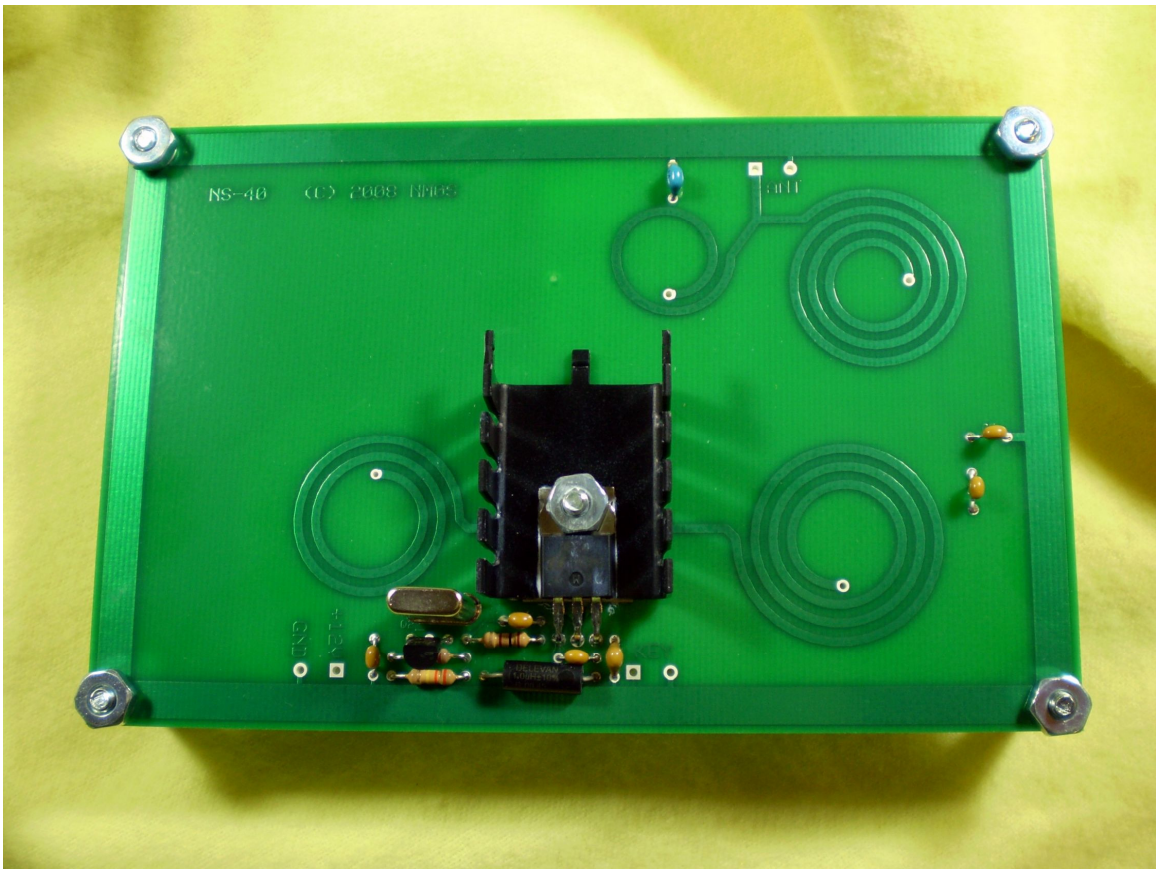
NS-40 - "None Simpler"
40 Meter QRP Transmitter



Populated Board built by NØSM

The NS-40 is a five watt, 40-meter QRP transmitter of *very* simple construction. How simple? **NONE SIMPLER**!

The circuit is a two-transistor, crystal-controlled Master-Oscillator, Power Amplifier circuit, using only fourteen, through-hole electronic components. This kit has no coils to wind, since all the inductors in the transmitter output circuit are made of spiral traces on the high-quality PC board. This kit can be assembled and put on the air in less than 30 minutes. How simple is that?

Despite its simple circuit and easy construction, this circuit delivers a 'full QRP gallon' of five watts into 50 ohms. The power amplifier transistor operates Class-E, for high efficiency and VSWR tolerance. This rig delivers a clean, click-free and chirp-free signal, and the output filter network limits harmonic to 50 dB below carrier or better. This may be a simple rig, but there is no compromise in its performance.

ASSEMBLY

Because of the simplicity of this kit, it will have appeal as a first project for beginning kit-builders. For those with little or no experience with soldering, there are a few things to keep in mind before starting.

It is recommended that a low wattage, 25 to 30 watt, pencil-tip soldering iron be used. Only rosin-core solder may be used, as acid core plumbers solder will corrode the board and components. Either lead-free or tin-lead solder may be used, though the builder should be aware of the potential toxicity of lead-based solders.

Soldering is not hard if the proper procedure is followed. The soldering iron is to be used to heat up the PC pad and component lead, and the solder applied to the pad, where it melts and flows into the hole. Do not melt the solder onto the tip of the iron and then attempt to dab it onto the joint – a defective connection will result! After soldering, check the top (component side) of the board, to be sure the solder has filed the hole completely, and wicked up around the component lead. Re-heat and apply more solder if necessary.

The PC board has the reference designators for the component mounting locations in copper trace lettering on the component side of the PCB.

Resistors … check off the part as you install the components.

The value of the resistors is designated by three color coded bands. A fourth gold band at the right side of the resistor indicates 2% tolerance of the resistor value. Install and solder one at a time, clipping the leads flush with the back of the board when finished.

( ) R1 – 1.0 Meg - brown black green
( ) R2 – 330k - orange orange yellow
( ) R3 – 100 ohms - brown black brown

Capacitors … check off the part as you install the components.

The value of the capacitors is designated by a three-digit code printed on one side.

( ) C1 – 0.1uF - 104
( ) C2 – 0.01uF - 103
( ) C3 – 470pF - 471
( ) C4 – 470pF - 471
( ) C5 – 1000pF - 102
( ) C6 – 750pF - 751
( ) C7 – 0.01uF - 103

Choke … check it off as you install it..
The single choke in the circuit is a larger cylindrical-bodied component. Its value will be printed on the side.
( ) L1 – 1.0uH - 1.0uH

Transistors … check off the part as you install the components.
Both transistors Q1 and Q2 are MOSFETs, which are can be damaged by static discharge. Keep them in their protective anti-static bags until ready for installation.

Transistor Q1, the larger of the two, is mounted with a heat sink between it and the board. The thermal performance of the heat sink can be improved, if the builder desires, by applying a small dab of heat sink grease (available at Radio Shack) to the back of the transistor mounting tab before installation. Bend the transistor legs back at right angles, ¼" (6mm) from the body of the transistor. Mount the transistor and heat sink to the board using the 3/8" (8mm) screw, lock washer and nut. Be certain that the heat sink does not inadvertently contact any other components on the board. After the transistor is mounted to the board, solder its leads in place.
( ) Q1 – IRF510

The smaller transistor is Q2, the 2N7000 oscillator/driver. Mount it with its flat face oriented toward the top edge of the board, with roughly half the length of the leads extending below the board.
( ) Q2 – 2N7000

Crystal … check it off as you install it.
Finally, the crystal is to be mounted. X1 is a 7.030 MHz crystal in an HC-49 package.
( ) X1 – 7 MHz

Final hook up.
During the operation of the transmitter, it is important that the board not be close to conductive surfaces that might couple to the spiral inductors. Standoffs are provided to mount in the corners to elevate the board above a desktop, or, if the builder wishes, to be used to mount the transmitter in an enclosure.

Finally, it will be necessary to connect pigtail connections to the +12V, KEY and ANT terminals, and their respective ground returns. Twenty or twenty-two AWG insulated wire (not included in the kit) will be adequate. Pay attention to the polarity of the power connection. It would be recommended to use color-coding of the hookup wires to keep the connections from accidentally being reversed.

Operation
The power requirements for the transmitter are 9 to 14 volts, at up to 750 mA current. The keying circuit must handle these same voltages and currents. To avoid damage to the transmitter, do not exceed 15 volts supply voltage. The power supply should be fused at 1.5 amperes. Double-check that the polarity of the supply before applying power – the circuit may be damaged if the voltage is reversed.

The NS-40 is designed to operate into a 50 ohm antenna impedance. VSWR should be kept to a minimum, preferably less than 1.5:1. It is also intended to operate into a resonant, 40 meter antenna. To limit any potential for harmonic radiation if the transmitter is to be operated into a multi-band antenna such as a trapped dipole, or G5RV, an in-line 40-meter low-pass filter or antenna tuner should be used to limit output harmonic current.

When operating from 12 to 13.6 volts, into a 50 ohm antenna, the output power of the NS-40 will be 4 to 5 watts, depending on the tolerance variations of the components in the transmitter circuit. The high efficiency of its Class-E power amplifier will be evident in the very slight heating of Q2 that will be generated.

CLASS-E POWER AMPLIFIER

Even though the Class-E power amplifier was invented and patented over thirty years ago by Nate Sokal WA1HQC and Alan Sokal WA1HQB, it has not appeared in many ham radio projects. Not many amateurs know about the advantages that it can bring to a transmitter project. A Class-E power amplifier is no more complicated than the more well-known Class-C circuit, but offers some real advantages in performance.

The schematic of the NS-40 circuit is shown in Figure 1. At first glance, there is no real difference between the schematics of a Class-E PA and the more common Class-B or –C amps. The difference is in the exact values of the inductors and capacitors surrounding the final MOSFET. The Class-E power amplifier has a much lower Q tuned circuit at the amplifier than a Class-C amp of similar power. The Class-E output device is driven hard for 180 degree conduction, so that the transistor acts as a switch. The tuned circuit shapes the transistor voltage and current waveforms so that the transistor converts DC to RF at efficiency much higher than is capable with a Class-B or –C amplifier. Depending on antenna VSWR, the final amp of the NS-40 will operate at near 90% efficiency. When delivering 5W power into 50 ohms, the output device will barely be warm to the touch.

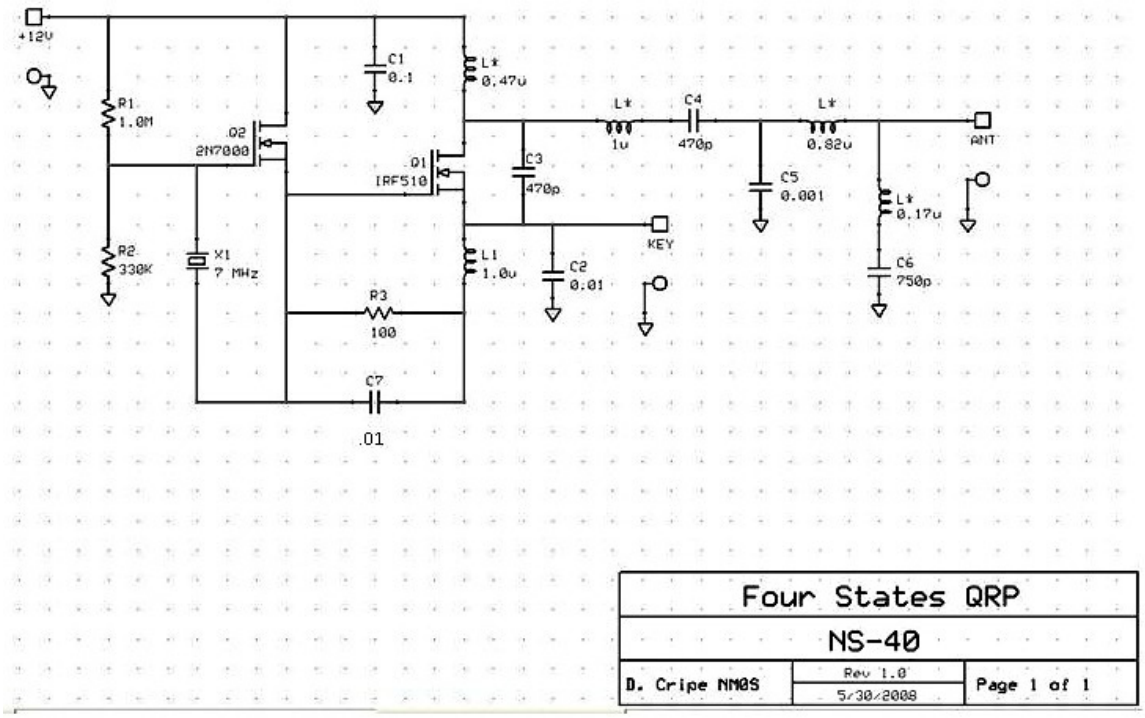
Nat Sokal has written an excellent article explaining in detail the operation of the Class-E power amplifier, which can be found at: http://www.classeradio.com/sokal2corrected.pdf and
http://www.mendeley.com/research/class-ea-new-class-highefficiency-tuned-singleended-switching-power-amplifiers/

TROUBLESHOOTING

Since there so few components on this board, there is little to go wrong with it. If a newly-completed board does not generate RF power when connected to 12 volts, an antenna and key, check for the obvious, such as incorrectly located components, or transistors installed backward.

In the event something gets 'broken', odds are it will be one or more of the MOSFET transistors. Trouble-shooting these components requires an ohm-meter. A failed MOSFET will read close to zero ohms between two or more of its terminals. In this case, remove the failed MOSFET by snipping the body off of its leads using diagonal cutters. Then, using the soldering iron, heat each leg and pull out of the board one at a time. Replacement components are available from a number of sources, including Jameco, Mouser, and Digi-Key.

Figure 1: Schematic of NS-40 Transmitter



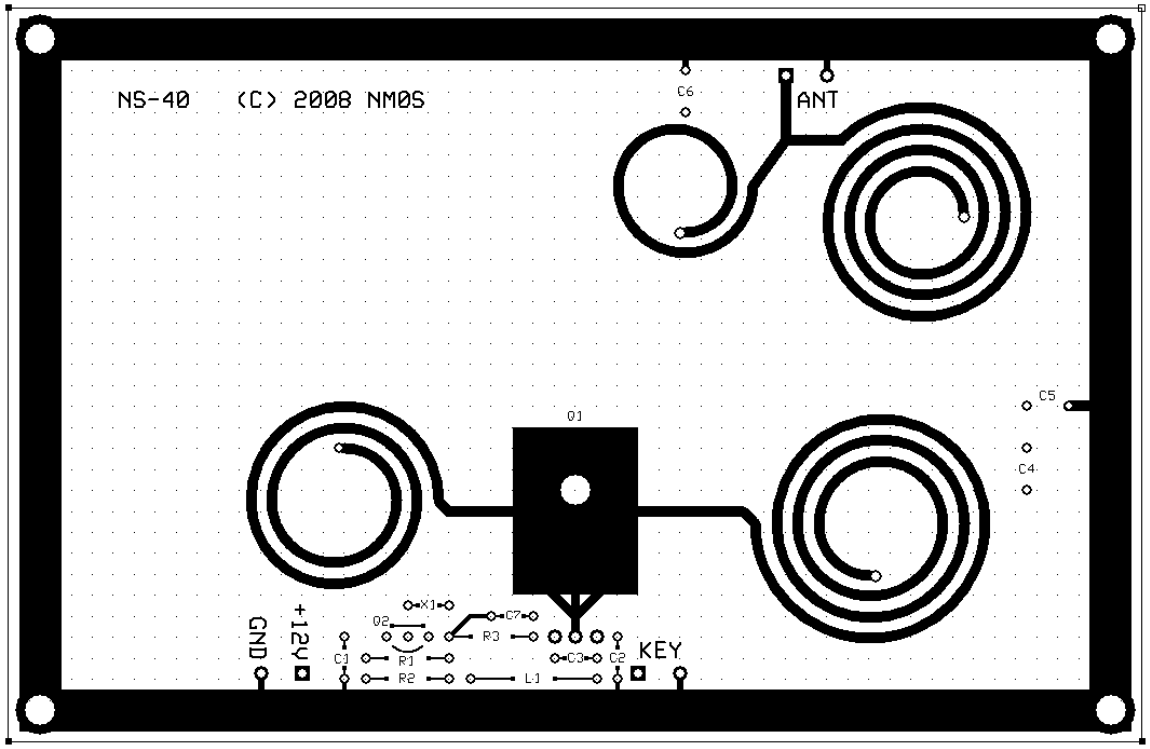


Figure 2: Component Placement on the PC Board

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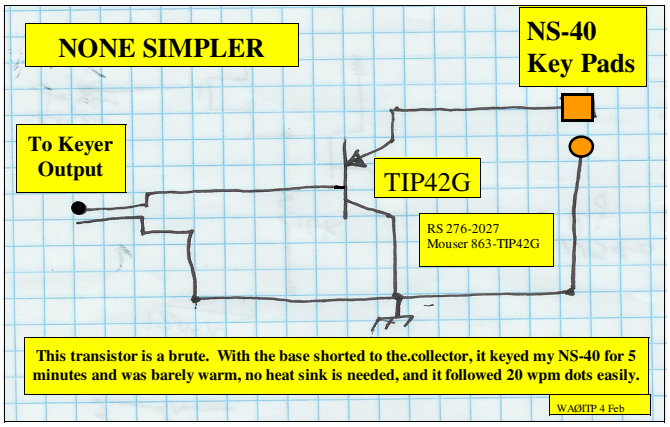
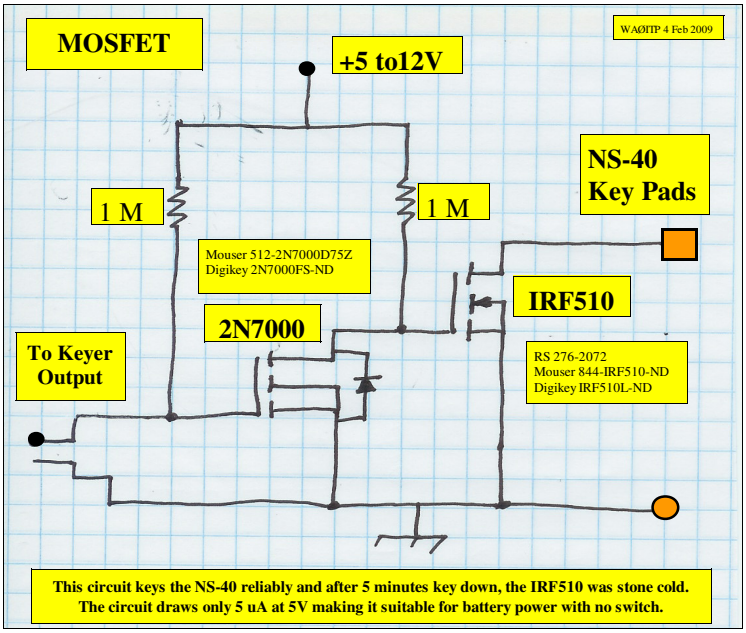
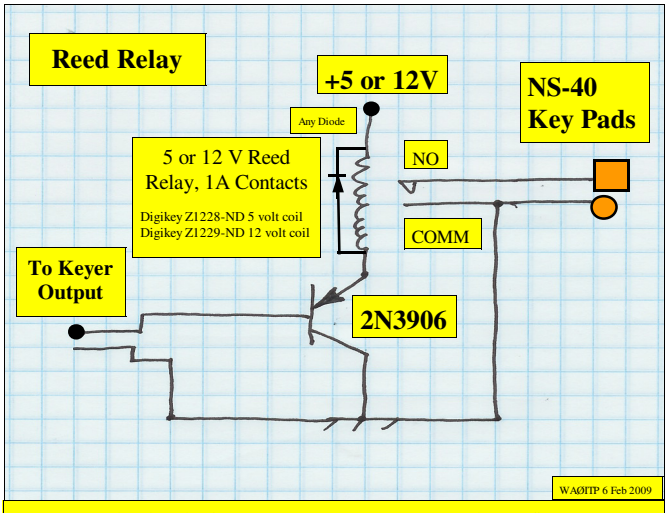
Enjoy!

Easy To Build Keyer Interfaces For The NS-40

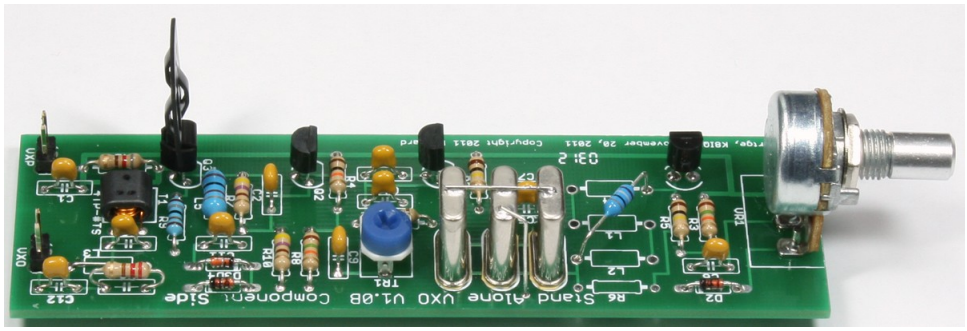
The keying current of the NS-40 is about 750 ma or so, which is a little stout for most solid state keyers. Any of these circuits handles that current easily and protects the output transistor in your favorite keyer. All have been tested so you can build them with confidence. They can be built inside the NS-40 enclosure, or in an Altoids® tin and plugged in between the keyer and the rig.







Connecting the SAVXO to a NS-40 Transmitter

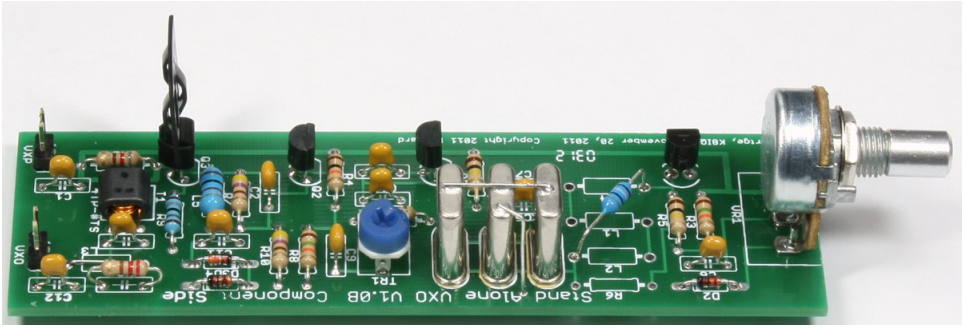


SAVXO built to drive a NS-40 Transmitter

Jim Kortge, K8IQY
February 24, 2012
Version 1.0A

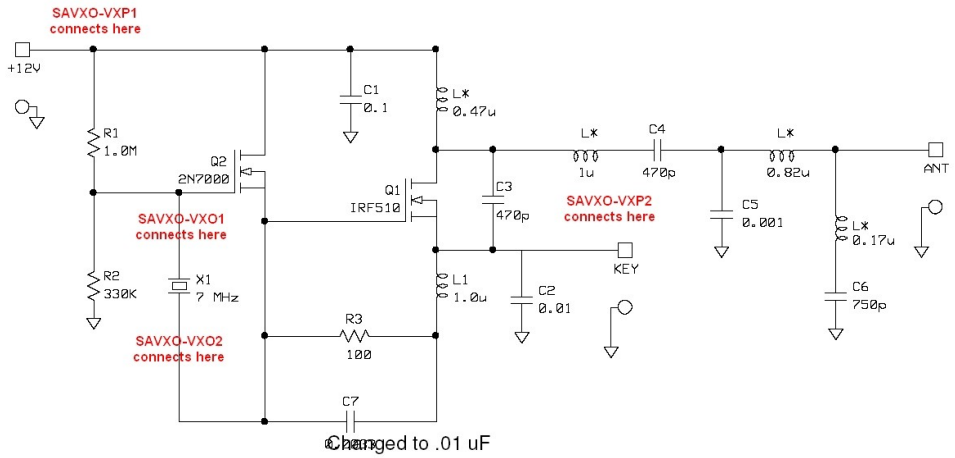
Many builders of the Four State QRP Group Stand Alone VXO (SAVXO) intend to use it to drive a new or existing NS-40 Transmitter, also sold by Four State. What will not be obvious to most is the way the SAVXO is connected to the NS-40, so that they both work as intended. This document addressed that need.

The SAVXO has two build options available. When built to drive the NS-40 transmitter, the SAVXO has a 220 Ohm resistor across the output to properly load the NS-40, so that it is stable and can run without a crystal. Below is a photo of the SAVXO with that option shown.



The 220 Ohm resistor used in the NS-40 option is the one shown just to the right of C12.

Connecting the SAVXO to the NS-40 requires 4 connections. These are shown in the next photo, which is the NS-40 circuit diagram that has additional information appended to it to show where the SAVXO connections go.



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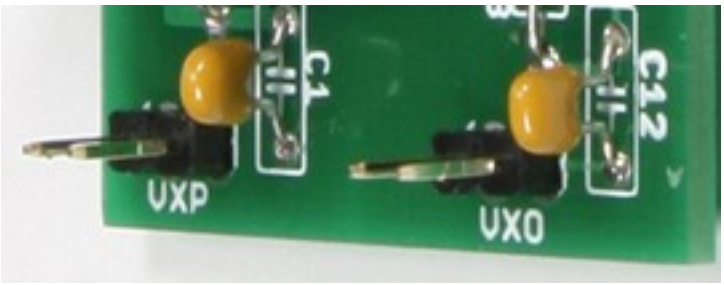
First of all, the NS-40 and the SAVXO need to receive their power from the same power supply, so that they share the same ground reference. Also very important, if the NS-40 and SAVXO pair will be keyed by a MagicBox T/R unit, that should also be powered from the supply common to the NS-40 and SAVXO. Using the same power supply will eliminate any kind of grounding issues which might occur if using different power supplies.

Referencing the photo below, the VXP header contains the SAVXO power supply connections with the left pin being pin 2 (- connection) and the right pin being pin 1 (+ connection).



Referencing the NS-40 circuit diagram and the above photo, VXP1 is connected to the +12 supply point on the NS-40 PCB. VXP2 is connected to the "hot" side of the NS-40 key line, the point on the NS-40 diagram and PCB labeled "Key". That takes care of the first two connections. Use the supplied female header supplied with the SAVXO kit to make these connections.

Referencing the photo above, the VXO header contains the SAVXO RF output connections with the left pin being pin 2 ("cold" connection) and the right pin being pin 1 ("hot" connection). This part of the SAVXO circuitry is floating and does not share a ground common to the rest of the SAVXO PCB.

Again referencing the NS-40 circuit diagram and the above photo, VXO1 is connected to the NS-40 crystal pad that shares a connection with the 2N7000 gate. Looking at the NS-40 PCB, that would be the left lead of the crystal. VXO2 is connected to the NS-40 crystal pad that shares a connection with the C7, R3 and IRF510 gate, which is also the right lead of the crystal. As before, use the supplied female header supplied with the SAVXO to make these connections.

Note: The crystal of the NS-40 must be removed prior to making the connections from the SAVXO. It is recommended to use 3 pins of a machined pin IC socket as a crystal socket after the crystal is removed. The center pin of the 3 is cut off on the bottom side, so that only the outer pins remain. This can then be soldered to the NS-40 PCB where the crystal was and the crystal can be reused if desired, as long as the SAVXO isn't plugged in. As another suggestion, on the other end of the leads coming from the VXO header, use another set of 3 pins with the center one cut off as a male plug to plug the SAVXO RF drive into the NS-40. The VXO leads should be kept under 6 inches in length and the pair of wires color coded so that the "hot" lead is distinguishable from the "cold" lead. Twist the leads together at 3-4 turns per inch to improve the immunity of this pair to stray RF. The power supply leads to the SAVXO should be as short as practical to reduce stray RF pickup.

Once the SAVXO is properly connected, close the key and while driving a dummy load, watch the power output of the NS-40 on a suitable meter. Increase the drive from the SAVXO using the SAVXO TR1 trimmer until the NS-40 power output peaks. When a peak is reached, back down the drive from the SAVXO about 5%, just so the NS-40 isn't being over driven.