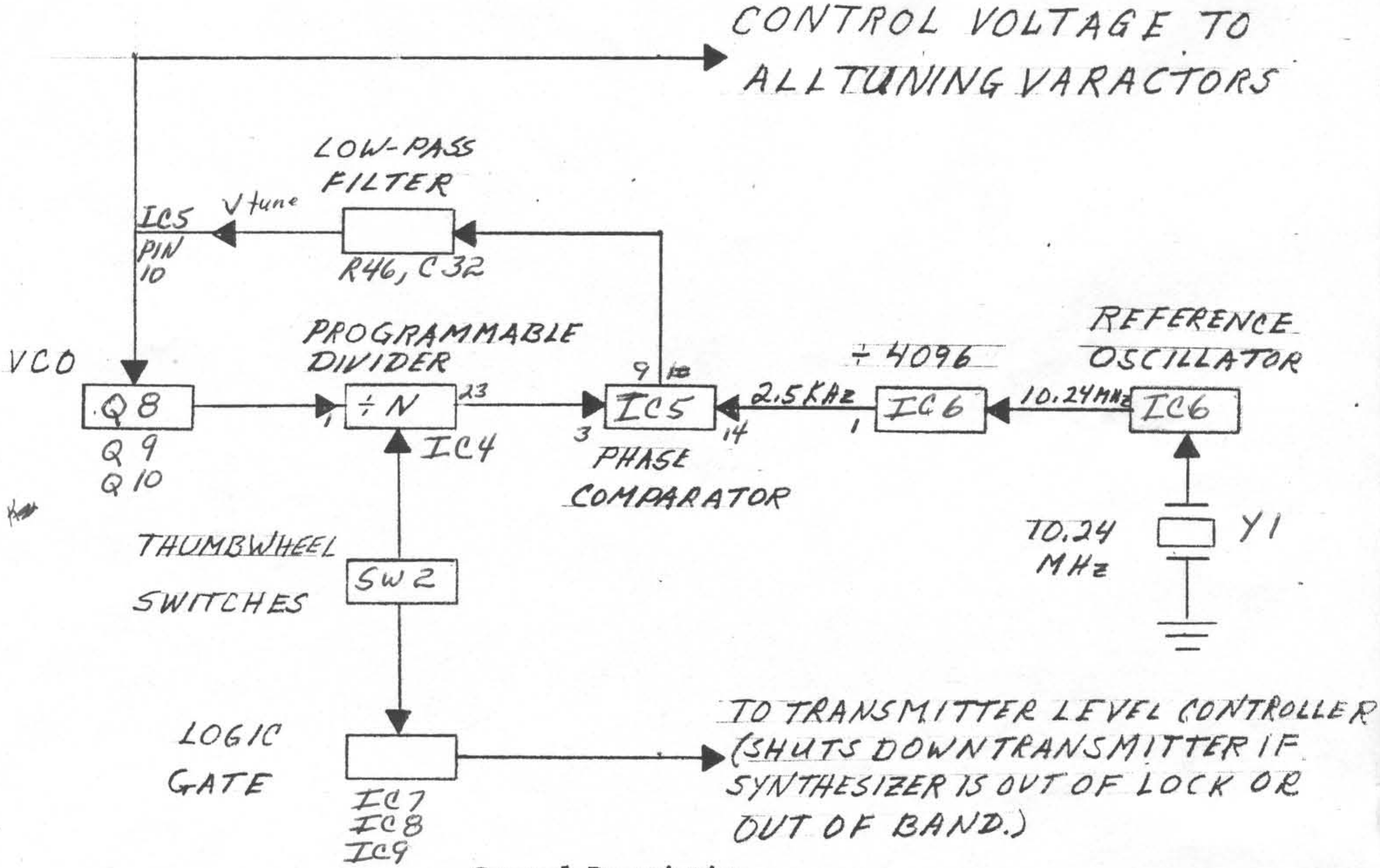
10.8

Section A   Synthesizer - TPX 720



General Description

The output of a stable reference oscillator, and the output of a voltage-controlled-self-excited oscillator, are fed to a phase comparator. A DC error voltage is derived, from the phase comparison, that is fed back as a control voltage to the VCO in a manner that will cause the two frequencies to synchronize. The error voltage is also used as a tuning control voltage for the varactor diodes in the receiver and exciter.

The code set by the front panel digital switches is fed through a logic circuit that removes a transmit inhibit voltage only if the code programs a legal transmit frequency. All other codes will prevent transmitter operation.

Transmitter shutdown occurs, also, if the reference frequency and the VCO frequency are out of lock.

The VCO, when in lock, produces the selected channel transmit frequency when the transmit switch is operated. It switches to the correct receiver local oscillator frequency to enable the receiver on the same channel when the switch is released.

Detailed Description

IC6 functions as a crystal-controlled oscillator and a frequency divider. Crystal, Y1, is a 10.24 Mhz quartz crystal. Capacitors C33, C34 and C3 are used to provide the phase shift required to get the circuit oscillating. R52 provides a D.C. path across the crystal. The 10.24 Mhz oscillator frequency is divided by 4096 inside of IC6 and the resultant frequency of 2.5 Khz appears at pin 1.

Pins 14 and 3 of IC5 are the inputs to the phase comparator. Pin 1 of IC6 connects directly to pin 14 of IC5. This is the reference frequency input (2.5 Khz).

Transmitting frequency is generated by Q8. This is a series-tuned Colpitts-type oscillator. Capacitors, C50 and C51, form the feedback divider. Current through resistor R64 creates a voltage drop that is in phase with the voltage at the base. This reinforces the signal at the base of Q8 to sustain oscillations. Inductor L6 tunes the oscillator, along with CR19, to the desired frequency. L6, CR19, C50, C51, C52 and the input capacitance of Q8 form a resonant circuit that determines the operating frequency of the oscillator. R138 loads L6 to reduce its Q (figure of merit) to provide more stable oscillations. R62, R63 form a voltage divider across the DC supply. The junction voltage is the base bias for Q8. R66 is the load resistor for the collector of Q8. The output signal is developed across R66. C49 and R65 form a filter to decouple the oscillator from the power supply. DC control voltage is fed to the varactor, CR19, through R61. The control voltage is filtered by C48. Changing the DC voltage applied to the varactor causes it to change capacitance. Because the varactor is in the resonant circuit, any change in capacitance will charge the oscillator output frequency.

The oscillator is tuned to the transmit frequency or to the receiver local oscillator frequency, whichever mode is selected. The receiver local oscillator is 10.7 Mhz above the transmit frequency. Output of the oscillator is fed to the exciter through C53; and, also, to a buffer amplifier, Q9. C53 and C117 form a capacitive divider to match the oscillator output impedance to the input impedance of the first exciter transistor. The exciter amplifier will be described in another section.

The oscillator output is fed to Q9 through coupling capacitor C54. R67 and R68 form a voltage divider across the power supply to establish the base voltage for Q9. R70 is the collector load resistor across which the output signal is developed. C10, in conjunction with R70, forms a low-pass filter to reduce spurious frequencies. R69 is the emitter resistor, which establishes the operating bias, along with R67 and R68. C55 decouples the emitter for RF.

Output from Q9 is coupled through C27 to the base of Q10. The output from the side-step oscillator, Q7, is also coupled to the base of Q10. Q10 is a mixer circuit.

The resistors R71 and R72 set the operating point of Q10. R72 is also the collector load for Q10. C58 and L9 form a low-pass L-section filter to reduce higher spurious frequencies. The difference between the VCO frequency and the side-step oscillator frequency is fed to the programmable frequency divide, IC4-pin 1.

The side-step oscillator is a series-tuned Colpitts crystal oscillator. The 10 Mhz crystal is used for transmit frequency synthesis and the 11.07 Mhz crystal is used for receiver local oscillator frequency synthesis. Both crystals are connected to the base of Q7. Q5 is a switching transistor connected to Y3, the transmit crystal. It is biased into saturation when the PTT switch is pressed. This provides a ground return for the crystal through Q5 and effectively connects the crystal into the Q7 base circuit. Q6 is non-conducting while Q5 is saturated because its base is connected to the receiver power line, which is at zero potential during transmit. When the PTT switch is released, the transmit power source drops to zero potential causing Q5 to switch off and disconnect the crystal circuit. At the same time the receiver power source goes to operating potential, which causes Q6 to saturate and connect Y2 to ground. Y2 now generates the receiver local oscillator side-step frequency.

C40 and C41, in parallel, form the series tuning capacitor for crystal Y3. C41 permits slight adjustment of the oscillator frequency for proper alignment of the transmitter. C42 and C43 perform the same function for Y4. C43 permits slight adjustment of receiver tuning. Resistor R59 is the feedback and output load resistor for the oscillator. C44 and C45 form the phase shift network to provide in-phase feedback to the base of Q7. R60 and C46 decouple the collector for RF. R57 and R58 establish the base operating voltage for Q7.

The output signal from Q10 is fed through the low-pass filter L9, C58, and the coupling capacitor, C59 to pin 1 of IC4. IC4 is a divider in which the divisor can be digitally programmed. It is a count-down type and divisor N can be programmed from 3 to 15,999. For this transceiver N ranges from 720 at 118 Mhz to 1440 at 136 Mhz. The divisor increases by one for each channel increment above 118 Mhz. For the navigation band (108-117) the divisor is 320 to 680 in steps of 2. The synthesizer actually ranges from 320 to 719 in steps of 1. The extra channels are not used. So, in summary, the divisor ranges from 320 to 1440 to cover the communications band and the navigation band.

The frequency derived from the division process appears at pin 23 of IC4 and is connected to the input of IC5 on pin 3. IC5 is a phase and frequency comparator. The signal from the divider is compared with the 2.5 Khz reference frequency from IC6, the reference oscillator. An error voltage is derived from the comparator. This voltage is a DC voltage of such a polarity that it can shift the voltage-controlled oscillator frequency in a direction to maintain a constant frequency. This error voltage appears at pin 10 of IC5. The error voltage is fed to CR19 of the voltage controlled oscillator through resistors R48, R50 and R61. The voltage is filtered by C48. R49 is a DC return for C36 and pin 10 of IC5. R51 couples the error voltage to the receiver and excited tuning varactors. C36 decouples the tuning line and controls the rate of change of tuning when channels are switched.

C32, C37, R46 and R47 form a low-pass filter to smooth the pulses out of the comparator signal before passing it back into the internal source-follower. The voltage out of the source-follower is the error signal appearing at pin 10.

Another signal, which indicates if the voltage controlled oscillator is locked to the reference frequency, appears at pin 1 of IC5. This signal is at a logic "high" when the oscillator is locked and at a logic "low" when the system is <u>not</u> in lock. This signal is applied to pin 11 of IC7. IC7 uses it to inhibit the transmitter if the system is not locked.

The programmable divider is set with the digital switches to divide by any integer between zero and 1597. We are interested only in the range of 320 to 1440. Unwanted divisors are avoided by modifying the switch. Those that cannot be eliminated by switch modifications are sensed by IC7, IC8 and IC9. The digital levels of the switch sections are tested with a logic gating network which produces a transmitter inhibit signal for unwanted divisors. Receiver frequencies are permitted within the capabilities of the modified switches.

The divider, IC4, is permanently programmed to divide by 4 in the first counting section. This is done by the way that pins 11, 13, and 14 are strapped. To divide by 4, pin 14 is tied to ground and pins 11 and 13 are tied to the +12 volt supply. Pins 5 and 6 are grounded. This prohibits divisors above 999. Pins 7 and 8 are also grounded. Divisors greater than 399 are forbidden due to these connections.

Our original divisor "N," for each channel (such as 720 for 118.000 Mhz or 721 for 118.025 Mhz) is divided by 4 by the connections of pins 11, 13 and 14. The number, $^N/_4$, is used to program the remainder of the IC4 programming inputs. As an example 721/4 becomes 180 with a remainder of 1. The most significant number, 1, is programmed into the "hundreds" counter, pin 9 and 10. The binary code for 1 is 0001. The first two zeros are permanently programmed to pins 7 and 8. The third zero is programmed on pin 9. The 1 is programmed on pin 10. This, in effect, correspondes to the number "1" on the second wheel of the thumbwheel switch. This is the second most significant number of the channel operating frequency.

The next significant number of our divisor (180 + remainder 1) is the 8. The binary code for the 8 is 1000. This is programmed into the "tens" counter, pins 15, 16, 17, and 18. The 1 is programmed to pin 15 and the zeros to pins 16, 17 and 18. This will correspond to the number "8" on the third wheel of the switch. It is the third most significant number of the channel operating frequency.

The third number of our divisor, the zero, has a binary code of 0000. It is programmed into the "units" counter on pins 19, 20, 21, 22. This will correspond with the zero on the 4th wheel of the switch, and is the 4th most significant number of the channel operating frequency.

We now come to the remainder of 1 from our division of 4 into 721. The binary code for 1 is 0001. The first two zeros are permanently programmed to pins 5 and 6. They are tied to ground. The third zero is programmed to pin 4. The 1 is programmed to pin 3. This will correspond to the 2 on the thumbwheel switch and sets the last 2 numbers of the channel frequency. The 5 is implied in the readout and is present in the actual frequency.

The divider is now programmed to synthesize an operating frequency of 118.025 Mhz. The same procedure will program other frequencies if correct binary codes are applied to the inputs.

Pins 9, 10, 15, 16, and 17 of IC4 are connected to various pins of IC7, IC8 and IC9. Pin 1 of IC5 is connected to pin 11 of IC7. The voltage at pin 11 is high when the phase-locked loop is locked and low when it is unlocked. Regardless of the inputs from pins 9, 10, 15, 16 and 17 of IC4, the transmitter will be inhibited if pin 11 goes low. The voltage from P11 is inverted and the output of the inverter is connected to the ALC line to the transmitter. A low on pin 11 will produce a high on pin 10 of IC7. Pin 10 connects to the ALC line through steering diode CR33. CR33 and CR9 form an "or" gate to the ALC line. A high on the ALC line causes CR26 to shunt T15 and kills transmitter output.

IC7 consists of 6 inverters in a single package. The one having pin 8 as its output functions as a gate to inhibit out-of-band transmit frequencies. The one with pin 10 as its output functions as a gate to kill the transmitter when the phase-locked loop is out of lock. All of the remaining inverters function as elements of the logic system that determines if combinations of logic levels present at IC4 pins 9, 10, 15, 16 and 17 should permit transmission or inhibit it.

Diodes CR14 and CR15 form a 2-input "or" gate for part of the logic system. Diodes CR16, CR17, and CR18 form a 3-input "or" gate as another part of the system.

A truth table and schematic for the control logic is attached to this description

TITLE: TPX 720 - Detailed Circuit description.

SECTION B: Receiver section from antenna input.

The signal picked up by the antenna is coupled through the filter network L4, L5, C107, C108, and C109 and through C110 to the receiver. Diodes CR1, CR34 act to limit input signals from the unit's own transmitter, or nearby transmitters, and from atmospheric or static discharges. The signal is limited to the forward voltage drop of CR1 and CR34. The signal then passes to C1, which isolates CR1, CR34 from the receiver tuned circuits and couples the signal to T1, CR2, T2, CR3, C2. CR31 provides additional large signal protection across the receiver input. Varactor diodes CR2, CR3, CR4, and CR5 tune the receiver to the incoming signal. These are special diodes that change capacitance in a predictable way when a DC Control voltage is applied to them. Control voltage is obtained from the synthesizer and has been discussed in the synthesizer description.

From the secondary of T2 the signal is applied to the base of Q1. Q1 amplifies the signal. Operating bias for the base of Q is derived from the voltage drop across R3 added to the automatic gain control (AGC) voltage. A strong signal makes the base quite positive. The bias is less positive for weak signals. High AGC voltage reduces Q1 amplification.

Decoupling of the AGC voltage is done with R4 and C3. Decoupling of the tuning control voltage is done with R146, C4, C5, R1 and R2. C4 bypasses lower frequencies and C5 takes care of the higher frequencies. The 12 volt supply line is decoupled with R5 and C6.

The signal at the collector of Q1 is passed through the tuning network T3, CR4, CR5, T4, C7 and C8 to the base of the first mixer, Q2. AGC is not applied to the transistor. Tuning control voltage is applied to CR4 and CR5 through decoupling resistors R6 and R7. The supply voltage to Q2 is decoupled with R10 and C11. R8 and R9 establish the fixed operating bias for Q2. C9 is the decoupling capacitor for the bias voltage derived from divider R8 and R9. Q2 is biased near cutoff to insure good mixing. Local oscillator signal obtained from the base of the exciter output stage, Q21, is injucted to the base of Q2 through R144 and C126 in series.

The signal appearing at the collector will consist of 4 frequencies. They will be the local oscillator frequency, the incoming signal frequency, the sum of these two and the difference between them. T5 is tuned to the difference frequency. The other three frequencies are rejected. The output from T5 is the first intermediate frequency of 10.7 MHz. T5 is coupled to a 10.7 MHz ceramic filter by C128. The ceramic filter FL1 is mechanically resonant at 10.7 MHz and rejects all other frequencies. T5 serves also as an impedance step-up to match the high input impedance of the filter to the lower output impedance of the mixer collector. FL1 shapes the passband to a narrow band centered around 10.7 MHz with very steep drop off in response above and below 10.7 MHz.

The signal passes from FL1 to T6 which is tuned to 10.7 MHz. T6 serves to match the high output impedance of FL1 to the low input impedance of the second mixer residing within IC1. There is, within IC1, all the necessary circuitry for an oscillator, without the frequency- determining components.

These are connected externally to pins brought out for this purpose. Our receiver has a quartz crystal, Y4, and phase shift capacitors C14 and C15 connected to oscillator circuit pins 4 and 6 of IC1. The crystal frequency, 11.155 MHz, is mixed, inside of IC1, with the 10.7 MHz first intermediate frequency. This produces a 455 KHz second intermediate frequency. The 455 KHz signal is amplified within IC1. An amplified version is brought out on pin 15, passed through a 455 KHz ceramic filter FL2 and returned to IC1 on pin 12. The narrow, sharp signal is amplified further and leaves IC1 on pin 7. Unamplified AGC is fed to the mixer on pin 3 and the IF amplifier on pin 9. C19 is an AGC smoothing filter and R14 and C16 decouple the AGC to the second IF amplifier. R14 and C16 also set a time constant for this AGC voltage. R12, C17, C18, C12, and C3 are decoupling components for various parts of the circuit inside IC1.

T7 is tuned to 455 KHz and serves to peak the signal at CR7 as well as to discriminate against other frequencies that might be present at pin 7 of IC1. The signal is fed to detector diode CR7 which rectifies the signal, filters off the remaining 455 KHz signal by bypassing it with C123, and passes the audio portion on to the automatic noise limiter at the junction of CR7, R26 and R27. This junction also feeds the AGC routing diode which steers the AGC voltage to IC1 and the AGC/squelch amplifier IC3.

IC3 is a dual operational amplifier. Pins 2 and 3 are the inputs and pin 1 the output of the "A" section. Pins 5 and 6 are the inputs and pin 7 is the output of the "B" section. The "B" section is used to amplify the AGC to Q1. The "A" section provides the signal to override the squelch bias.

AGC signal from CR6 is fed to the non-inverting input, pin 5, of section "B". The inverting input is tied to a fixed positive voltage. Gain is set to 20 by resistors R19, R21. Resistors R17, R18 establish the offset voltage for the inverting input. AGC is amplified without inversion and fed to the base of Q1.

The second IF signal is detected and converted to audio by CR7. The audio is developed across the detector load resistor, R20. C123 is used to by-pass any residual IF frequency. Audio present at the cathode of CR7, is fed to a series automatic noise limiter circuit (ANL). Diode CR8 is normally forward biased by R128, R25, R26, R142. Audio readily passes through it to C22. Large repetetive noise pulse signals cause the charge on C22 to build faster than C22 can discharge through the long time constant filter C21, R27, R28, R142. The charge on C22 back biases CR8 thus causing it to block during the noise.

C1 couples audio to amplifier Q3. Q3 is biased in the linear range by means of R29, R30. C23 provides negative feedback for unwanted high frequencies. Desired audio response range is 300-4000 Hz.

The audio derived from the collector of Q3 is coupled to the volume control by means of C24. The moveable tap of the volume control is coupled to the input, pin 2, of IC2 by means of capacitor C25. C26 shunts the higher frequencies to ground to limit audio frequencies to the voice communications range

~~[illegible]~~ Second conversions

Pin 2 is the inverting input of IC2. Pin 3, the non-inverting input, is pinned to audio ground by means of C27. Power is fed to pin 6 through R128. R128 serves to provide a voltage for forward-biasing the ANL diode. This voltage is decoupled with C31. Audio output to speaker and head phones comes from pin 5 through coupling capacitor C30. Capcitor C29 is used to reduce high frequency response.

Squelch is applied to turn the audio output stage off if no signal is present. This is done by using Q4 to shunt the audio in IC3 to ground before it can reach the output pin. Resistors R16, R15, and R145 form a voltage divider across the 12V power supply. Squelch bias is derived from the drop across potentiometer R15. The range is approximately 0 to +1 volt. If the arm of the potentiometer is adjusted near ground, Q4 will be non-conducting and full audio will appear at pin 5 of IC2. If the arm is near +1 volt the transistor will be in full conduction and the audio routed from pin 1 to ground through Q4. Normal setting is somewhere between these points. CHeck exact

AGC voltage from CR6 is fed to section "A" of IC3. It is fed to pin 2, the inverting input of section "A". The non-inverting input is tied to the squelch potentiometer arm. Resistors R22, R23 set the amplifier gain to approximately 10,000. At this gain setting, the amplifier will switch from full positive output to full negative output when the AGC voltage exceeds the voltage at the squelch potentiometer arm. This negative voltage will appear at pin 1 of IC3 and at the base of Q4, where it will drive Q4 to cutoff and allow full audio output. C127 provides some hysteresis for the squelch to prevent a click in the audio when it switches in and out.

The receiver is muted during transmit by removing the 12 Volt supply voltage from it. Q15 is used to turn the supply on and off. Q15 is biased in full conduction by R99 and R98 which establish a base voltage high enough to drive Q15 into full conduction and routing the supply voltage from emitter to collector to receiver section. Closing the PTT switch, SW3, grounds the cathode end of CR10, pulling the voltage at its anode down to approximately 0.6 volt. This voltage is applied to the base of Q15 causing it to cut off, thus removing the supply voltage from the receiver. At this time the transmitter is enabled by Q14, Q16.

This completes the receiver section.

TPX 720 TRANSCEIVER
SECTION C - EXCITER - TRANSMITTER SECTION

1. EXCITER PORTION

Transistors Q27, Q19, Q20, and Q21, along with their associated circuitry, amplify the transmitter frequency or the receiver local oscillator frequency to a useful level. This is the exciter portion of the transceiver.

ONE-TENTH of the transmit, or of the local oscillator operating frequency, is coupled out of the collector of Q8. C53 and C117 form a capacitive voltage divider from the collector of Q8 to ground. The base of Q27 is fed from the tap between the two capacitors. C117 helps to reduce harmonics and higher frequency spurious signals. R131 and R147 form a voltage divider to establish the base bias on Q27. C119 and R132 make up the decoupling filter for the +12 volt supply. T8 is parallel-tuned by C75 and CR20 and slug-tuned with a powered-iron core to the transit or receive local oscillator frequency. It is coupled, using leakage inductance and stray capacitance, to T9. In practice the transformers are mounted close together. Both have shield cans. The cans have openings in the sides where they are adjacent. The leakage and stray coupling escapes through the slot in the driving transformer can and induces signal, in the driver transformer, through the slot in its can. Careful positioning of the coils and cans is necessary to provide optimum coupling.

RF Voltage

T9 is tuned to the operating frequency by means of a slug, C76 and CR21. The secondary of T9 feeds the base of Q19. C77 holds the low end of T9 primary at RF ground. R102 is the base biasing resistor. The emitter is grounded. The collector of Q19 connects to the primary of T10. The supply end of the primary is decoupled with R103 and C81 to keep signal out of the 12 Volt supply. R130, along with C118 provides additional isolation.

The secondary of T10 is tuned to the operating frequency by means of a slug, varactor CR22, and C80. T10 is leakage coupled to T11 in the same manner as T8 was coupled to T9. T11 primary is tuned with a slug, varactor CR23 and C82. T11 secondary connects to the emitter of Q20. Q20 is connected as a grounded base amplifier. This type of amplifier is less prone to oscillation than the grounded emitter type normally used.

The base of Q10 is held at signal ground by C83. A ferrite bead at the base helps to reduce spurious signals. R106 is the base biasing resistor. R107, C85, C130 and R148 make up a double section decoupling filter for the Q20 supply voltage.

The collector of Q20 is connected to the primary of T12. The secondary of T12 is tuned by a slug, C84 and CR24. T12 is leakage coupled to T13. The primary of T13 is tuned with a slug, C86 and CR25. The secondary is connected to the base of Q21 through a spurious frequency filter consisting of R133 and a ferrite bead around the end of the R133 that is connected to the base. The local oscillator signal for the receiver is taken from the junction of R133 with the secondary of T13. It is coupled through C126 and connected to the base of the receiver mixer, Q21 through resistor R144. The emitter of Q21 is grounded.

R110 is the biasing resistor for Q21. C88, R111, C120 and R134 decouple the supply voltage to Q21. The collector load for Q21 is the torroid transformer T14. This is a broadband transformer that is tapped to impedance match to the base circuit of Q22.

Transformers T8 through T14 are varactor-tuned to the operating frequency. Each has its own varactor. The control voltage, which is the error voltage out of the PLL phase comparator, is applied to the control electrodes of the varactors through the isolation resistors R100, R101, R104, R105, R108, and R109. C78 and C79 bypass any AC signals that may find their way to the control line. Control voltage is a variable DC. Its level is dependent on the frequency of operation.

This completes the description of the exciter portion of the transceiver.

2. TRANSMITTER PORTION

Transistors Q22, Q23, Q24, Q25 and Q26 make up the driver and final amplifier of the transmitter. These transistors, along with Q21 are supplied with 12V only when the transceiver is in the transmit mode. The following description will assume the transmit mode.

The transmit frequency out of the exciter appears at the tap of T14. It is coupled from this point through C90 to the base of Q22. R112 and R113 establish the base bias. R114 sets the emitter operating voltage. C92 pins the emitter to RF ground. Diode CR26 acts as a modulator and as a power level controller for the transmitter. Basically, it functions as a variable shunt load across T15. In this capacity it varies the effective drive to Q23 and, ultimately, the transmitter power output.

When no voltage is applied to the diode, it has little affect on the signal across T15. At this time the collector signal voltage swings, at the signal frequency, around a center value that is approximately ½ of the supply voltage. The magnitude of the signal voltage depends on the supply voltage, the base driving signal level, the gain of the transistor and the "Q" of "figure of merit" of the transformer coil.

As the voltage at the anode of the diode is increased, the diode becomes conductive. Signal voltage, at the collector of Q22, is conducted through the diode to C91, where it is bypassed to ground. This signal path is in parallel with the signal across T15. The more voltage applied to the diode anode, the lower the resistance of the shunt path and the smaller the signal becomes across T15. Ultimately very little signal is present to drive the next stage. This is the Level Control Mode.

Superimposing an AC audio signal on the DC level control voltage will cause the power level to vary at the same rate as the audio signal. Our transmitter output signal is now amplitude modulated.

R115, and C89 decouple the supply voltage to Q22. T15 is another broadband torroid.

The output from Q22 is taken from the tap between the coils of T15. It is coupled through C94 to the base of Q23. R116, CR27 and R117 comprise the bias network for the base of Q23. CR27 rectifies the driving signal to adjust the Q23 bias proportionally to the signal level. Emitter resistor R118 provides additional small bias. C95 maintains the emitter at RF ground. Q23 operates in the class "B" mode. The collector is connected to T16. T16 is a broadband torroid. R135 and C93 are for power supply decoupling. C121 bypasses unwanted spurious frequencies.

The signal is taken from the tap on T16 and coupled to the base of Q24. Q24 base bias is at ground level DC. Choke L1 isolates the base for RF. Thus the base can be at the ground for DC but at a high level for RF. This stage will operate in the class "B" to class "C" region. It is the driver stage for the parallel-connected final amplifier transistors.

R120 provides base current limiting for excessive input signal. C115 bypasses high frequency spurious signals. C97, C98, and R119 decouple the supply voltage.

T17 couples the signal to the bases of Q25 and Q26. L7 is in parallel with T17 to reduce the inductance of T17. Because T17 has only 1 turn it is impossible to trim it mechanically. This makes L7 necessary. Parallel inductors have an inductance that is less than that of either one individually.

The signal to Q25 and Q26 is taken from the tap of T17. This matches the impedance of the base curcuit to the collector impedance of Q24. C103 and C104 couple the signal to the respective bases of the final amplifier transistors.

L2 and L3 permit the bases to be at high impedance for RF and to be at ground for DC, all at the same time. The emitters are grounded. C105 bypasses the collectors for high frequency spurious signals. The collectors are tied together to the primary of T18. C101, C102, and C100 are bypass caps to keep RF out of the power supply. Each is effective within a different frequency range.

The collectors of the final amplifier are at a relatively high impedance. Base fed resonant antennas usually have an impedance that is quite low. Theoretically, the impedance is 36 OHMS. In practice, it may range up to 100 OHMS or more and could be reactive rather than resistive. And, to worsen matters, it usually is not resonant at all operating frequencies. A useable match must be provided, somehow, between the final amplifier and the antenna. A double PI-section low pass filter, consisting of L4, L5, C107, C108, and C109 provides the necessary impedance match (approximate match) and at the same time discriminates against higher spurious frequencies and harmonics.

The output signal is developed across C109 and appears at antenna jack AJI.

Section D TPX 720 Transmit/Receive Control and Modulator Section.

The TPX 720 uses solid-state switching to change between the transmit mode and the receive mode. The switching function is performed by transistors Q14, Q15, and Q16. Q15 supplies power to the receiver section in the receive mode. It removes power from the receiver section in the transmit mode. Q14 removes power from the transmitter in the receive mode and supplies power during the transmit mode. Q16 deactivates the internal microphone when an external microphone is used. It also modifies the audio path when the external microphone is in use.

Q15 is in full conduction (saturation) in the receive mode. Q14 and Q16 are non-conducting (cut-off). The collector of Q15 and the emitter of Q14 are connected directly to the supply voltage. Q15 is an NPN transistor. When the base of Q15 is at a higher voltage than the emitter, Q15 will conduct. Q15 is connected as an emitter follower. The receiver section forms the emitter load. The base of Q15 is connected to the positive supply through resistors R98 and R99. An emitter follower draws little or no base current. Therefore the base voltage will be essentially the same as the supply voltage. Because of the emitter follower connection, the emitter voltage will be very nearly equal to the supply voltage. The emitter voltage is the supply to the receiver section when the receiver is operational.

In the receive mode, the transmit controller, Q14, must be non-conducting (at cut-off). Q14 is connected as a common emitter or conventional collector load type of amplifier. It is a PNP transistor, therefore a high positive base voltage will hold it at cutoff. The emitter is tied to the positive supply voltage. The base connects to the supply through R96. Since the base and the emitter are at the same high positive voltage, Q14 is at cutoff. The collector voltage will be at ground or zero level. The transmitter is the collector load. If there is no current through Q14 there will be no voltage at its collector and no voltage applied to the transmitter.

Q16 is also a PNP transistor. Its emitter is connected directly to the base of Q14 and, through resistor R96, to the positive supply voltage. Its base is connected to its emitter through resistor R94, and since the base and emitter are at the same potential, Q14 operates at cutoff. At cutoff, the collector voltage of Q14 is zero volts.

Summary of Receive Mode:

1. Q15 conducting - receiver has operating voltage supplied to it.
2. Q14 and Q16 non-conducting - no power is supplied to the transmitter or modulator section.

Q14 must become conducting and Q15 must cut off when the push-to-talk switch is operated. This is SW-3 on the schematic.

Operation of SW-3 connects to ground the junction of diode CR10 and resistor R97. This, in turn, pulls the junction of diodes CR10, CR11, CR32, R98 and R99 to a few tenths of a volt above ground. Emitter follower, Q15, will have its emitter voltage follow the drop in voltage at its base and it will also be near zero. With no supply voltage, the receiver will be deactiviated. Capacitor C68 and resistor R98 form a time delay circuit to prevent switching transients that might occur if the transition was very abrupt. Diode CR32 serves to discharge the decoupling capacitors along the receiver supply line. Diodes CR10 and CR11 isolate the two push-to-talk lines from each other so that two different modes of modulation control can be obtained.

Closing the push-to-talk switch connects one end of resistor R97 to ground. Resistors R96 and R97 now form a voltage divider across the supply voltage. The junction between the two resistors is connected to the base of Q14. This reduces the voltage at the base. With the emitter of Q14 connected to the supply voltage and the base tied to a lower voltage, Q14 will become conductive. A voltage will now be present, at the collector, that is near the supply voltage value. This voltage becomes the supply for the modulator and for Q21, Q22 and Q23 in the transmitter driver chain.

Q16 remains at cut-off because its base and emitter are at the same potential. At cut-off, the potential at its collector will be near zero. The collector is connected to the base of Q18 through resistor R93. Q18 is an NPN transistor. With its base at zero and its emitter grounded, it operates at cut-off and allows signal from the internal microphone to reach the speech amplifier portion of the modulator. In this mode Q17 serves as a microphone preamplifier with resistor R89 being its collector load resistor.

Q16 deactivates the internal microphone and connects the external microphone when one is used. The specified type of microphone is a high level carbon microphone. This microphone does not need a preamplifier. Q17 is deactivated when the external microphone is used.

Closing the push-to-talk switch on the external microphone grounds the end of resistor R95. Resistors R96, R94 and R95 now form a voltage divider across the supply voltage. The base of Q14 and the emitter of Q16 are connected to the tap between R94 and R96. This makes the base of Q14 more negative than its emitter and Q14 becomes conducting to turn the transmitter on.

The base of Q16 is tied to the junction of R94 and R96. This makes the base of Q16 more negative than its emitter and causes Q16 to conduct. A positive voltage appears at its collector and on the base of Q18, causing Q18 to conduct. Conduction in Q18 effectively connects the input from the internal microphone to ground. It also pulls the base of Q17 to ground causing Q17 to go into cut-off. This makes Q17 appear as though it is not even there.

Carbon microphones need to have a current flowing through them. The supply voltage is fed to the microphone through R89. The variable resistor, R90, is in parallel with the external microphone, when one is used, or with the Q17 output when the internal microphone is used. This control sets the signal to the proper level for good modulation under normal voice levels.

Audio from either microphone is fed from the moveable contact of R90 through R87 and C65 to the inverting input of IC 10B (pin6). C66 bypasses to ground audio frequencies above 3 Khz. Transistor Q11 serves as a variable shunt from the IC 10 B input to ground. The output from IC 10B is rectified by CR13, filtered to DC by capacitor C64 and applied to the base of Q11. The greater the signal, the higher the positive voltage at the base of Q11. Q11 is an NPN transistor. The more positive the voltage applied to its base, the more conductive it becomes. The more conductive Q11 becomes, the more signal it shunts to ground. Thus, high signal levels act to reduce the signal level out of IC 10B. Ideally, this would provide for a constant audio level out of IC 10B. In practice, however, the resultant audio level does vary but the variation is less than the variation at the microphone input. Q11, in conjunction with CR13 and IC 10B form an audio compression or automatic gain control circuit.

IC 10B functions as a simple audio amplifier. Resistors R85 and R86 form a voltage divider across the supply voltage. The voltage at their junction is one-half of the supply voltage. This voltage is fed to the non-inverting input, through R84, of IC 10B. It sets the operating level in the most linear region for audio amplification. Resistor R83 provides some negative feedback to improve linearity. Capacitor C63 provides negative feedback to eliminate higher audio frequencies. Resistor R88 is a current limiting resistor for the base of Q11.

Audio is coupled out of IC 10B through C62 to two potentiometers. Potentiometer R82 sets the modulation level for high power transmission and potentiometer R126 sets the modulation level for low power transmission. The appropriate potentiometer is selected by a section of the same switch (SW-4) that selects the power level.

The moveable contacts of the potentiometers are tied together to capacitor C61 which couples the audio to the inverting input of IC 10A (pin 2) through R81. Resistors R81 and R79 set the gain of the amplifier at 10 times. The audio is amplified by IC 10A and fed through current limiting resistor R78 to the modulation diode, CR26. CR26 varies the power output of the transmitter in proportion to the magnitude, rate of change and polarity of the audio signal.

The non-inverting input of IC 10A serves as a summing junction of various signals that control the transmitter power level. Inhibit signals from CR9 and CR33 are applied to this input. So is the power level signal from either R124 or R122, and the automatic level control derived from the rectified output signal picked up from a pattern on the circuit board located adjacent to the atenna feed pattern.

Transmit supply voltage, from Q14 collector is supplied through SW-4 to potentiometer R124 or potentiometer R122. R124 is used to set the low transmit power. R122 sets the higher power level. A portion of the supply voltage is present on the moveable contact of whichever potentiometer is selected. This is passed through either CR29 or CR30 steering diode and through CR28 to the input of IC 10A. CR28 rectifies the signal obtained from the board pattern to get the automatic level control voltage. R137 is a current limit protector. R136 provides a ground return for the input to IC 10B. Capacitors C124, C129, C132, C114, C69, C68, C74, C73, C71, C66, C63, C60, C91, C112, C125, and C111 serve to bypass audio and radio frequencies to keep them off of DC supply lines and control lines.

Certain portions of the circuitry are supplied with operating voltage during all modes of operation. The voltage for the inhibit logic chips and the programmable divider is taken directly from the on-off switch. Voltage for the synthesizer oscillators, the comparator and the exciter filter, is obtained through a 10 ohm current limiting resistor (R140). The transmit driver transistor Q24 and the transmit output transistors get their power directly from the on-off switch. These transistors are biased to cutoff and draw no current until a driving signal is present.