A simple, yet still "fool-resistant," sequencer for transverters
New version with LED indicator for power output

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The availability of reasonably high-power microwave amplifiers has made switching in transverters more troublesome. At milliwatt power levels sequenced switching was not essential, and even at powers up to one watt, many operators get by without any sequencing. However, at higher power levels, like the 40-watt amplifiers for 3456 MHz which recently became available as surplus, the possibility of damaging a coaxial relay by "hot-switching" (with RF power applied) becomes significant. Even at 10 GHz, with amplifier outputs of 3 watts and more becoming common, we are pushing the hot-switch (switching with RF power already applied) capability of small SMA relays. The DB6NT[1] 10 GHz transverter MK2 instructions state: "Urgently the use of a sequence controlers is recommended."

New Version Option: Output Power LED

Many of the available microwave amplifiers have an internal RF output detector, usually just a diode detector sampling the RF output power. When no one is answering, any indication of output power is encouraging. The output is typically capable of driving a microammeter but not an LED. To minimize feedline loss, we would prefer to have the transverter mounted at the dish, with the IF rig in a dry place with the operator. A meter is difficult to read at a distance, but an LED is more apparent. The problem with an LED is that it may only give short, barely visible, flashes on SSB voice peaks. With help from N1EKV, I added an amplifier and pulse stretcher to drive an LED and extend the flashes for voice peaks.

Safe switching

All RF relays are capable of safely handling much more RF power than they are capable of hot-switching without damage. A sequencer ensures that the relay has time to switch before RF power is applied. Several years ago, I described[2] a "Fool-resistant" transceiver interface and sequencer, which improved some of the shortcomings of previous sequencer designs. Now that packaged transceivers (including the IF interface) for most microwave bands are readily available from Down East Microwave[3] and from DB6NT, such a complex interface is not necessary. The addition of a power amplifier, however, brings with it the need for sequenced switching.

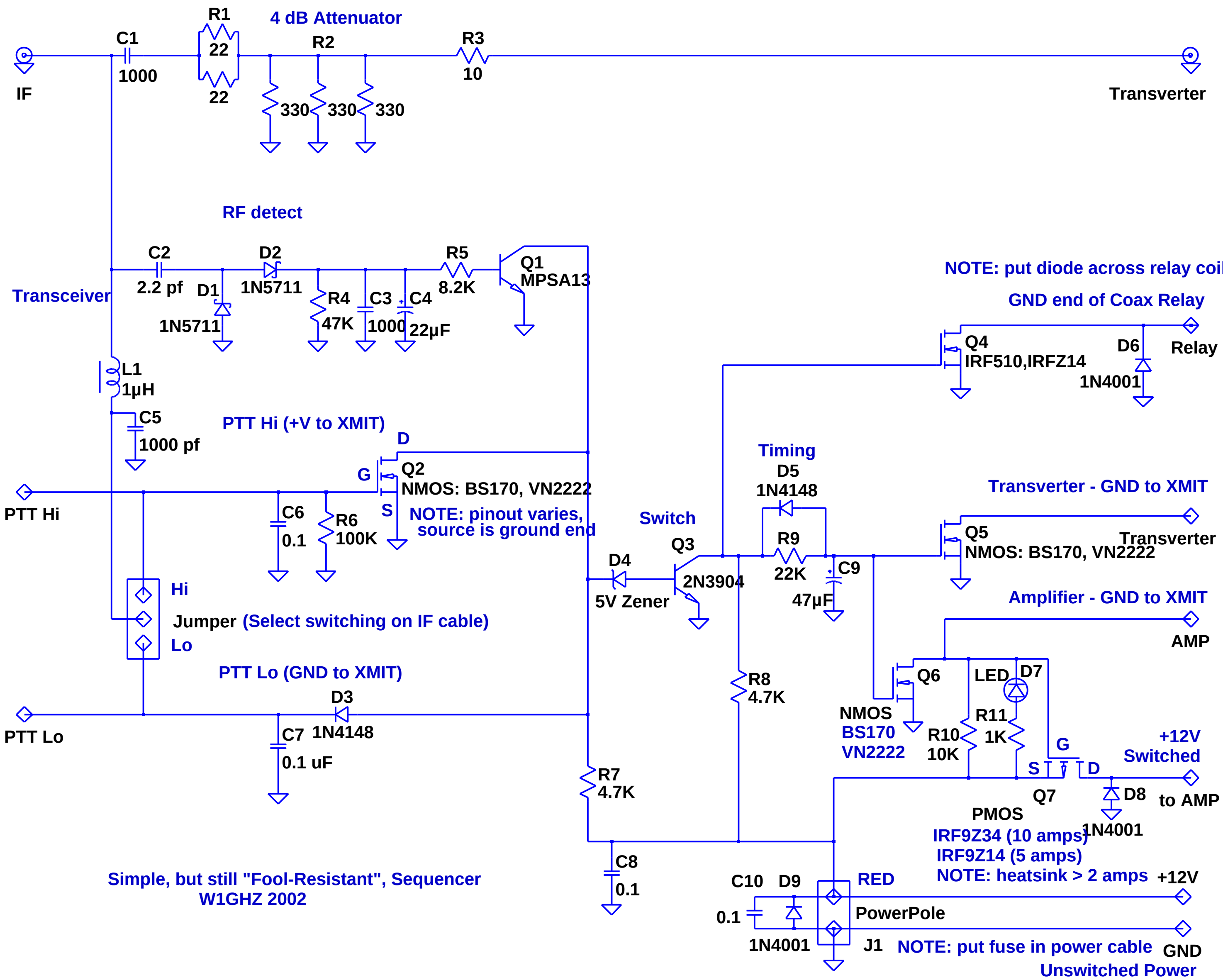
A very attractive new IF transceiver is the Yaesu FT-817. One of its features is break-in CW – touch the key to transmit. I tested mine to see how quickly the transmitter is activated, and found it to be perhaps 10 milliseconds, not enough time for a relay to operate. Amongst the myriad menus in the FT-817 is a setting for break-in delay, but the setting unfortunately only affects the time before returning to receive, not the transmit start time.

One alternative to a sequencer is to turn off the break-in feature and rely on manual switching. But how long will it be before you throw the switch with the key already closed, or start shouting before the mike button is depressed? Only a fool would say never!

For 3456 MHz, I wanted to integrate a Down East Microwave transverter with a surplus amplifier. Rather than tear apart a finished transverter to add the "fool-resistant" interface, I decided to make a small, simple, external sequencer which retains the fool-resistant functions: switch the relay before activating the transverter and amplifier, and make the switching as fail-safe as possible. One fail-safe feature is provided by RF sensing in addition to hard switching, so that even if the control cable fails (or is forgotten), the transverter will be switched safely. Since I prefer to run the control signal up the IF coax cable, I added this capability also.

Sequencer design

The schematic diagram of the sequencer, shown in Figure 1, is drawn to separate and label functional sections. At the top left is the IF input; the RF is passed through a small 4-dB attenuator to reduce the nominal 2.5 watt output of many portable transceivers to the 1-watt level needed by many of the packaged transverters. Down East Microwave Design Note 015 reports[8] that transverters occasionally suffer damage to the receive mixer when driven with an IF level > 1 watt, so this attenuator reduces the danger of damage. Even if the attenuator is not needed, RF sensing is still possible for IF power levels > 100 milliwatts by connecting the IF input to C2.


4 dB Attenuator
R1
22
22
C1
1000
R2
330
330
330
R3
10
IF
Transverter
RF detect
C2
2.2 pf
D2
1N5711
D1
1N5711
R4
47K
C3
1000
C4
22µF
R5
8.2K
Q1
MPSA13
Transceiver
NOTE: put diode across relay coil
GND end of Coax Relay
Q4
IRF510,IRFZ14
D6
1N4001
Relay
L1
1µH
C5
1000 pf
PTT Hi (+V to XMIT)
D
G
Q2
NMOS: BS170, VN2222
S
NOTE: pinout varies,
source is ground end
PTT Hi
C6
0.1
R6
100K
Timing
D5
1N4148
Transverter - GND to XMIT
Switch
Q3
2N3904
D4
5V Zener
R9
22K
C9
47µF
Q5
NMOS: BS170, VN2222
Transverter
Amplifier - GND to XMIT
AMP
Hi
Jumper (Select switching on IF cable)
Lo
PTT Lo (GND to XMIT)
D3
1N4148
PTT Lo
C7
0.1 uF
R8
4.7K
Q6
NMOS
BS170
VN2222
LED
D7
R10
10K
R11
1K
G
S
D
+12V
Switched
Q7
PMOS
IRF9Z34 (10 amps)
IRF9Z14 (5 amps)
NOTE: heatsink > 2 amps
D8
1N4001
to AMP
R7
4.7K
C8
0.1
Simple, but still "Fool-Resistant", Sequencer
W1GHZ 2002
C10
0.1
D9
1N4001
RED
PowerPole
J1
+12V
NOTE: put fuse in power cable
GND
Unswitched Power

There are three potential sources to activate the sequencer: *RF*, *PTT hi*, and *PTT lo*.

- The *RF* sensing circuit, between C2 and Q1, detects any transmit power from the IF transceiver and begins the switching sequence.
- *PTT hi* is the input for transceivers that supply a positive voltage on transmit.
- *PTT lo* is the input for transceivers that ground the control line on transmit.

Normally, only one of these is used in any installation, but both *PTT* variations are common. The jumper is used to select whichever polarity is expected on the IF cable. If the control signal is on the IF coax cable, it is separated from the RF path by C1 and L1. My preference is to run the control signal up the IF cable and have RF sensing as a fail-safe, so that the transverter is switched anytime the IF rig is transmitting. RF sensing also allows the use of a spare IF rig, even a handy-talkie, in the event of a failure.

Any of the three inputs will activate the switch transistor, Q3, which will immediately drive the relay driver, Q4. After a delay time set by R9 and C9 (roughly ¼ second with the values shown), the switches for the transverter and amplifier are activated. To return to receive, all inputs cease and Q3 switches back to the receive state, turning off all outputs; diode D5 removes the delay in this direction so all outputs switch off immediately. The immediate turnoff is another fail-safe – it resets the delay time if the PTT is "stuttered" – so the coax relay may chatter but no RF will be applied so it won't be damaged. The transmit delay may be increased or decreased by changing the value of C9 – the delay is proportional to the capacitance.

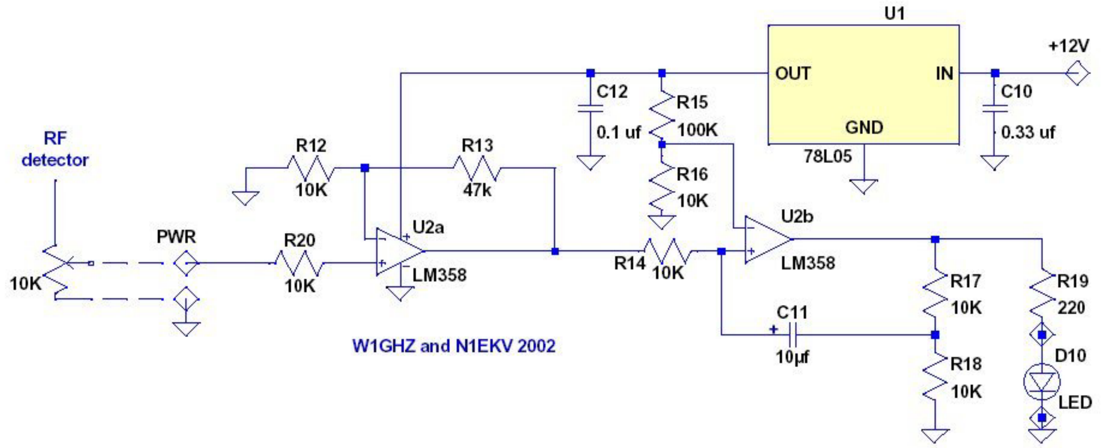
The three outputs are all FET switches to minimize size and power comsumption, so there are no relays to fail. The whole sequencer should only draw a few milliamps, mostly for the LED transmit indicator:

- The first output is the relay driver, Q4, an NMOS power FET which grounds the low end of the coax relay, with the other end connected to +12 or +28 volts, whatever is required (the negative end of a +28 volt power supply would be grounded). The FET is capable of driving a hefty relay, but don't forget to put a diode directly across the relay coil.
- The second output switches the transverter; a small power FET, Q5, pulls this output to ground. It is adequate to drive the small relays inside most transverters.

- The third output switches the power amplifier. Here we have two possibilities: the first, for amplifiers with a control input and internal switching, like those from DEMI, Q6 pulls the terminal marked "AMP – GND to XMIT" to ground to activate the amplifier. The second, for amplifiers without any switching like those from DL2AM[4], require that the 12 volt supply to the amplifier be switched (we don't want to leave the amplifier drawing power continuously). In this case, Q6 drives a PMOS power FET, Q7, which switches the voltage at the terminal marked "+12V SWITCHED" with little voltage drop. The schematic lists an inexpensive FET good for 5 amps or so, and a heftier one good for 10 amps or more. If the amplifier draws more than a couple of amps, a heat sink is needed on Q7.

Output Power LED - pulse stretcher

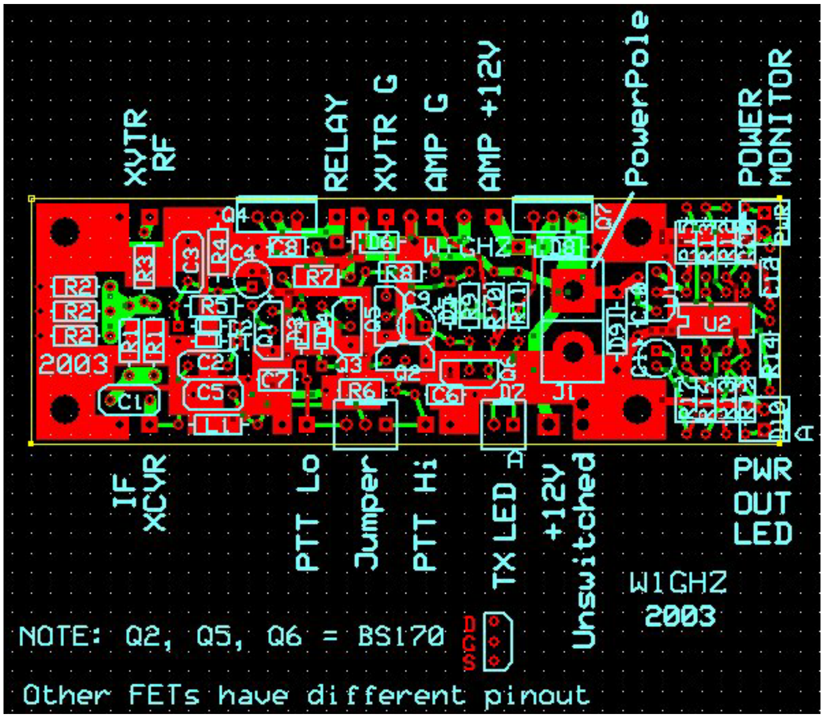
Figure 2



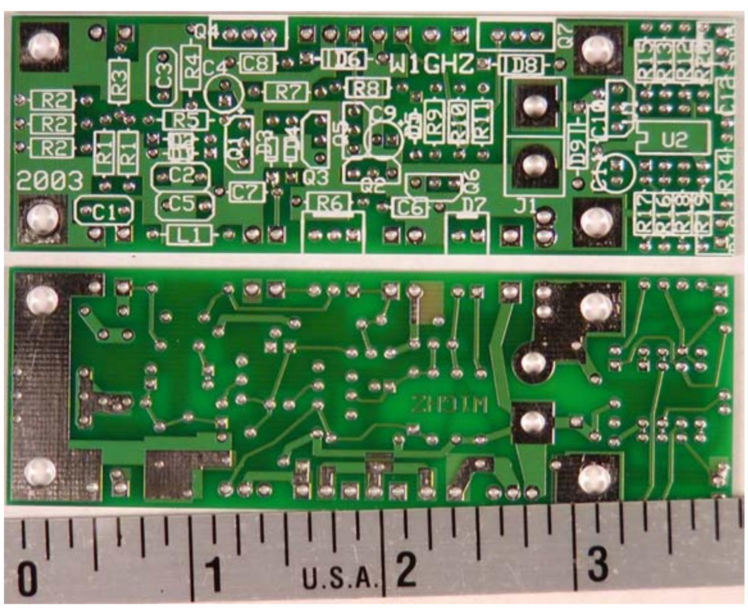
The schematic for the output power LED driver and pulse stretcher is shown in Figure 2. With the component values shown, the LED will stay on for a minimum of about ½ second, so even a dit won't be missed. An external pot may be adjusted to set the minimum power level needed to activate the LED. The additional components increase the board area slightly and add about $1 to the parts cost. If this option is not desired, the parts may be omitted, and this end of the board cut off is space is at a premium.

Construction

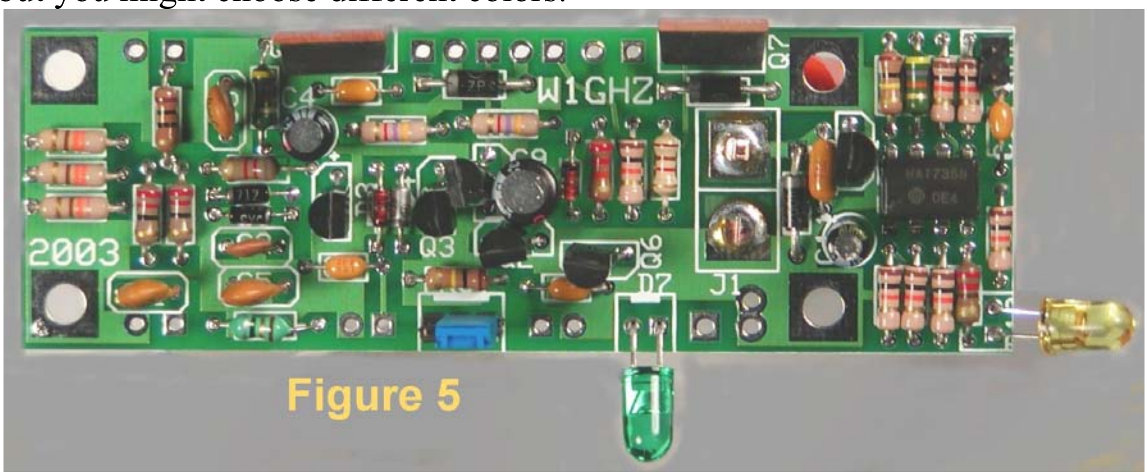
The circuit fits on a small printed circuit board. I included an Anderson PowerPole[5] connector for the power input in the layout, so that the sequencer can be mounted on the panel as the power connector for the complete rig. The final fail-safe is the idiot diode, D9, to protect against reversed polarity – it will blow the fuse, so make sure there is a fuse in the power lead! The layout and connection diagram for the board is shown in Figure 3.



Component locations are also marked pretty clearly by the silk-screen pattern on the top of the board, as shown in Figure 4, a photo of the bare board.



A photograph of a completed sequencer is shown in Figure 5. Construction is straightforward with common thru-hole components, and assembly goes pretty quickly. The LEDs are shown mounted on the board, but you'll probably want them mounted to the box for visibility, probably with an additional LED to show that the power is on. My station sort of evolved into using red for power, green for transmit, and yellow or blue for other things, but you might choose different colors.



Assembly order isn't critical. I usually start with the PowerPoles, then resistors in order (R1, R2, etc.), then capacitors, followed by diodes, then transistors and the remainder. Soldering and lead trimming is in groups so there aren't too many leads in the way. All the components are on the top side, so soldering is on the bottom except for the PowerPoles. The boards are soldermasked to help prevent solder bridges causing unwanted shorts.

I tried to use cheap, common components so I could use a sequencer in each transceiver without pain – if you buy everything from Digi-Key[7], total cost including the PC board should be under $20. None of the part values is critical, so you should be able to find some of them in the junk box. The parts list in Figure 6 includes Digi-Key part numbers, plus some alternative suggestions. *One caution: the BS170 FETs in the parts list have a different pinout than some of the alternate parts, so check carefully before installing alternates.*

Since the schematic is organized into functional sections, you may leave out the components for any unneeded functions. Figure 7 lists the parts that may be omitted for each function not used. Since the parts are cheap, I usually include them all, since it is easier to change a few connections than to modify the board later.

Inclusion of this simple, easy to build, sequencer in a transverter should help to make microwave operation more fool resistant, but never foolproof.

NOTES:

1. www.db6nt.com
2. P. Wade, N1BWT, "A Fool-Resistant Sequenced Controller and IF Switch for Microwave Transverters," *QEX*, May 1996, pp. 14-22.
3. www.downeastmicrowave.com
4. www.dl2am.de/
5. www.andersonpower.com; available from www.powerwerx.com
6. www.expresspcb.com
7. www.digikey.com
8. http://www.downeastmicrowave.com/PDF/Dn015.PDF

Simple, yet Fool-resistant, Sequencer

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Figure 6

REFDES	Value	DigiKey	Alternate	Note
C1	1000 pf	1383PH-ND		
C2	2.2 pf		gimmick	
C3	1000 pf	1383PH-ND		
C4	22 uf	P976		
C5	1000 pf	1383PH-ND		
C6	0.1 uf	399-1880-1-ND		
C7	0.1 uf	399-1880-1-ND		
C8	0.1 uf	399-1880-1-ND		
C9	47 uf	P983		
C10	0.1 uf	399-1880-1-ND		
D1	1N5711	Schottky	DEMI HP2800	
D2	1N5711	Schottky	DEMI HP2800	
D3	1N4148	1N4148FS-ND	1N914	
D4	5V Zener	1N751ATRCT-ND	1N5231	
D5	1N4148	1N4148FS-ND	1N914	
D6	1N4007	1N4007GICT-ND	1N4001-4006	
D7	LED	generic		
D8	1N4007	1N4007GICT-ND		
D9	1N4007	1N4007GICT-ND		
L1	1 uh	M7813-ND	RF choke	
Q1	MPSA13	MPSA13-ND		
Q2	BS170	BS170-ND	VN2222	
Q3	2N3904	2N3904-ND	NPN	
Q4	IRF510	IRF510-ND		
Q5	BS170	BS170-ND		
Q6	BS170	BS170-ND		
Q7	IRF9Z14	IRF9Z14-ND	IRF9Z34	
R1, R1a	22	22QBK-ND		
R2, R2a, R2b	330	330QBK-ND		
R3	10	10QBK-ND		
R4	47K	47KQBK-ND		
R5	8.2K	8.2KQBK-ND		
R6	100K	100KQBK-ND		
R7	4.7K	4.7KQBK-ND		
R8	4.7K	4.7KQBK-ND		
R9	22K	22KQBK-ND		
R10	10K	10KQBK-ND		
R11	1K	1KQBK-ND		
J1	PowerPole	www.powerwerx.com		
header posts	breakoff	WM6432-ND		

OUTPUT POWER LED OPTION

C10	0.33 uf	399-1883-1-ND
C11	10 uf	P966-ND
C12	0.1 uf	399-1880-1-ND
D10	LED	generic
R12	10K	10KQBK-ND
R13	47K	47KQBK-ND
R14	10K	10KQBK-ND
R15	100K	100KQBK-ND
R16	10K	10KQBK-ND
R17	10K	10KQBK-ND
R18	10K	10KQBK-ND
R19	220	220QBK-ND
R20	10K	10KQBK-ND
U1	78L05	LM78L05ACZFS-ND
U2	LM358	LM358ANNS-ND

Figure 7

Unused option	Omit parts
INPUTS	
PTT hi	C6,R6,Q2
PTT lo	C7,D3
RF sensing	C2,C3,C4,D1,D2,R4,R5,Q1
Switch thru IF coax	L1,C5,jumper
4 dB attenuator	R1,R2,R3
	or change values
PowerPole	J1
OUTPUTS	
Coax relay driver	Q4,D6
AMP - Gnd to xmit	
"+12V switched"	Q7,D8