

PPN 15616 Transceiver Module – Theory of Operation

The LCU transceiver module (PPN 15616) utilizes three PCB assemblies. The three PCB assemblies are referred to as: Synthesizer PCB assembly (PPN 11434), Power Amplifier PCB assembly (PPN 11407) and the Receiver PCB assembly (PPN 11650). Each of the three PCB assembly's theory of operation will be described below.

Synthesizer PCB assembly (PPN 11434)

- 1) U6 is a linear, low-dropout voltage regulator with an output voltage of +5.0 Vdc. This voltage is used by much of the subsequent circuitry on the Synthesizer PCB assembly.
- 2) U1 is an op-amp configured as a comparator. U1 is used by the microprocessor (U2) to determine whether the radio should be set for either 2 or 8 Watt mode. If Vcontrol is 7 Vdc then Pout = 2 W and if Vcontrol is 12 Vdc then Pout = 8 W. The DAC A output (RF POWER CONTROL) is programmed properly by the microprocessor (U2) using the Vcontrol information. The RF POWER CONTROL voltage is routed to the interface connector (J1-12) and is used on the Transmitter PCB assembly to control RF output power.
- 3) U2 is a microprocessor used to program the DAC (U3) and the synthesizer IC (U8). U2 is also used to calibrate the VCO coarse tuning and to determine whether the synthesizer has locked or not.
- 4) U3 is a quad, 8 bit DAC used to coarse tune the VCO, set the deviation level, fine tune the TCXO (U9) and set the RF power level. The maximum output voltage from the DAC is +4.0 Vdc.
- 5) U4 is a unity gain op-amp stage which supplies +2.0 Vdc to the DAC D reference input by making use of the voltage divider created by R18 and R55. Additionally, U4 attenuates the modulating input signal (TX audio) by 66%. The output signal level from U4 is 2.2Vpp with a 3.3Vpp input signal level.
- 6) U5 is an op-amp configured as a summing amplifier. The output voltage of U5 varies from +1.0 Vdc to +7.5 Vdc as the VCO coarse tune voltage varies from 0 Vdc to +4 Vdc. This voltage is used to coarse tune the VCO. R24 and C11 are used to LPF the coarse tune voltage to improve synthesizer noise and spurious performance.
- 7) U7 is an op-amp configured as a comparator. The fine tune voltage from the synthesizer loop filter is one input to U7. The other input is from U3 DAC A. The fine tune voltage can be determined by the microprocessor by varying the DAC A output voltage and sensing when the output from U7 switches state. This circuitry is used to calibrate the VCO coarse tuning.
- 8) U8 is the synthesizer IC. Together with the VCO, loop filter and reference oscillator (U9) it generates the TX output frequency of 452.9375 MHz. The value of R50 was chosen to optimize the fractional-N reference spurious signals.
- 9) U9 is a 12.8 MHz, temperature compensated crystal oscillator designed to operate from -30°C to +60°C with ± 2.5 ppm accuracy. U9 determines the frequency accuracy of the transmitter. U9 is fine tuned during test using the DAC C output.
- 10) Q1 is a PNP transistor switch used to enable or disable the VCO circuitry.
- 11) Q2 is an RF buffer for the VCO circuit. This buffer amplifier improves the load pull performance of the VCO.
- 12) Q3 is the active device for the VCO circuit. The VCO is a Colpitts type design. Z1 is a high Q resonator for the VCO circuit. The superior VCO phase noise performance is largely due to Z1.
- 13) Q4 is used to filter noise from the +5 Vdc supply. This also improves phase noise performance of the synthesizer.
- 14) CR1 and CR4 are dual varactor diodes used to coarse tune the VCO. The output voltage from U5 provides the reverse bias for CR1 and CR4.
- 15) CR2 is a varactor diode used to FM modulate the VCO. The attenuated modulating signal from U3 DAC D together with low pass filtered +5 Vdc provides the reverse bias for CR2.
- 16) CR3 is a varactor diode used to fine-tune the VCO. The synthesizer IC (U8) charge pump current outputs (PHP and PHI) are converted to a voltage and low pass filtered by the loop filter. The loop

outputs (PHP and PHI) are converted to a voltage and low pass filtered by the loop filter. The loop filter components are: R43, C42, C44, R42 and C18. The output from the loop filter provides a reverse bias for the varactor diode via L4.

- 17) CR5 is a dual "speed-up" diode used to quickly charge or discharge the coarse tune filter capacitor (C11). This design approach allows the synthesizer to lock quickly.
- 18) FL1 is an RF low pass filter that attenuates spurious harmonics from the VCO. Without this filter the synthesizer IC (U8), may attempt to lock to a harmonic of the VCO rather than the desired fundamental.

Transmitter PCB assembly (PPN 11407)

- 1) U1 is a linear, low-dropout voltage regulator with an output voltage of +8.0 Vdc. This voltage is used by much of the subsequent circuitry on the Transmitter PCB assembly.
- 2) Q3 and Q5 form a transistor switch for the +8 Vdc regulator output.
- 3) Q4 is the first stage in the transmitter amplifier chain. It has a power gain of 15 dB and the output power is typically +12 dBm.
- 4) Q6 provides an active bias for Q4.
- 5) Q8 provides temperature compensation for the active bias provided by Q6.
- 6) CR2 is a PIN diode used as an attenuator after the Q4 amplifier. It is used in conjunction with U2 to provide RF power control.
- 7) Q7 is a driver amplifier with 12 dB power gain with a typical output of +24dBm.
- 8) Q9 provides an active bias for Q7.
- 9) Q10 provides temperature compensation for the active bias provided by Q9.
- 10) Q1 is an RF power transistor with 9 dB of power gain and a typical output of +33 dBm.
- 11) Q2 is the final RF power transistor stage with 8 dB power gain and a typical output of +41 dBm.
- 12) C31, L10, C29, and C30 form a low pass filter to attenuate harmonics of the Q2 power amplifier.
- 13) Z3 is a 20 dB directional coupler that is used in the power control circuitry.
- 14) C34, L11, C32, and C33 form a second low pass filter to attenuate harmonics of the Q2 power amplifier.
- 15) CR31 forms a PIN diode switch used to switch the output of Q2 to the antenna during transmit.
- 16) CR3 is a Schottky diode used to rectify the coupled RF signal for the power control circuitry.
- 17) CR4 is a Schottky diode used to provide temperature compensation for the RF power control circuitry.
- 18) U2 is an op-amp configured as an integrator. It uses the rectified RF signal as its input and its output controls a PIN diode attenuator to regulate and control the RF power output.

Receiver PCB assembly (PPN 11650)

- 1) The receiver is a dual conversion single frequency crystal controlled design and operates at 457.9375 MHz. Y1 is a third overtone series operated crystal at 54.567188 MHz and determines the receive frequency by the following formula: $\text{Receive Freq} = (\text{Fxtal} * 8) + 21.4$
- 2) Q4 is an oscillator/doubler that functions as the 1st LO. Its output at 109.134375 MHz drives Q5.
- 3) Q5 is a frequency doubler whose output at 218.26875 MHz drives Q6.
- 4) Q6 is a frequency doubler whose output is at 436.5375 MHz.
- 5) Helical bandpass filter U3 attenuates harmonics and subharmonics of the 1st mixer injection voltage generated by the previous stages.
- 6) RF from the antenna is fed to helical bandpass filter U1 which attenuates image and other unwanted mixer responses.
- 7) RF amplifier Q1 amplifies the received signal.
- 8) Helical bandpass filter U2 provides additional attenuation of unwanted mixer responses.
- 9) 1st mixer Q2 generates the difference frequency between the received signal at 457.9375 MHz and the 1st LO frequency of 436.5375 MHz at the 1st IF of 21.4 MHz.
- 10) Four pole crystal filter FL1 attenuates the 1st mixer sum and other unwanted response frequencies.
- 11) Q3 functions as a 21.4 MHz 1st IF amplifier.