THE KNIGHTLITE SMITE 80m CW QRP TRANSCEIVER

The Oscillator

The components that make up the oscillator section of the KnightSMiTe are Q1, R1, R2, R7, C1-C3, Y1 and L1. The output of the oscillator is coupled to the following stage (Q2) via capacitor C4.

** Q1 **

Q1, a 2N2222 in this design, can be any general purpose NPN bipolar transistor. In an oscillator, the active device (usually a transistor or FET) provides gain which must be greater than unity at the operating frequency. In addition, a feedback network couples a portion of the output signal back to the input. The energy coupled back must be in phase with and slightly larger than that which produced it at the input in order for the system to oscillate and run continuously. A resonator or resonating network used in the feedback path sets the frequency of oscillation.

Oscillators are named for their designers and for a unique feature of their architecture... usually the manner in which feedback is introduced.

The KnightSMiTe uses the popular Colpitts configuration identified by the capacitive voltage divider (C2 and C3) between the base and emitter used for feedback.

A crystal, used to set the frequency of operation, behaves as an inductor and series resonates with the network that consists of C1, C2, C3 and L1. C1 is variable and provides a means to alter the resonant frequency of the network slightly. A crystal appears inductive only for a very small region of frequency (between series and parallel resonance) and capacitive elsewhere. Thus, the frequency of oscillation can only be altered to within the limits of the two resonance modes.

In the KnightSMiTe, the oscillator runs continuously during both transmit and receive. In the transmitter, it supplies the signal which when amplified becomes the transmitted carrier. In the receiver, it serves as a local oscillator to Q2 where it mixes with the signal intercepted by the antenna to produce a difference frequency in the audio spectrum. That signal is then amplified by the audio amplifier U1 (the LM-386) to a sufficient level to drive a pair of low impedance headphones or a small speaker.

** R1 **

R1 is only used for a moment... at startup. It injects a turn-on bias boost into the base of Q1 to kick start the oscillator when power is first applied. In some cases it's not required, but having it guarantees oscillator startup. It should be a high value to minimize loading of the crystal which would otherwise serve to reduce tuning range or inhibit oscillation altogether. It should be low enough to provide a sufficient "surge" of base emitter current to get the oscillator up and running.

** C2 and C3 **

Once started, oscillation is sustained by feedback to the base of Q1 from the output taken from the emitter via the capacitive voltage divider consisting of C2 and C3.

C2 works with C3 as an autotransformer (the primary and secondary share a common path - C3) to provide the positive emitter to base feedback (i.e. the output at the emitter is in phase with the input at the base) required for Q1 to sustain oscillation.

The ratio of C2 to C3 establishes the amount of feedback. Too little feedback (C2 small relative to C3) will not adequately sustain oscillation. Too much feedback (C3 large relative to C2) will degrade

oscillator stability and increase harmonic content at its output. An abrupt frequency shift or chirp may also result as the oscillator is keyed.

** R2 **

R2 provides DC degenerative feedback at the emitter of Q1 and sets the source impedance for both the feedback autotransformer (C2 and C3) and the output load presented by the input of Q2 via the coupling capacitor C4. Its value is somewhat non-critical.

A larger value for R2 would increase the source impedance and make the oscillator sensitive to frequency pulling (called load pulling) due to the changing input impedance of the power amplifier when it's keyed. The result would be an objectionable "chirp" in the transmitted output waveform.

Making R2 smaller would increase the current drain in Q1 making the oscillator less power efficient. Decreasing it significantly would cause an increase in Q1's operating temperature (high collector current), reduce its reliability and degrade frequency stability.

The values of C2 and C3 would have to be scaled inversely with a change in value of R2 to maintain the same degree of feedback employed for sustained oscillation. Taken to an extreme this could result in spurious oscillations (undesired frequencies) or even destruction of the crystal due to excess drive.

** R7 **

R7 is a zero ohm jumper providing a return path to ground for the oscillator. It was originally implemented to facilitate keeping the wiring on one side of the board. That need was eliminated but we decided that keeping the jumper would provide flexibility to users who might wish to pursue optional uses of the transceiver. If this jumper is removed, the oscillator can be keyed on and off by connecting a key across this junction. This may be desired if only the transmitter section of the KnightSMiTe is used and an independent receiver is employed.

Removing R7 also permits independent use of the audio amplifier by disabling Q1 and Q2.

** C1 **

C1 works in conjunction with L1 to vary the operating frequency of the KnightSMiTe. To some degree, its value is critical. Maximum adjustment range is realized with a capacitor having a low minimum value capacitance (on the order of 3 pfd or less, while maximum values greater than 50 pfd will do little to improve the frequency pulling range of the oscillator.

Although C1 can be used to some extent as an RIT (receive incremental tuning), SMT capacitors are not sufficiently robust to survive in this environment. A varactor makes a better choice for an RIT control but will require a carefully regulated bias supply and increase the complexity of the design.

Oscillator frequency is highest for both receive and transmit when C1 is at minimum capacitance. The frequency shift between transmit and receive however is smallest at this end of its range... on the order of 100 to 200 Hz .

With C1 at maximum capacitance (lowest frequency), the shift between transmit and receive increases to approximately 500 to 700Hz.

In both cases the oscillator frequency increases when switching from receive to transmit. This means that when a station zero's your frequency, you will hear a tone between 100 and 700 Hz depending on where C1 is set. Since the KnightSMiTe frequency increases when switching to transmit, a responding station will likely be above your receive oscillator (i.e. in your upper sideband) by the same amount. The difference frequency is the tone you hear.

** Operators Note **

Once contact is made, ask the station to move his TX frequency up 500Hz or so. This will produce a more pleasing tone in your receiver. Don't ask them to QSY or you may lose them. QSY generally

implies "Both" stations change frequency. You only want "them" to move while you stay put. If he/she decreases their TX frequency, you'll receive a lower pitch until they move far enough into your lower sideband that you hear them emerge once again.

** *L1* **

As with C1, the value of L1 is somewhat critical. Reducing it will reduce the tuning range of the oscillator, while increasing it may result in the oscillator ceasing operation. L1 provides an inductive reactance in series with the crystal Y1 to compensate for (cancel) the contribution of the series modal capacitance of the crystal at series resonance. This technique enables the frequency of crystal oscillators to be "pushed" up in frequency while C1 serves to offset the reactance of L1 and "pull" the frequency lower. Together they maximize the range at which the frequency can be shifted. The KnightSMiTe is tunable in excess of 1.5 kHz in this manner.

** *Y1* **

The Crystal (Y1) controls the operating frequency of the KnightSMiTe. Any 80 meter Crystal should work well in this transceiver. A crystal series resonant at 3686.4 kHz is provided with the KnightSMiTe kit.

** *C4* **

C4 provides interstage coupling from the output of the oscillator to the input of Q2. It needs to be sufficiently large to permit Q2 to be driven to full output power yet small enough to prevent the loading presented by Q2's input from pulling the oscillator frequency during transmit. Its value is not critical but should remain small consistent with the drive requirement of Q2 for efficient Class-C operation at the desired operating supply voltage.

The Receive Mixer

R3, R4, C5, L2, L3 and Q2 together form the active mixer circuit. Local oscillator injection from the oscillator Q1 is via coupling capacitor C4 and the RF input from the antenna is coupled into the collector via capacitor C6. The detected audio, extracted from the emitter, is coupled to the audio amplifier U1 via capacitor C15.

** *Q2* **

Q2 performs two functions in the KnightSMiTe. During receive, it operates as an active mixer serving as a product detector for signals at or near the frequency of the injection (local oscillator) circuit of Q1. This process is called direct conversion since the desired signal is detected (demodulated) at the operating frequency avoiding the process of conversion to an intermediate frequency (IF) as is done in superhetrodyne receivers.

** *Q2 (as a mixer)* **

The oscillator switches Q2's base emitter junction on and off causing the RF signal applied to the collector to combine in the emitter. Q2's emitter current is highly nonlinear when its base emitter junction is switched in this manner. This produces strong sum and difference components (as well as the oscillator and input RF signals) at the emitter. An approximate conversion gain of 4 dB was measured on one prototype of the KnightSMiTe.

** *R3* **

R3 forms a voltage divider with R4 while providing only a trickle forward bias across the base-emitter junction of Q2 which remains biased Class-C due to the shunting effect of L2 which parallels (shunts) Q2's base-emitter junction.

The quiescent current in the emitter of Q2 serves to ensure the linearity of the detected audio extracted from the emitter junction and minimizes large signal distortion.

R3 is to some degree redundant in the presence of D1 which biases Q2's emitter above ground via R5 and can thus be removed without degradation in performance. Without D1 however, R3 is required and the following applies.

R3 is not critical and any value between 10k and 50k should work well. Decreasing its value increases LO radiation while increasing it may lead to audio distortion.

** C5 and R4 **

C5 and R4 form an audio highpass filter and bypasses all but the difference components (audio frequencies) appearing in the emitter of Q2 to ground. What remains becomes the receive audio which is coupled to the audio amplifier U1 via C15.

The RC time constant set by C5 and R4 establishes the detected audio frequency response of the receiver, passing only the difference frequency components (audio frequencies) created by the mixing (frequency multiplication) process in Q2. Any change in value of R4 would require an inversely proportional change in the value of C5 to maintain the same response.

** R4 **

R4 raises Q2's emitter voltage above ground to ensure the detected output of Q2 operating as an active mixer doesn't distort in the presence of high level input signals. The mixers output must remain linear over the receivers dynamic range. The bias on the emitter of Q2 permits large negative excursions of the detected waveform without clipping. The voltage only needs to be raised to 1/800 of the power supply voltage which represents the peak-to-peak input level where distortion in the audio amplifier (with a voltage gain of 200) begins to dominate.

Q2 would operate well as an RF power amplifier with the emitter close to ground however, and local oscillator radiation would be excessive. Raising the value of R4 increases the emitter voltage placing Q2 far beyond cut off. With collector current significantly limited, LO radiation is reduced. An excessive increase in R4 will result in weak oscillator injection causing distortion on large signals due to reduced dynamic range.

** C5 **

C5 grounds the cathode of switching diode D2 (reverse biased during receive) to provide immunity to noise on the keying line.

During transmit, C5 and R4 are shorted to ground and not functional with the key closed. C5 snubs any tendency of the key to arc when opening and key clicks are thus avoided.

** L2 **

L2, as a near short circuit to DC, prevents R3 and R4 from biasing Q2 into conduction. It's primary function is as an RF choke appearing as a high impedance at the operating frequency. This ensures Q2 is turned off until a signal is injected via coupling capacitor C4. The positive half of the oscillator signal causes the base-emitter junction of Q2 to conduct while the negative excursions of the signal allow Q2 to turn off. Q2 is said to be operating Class C when driven in this manner (i.e. emitter current flows over less than half of the input cycle).

Class C amplifiers are highly non-linear and by heavily restricting collector current power amplification is suppressed and the device becomes a mixer.

The value of L2 is not critical but needs to provide a high reactance at the operating frequency. Too low a value reduces coupling efficiency and too high a value consumes valuable board space.

** *L3* **

L3, also an RF choke, serves as Q2's collector load. Q must remain high for good coupling efficiency at higher values of L3. A smaller value will reduce coupling efficiency if its reactance is low relative to the output impedance at the antenna port.

The Audio Amplifier

** *C15* **

C15 provides a DC block and couples the detected audio at the emitter of Q2 to the input of the audio amplifier U1.

U1 along with C11 through C14 and R6 complete the receive portion of the KnightSMiTe.

** *U1* **

The audio amplifier (U1) increases the level of the detected signal voltage 200 times and provides sufficient output power to drive low impedance headphones or a small speaker. This self contained audio processing stage is the primary source of amplification in the receiver (46 dB compared with a measured 4 dB conversion gain in Q2 operating as an active mixer).

** *C11* **

C11 provides an audio bypass at the emitter of the input differential amplifier stage of the LM-386 audio power amplifier IC. This reduces emitter degeneration from 1.5 K-ohms to 150 ohms at audio frequencies effectively increasing the voltage gain of the input stage (and thus the amplifier chain) by a factor of 10 without increasing the quiescent DC current drain. A short circuit (jumper) here would achieve the same result with a tenfold increase in DC bias current but no improvement in performance.

Reducing the value of C11 will degrade the low frequency response of the amplifier. Reducing this to 1 ufd or even 0.1 ufd may be desirable if a sufficient transmit offset is achieved. Stations that zero the calling frequency must be at a sufficient offset to produce a tone in the 1 kHz frequency range or higher to overcome the degradation in low frequency response of the audio power amplifier that would result from this change.

Adding a 1.5 K-ohm potentiometer in series with C11 will provide an effective audio gain control but this should not be a requirement with the KnightSMiTe since the receiver derives most of its gain here and all of it is required for detection of weak signals. Gain control can be introduced here if the volume is objectionably high.

** *C12* **

C12 works in conjunction with R6 to stabilize U1 and prevent motorboating (low frequency oscillation) when connected to a low impedance load such as an 8 ohm speaker or headset. Together, they serve as a phase shift network to prevent the amplifier from becoming unstable.

** *C13* **

C13 serves as a DC block and couples the audio amplifier (U1) output to the speaker or headset. It's value is large to maximize the low end frequency response of the receiver.

** C14 **

C14 is optional but enhances the noise immunity of the audio power amplifier especially at high gains. It is nothing more than a bypass capacitor used to minimize noise that may be riding on the power supply from becoming amplified by the high gain input stage. A higher value capacitor here (on the order of 10 ufd or better) might be used to reduce hum on the output if using a poorly filtered AC power supply. Its value is non-critical, however a large reduction in value may degrade the low frequency response slightly and increase susceptibility to local broadcast interference. A larger size would result in a larger size package and consume valuable board space.

The RF Power Amplifier

** Q2 (as an RF Power Amplifier) **

Although Q2 is also a 2N2222 it has a larger package (SOT-89) than Q1 (SOT-23). The larger size dissipates heat more efficiently. Its second function, as an RF power amplifier during transmit, can cause Q2 to dissipate as much as half a watt when poorly matched to an antenna. When matched, it still needs to dissipate as much as 300 milliwatts. Any general purpose transistor in a SOT-89 package should work well in the KnightSMiTe.

Only 3 components are required to make up the RF power amplifier in the KnightSMiTe. These are L2, L3 and Q2.

** L2 and L3 **

The function of L2 and L3 remain as described in the receive mixer description.

** Q2 **

The function of Q2 is only slightly altered by virtue of shorting its emitter to ground during transmit. This effectively removes C5 and R4 from the circuit as well as the redundant bias path introduced by R5 in series with switching diode D1. When keyed, the only components surrounding Q2 that remain active are L2, L3 and R3.

With the emitter of Q2 at ground potential, maximum collector current flows when its base-emitter junction is forward biased by the positive excursions of the oscillator. The resultant high collector current is an amplified replica of the oscillator signal and is coupled via C6 to the antenna port J3, completing the transmitter portion of the KnightSMiTe.

** Historical Note **

Q2 biased in this manner, serving both as an RF Power amplifier and a receive mixer is the "elegance" of Oleg's (RV3GM) design. The result is a combined high performance receive mixer and RF power amplifier at low cost.

Oleg's approach also avoids T/R switching losses encountered in most classical transceiver designs. It's only shortcoming is that it suffers from LO radiation during receive much like a regenerative receiver.

** R3 **

R3, although not required during transmit, provides a small base-emitter bias thru Q2 which remains cut off because most of the bias is shorted around the base emitter junction by L2. R3's presence has negligible effect during transmit. See the receive mixer discussion for its function in the KnightSMiTe.

The RF Lowpass Filter

The RF input to Q2 operating as an active mixer arrives at the collector from the antenna through an RF low pass filter (LPF) consisting of C7, C8, C9 and L4 via coupling capacitor C6.

During transmit, the RF power at the collector of Q2 is coupled in reverse via the same path to the antenna port J3.

** C6 **

C6 serves as a DC block between Q2's collector and the antenna to prevent a DC short at the antenna port from shorting out the power supply and/or burning out L3. Within an order of magnitude in either direction, it's value is not critical.

** C7, C8, C9 and L4 **

C7, C8 and C9 along with L4 serve as a low pass filter (LPF) to reduce the output harmonics of the transmitter. This filter, also in the receive path, provides suppression of interference from strong out of band transmitters operating at frequencies above about 5 MHz.

C9 was chosen to resonate with L4 at 7 MHz (the second harmonic of the fundamental transmit frequency). This maximizes second harmonic suppression as well as susceptibility to 40 meter foreign broadcast band interference (BCI).

Transmit/Receive Switching

R5, C10, D1 and D2 are used to accomplish transmit/receive switching.

** R5 **

R5 limits the amount of current wasted when the KnightSMiTe is keyed. Grounding the cathode of D1 reduces the power supply of U1 to one diode drop above ground. Without R5, the power supply of the KnightSMiTe would be reduced to 0.7 volts and either rapidly deplete the battery or burn out the diode D1. If D1 is removed, R5 can be replaced with a jumper to improve receive dynamic range slightly. The improvement would only be slight however while its presence along with C10 provide a good degree of power supply noise suppression in the audio amplifier.

1 k-ohm is an optimum value for R5 and I wouldn't recommend changing it's value. Making it larger improves noise immunity but reduces the voltage supplied to the audio amplifier. A reduction in dynamic range results which will lead to distortion. Making R5 smaller increases its dissipation during transmission and increases the power wasted by virtue of shorting the cathode of D1 to ground.

** C10 **

R5 and C10 provides form a low frequency bypass of the power supplying the audio amplifier (U1) minimizing the effects of noise on the power supply.

** D1 **

D1 isolates U1 from drawing current from the emitter bias of Q2 during receive. Its function is to provide a short circuit path to ground for U1's power supply during transmit thereby muting the audio amplifier. Eliminate D1 for a slight improvement in power supply efficiency if listening to low level white noise while transmitting isn't objectionable or U1 if is needed to amplify a sidetone from a Tick keyer or other external tone source.

** D2 **

D2 introduces a capacitance change between transmit and receive to offset the oscillator frequency and enable detection of signals that zero your transmit frequency. D2 is reverse biased in receive (minimum capacitance) and zero biased during transmit (maximum capacitance).

D2 can be eliminated at the risk of not hearing stations that respond on your transmit calling frequency or if an alternate means of achieving transmit/receive offset control is introduced.

Any diode will work here, but feel free to experiment with different diodes types to find one that produces the greatest transmit offset. One that exhibits a high change in capacitance between zero and reverse bias will produce the best result.

Input/Output Ports

J1 through J6 are not components but rather wiring connections to the board. They are included and discussed here for completeness.

J1 - Power supply/signal ground (common to J4). Use also for keying and/or audio ground return.

J2 - DC Power input (7 to 12.6 VDC) ... Remember to fuse this line in your installation to save damage to your KnightSMiTe from inadvertent short circuits. A SPST (power on/off) switch is a nice feature toward conserving your battery resources.

    J3 - RF input/output (Antenna coax center conductor connects here).

    J4 - Same as J1.

    J5 - Keying control (float to receive and ground to transmit).

    J6 - Audio output to low impedance headphones or 8 - 16 ohm speaker.

Variations of the KnightSMiTe (Hints and Kinks)

** Operating the KnightSMiTe on other Bands **

The KnightSMiTe can easily be configured to operate on other bands. Y1 should be replaced with an appropriate crystal operating in fundamental mode. Frequency scaling of C7, C8, C9, and L4 (the components that make up the output filter) will complete the conversion..

These modifications will be offered in forthcoming Hints and Kinks as well as other useful modifications discovered, invented, or designed by KnightSMiTe users and made available to all on the KnightLites Web site.

KnightSMiTe MODS

This area will contain some modification notes for the SMiTe, our little surface-mount 80-meter transceiver.

This is a note from Gary, N3GO, one of the KnightLites' ENGINEER EXTRAORDINAIRE, describing a mod to the SMiTe that should REALLY increase the usefulness of our little rig.

Greetings Gang;

I got a query about whether one could mod the KnightSMiTe to transmit in the lower sideband. (i.e. below the receive frequency. This is desirable if one wishes to check into a sideband net (as an emergency appliance).

The answer was yes, and the solution should appeal to us all. I sure wish I'd figured this out before I decided to release it for production :-)

The mod fix tunes the transmitter on the KL Net frequency... The TX no longer moves with the tuning of the RIT control capacitor. The RIT function remains unchanged and the result is a RX/ TX offset that's user selectable. On two units tested, I was able to achieve nearly a KHz offset. This means that you'll be able to call CQ and hear stations that zero your carrier when responding.

To achieve this result do the following:

Remove diode D2 and connect an N-channel J-FET (J309 or equivalent) as follows:

Source - Connect to pad where the cathode of D2 was connected. (This is also connected to the pad where the rig is keyed)

Gate - Connect to any convenient ground reference. (I choose the bottom of C3 and R2)

Drain - Connect to the junction of Y1 and C1. (I found the top of C1 most convenient for me.

How it works:

The gate of the N-channel J-FET is negative with respect to the source during receive and thus the channel (drain to source path) is pinched off which presents an extremely high resistance (and considerably less capacitance than a 1N914 diode) and is effectively an open circuit. As such it has no effect on the oscillator tuning network (C1 and L1 in series) to which it is connected and C1 permits tuning of the oscillator frequency during receive. When the rig is keyed, the source is grounded placing the gate and source at the same potential (zero volts). The drain to source resistance of the FET is minimum under this bias condition effectively connecting the bottom of the crystal Y1 to ground by short circuiting (and thus disabling) the oscillator tuning network (C1 and L1).

The result allows the crystal to operate at (or very near) its marked series resonant frequency during transmit and the tuning network serves as a true RIT.

For best performance, adjust the receive frequency as high as possible for maximum TX/RX offset which will result in a receive tone of several hundred Hertz.

> 72
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> Gary, N3GO
>
> Raleigh, NC

Prof Jay and Gang;

I did the legwork to resolve the question of FET substitution for D2 on the KnightSMiTe. So far, I haven't found an N-channel J-FET that doesn't work in this application, so if you have any N-channel J-FET not included here, give it a try. For the record, I tested the following 4 devices and all produce identical results... (i.e. fixed TX with independent RIT):

MPF-102	(Radio Shack P/N 276-2062 @ $0.99 each)
2N3819	(Radio Shack P/N 276-2035 @ $0.99 each)
J-309	(don't recall where I got these)
NTE-312	(Same here... Perhaps Dan's Small Parts???)

The pinout of the MPF-102 and J-309 are identical, but the others are different. For convenience, I'll attempt to describe the pinout's here. Viewing the pin side of the package with the flat side horizontal and facing skyward, the pins appear from left to right as follows:

MPF-102 & J-309	-	Drain	Source	Gate
2N3819	-	Source	Gate	Drain

NTE-312   -   Gate   Source   Drain

The mod is as follows:

Remove diode D2 and install the J-FET of your choice as follows:

Source - Connect to pad where the cathode of D2 was connected. (This is also connected to the pad where the rig is keyed)

Gate - Connect to any convenient ground reference. (I choose the bottom of C3 and R2)

Drain - Connect to the junction of Y1 (the crystal) and C1. (the RIT tuning capacitor)

This should adequately and abundantly document this modification accurately until my next revision, and offer a bit of encouragement to those who may be uncertain of the consequences of part substitution :-).

      72 and keep those mod ideas pouring in :-)

      Gary, N3GO

Gang;

As a test exercise on my recently procured copy of the ARRL Radio Designer circuit simulator, I attempted to optimize the KnightSMiTe for power output while maintaining the harmonics below the FCC limits of -30 dBc (30 dB below the (output) carrier). I incorporated the result on my own KnightSMiTe and am happy to report the outcome was as predicted by the simulator.

To keep this brief, the following modifications will improve the KnightSMiTe transmit performance without degrading receiver performance (other than susceptibility to 40 meter broadcast interference... not an issue for most CONUS users).

Change the coupling capacitor C4 (between the emitter of Q1 and the base of Q2) from 82 pfd to .02 ufd.

Change C7 and C8 (the output filter capacitors) from 820 pfd to 470 pfd.

Change C9 (output 40 meter trap) from 220 pfd to 180 pfd.

The power output will increase to nearly half a watt (the bad news is that the rig now consumes 100 ma of current at 9 VDC). Transmit efficiency appears to be just over 50 percent with this mod, but the rig will now put out quite a healthy signal. I was able to extract a full watt at 12.6 Volts, but eventually burned out Q2. I was using a small package (SOT-23) 2N3904 for my test.

Those with the hefty 2N2222 may get more output power... (it has higher gain than a 2N3904) and it will handle the higher power dissipation.

      GL and 72

      Gary, N3GO

You can simply change C7 and C8 and get nearly the same result. C4 and C9 only improve output power slightly. In addition, you may in fact wish to leave C9 alone (i.e. 220 pfd) to maximize second harmonic attenuation and enhance rejection of 40 meter broadcast band interference.

Here is a message from Gary, N3GO, sent to a SMiTe owner who was having some trouble. This message can serve as a nice summary of troubleshooting the KnightSMiTe!

The KnightSMiTe is quite easy to troubleshoot, so don't despair. First plan of action is to determine what's not working... and the important assumption here is that it was working for some period of time implying that it was assembled correctly. If that assumption isn't correct, it would serve you well to verify the diodes and tantalum capacitors are installed in the correct orientation. Inspect the

transistors to verify they are not installed upside down :-) These critters are so small it's actually possible to install them that way... experience speaking here :-(Given that you're certain it's properly assembled and an actual failure has occurred, finding the fault should be straight forward.

With 9 Volts power applied, proceed as follows:

1). Connect a short wire (or test lead) to the emitter of Q2 (in receive mode). You should hear a 60 Hz buzz at the output of the audio amplifier. This confirms that all is well with the receive detector on :-)

2). Next, tune an external receiver to around 3687 KHz. (+/- 700 Hz)... still in receive mode, and with the short wire still connected. Your signal if it exists will appear in this region of the spectrum and confirm that the oscillator is working.

3). Finally Key the rig (dummy load desired, but not required with 9 Volt supply), and verify that the frequency of the oscillator shifts to 3684.4 (+/- 100 Hz or so) assuming you have replaced D2 with an N-channel J-FET. The frequency will only shift slightly (100 to 400 Hz or so depending on the trim capacitor setting) if your KnightSMiTe doesn't have this modification. This test verifies the keying circuit operation...

Completing these steps will identify where the problem has its roots :-).

At this stage, you go to the ABC's of troubleshooting :-)

A). Verify power is applied to the circuit and is of the proper voltage (in both receive and transmit modes). A weak battery may work in receive, but drop out when switching to transmit due to the increased power supply load.

B) Verify the voltages around each device (particularly the one that appears to be inoperative) is reasonable (i.e. zero if it's supposed to be at ground or isolated via a coupling capacitor such as the output filter, or the same as the battery supply if directly wired that way, and somewhere in between if isolated from supply and ground via resistors or transistors.) Note that inductors look like direct connections (short circuits) for this test. For example the base of Q2 (the output transistor) is connected to ground via the inductor at the base during transmit but should be about 1 to 1.2 V lower than the supply voltage in receive mode, while the collector is connected directly to the supply via the inductor on the collector.

C) Verify that voltages don't appear where they shouldn't appear. For example, a common problem reported with the KnightSMiTe is that with no antenna connected, a small DC voltage appears at the antenna terminal which should be isolated from DC via the coupling capacitor C6. The problem manifests itself as motorboating in the receiver and reduced or no transmit output power. The cause (in every reported case thus far) is a solder bridge across C6 during assembly.

A failure of any of the above tests should point you to within a component or two of the problem. Since you've already changed the two transistors, I'll assume step 1 passes Armed with these two pieces of information, I predict that the failure is due to a solder bridge or open, so inspect carefully... with lots of magnification. Check for shorts first with your ohmmeter in the low ohms position (if you have a continuity "beep" function, so much the better... The test will go fast in that mode.

In any case, the KnightSMiTe is quite robust and you're not likely going to be able to damage anything catastrophically... including connecting the battery backwards :-) At high voltages (12.6 Volts and above however, you run the risk of burning out Q2 due to over dissipation if not well matched on the output.

Gary, N3GO

This is a note from Pierre, KA2QPG:
I have a Pixie II, which I built from the K5FO schematic found on the Web. It is a fine minimalist rig, and I have made several QSO's with it, but the selectivity of the receive section leaves a lot to be

desired. Particularly annoying are the SW broadcast stations which fade in and out with music and voice, sometimes wiping out the CW. SMiTes and other Pixie variants also have this problem. Several have suggested audio filtering, which is possible with additional circuitry. But I wanted to keep the rig in its minimalist beauty, while improving its performance. So I concentrated on the RF end, and after some experiments I came up with a fix that eliminates almost all the BCI with no active components: a quarter-wave shorted stub.

The idea is nothing new. I found it mentioned in a 1947 ARRL Antenna Book! All you need is an electrical ¼ wavelength of 50 ohm coaxial cable (44 feet of polyethylene RG-58 or 53 feet of foam RG-58, for the KL frequency) and a "T" adapter to attach it to the antenna jack of your rig. I used an Ethernet BNC "T" from my computer job. One end of the coax has a BNC plug, and the other end is soldered short and taped up.

When I plug this stub into the "T" while listening to the Pixie, the broadcast interference just disappears, leaving only 80m CW signals audible. It's really an impressive improvement. Also, the high, steady carriers I usually hear (probably from the crystal's second harmonic beating with 7 MHz broadcast carriers) disappear.

I would recommend this filter for anyone who wants to use a Pixie or SMiTe for actual communication. It would work on 40 meters with the appropriate scaling, but would probably not be so effective because many broadcasters are right near the frequency of operation.

72 de

Pierre Thomson KA2QPG

Note: Pierre also is looking into an LC bandpass filter and suggests the following reference:

For plans of an LC filter suitable for multiband field work, see June 1994 QST, page 32, for an article by N1AL.

He also has another tip: Another simple fix that helps the CW copy... add a largish inductor (a potted 100 mH in my case) in series with the 10 uF gain cap at the LM386 chip. That gives some preference to low audio freqs and reduces the "ultrasonic CW" to comfortable levels. At this time of the year, it also cuts the general QRN crash level by 10 dB or so.

Sam, AE4GX, offers these notes:

I am MODing the PIXIE 2 to try to get as much out of it as possible. I am working on two problems.

BC Breakthrough: I have eliminated it with a tuned LC toroid circuit tapped up from the grounded end(about 25%) to join the output of the LP filter. There is a 5 turn link on the grounded end of LC circuit that connects to the antenna and ground. (This basically looks like a tiny antenna coupler). I was thinking about replacing the LP filter with this same tuned circuit and link arrangement. I think I have seen this tuned output circuit configuration in one of the old SPRATS. I can see I still may need the LP filter to reduce the harmonics but was thinking that the tuned circuit directly at the collector of the PA Q2 might help the selectively. Has anyone tried this?

Sensitivity: I can hear CW signals but the volume is fairly low. Has anyone played with the bias resistors to the PA Q2 to see if the RX mixer action could be improved without affecting the power output during TX. It looks like the bias resistors are effectively out of the picture during TX. I wanted to try this before adding any AF Filter/preamp. I see a fairly BIG OSC signal at the BASE of Q2 and was wondering if it could be OVERDRIVING the DIODE detector action during RX?

Trying to increased my QRP knowledge. Any comments would be appreciated.

Sam AE4GX

(and more from Sam:)

I continue to try to improve my PIXIE2. The latest change is to put a tuned LC toroid/cap circuit tapped down(about 30%) and connected to output of the LP network with the end of the new LC grounded. A link coupled winding over the cold end of the LC circuit connects the antenna and ground. This acts like a miniature antenna tuner and eliminates the BC feedthrough even using my 125 endfed longwire. Before this change the PIXIE was completed swamped with BC interference. After making a QSO with Lou in Knoxville, TN (I live in Atlanta, GA) on 7.040 (2-way QRP at 5w both about 569) I asked could he listen for me about a 1KHz lower on the PIXIE. Changed gear(same antenna my inverted L longwire at 35 ft) and called. He came back with a 519 and he got a 559. Another PIXIE 2-way QRP QSO.

Right after the call I checked the PIXIE into a dummy load with my scope and calculated 18milliwatt (my battery under load 6.6volts at 60ma..???? not very efficient). The input into the LC added circuit was about 50 milliwatt.

Again I chalk up my personal records with this amazing $10 rig and I'm still not done yet. Stay tuned!

Sam AE4GX

(and yet more from Sam:)

When I ended the last segment of this story I had a miniature antenna tuner coupled to the antenna connection of my PIXIE. I saw I putting out a very low 18mw and knew something was wrong since I was pumping in about 400mw. Taking the new tuner addition out and checking it found two interesting things: First, the LC was tuned to 5.9MHz so I had to take off some turns and re-tweek the cap. Second, using my MFJ SWR analyzer and a dummy load I found the SWR very high : >>3:1. So I put two four turn links (one end of each link grounded) on the cold end of the LC and rechecked the SWR. Now its Now Local AM broadcasts breakthrough is GONE but occasionally I hear foreign broadcast. Found out that it was station on 7.535 kHz coming in at S9+60 db on my ICOM756 with the endfed 135 ft longwire. Plan to put a series LC circuit from input to antenna tuner to ground. Should eliminate this guy or at least greatly reduce him.

Now for the BIG change: VXO operation. I hated the fact of the two fixed frequencies. I was moving the xtal frequency using the two different caps (switched) to ground. This originally gave me about 800Hz shift. Good for another PIXIE (I worked AE4NY's PIXIE at two feet. HiHi.)

So I wound a FT50-61 ferrite toroid with 31turns and put it and a 25pF var. cap in series with the Xtal. Now get 6KHz swing (7038 to 7044KHz). BETTER. Took the original offset switch and switched in or out a very low cap to provide tx/rx shift. Works great middle of the range but too much or too little at the ends. BTW the 0 - 50% of 25pf shift covers 2/3's of the range. So the fix offset would be different between the ends. Hum ....Plan to put two var. caps in rig and switch them manually between rx/tx. This should give me flexibility between tx/rx operations over the 6 kHz range. Watch out guys her I come. VXO(6kHz), 180mw and a wire antenna. How's that for PURE QRPing.

Sam Billingsley AE4GX

e-mail: sbillingsley@usaninc.com

Mike, DF2OK, shares some ideas and experience on filtering for BC interference on his 80m SMiTe (and is working on 20m versions of the SMiTe!):

I've noticed, that the audio-amplifier is overloaded in the evening because of the strong signals on 7MHz BC band. My mods are:

Protection against wrong polarity with two diodes, one in the 9V bus and the other in the ext. (13V) bus. The voltage lost and the higher inner resistance of the diodes in this circuit are the reason that I connect an elko of 330 uF from +UB to ground behind the diodes, 9V in of the TRX.

As I wrote some time ago, I reduced some hiss by soldering a 2,2 nF Cap from Pin 1 to Pin 5 of U1. The higher external power of about 11 Volt and up produces a buzzing noise out of the audio amplifier. Trying around I get this terrible noise off by connecting a 4.7 nF Condenser from Pin 8 to nearby ground of U1.

The next step was to increase the value of C10 up to 100 uF. After this mods where done, I was able to use this nice rig in the late evening and night here in DL, too.

I found some solutions of reducing BC interference by searching in the Internet of 'PIXIE2' as a keyword in searching machines. I found for me, that a low-pass LC circuit helps a lot.

Between C15 and Pin 2 of U1 I put a choke of 1 MilliHenry in series and a capacitor of 0.1uF from Pin 2 to ground. All these components are not SMD, but what shall I do if you have none, hi :-)

Changing the band on which the SMiTe operates involves changing the crystal and the output L and C. Here is a response from Gary, N3GO, to Mike's, DF2OK, query about getting the rig on 20m:

Try the following:

68pF for C7

15 pF for C8

15 pF for C9

1.5 uH for L4

I did an optimize of the circuit using ARRL's Radio Designer. I haven't tried these out on the bench though so you are on your own. I think the values will work well though. The Pi values should give

you best power output into 50 ohms with 2N2222 and C9 resonates with L4 to trap the second harmonic (28 MHz) to keep you within FCC limits on harmonics (< -30 dBc). 10 or 12 pF may be a good compromise on C9 if the 3rd harmonic comes up too high. It will suppress the third at some sacrifice to rejection of the second.

L3 should be OK as is (i.e. 22 uH). It serves as an RF choke and should still work fine at 14 MHz. Reducing it to 5 uH doesn't degrade performance much though so do as you wish with it.

Ditto with L2. Same story here. Reducing the value may improve efficiency here just a bit, but I doubt you'll notice much difference. It will increase the drive into the Q2 but probably won't increase your output power much.

>I know, that the circuit C9 L4 is a resonant circuit for >about 7.2 MHz. So how to modify this?

Yep... It's a harmonic trap. Adjust C9 to null the second and third harmonics equally. This will minimize transmit harmonics as well as suppress strong signals in those bands from creating interference in your RX. I guess you don't need to worry much about FCC requirements :-)

You didn't mention L1... You may need to reduce it's value to 30 to 50 uH. Leave it alone until you determine if it needs changed though. The "problem" that it may introduce is it may cause your oscillator to stop when you attempt to push it too far. If it becomes annoying to you, reduce the value to one that gives you the largest tuning range whilst maintaining oscillation.

For 14 MHz, you may want to see if you can get a higher frequency NPN for Q2. This will improve your output power, and transmitter efficiency.

Here are some very interesting notes from Todd, KB0HQU:

Some of the folks wonder about modding the SMiTe. Well, I have a suggestion for how to do it! It requires a little mechanical finesse. In other words, don't drink a pot of MY coffee, the way I like to make it, and then try to do this.

Gang, we have a whole back of the board to put things on. If you have access to copper tape, you can put that down for pads. If not, you can nibble out little squares of pcb and glue them down for pads (old idea, new area :-). If you don't have that, then you can run little runs of bus wire around, and just solder the parts directly to the wire. Optionally, you can super glue the parts down before routing the wire. Here is the really tricky part: get a Dremel or some other way to turn really small drill bits. Then get a really small drill bit. A pcb bit is what I have in mind here; the 1/16" bit is too big. Something on the order of 0.040" or 0.030" is fine. Drill from the backside into the copper pads where you need to make the interconnect. Then reflow the solder on the top around a piece of wire you stick through to make a via. If you did that first, you could then bend and route the wire flush to the board on the back, and solder the added parts to it.

Now, this puts parts on the back of the board, and you can't mount it flat down on a surface. But if the parts are all on one side, you can still use a piece of double-sided foam tape Radio Shack has, or used to have, some). If the parts are all over the back (meaning you are very mod-some :-), then just cut little pieces of this stuff, and put it where parts aren't, and stick it down in your tin or whatever. After you do your mods this way, folks won't be able to tell at a casual glance that mods were even made. Heck, at a casual glance, most non-hams can't even tell that it's a RADIO :-)

Todd

Here is a hint from Gary, N3GO:

replacing D2 with a J-FET is quite worthwhile and I humbly apologize for not solving that issue prior to releasing the final layout :-(I was focused on getting the rig out before Christmas and agreement was unanimous that most folks on this list might consider room for improvement a design "feature" :-)