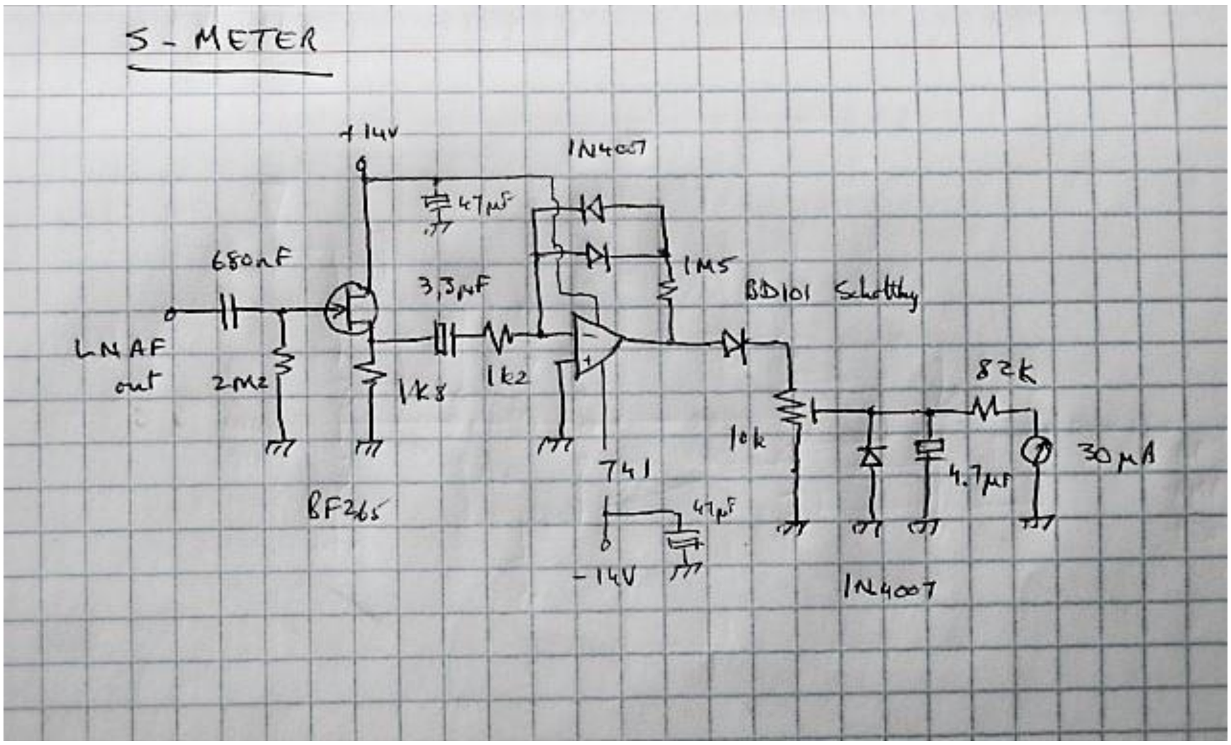
The AGC control voltage is often used to drive an s-meter. Its use was investigated here but it was found unsuitable, the AGC circuit is quite complex.

3. S-meter implementation

After a lot of experimentation with different designs, it was decided to implement a non-linear amplifier connected to the output of the low noise AF amplifier (LNAF). Since the LNAF has a high output impedance, the first requirement was a high input impedance.

Secondly, quite a high gain is required since the input signals can be very small.

The circuit is as follows:



Although only the positive part of the ac signal is measured, the op amp is symmetrical in its design. This is done because the high gain will otherwise drive the op amp into saturation on the negative cycles.

A low threshold voltage Schottky diode is used to rectify the signal to the meter. This is done because the exponential V-I characteristic of a normal Si diode cancels the non-linearity achieved by the op amp circuit.

4. S-meter calibration

Calibration is a bit tricky in theory because the S values refer to the antenna input signal. The gain of the LNAF is about 100, but it is preceded by an RF stage with variable gain. Thus, certain assumptions must be made.

It is assumed that the S-meter will be correctly calibrated when the RF gain is at its maximum stable value. (The AGC stage can only handle input signals up to a certain maximum, where-after it does not produce a smooth output anymore.)

It is further assumed that the overall gain from the antenna input up to the LNAF output is 200 at that point.

This leads to the third column in the table above. Vp-p is listed because the signal generator used is calibrated that way.

So, to calibrate, inject a 1 kHz signal as per the third column above, adjust the pre-set pot and mark the scale of the meter accordingly.

It was found that the lowest distinguishable measured signal strength with the above design is S-4, and the highest is S-9 + 10dB. (This accounts for the non-comprehensive set of values in the table above.) S-4 as a low limit is not a problem in practice since the author has not seen daytime atmospheric / background noise levels below S-5 where he lives. (The highest seen was between S-8 and S-9 at 40m, which in practice really hampers communication. It is not known what causes these high levels of noise.) The high limit of S-9 + 10dB is a bit of a limitation although not too serious.

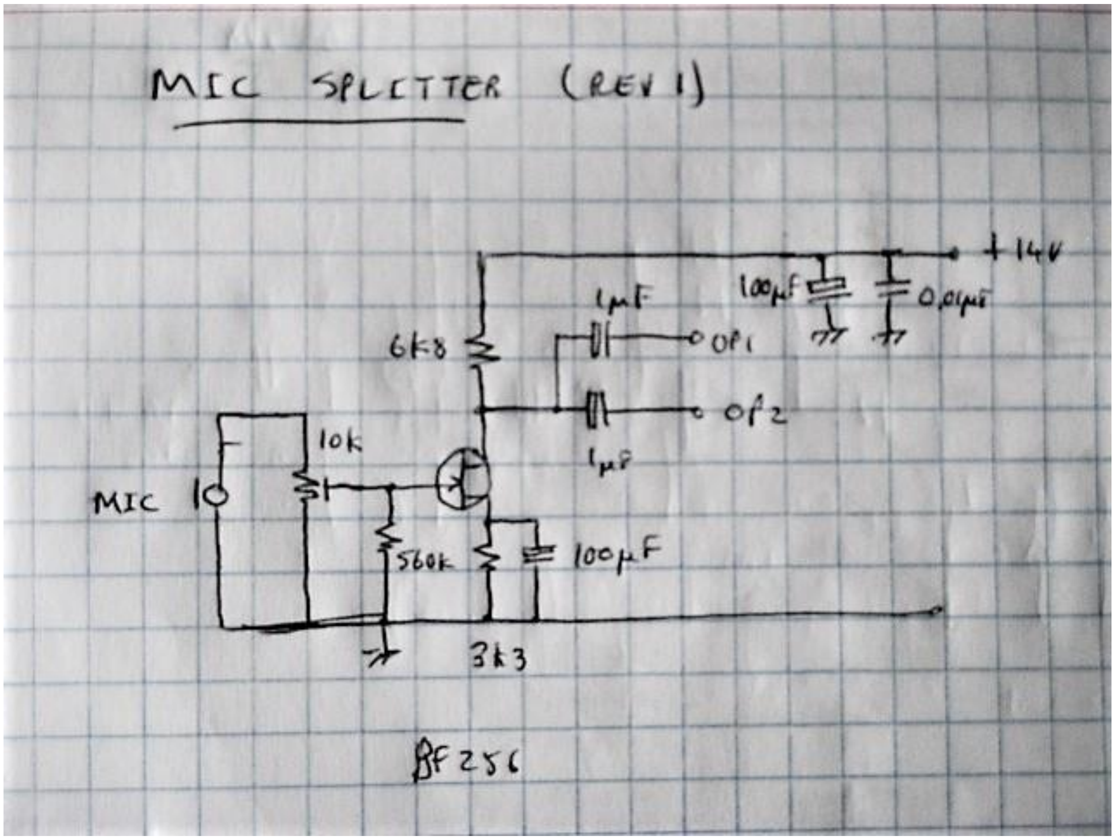
The author also used the live internet S-meter information of a (relatively) close-by WEBSDR station to verify the above calibration.

5. Audio quality on transmit

Following reports from other radio amateurs that the audio quality on transmit was poor, an investigation firstly revealed that the audio level from the microphone was insufficient to properly drive the next stage (the AGC amp). Secondly, the audio levels feeding into the balanced mixers needed adjustment.

5.1 Microphone splitter

To increase the microphone audio level, a simple amplifier replaced the old splitter. The gain from a single stage FET amplifier was sufficient, and the circuit is as follows:

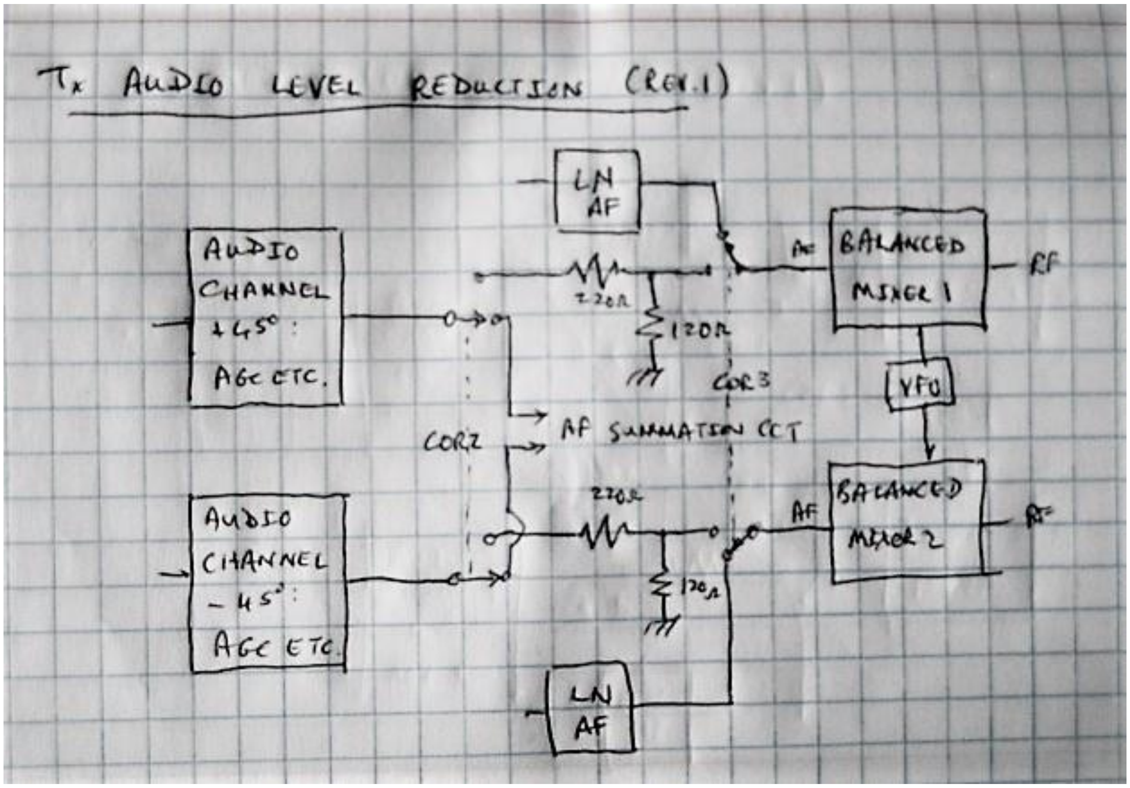


The gain is about 10 but needed downward adjustment to about 4 with the pre-set pot for the author's moving-coil microphone to prevent overloading the AGC stage.

5.2 Audio levels feeding into the balanced mixers

The Local Oscillator (LO) signal levels (from the external VFO) feeding the balanced mixers are quite low, being 0,9Vp-p. It was experimentally determined that the minimum (and best) level is 0,7 Vp-p, or just enough to exceed the threshold voltage of the two Schottky diodes in series in the balanced mixer. A level of 0,9 Vp-p still worked well in Rx and was considered an optimal trade-off between the Rx requirements and mixing the Tx audio signals which are much stronger than the Rx RF signals. But there was distortion of the Tx RF envelope, probably through incomplete modulation of the higher audio peaks, although the exact mechanism is unknown. This was visible on an oscilloscope as spurious audio oscillations on the higher peaks of the RF envelope. When the LO levels were increased to about 1,7 Vp-p or more, this distortion disappeared, but these LO levels did not work well in Rx.

To keep the optimal 0,9Vp-p LO level, the audio levels to the mixers were reduced by adding a 120-ohm resistor to ground after the 220-ohm resistor, between LPF2 and the balanced mixer, forming a voltage divider. This also reduces the AF impedance into the mixer, which is desirable. It is shown below:



This action reduced the power output of the transceiver which could fortunately be compensated for by reducing the attenuation to the RF driver, maintaining an overall 100 Wpep output.

6. Conclusion

The addition of the S-meter to the transceiver has been found to be very useful.

Bringing the audio quality on Tx to normal will in future spare other radio amateurs the pain of listening to a very poor voice quality!