



## Antenna



In this setup a very high Q antenna is needed for narrow bandwidth during DX operation and image rejection. For strong local operation a bandwidth wide enough to support full fidelity performance is also needed. The typical antenna may or may not use Litz wire but is wound in a single layer paralleled fashion where the turns completely touch increasing parasitic capacitance. Using a diamond weave pattern (see above ↑) with good spacing will greatly reduce this. To maximize Q placing the winding in the center of the rod will maximize inductance for the number of turns and spreading it over most of the rod will help realize this. Spreading the windings out can reduce inductance so a balance of the winding method is needed to obtain the desired inductance. A large Q limiting factor is the winding resistance and this will produce a relatively fixed bandwidth across the tuning range if kept low. The other alternative is to use a 10" dia. air core loop like that used in old tube radios and to keep the Q high heavy Litz wire is needed to keep the resistance low. Center tapping the loop and buffering it with a J-FET to drive the differential pair will provide a high level signal with a constant drive impedance. In a table radio the loop could be mounted internally on the back cover or external for easy orientation. The ferrite material also introduces its own Q limiting factors. In a pure mathematical LC tank setup and DeQing the tank with a series resistor representing the winding resistance produces a unique bandwidth characteristic. Where  $X_L/R_L$  defines the Q this produces a constant bandwidth across the tuning range. During high Q operation for DX with a 10kHz bandwidth the Q at the low end of the dial is 54 (540) and at the high end it is 170 (1700). For local with a strong signal and a 25kHz bandwidth the Q is 22 & 68 respectively. While 22 is low for antenna Q for a strong local signal image issues are minimized since the local signal will be much stronger than the image. This is accomplished by varying the effective  $R_L$  using an AGC controlled current diode shunt (2x1N914). The minimum Q is limited by a fixed resistor when the diodes present no load during minimum AGC for the 25kHz bandwidth.

## Oscillator

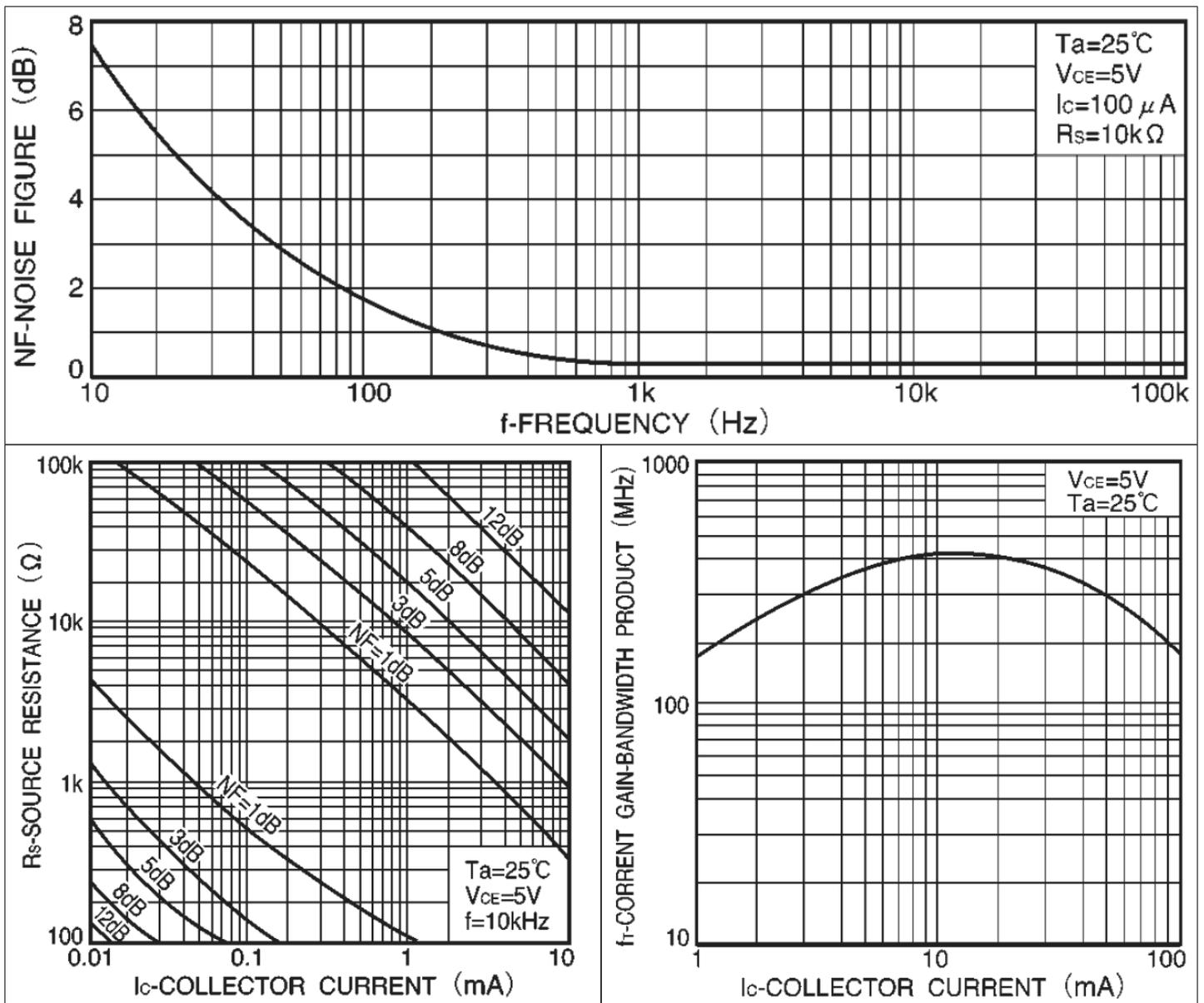
The oscillator is of the Hartley type. A high Q ferrite torroid core is used to minimize noise and eliminate any magnetic flux from interfering with the rest of the circuit. Instead of using a bias resistor for the 2N222A transistor, which would DeQ the tank, the bias is supplied through the coil winding so the only load to the tank is the base loading. Given that the hfe is ~150 and that the emitter swamping load is ~350Ω the base loading on the tank is ~52K. Instead of using the 100% tap to drive the base it is at 1/2 which will present a >200K load for the tank which is much less than most setups and

requires less negative resistance (conductance) to realize stable oscillation. The feedback is a resistive divider driven by the emitter swamping resistor but the swamping resistor could be the divider itself for minimum drive impedance. The optimal drive impedance and feedback level should be chosen for the best performance across both tuning and AGC range and an  $\sim 68\Omega$  may be a good ballpark value. This oscillator setup is designed to provide some AGC by varying the output level so the RF will benefit from this. Now during minimum output level for strong local signals the oscillator will run on its lowest current and in most oscillator setups this can present less than optimal performance and most are run with  $\sim 1\text{ma}$  idle current. In this case it may run with  $\sim 300\mu\text{A}$ . If properly designed this should not be a problem. The drive tap for the tank is at  $\frac{1}{3}$  and this is typical for most tank injection levels and the tap for transistor base is at  $\frac{1}{2}$ . Now depending on the feedback necessary, the resistive divider, and some other factors the base drive tap could be as low as  $\frac{2}{5}$ , reducing the tank load even more. Finding the right tap to base ratio, drive impedance and divider ratio, some experimental testing will need to be done. I reference the oscillator setup in the SA612A Osc/Mix chip. The oscillator transistor emitter is swamped with a 22K resistor and running with a 6V supply provides an  $\sim 250\mu\text{A}$  idle current max. The notes say that an additional resistor can be used to increase current for poor low Q tanks for reliable oscillation but too much would cause oscillator output to exceed design levels and it cautions that only so much additional drive current can be tolerated. So it appears that through proper design an oscillator could run at much lower currents than what good oscillator design specifies and in the SA602A chip it is designed to do this reliably.

### **RF / Mixer / IF**

This a differential transistor pair comprised of  $2 \times 2\text{N}3906$  ROHM units which are very low noise. While r'e mixers are not known to be the quietest setup its thought that using very low noise transistors and supplying a strong signal to the differential inputs will help to overcome these limitations, otherwise more than 3 transistors would be needed in a switch-mode setup.

There are 2 more IF/AGC stages that provide a total of 70 dB of AGC. To get the same drive level that is used with a differential pair and not distort the signal the unmodulated input level is half ( $6.3\text{mVp-p}$ ) of the differential level. Now this is more than twice the level that a single transistor can handle before distorting but the output of the 1<sup>st</sup> transistor is fed into the 2<sup>nd</sup> transistor to invert the distortion to cancel it out. To accomplish this one transistor needs to be turning on while the other needs to be turning off, just like it happens in a differential pair. To accomplish this when feeding a PNP from an NPN it is necessary to invert the signal via a broadband transformer, a bi-filar wound center-tapped choke. This particular setup also transfers the AGC signal to the 2<sup>nd</sup> transistor.



## Transistors

The graphs above illustrate ROHM's 2N3906 performance. It should be easy to operate the units well within the  $NF \approx 1\text{dB}$  range if the source resistance is carefully chosen as shown in the graph on the left  $\searrow$ . While the top graph shows it leveling off at  $\sim 1/3\text{dB}$  it only goes up to 100kHz but it is assumed that this trend should continue up to 1.7MHz with minimal increase if any. There should be good headroom for the GBW product too as shown in the graph on the right  $\nearrow$ . With so much headroom and the low operating frequencies the performance should not be much different than what would be seen in the audio frequency range.

The 2N222A is also a low noise transistor. While not as quiet as the ROHM units it is commonly used as an oscillator which is why it is used in this manner for the LO. It is also used as the 1<sup>st</sup> IF post ceramic filter. The 1<sup>st</sup> NF  $\downarrow$  graph demonstrates that the NF decreases to  $<1\text{dB}$  while the 2<sup>nd</sup>  $\downarrow$  NF

graph shows that if the source impedance is properly chosen the NF could be kept within the 1dB boundaries. In the 3<sup>rd</sup> graph the GBWP at 1mA is half that of the 2N3906 but even at 100ua should not produce any limitation. In the 4<sup>th</sup> graph the output admittance remains flat down to a  $V_{CE}$  of 400mV and the verticalness in the unsaturated region illustrates that the impedance is very high.

