A Multifunction Sequencer for VHF/UHF/Microwave Transverters

By Hamish Kellock, OH2GAQ

Most high-power VHF/UHF transverters and even not-so-high-power Microwave transverters require some kind of sequencing and/or protection and monitoring circuitry. In the past this has often been implemented with analog timers, or simple processor based timers and random logic. Often a fairly large number of smaller items have been assembled together to provide the complete needed functionality. In this article a unit is described in which most of the functionality needed to control, monitor and sequence a transverter and associated relays/waveguide switches and power amplifiers has been integrated into one unit. The same unit may be used with many different relay types for sequencing high powered VHF/UHF and SHF systems, possibly with some timing SW changes if the relays/switches involved need significantly over 80 milliseconds to switch. The unit also switches the PA supply voltage at up to in excess of 20A and 50V, dependent on the PCB tracks and FET heatsink.

The control scheme used at OH2GAQ divides the control functionality for a complete microwave station into two parts:

(a) The high-speed part which controls and monitors the “near antenna” sensitive and high-power parts (and generally expensive and hard-to-replace), and protects them quickly if needed (the sequencer covered here)

and

(b) The more slow and complex parts, normally located near the operator, such as the tuneable IF and other general functions, such as PTT or computer-generated PTT (in the authors case, this is contained in the Microwave Transverter Controller, which also provides the RF signal path and reference signal).

These two parts work together via a simple handshake mechanism to provide the complete station control. A critical item is the feedback from the “sequencer” to inform the “transceiver” that all is OK.

A brief description of the Sequencer functionality follows.

The inputs to the unit are:

1. PTT / Transmit command (from the tuneable IF, active low). This is the request to go into “transmit” mode or return to “receive” mode, to the sequencer.

2. The DC power (nominally +12V and +26V) used by the Sequencer itself, and supplied to the driven changeover relays/waveguide switches.

3. The DC power (+12V to +50V) which is switched to the high-power PA stage(s).

4. One analog signal which is passed through to the station/operator without monitoring. This is normally an analog voltage proportional to the power output from the transverter/PA.

5. Two analog signals representing either alarm condition(s) or just for monitoring purposes. These are normally the reflected power from the antenna, and a temperature monitor (e.g. from the PA).

6. A digital signal representing the status of any key functions in the transverter, for example the state of a PLL etc.

5. Two positional feedback signals (digital, usually contact closure) from antenna switching relays or waveguide switches.

The outputs from the unit are:

1. An (active low) signal to the tuneable IF to indicate the unit is in transmit mode, with no errors. The tuneable IF should use this to remove its output if it is not indicating a good status. See notes below regarding this signal and how it is used in a companion Microwave Transverter Controller which provides the tuneable IF functionality at OH2GAQ.

2. LED's to indicate power supply health, Transmit mode request, and the status of the analog alarm or monitoring inputs.

3. Switched DC power to the high-power stage(s). 10A maximum may be switched by the sequencer using the current PCB tracks and heatsinking of the switch FET.

4. A switched output suitable for a typical co-axial latching relay, although through SW change it can be used with a conventional ("failsafe") relay. Relays needing up to 26V at 0.5A may be driven from this output.

5. A switched output suitable for either a waveguide switch or high-power co-axial switch, assumed to have position feedback contacts. Relays needing up to 26V at 1.0A (if latching type) may be driven from this output. Functionality may be changed by SW to accommodate conventional ("failsafe") relays or switches. Due to the large number of different microwave relays and waveguide switches, provision is made to drive relays in which the "common" terminal is held at positive voltage and switching is accomplished by driving the other terminal(s) low, or the converse in which the "common" terminal is held at ground potential and the other terminals must be driven high. These conditions are often forced by the inbuilt protection diodes in some relays/waveguide switches.

6. An open-collector (nominally active low) output to switch any low-power parts of a transverter from the RX mode to the TX mode.

The diagrams below shows the Sequencer operation both in the normal condition of a change-over from RX to TX, and back again, and in the case of a fault situation. In these diagrams, the timing is in units of 20 ms (20 milliseconds), which is used in the authors 24 GHz station. All timing is under SW control, and can easily be modified.

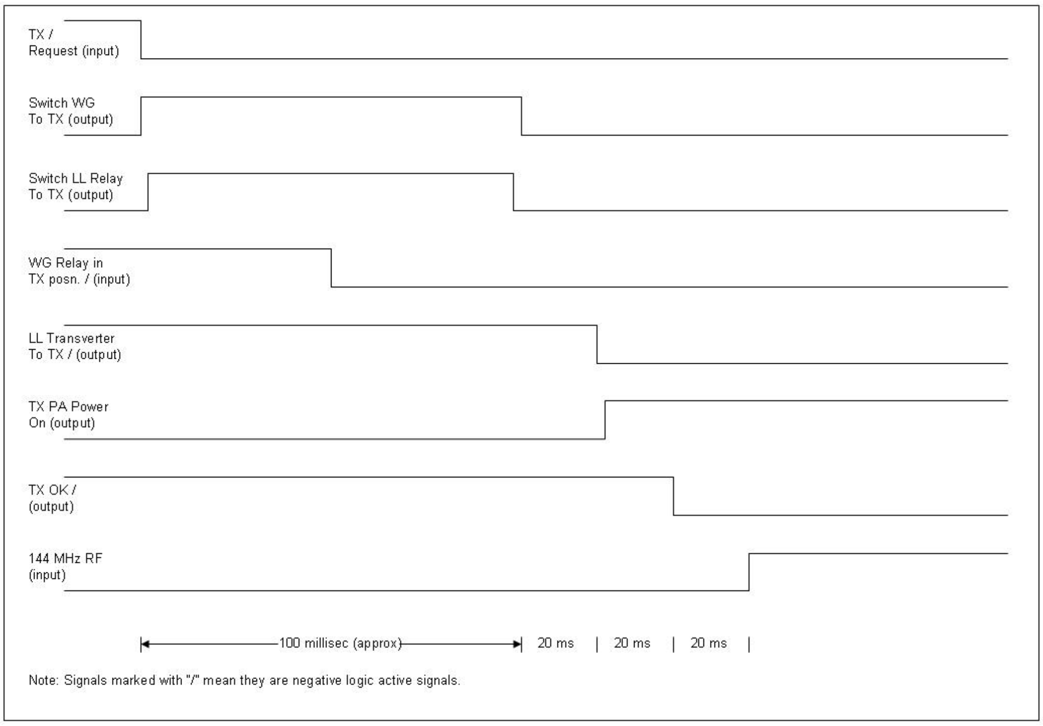

Figure 1. Sequencer operation in normal RX to TX changeover.

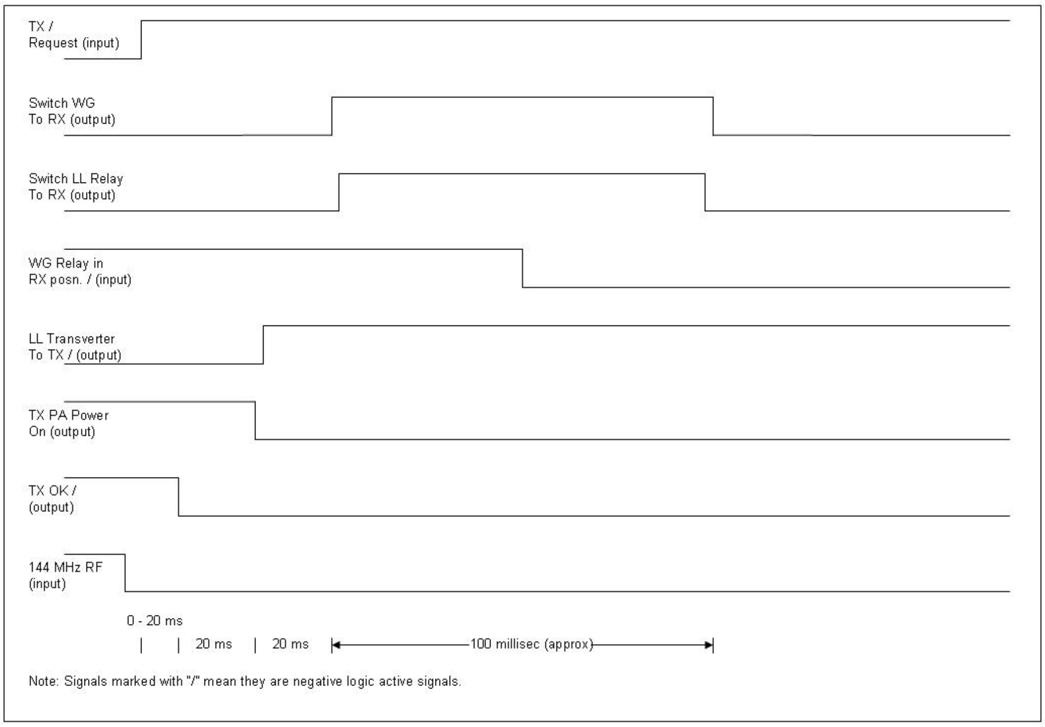

Figure 2. Sequencer operation in normal TX to RX changeover.

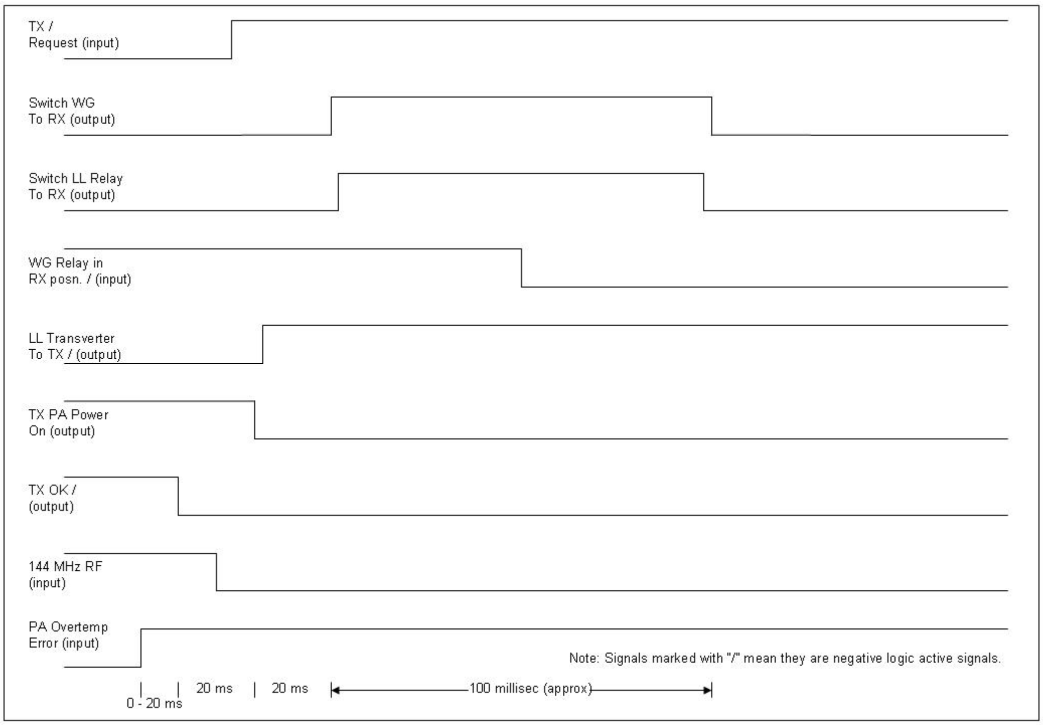

Figure 3. Sequencer operation in fault-initiated TX to RX changeover. In the example shown, the fault condition is a PA Overtemperature alarm, but it can be any of the alarm inputs.

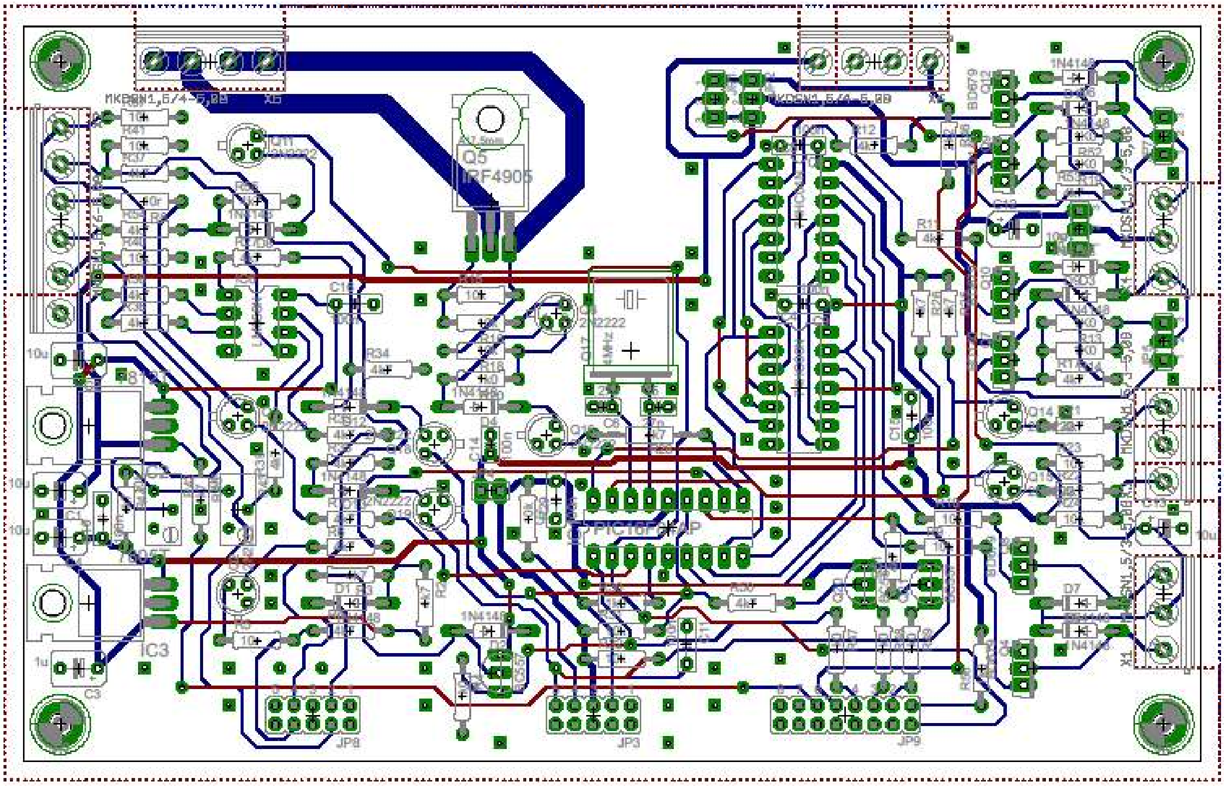

Figure 4. Topside view of the PCB layout showing components, tracks on both sides (blue on bottom of PCB), but without the groundplanes.

The unit is constructed on a 100mm by 160mm double-sided PCB. Although there are no particularly high-speed signals in the sequencer itself, as much as possible of the board is groundplane, in an attempt to lower its sensitivity to stray RF signals. All signals are brought to either screw terminal strips for wiring to the local transverter parts, or PCB mounted pin headers which allow for a standard personal computer 9-pin “D” connector and cable to allow cabling directly to the tuneable IF / Microwave Transverter Controller. The LED’s are connected through a second pin header strip, or can be mounted directly in place of the header.

The processor used is a Microchip PIC, type 16F84A, although any similar type with the same pinout could be used. A standard 4 MHz crystal is used with the PIC. A pin header (JP3) is provided to allow connection of an in-circuit programmer, and a separate pin header (JP4) allows disconnection of the power supply during programming. Components used are normal through-hole parts.

The interface circuitry is generally implemented by discrete transistors. The analog inputs are routed through to the “down-stream” tuneable IF (X7, 9 pin “D” connector), for use if needed. Two analog comparators with individually settable thresholds can be used to produce alarms. Typically these are used with high reflected power sensors or PA temperature sensor. A digital input is also provided to monitor the health of key parts of the transverter, in the case of the authors equipment a PLL lock indicator to indicate if the RF unit PLL is locked to the 10 MHz reference. The occurance of an alarm condition can be used to almost instantaneously remove the PA supply, and cause a switch-back to RX mode when the downstream IF indicates it has removed its output.

The power switch is implemented with a low on-resistance (0.02 ohm, 50A) P-channel FET (IRF4905). Depending on whether it has to switch 26V (or even up to 50V), or 12V, a resistor change may be needed on the PCB. See the schematic for notes. A larger heatsink may be needed if currents higher than 10A are to be switched, and extra wires to the Drain and Source should be added as the PCB traces, although quite thick, are limited. X5 provides connection to the PA power switch.

The drivers for the relays are implemented with nominal 4A darlington transistors (BD679) or 1.5A transistors (BD140) in the case of positive voltage drive, and protected with diodes from inductive kick-backs from the relay and/or waveguide switch(s). The transistors are not heat-sunk, as in the case of normal latching relay devices the current flow is for (normally) not more than 100 ms. If non-latching relays or switches are used, which have a heavy current consumption (greater than 0.5A), the transistor(s) should be heat-sunk. One “feature” of the relay drivers is that external logic to the PIC is added to ensure that only one coil of a typical two-coil latching relay can be active at once. This protects the relay from rapid cycling should a SW fault occur which would cause both coils to be driven active at once. Probably not really needed ! JP1 and JP2 allow connection of the relay drivers to either 26V or 12V supply, on an individual basis. JP5, JP6 and JP7 allow selection of either positive or negative pulse drive for the main transmit relay/waveguide switch.

The schematic is available as a separate .pdf file.

The SW for the sequencer is developed in PIC assembler, and uses only a small portion of the total code and RAM space of the 16F84. The SW design is based on simple timed loops, with all monitoring occurring in either the main RX or TX loops. There are no interrupts used. The basic clock tick is about 2 ms, but normal operation uses 20 ms loops, so there is plenty of spare time if it is needed to speed up parts of the code in future. All checking for alarm conditions is done every 20 ms, so the longest delay from occurance of an alarm condition until removal of power from the PA is about 40 ms, of which 20 ms is allowed for the IF / Microwave Transverter Controller to remove the 144 MHz driving power and the PTT request.

The SW is developed with Microchips free MPLAB IDE, and the PIC is programmed by using WinPic programming SW with a home-built programmer based on SM6LKM’s PIP84 interface.

The PCB layout, component placement and parts lists for the sequencer and the SW source code and hex file executeable are available on request from the author.

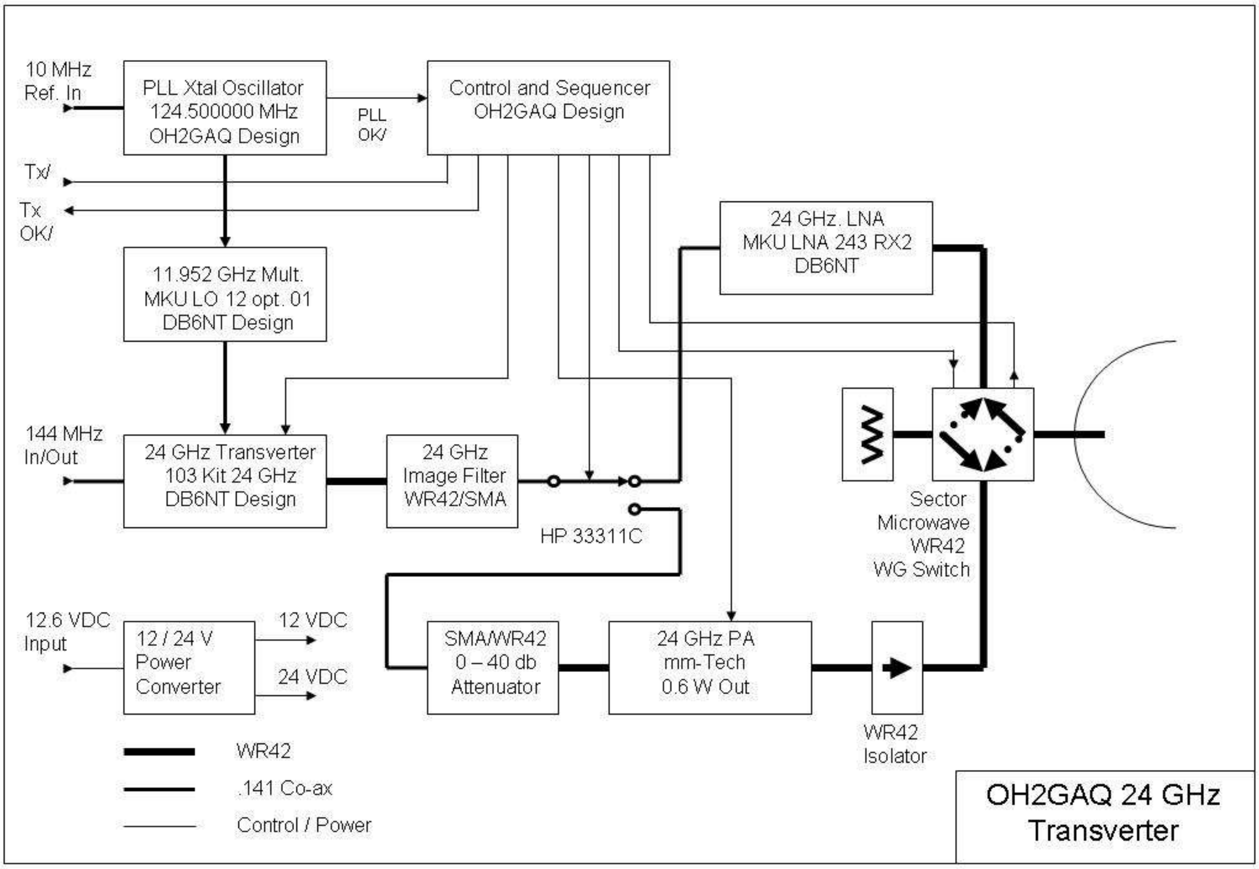

Figure 5. Block diagram of a complete 24 GHz transverter, showing how the various signal are connected to the sequencer.

References:

1. Jim Klitzing, W6PQL, “Amplifier Control Board”, available from W6PQL website http://www.w6pql.com

2. Jim Klitzing, W6PQL, “LNA Sequencing and Protection”, available from W6PQL website http://www.w6pql.com

3. Many ARRL & RSGB publications, and also other ham websites too numerous to mention.

4. Microchip “PIC 16F84A” Data Sheet, available from Microchip website.

5. Microchip “MPLAB IDE v8.10 (and later)”, available from Microchip website.

6. Wolfgang Buescher, DL4YHF, “WinPIC, PIC programmer for Windows”, available from DL4YHY website http://www.qsl.net/dl4yhf/

7. Johan Bodin, SM6LKM, “PIP84, Do-it-yourself Flash PIC programmer”, schematics available from SM6LKM website http://home.swipnet.se/~w-41522/pic/pic.html