SBE®

FORMULA D

(MODEL SBE-26CB)

SERVICE MANUAL

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ILLUSTRATIONS

SECTION 1
GENERAL

1.1 CUSTOMER SERVICE

The SBE Technical Services Department functions as a source of information on the application, installation and use of SBE products. In addition, the Technical Services Department provides technical consultation on service problems and availability of local and factory repair facilities.

In any communications to the Technical Services Department, please include a complete description of your problems or needs, including model and serial numbers of the unit or units in question, accessories being used, any modifications or attachments in use, or any non-standard installation details.

For assistance on any of the above matters, please contact SBE, Incorporated, Technical Services Department, 220 Airport Boulevard, Watsonville, California 95076. Phone: 408/722-4177.

1.2 PARTS ORDERS

SBE original replacement parts are available from the Factory Parts Department at 1045 Main Street, Watsonville, California 95076.

When ordering parts, please supply the following information:

Model number of the unit.
Serial number of the unit.
Part number.
Description of the part.

1.3 FACTORY RETURNS

Repair services are available locally through SBE Certified Service Stations across the country. A list of these Service Stations is available upon request from the Technical Services Department. Do not return any merchandise to the Factory without authorization from the Factory.

SECTION 2

SPECIFICATIONS

2.1 GENERAL

Compliance	F.C.C. Type Accepted (Part 95, Class D)
Channels	23
Frequency Range	26.965-27.255 MHz
Frequency Control	Single Crystal, Digitally Synthesized
Frequency Tolerance	±.003%
Operating Temperature Range	-20°C to +50°C
Humidity	95%
Input Voltage	11.7 V DC to 15.9 V DC, Positive or Negative Ground
Microphone	Dynamic 500 ohm Nominal Impedence
Size	2.5"H (60mm), 6¾"W (170mm), 9-3/8"D (240mm)
Weight	6 pounds (2.73 kg)
P.A. Output	3.5 watts into an external 8 ohm speaker. The front panel microphone P.A. gain control allows the operator to control the P.A. speaker volume when the CB/PA switch is in the P.A. position. When the CB/PA switch is in the P.A. position, the P.A. speaker also monitors the receiver.
Power Consumption	Receive (squelched) 0.5 A Receive (3.5 watts audio) 1.3 A Transmit (95% modulation) 1.7 A
Fuse	2 ampere fast blow (Type 3AG or A.G.C.)

2.2 RECEIVER

Sensitivity	0.5 microvolt for 10db S+N/N Ratio
Selectivity	50db @ ±10 KHz, 60db @ ±20 KHz, 65db @ ±30 KHz
I.F. Frequencies	10.695 MHz, 455 KHz
Receiver Delta Tune	±750 Hz, Nominal
A.G.C. Response	Less than 10db for 10 to 500,000 microvolts

Squelch Threshold	Less than 0.5 microvolts
Audio Power Output	Greater than 3.5 watts @ 10% T.H.D.
Built-in Speaker	8 ohms 3½" Round
External Speaker	(Not Supplied) 4 or 8 ohms. Disables internal speaker when connected.
Spurious Rejection	
Image	-40db
I.F.	-70db
Others	-50db
Squelch Range	200 microvolts (Minimum)

2.3 TRANSMITTER

Power Output	4 watts maximum, 3 watts minimum
Modulation	90% minimum
Modulator Response	300 Hz to 2500 Hz, +3 -10db
Output Impedence	50 ohms, Unbalanced
Output Indicator	Front Panel Meter
Emission	6A3

SECTION 3
INSTALLATION

GENERAL

The first step in installation of the mobile transceiver is selection of antenna and transceiver mounting positions.

The selection of an antenna and its mounting position is the most critical factor in determining the end performance of an installation. Generally, the most satisfactory installation position for most vehicles is the center of the passenger compartment roof. As a second choice, the trunk can be a satisfactory antenna mounting point, especially on those cars where the trunk is large and flat. Due to increased susceptibility to ignition noise, mounting the antenna in the hood area is discouraged. Follow antenna manufacturer's recommendations carefully during installation.

The Formula D is supplied with a universal mounting bracket and microphone holder. The transceiver may be mounted in any position and on any rigid surface, such as underneath an automobile dashboard, truck roof or vertically on a boat bulkhead.

The transceiver should be mounted with accessibility and operation convenience in mind.

CAUTION: Avoid mounting the transceiver in the direct air stream of the vehicle's heater. Temperatures in this area can exceed 150° F and can result in serious damage to the unit.

It is recommended that the mounting bracket be installed on the transceiver and mounting clearances checked, with the unit held in the desired mounting position. It is especially important to leave sufficient space behind the unit for antenna and accessory cable connections.

When the most desirable mounting installation point has been decided upon, a pencil or other marking device should be used to outline the mounting bracket on the mounting surface. The transceiver should then be removed from the mounting bracket and the bracket held against the dash or other mounting surface, in the position marked, so that mounting holes may be marked and drilled.

CAUTION: Be sure to check behind the dash or other mounting surface to insure against damage of wiring and other devices before drilling any holes.

Install the microphone holder on the radio or other mounting surface as desired.

Install any accessories at this time, including external speaker, public address speaker, etc.

This unit is designed for either 12 volt positive or negative ground systems. In either system, the positive battery terminal always connects to the red supply wire, and the negative battery terminal always connects to the black supply wire. If the transceiver's power lead must be lengthened, use No. 14 or larger wire.

CAUTION: When using this radio in a positive ground system, it is important that none of the accessories are electrically connected to the vehicle's chassis (external speakers, P.A. speakers, etc.). Positive ground installations must utilize an additional 2 ampere fuse in the negative (black) supply lead to avoid possible damage to the transceiver. NOTE: The transceiver power lead may be connected to the accessory section of the ignition switch if desired. However, due to the possible presence of high-level noise from the ignition and accessories, this connection may not be desirable. In cases where excessive noise is present on the accessory line, a direct connection to the battery is recommended.

3.2 ANTENNA TUNING

The final step in installation is to trim the antenna for minimum S.W.R. The recommended method of antenna tuning is to use an in-line wattmeter or S.W.R. bridge to adjust the antenna for minimum reflected power on channel 11. A properly tuned antenna system will present a suitable load to the transceiver and will insure that maximum power is transfered from the radio to the antenna. If the antenna system in use presents a poor load, as indicated by a high S.W.R. reading, transmitter range will be substantially reduced and damage to the transmitter final amplifier transistor may occur. Poor S.W.R. can usually be corrected by altering the antenna's electrical length in accordance with the manufactures instruction. Extremely high S.W.R. readings may be indicative of a defective transmission line, antenna, or connections.

To determine whether the antenna should be lengthened or shortened, test the S.W.R. on channels 1 and 23. If the S.W.R. is the highest on channel 23, the antenna is too long and if highest on channel 1, the antenna is too short. When the antenna system has been tuned correctly, channel 11 should have the lowest S.W.R. and channels 1 and 23 will be slightly higher.

3.3 FINAL CHECK

Test drive the vehicle and make an operational check-out of the transceiver to insure proper operation of it and all the accessories installed. At this time, note any degradation of performance due to vehicle noise and take appropriate action to correct any noise suppression and deficiencies as outlined in the following section.

3.4 NOISE SUPPRESSION

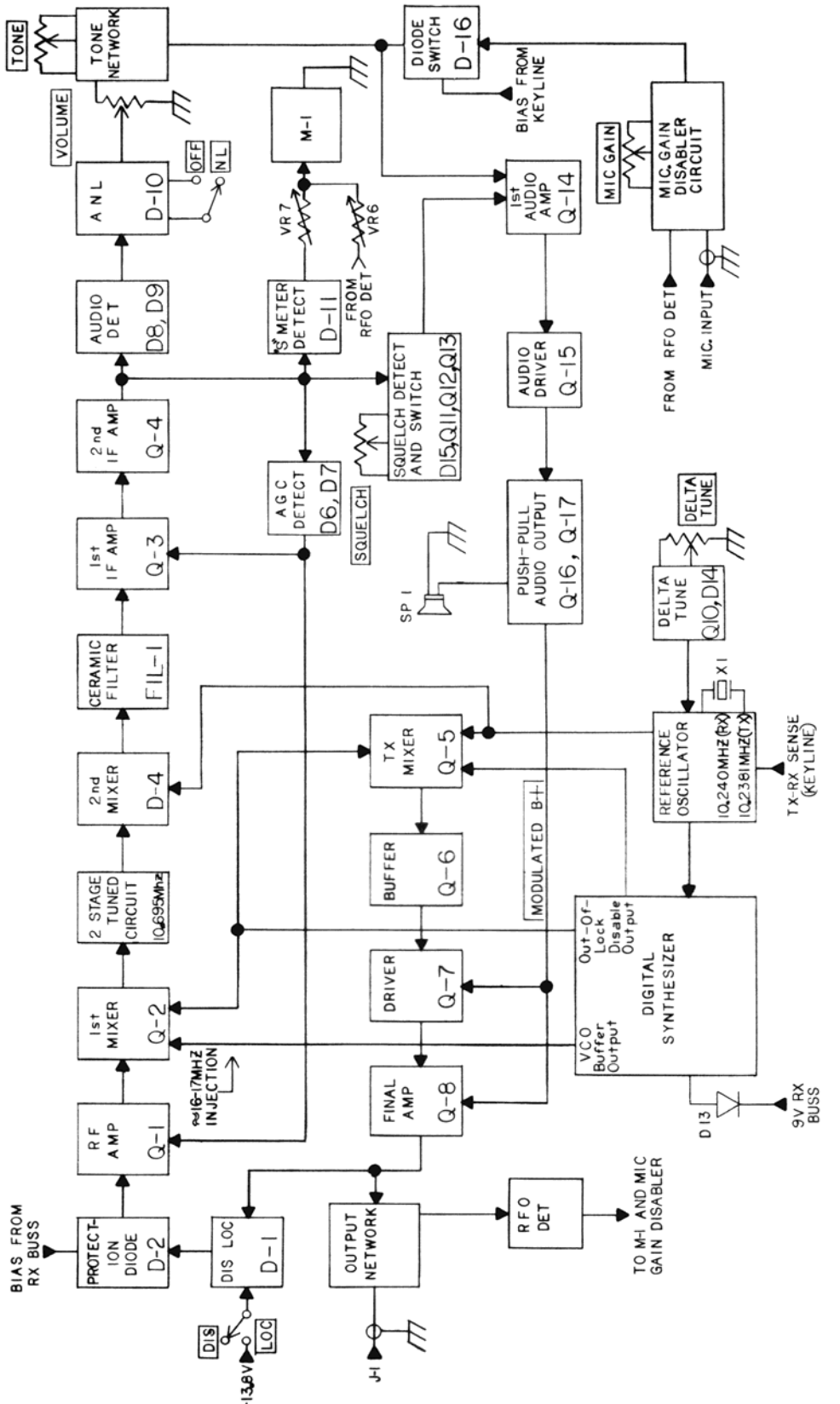
The first step in assuring minimum ignition noise is to insure that the engine ignition system is in a good state of tune, and all factory original noise suppression devices are installed and operational. This includes an inspection of distributor points and condenser, check to see that the spark plugs are clean and properly adjusted. The condition of the ignition wiring should be checked (radio resistor type ignition wire is standard on most late model vehicles and should be installed on vehicles not so equipped). The distributor cap should be checked for traces of carbon tracking or signs of arcing. Resistor type spark plugs are helpful in further reducing ignition noise and are standard as original equipment on many late model vehicles.

Alternator noise may be minimized by the installation of an alternator line filter, available from radio parts distributors.

Installation of bonding straps in the engine compartment will further reduce ignition noise. Short lengths of metal strap or heavy shield braid between the engine and frame, engine and fire wall, alternator and frame, exhaust pipe and frame, or hood to frame, will in many cases, greatly reduce ignition noise. Extremely high ignition noise levels or noise levels that become worse after a period of time are usually indicative of deterioration of the vehicle's electrical system. In some cases, interference may be caused by dash instruments including gasoline gauges, heater blowers and fans, etc. This interference may often be reduced by the installation of bypass capacitors from the terminals of the interfering instruments to ground. .01 microfarad capacitors of the ceramic disc variety rated at 500 working volts DC are recommended for this purpose.

For further information on the suppression of ignition noise in the automotive and marine environment, the Champion Spark Plug Company publication "Giving Two Way Radio Its Voice" is highly recommended. This publication is available from the automotive technical service department Champion Spark Plug Company, Post Office Box 910, Toledo, Ohio 43661. This publication is also available, at no charge, from the SBE Technical Services Department, upon request.

FIG. 4-1 TRANSCEIVER BLOCK DIAGRAM



SECTION 4

CIRCUIT DESCRIPTION

4.1 RECEIVER

GENERAL

The receiver circuitry of the SBE-26CB is of the dual conversion type. The initial R.F. amplification is performed by Q1, a common base amplifier operating at the receive channel frequency. The signal is then converted by means of a dual gate MOSFET mixer (Q2) to 10.7 MHz. The injection signal to this mixer is the approximately 17 MHz output signal from the digitally controlled synthesizer. After conversion to 10.7 MHz, the signal is filtered in a two stage filter consisting of T2-1 and T2-2. The filtered 10.7 MHz signal is then coupled from the output of T2-2 to D4, a 1N60 diode used as the second mixer. The crystal reference oscillator, Q9, which operates at 10.24 MHz, provides the injection signal for this mixer. The output frequency of the mixer is at 455 KHz. The output of the mixer is coupled to T3, which provides some filtering at 455 KHz, and also serves as an impedence matching device for the input of FIL-1, the 455 KHz ceramic filter, which provides the bulk of the bandpass filtering in the I.F. strip. The filtered 455 KHz signal from the output of FIL-1 is applied to the first I.F. amplifier, Q3. After amplification the signal is again filtered by T4 and T5 and applied to the base of the second I.F. amplifier, Q4. The output of Q4 is coupled to the various R.F. detector circuits via T6, the I.F. output transformer. The primary of T6 is coupled to the audio detector (D8 and D9), via C129. After passing through the automatic noise limiter, which will be discussed separately, the detected audio signal is then coupled to VR1, the volume control, and passes through the tone control circuit to the base of Q14, the first audio amplifier. R.F. output to the A.G.C., "S" meter and squelch detectors is provided by the secondary winding of T6. The operation of the squelch detector is discussed later in this section.

A.G.C. CIRCUIT

The A.G.C. detector of the Formula D consists of a full wave rectifier, the output of which is negative going. In other words, an increase in signal level at the secondary of T6 will tend to result in a higher negative voltage at the output (anode) of D6. This negative voltage is used to control the bias and therefore the gain of two stages. These are the R.F. amplifier (Q1) and the first I.F. amplifier (Q3). A range of expected voltages at various points in the A.G.C. system for various levels of input voltages is included in graph form to help in trouble-shooting.

"S" METER CIRCUIT

The "S" meter detector circuit consists of a half-wave rectifier (D11) and an "S" meter adjust Potentiometer. The positive going DC voltage from the detector circuit varies linearly with the R.F. voltage at T6.

SQUELCH CIRCUIT

The squelch circuit of the Formula D consists of a half wave peak detector which is biased with a D.C. voltage dependent upon the setting of the squelch and tight squelch controls. Rectified output of this detector is negative going and is used to control one input of a differential amplifier consisting of Q11 and Q12. The positive D.C. bias voltage on the cathode of D15 serves to "buck" the detected voltage appearing on D15's anode as the result of rectification of the input signal. The combined circuit con-

sisting of D15 and its bias circuits could be called a variable threshold detector, in that the R.F. input level required to result in a negative output from the detector can be varied by changing the D.C. bias on the cathode. Thus, if the squelch control is set toward the end of its resistance range which results in the maximum D.C. voltage of the cathode of D15, the delay in turn on of D15 is maximized, resulting in minimum squelch sensitivity, this is the fully clockwise position on the squelch control. Turning the squelch control counter-clockwise reduces the bias voltage, increasing squelch sensitivity. The output of the squelch detector goes to one input of a differential amplifier. DC biasing of this differential amplifier results in the following conditions: Q11 is normally turned on by base current from the base pull up resistor, (R303). This conduction of Q11 results in the emitter of Q11 being pulled up to just below the collector voltage of the transistor. Since the emitters of Q11 and Q12 are tied directly together, the emitter of Q12 is pulled up also. Since the emitter of Q12 is at a higher DC voltage than the base of the transistor, Q12 is turned off. The base voltage of Q12 is set by the voltage divider consisting of R304 and R305 at approximately one volt. Since Q12 is reverse biased, its collector voltage will rise to approximately eight volts. This turns on the output emitter follower of the squelch circuit (Q13). The conduction of Q13 causes its emitter voltage to rise to 3.2 volts which results in a reverse bias condition of Q14. The above conditions describe the squelched condition of the radio. Conversely, when a signal of sufficient amplitude is present in the cathode of D15 to result in a detected output voltage which overcomes the back bias inserted at the cathode by the squelch controls, the base of Q11 is pulled down sufficiently to turn off the transistor. When the emitter voltage of Q11 goes to a low enough value to allow Q12 to begin conducting, its collector voltage is pulled down turning off Q13 and allowing Q13's emitter to go to a low voltage which enables the audio amplifier by eliminating the pull up voltage on its emitter. Most problems in the squelch circuit should be easy to fix by comparing voltages found in the circuit with those specified in the schematic for the two conditions possible (squelched or unsquelched.)

AUTOMATIC NOISE LIMITER CIRCUIT

The automatic noise limiter in the Formula D is of the series noise gate type. This type of noise limiter circuit consists of a diode whose DC bias is controlled by the output voltage of the audio detector. In order to properly understand its operation you should remember that impedences are quite high in this circuit.

The normal action of the direct coupled output of the audio detector is to provide a positive DC voltage which increases as the level of carrier signal increases. Any modulation is detected as AC riding on the DC voltage.

A voltage divider circuit consisting of R120, R121, R122 and R123 is used to forward bias D10, the noise limiter diode, whenever sufficient positive voltage is present at the output of the audio detector. Because the anode end of the D10 diode is totally isolated from DC ground any voltage that appears at the output of the audio detector will also appear at the anode of D10. Although the cathode voltage will also tend to rise, the voltage rise will be approximately half that encountered at the anode. Since C132 (.22 microfarad electrolytic capacitor) is present at the junction of R122 and R123, audio voltages are shunted to ground and only DC voltage can appear at this point. Therefore, unless D10 is forward biased by sufficient positive voltage from the detector, the loss through the A.N.L. circuit will be very high and very little audio output will appear. However, as soon as the diode is sufficiently forward biased, it will conduct the audio signal through to the wiper of the volume control. It is normal for a very considerable loss to be found across the A.N.L. circuit, even when it is conducting. Please consult the schematic diagram for audio and DC levels to be expected in this circuit. (Please note that this is an extremely high impedence circuit and instruments used to assess its performance should have a load impedence of 10 meg-ohms or greater.) Generally, the easiest method of trouble-shooting this circuit is through static tests of the components (ohmmeter).

4.2 TRANSMITTER

The transmit section of the SBE-26CB is a four stage circuit consisting of a mixer, buffer, driver and final amplifier.

The transmit mixer is Q5, a dual-gate MOSFET. This stage mixes together the outputs of the reference oscillator (10.2381 MHz) and the synthesizer (approximately 17 MHz). The output is taken from the drain of the transmit mixer to a two stage filter consisting of L3 and L4, which are tuned to the output frequency (approximately 27 MHz). Further amplification is provided by Q6, which serves as a buffer amplifier. The output of Q6 is coupled through T7 to Q7, the driver transistor. After further amplification by the driver, the R.F. signal is coupled to Q8, the final amplifier. After the last stage of amplification by Q8, the signal passes through an impedence matching circuit consisting of L8, L9, C419 and C420. The output is further filtered by L10 and CV1, which is a 54 MHz second harmonic trap.

The modulation source for the transmitter is the same amplifier chain used in the receive mode (Q14, Q15, Q16 and Q17). The B+ supply is modulated by the secondary of T9 and this modulated B+ voltage passes through D19 to the collectors of the driver and final amplifier transistors. The modulation limiting circuit consists of VR9, D17 and C213. The operation of the modulation limiter is to detect the audio levels on the modulated B+ line and provide a positive going DC voltage to reduce the forward bias of Q14. The positive DC voltage reduces its gain and limits the maximum modulation excursion.

MIC GAIN CONTROL MODIFICATION

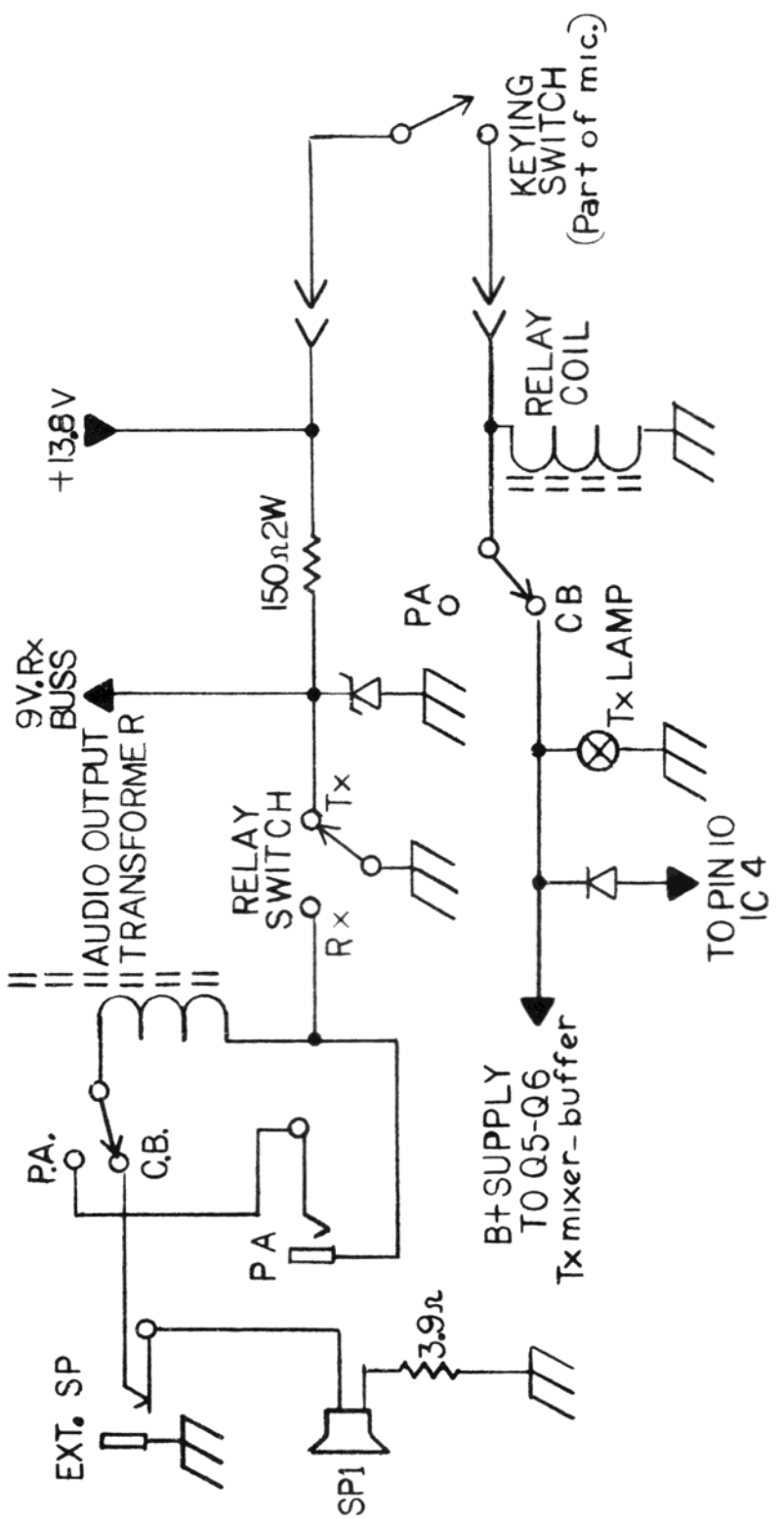
Compliance with the Federal Communications Commission Type Acceptance requirements for this unit requires that no external "front panel" modulation adjust be provided. This stipulation was added since the initial design of the radio was completed. Therefore, a modification was added to comply with these F.C.C. requirements.

This modification is located on the left front of the chassis apron, immediately adjacent to, and behind the microphone jack. The circuit is basically a diode switching system, the purpose of which is to disable VR2 (microphone gain) during the transmit mode, and allow it to function normally in the P.A. mode.

The switching circuit itself consists of 2 diodes, D901 and D902, and their respective control transistors, Q901 and Q902. In the transmit mode, D901 is turned on and D902 is turned off. Conversely, in the P.A. mode, D901 is turned off and D902 is turned on. This is accomplished as follows. The R.F. output detector, D12, is coupled via a 4.7K ohm resistor, R901, to the base of Q901, the first control transistor. In the transmit mode, detected R.F. output will cause a positive voltage of sufficient level to appear on the base of Q901 turning it on. This results in a low value of voltage appearing on the cathode of D901 and the anode of D902 respectively, through resistors R904 and R905. At the same time the collector of Q901 is pulling down the base voltage on Q902, thus turning it off. This results in a high voltage appearing on the collector of Q902, which results in forward bias on D901 and reverse bias on D902. Therefore, D901 is turned on and D902 is turned off. In this condition the audio voltage from the microphone is conducted directly through D901 to the base of Q14, via the transmit-receive switching diode, D16, which is discussed in the transmit-receive switching circuit explanation.

Conversely, in the P.A. mode, the output of the R.F.O. detector, of course, will be zero. This means that there is no forward bias for Q901, therefore, its collector voltage will be high. This forward biases Q902, turning it on. At the same time, D901 is reverse biased, turning it off. This condition is the opposite of that encountered in the transmit mode. D902 is now conducting and as its input is through C904 to the wiper of the microphone gain control, this control is active on P.A.

FIG. 4.3-1 TRANSMIT-RECEIVE SWITCHING



4.3 TRANSMIT-RECEIVE SWITCHING CIRCUITRY

The transmit to receive switching circuitry of the SBE-26CB utilizes a single pole, double throw relay. This relay serves two functions. In the transmit mode, it shunts to ground the 9 volt receiver B+ supply. In the receive mode, it provides a ground return for the audio output winding of T9, the audio output/ modulation transformer.

No switching is used as such between transmitter output and receiver input. Both the receiver input and the transmitter output are continuously connected to the same point. In the transmit mode, damage to the front end of the receiver is prevented by the action of D2. D2 is connected to the primary side of T1, which is the receiver R.F. input transformer. In the receive mode, it is reverse biased by the 9 volt receive bus and has no effect on performance of the receiver. However, in the transmit mode this bias is removed. This allows D2 to shunt to ground through C104, any large amplitude signals arriving from the transmitter. This, plus the impedence of C101, the 20pf coupling capacitor, protects the receiver against the large voltages present at the output of the transmitter.

The high level modulated B+ supply to the final and driver is not switched, and therefore, audio output from the receiver appears on this line in the receive mode. However, the B+ supply to the transmit mixer and the transmit buffer is supplied only when the microphone is keyed.

Pin 3 of the microphone jack is the unswitched "keyline"; this line is connected directly to the 13.8 volt B+ bus of the radio. Pin 4 of the microphone connector is the switched keyline. It is connected to the relay coil RL1, the transmit-receive relay, a bias circuit for D16, (microphone audio switching diode) and passes through the CB/PA switch, supplying voltage to PL1, the transmit light, also supplying B+ to the transmit mixer and buffer.

Keying the microphone shorts the two keylines together, providing 13.8 volts DC to the devices connected to the switched keyline. The microphone element of the standard SBE microphone is not switched. (The element is connected to the "hot" lead of the microphone input at all times.) Therefore, some means is required to remove the audio output of the microphone from the base of the audio amplifier "Q14" during the receive mode. This is accomplished by changing the biasing conditions on D16. During the transmit mode, D16 is forward biased by means of a bias circuit operating from the switched keyline consisting of R217, R218 and R204 in the base circuit of Q14. In the receive mode, the switched side of the keyline goes to ground, which removes the forward bias from D16, turning it off and removing the microphone audio from the base of Q14. The detector output of the receiver is connected directly to the base of Q14, through the volume and tone control circuits. No switching is necessary on this line, because the receiver is totally disabled on transmit by the shorting of the 9 volt receive bus to ground by RL1.

4.4 SYNTHESIZER

The synthesizer in the Formula D is of the indirect type. In this form of synthesizer a voltage controlled oscillator's output is compared in frequency to that of a highly stable crystal oscillator. To be more specific, the ratio of the two frequencies is compared (the stable reference oscillator's frequency need not be the same as that of the voltage controlled oscillator). The ratio of the frequency of the voltage controlled oscillator to that of the reference oscillator is set by "programming" the divider cicruitry internal to the synthesizer.

The circuitry of the Formula D synthesizer can be divided into seven sections. These are discussed in the following paragraphs.

REFERENCE OSCILLATOR

This is the only crystal controlled oscillator used in the Formula D. It provides the only frequency reference for the entire radio. The reference oscillator operates on a frequency of 10.240 MHz on receive and 10.2381 MHz on transmit.

REFERENCE DIVIDER

This is a divider circuit consisting of I.C.'s 5, 6, and 7 the purpose of which is to perform a division of the reference oscillator frequency by 1,024 to 1. This results in an output frequency of 10 KHz on receive and 9.9981 KHz on transmit.

VOLTAGE CONTROLLED OSCILLATOR

This section of the synthesizer provides the actual output signal at a frequency of 16.27 to 17.017 MHz. Its frequency is controlled by a D.C. input voltage provided by other circuitry in the synthesizer, which maintains its stability to crystal accuracy.

PROGRAMMABLE DIVIDER

The programmable divider serves the function of dividing the output frequency of the V.C.O. in such a manner as to result in an output frequency that is the same as that of the reference divider's output when the voltage controlled oscillator is operating at its correct frequency. To allow the V.C.O. to operate at a large number of different frequencies, the division ratio of this divider is variable.

PHASE DETECTOR

The phase detector in the SBE-26CB synthesizer is a section of I.C. 9, the MC4044 integrated circuit. The phase detector's function is to compare the two inputs for their phase relationship. These two inputs are the output of the reference divider and the output of the programmable divider. When the phase, and therefore the frequency, of the programmable divider's output varies from that of the reference divider, the phase detector acts to take corrective measures to return the V.C.O. frequency to its proper value.

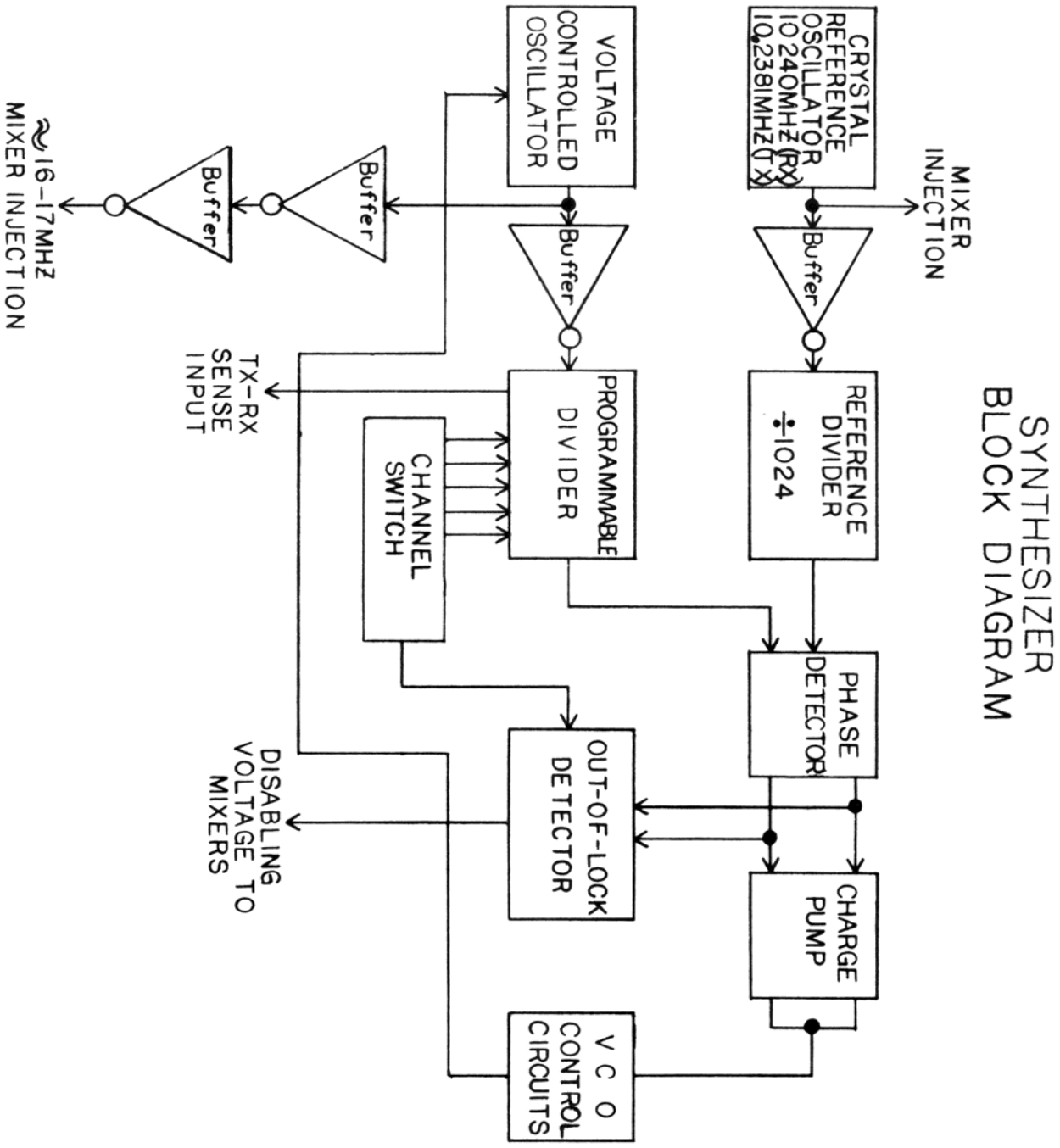
CHARGE PUMP

The charge pump is also a section of I.C. 9. The function of this circuit is to translate the phase detector output to a form suitable for driving the V.C.O. control circuitry.

CONTROL CIRCUITRY

The control circuitry of the synthesizer consists of an additional section of I.C. 9 and associated circuitry which will be explained in detail later in this description. This circuitry performs the function of translating the charge pump output into a suitable control voltage for use in setting the voltage controlled oscillator frequency.

FIG. 4.4-1


SYNTHESIZER
BLOCK DIAGRAM
CRYSTAL
REFERENCE
OSCILLATOR
10.240MHz (RX)
10.238MHz (TX)
MIXER
INJECTION
Buffer
REFERENCE
DIVIDER
÷1024
PHASE
DETECTOR
CHARGE
PUMP
V C O
CONTROL
CIRCUITS
VOLTAGE
CONTROLLED
OSCILLATOR
Buffer
PROGRAMMABLE
DIVIDER
CHANNEL
SWITCH
OUT-OF-LOCK
DETECTOR
DISABLING
VOLTAGE TO
MIXERS
TX-RX
SENSE
INPUT
Buffer
Buffer
≈16-17MHz
MIXER INJECTION

OUT OF LOCK DISABLE CIRCUIT

This section of the synthesizer insures that any improper output frequency from the synthesizer will be ignored by the radio. This is done by detecting the "out of lock" condition and generating a voltage which is used to disable the receiver and transmitter mixers.

PHASE DETECTOR CIRCUIT DESCRIPTION

General Description

No attempt will be made to describe the internal functioning of the phase detector used in the Formula D, as considerable knowledge of digital devices is required to grasp its mode of operation. Furthermore, understanding its operation is not required of the technician servicing the synthesizer. We will confine our description to the external effects of its normal operation.

The input of the phase detector is at pins 1 and 3 of the MC4044 I.C., which is shown on the schematic of the Formula D as I.C. 9. The outputs of the phase detector are pins 13 and 2.

Normal Operation

Operation of the phase detector is as follows: Two signals are applied to it, the reference divider's output to pin 1 and the programmable divider's output to pin 3. The internal circuitry of the phase detector compares the phase relationship of the negative going transitions of the pulses from the reference divider and the programmable divider.

In the normal operation of the phase detector, very narrow negative going pulses will occur at both phase detector outputs at 100 microsecond intervals. Should the voltage controlled oscillator drift slightly, the output pulses of the phase detector associated with the direction of the drift will widen (stay negative longer). For example, should the output of the V.C.O. tend to drift downward in frequency, the "lagging" output pulses of the phase detector will widen.

The voltage controlled oscillator will normally drift continually while the radio is in operation. This means that the small phase corrections from the phase detector will occur continually at 100 microsecond intervals, during normal operation.

Loss of Phase Lock

Loss of phase lock is described as a condition under which it is not possible for the control circuitry to alter the oscillator frequency sufficiently to bring the inputs to the phase detector at pins 1 and 3 into phase coincidence.

When the phase detector of I.C. 9 is operating normally, a loss of phase lock will result in a wide pulse from one of the phase detector outputs. This pulse will occur continually at 100 microsecond intervals. In other words, a considerable phase difference is detected by the phase detector, but the control range of the associated circuitry is, for some reason, not sufficient to bring the oscillator to the correct frequency.

A continuous train of wide pulse will occur at the leading output (pin 2) of the phase detector when an uncorrectable difference in phase at its two inputs occurs, such that the V.C.O. divider output frequen-

cy is higher than the reference divider frequency (the V.C.O. divider pulses lead the reference divider pulses in phase when their negative going transitions are compared by the phase detector). Conversely, a continuous series of wide pulses from the lagging output at pin 13 will occur when the V.C.O.'s divider frequency is lower than that of the reference divider (lagging reference divider in phase).

CHARGE PUMP CIRCUIT DESCRIPTION

General Description

The purpose of the charge pump is to change the negative going pulses at the two outputs of the phase detector to either positive or negative going pulses suitable for input to the circuitry that follows. The charge pump can be divided into two segments. Each segment couples one input to a common output.

Leading Input

This section of the charge pump is connected to the leading output of the phase detector. Although its circuitry is fairly complex, it can be thought of as an inverter followed by a diode (see diagram). The effect of this section of the circuit is to invert the input pulse from the leading output of the phase detector and couple it to the output in such a manner that only when the output of the inverter is more positive than the voltage at the common output are the two connected, otherwise the diode is back biased, effectively isolating this input from the common output.

Lagging Input

This input of the charge pump is very simple and obvious in operation. It merely consists of a diode connected with its cathode to the input and anode to the common output so that only when the lagging input is more negative than the common output, are they connected together. Otherwise, the diode isolates the lagging input from the common output.

Normal Operation

When the synthesizer is in phase lock, the normal inputs to the charge pump will be two very narrow pulses from the phase detector, both of which occur at the same time and at 100 microsecond intervals. Under these conditions, a D.C. voltage will appear (provided by external circuitry, which will be explained later) at the common output of the charge pump at pins 5 and 10. Reference to the block diagram will show that between the negative going pulses of the phase detector output, both of the coupling circuits in the charge pump will be in an isolating condition (both diodes will be back biased). Therefore, in practical terms, the common output of the charge pump is totally isolated from both inputs when the inputs are at logical 1. However, if a negative going pulse occurs on one of the inputs, the common output will have coupled to it either a negative going or positive going pulse, depending upon which input received the pulse from the phase detector. To reiterate, when a pulse occurs on the leading input, a positive going pulse appears on the output; when a pulse appears on the lagging input, a negative going pulse appears on the output. During the time when no pulses occur at either input to the charge pump, the common output is totally isolated from both inputs.

VCO CONTROL CIRCUIT DESCRIPTION

General Description

The basic purpose of this circuit is to provide a stable DC output voltage for the control of the voltage controlled oscillator which can be quickly altered as conditions require, by the action of the charge pump. The basic form this circuit takes is that of an inverting amplifier with its output capacitively coupled back to its input. This inverting amplifier has a very high current gain and therefore, although its output impedence is low, its input impedence is very high. This means that the relatively small capacitor (1 microfarad) connecting the input to the output can be used as a "memory", in other words, the charge across this capacitor sets the differential voltage between the input and the output. Therefore the output voltage of the amplifier is strictly dependent upon the charge of this capacitor. The circuit is coupled in such a way as to allow the output of the charge pump to vary the charge on C507.

Circuit Description

A one microfarad electrolytic capacitor (C507) is connected at its cathode end to the base of an emitter follower stage which is shown on the schematic diagram as Q20. The purpose of this emitter follower is simply to make the impedence at the cathode of C507 very high. The output voltage of the emitter follower directly tracks the voltage at the cathode of C507 and it drives the input of the last section of the MC4044 chip which consists simply of a Darlington DC amplifier. This amplifier greatly amplifies and inverts whatever voltage changes occur at the base of Q20. The output of this amplifier is connected to the anode end of C507 through a resistor of small value which for the moment can be discounted. Also connected to the cathode of C507 and the base of Q20 is an R-C filter network consisting of R505, R506 and C506. The other side of this low pass filter network is coupled to the output of the charge pump at pins 5 and 10. The purpose of this filter is to slow the rise time of the output pulses from the charge pump and also to reduce their value to a low enough level to insure against over reaction from the control circuitry which would result in oscillation of the system. The output of the control circuitry is taken at pin 8 of I.C. 9 and passes through R519, a 2.2K isolating resistor, to the cathode of D26, the varactor diode, used as the variable capacitance in the voltage controlled oscillator.

Normal Operation

It can be seen that the voltage appearing on the input of the inverting amplifier (base of Q20) is dependent upon the charge across C507. It is also obvious that the output voltage of the inverting amplifier is directly related to the input voltage. Therefore, the charge across the capacitor sets the output voltage of the inverting amplifier and therefore the DC control voltage to the V.C.O. Due to the fact that the high impedence of the inverting amplifier offers little loading to the capacitor, the charge across the capacitor will tend to remain stable for reasonably short periods of time, and therefore the output voltage of the amplifier will also tend to remain stable.

Control of the output voltage is affected by changes in the charge across C507, which are forced to occur by the action of the charge pump's output.

The charge pump controls the charge across C507 and therefore the output voltage of the V.C.O. control circuit in the following manner: Assume that the output frequency of the voltage controlled oscillator is slightly low. This will result in a narrow pulse from the leading output of the phase detector and a much wider pulse from the lagging output of the phase detector. The leading output of the phase detector will be inverted by the charge pump and the lagging output will be coupled through as a negative pulse. Due to the fact that the negative going "lagging" output pulse is much wider than that of the leading output, they will not cancel each other out completely at the common output of the charge

pump. The net effect will be a negative going pulse to the output of the charge pump which, after being reduced in amplitude by the integrator, will tend to cause a slight reduction of the base voltage of Q20. This will result in a still small but amplified positive change in the output voltage of the control amplifier. This will, of course, tend to slightly increase the charge across C507. This will result in the control circuit stabilizing at a slightly higher output voltage. This process is repeated at 100 microsecond intervals until such time as the voltage at the output of the control circuit reaches a sufficiently high level to bring the oscillator frequency to its proper value and allow phase lock to be regained. The exact same set of circumstances will reoccur if the oscillator frequency becomes too high. The only difference being that the polarities of the voltage changes will be reversed.

VOLTAGE CONTROLLED OSCILLATOR CIRCUIT DESCRIPTION

The voltage controlled oscillator of the Formula D synthesizer consists of Q21, D26 and associated circuitry. The oscillator circuit is of the common collector variety, with its output frequencies set by the resonance of a tank circuit consisting of D26 and L14. D26 is a voltage variable capacitance diode. It is operated with a variable reverse bias, which is provided by the output of the V.C.O. Control Circuits through R519.

When the reverse bias voltage on D26 is increased, its capacitance decreases. Conversely, when the bias voltage is reduced, the capacitance of the diode increases. An increase in capacitance in the tank circuit will tend to reduce the oscillator frequency and a decrease in capacitance in the tank circuit will tend to increase the frequency. Therefore, as the bias voltage rises, the frequency of the oscillator will also rise.

The output of Q21 forms the synthesizer's output signal after being amplified by two stages of buffer amplification (Q22 and Q23). The output of Q21 at its emitter is also used to directly drive the programmable divider input amplifier (Q25).

FIG. 4.4-2 OSCILLATOR CONTROL -- OUT-OF-LOCK DETECTOR

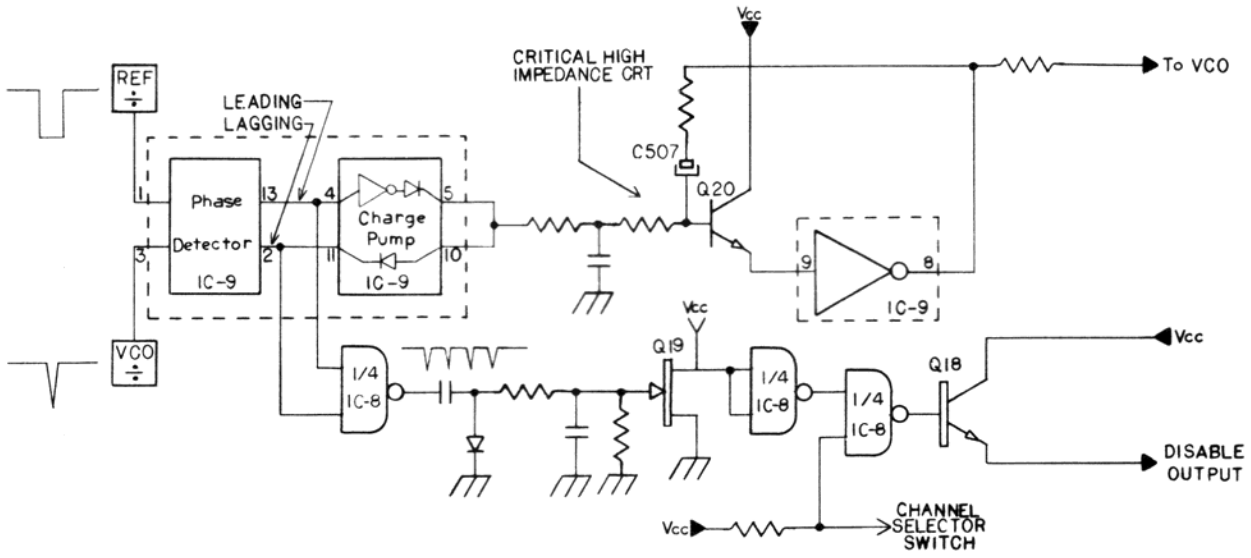
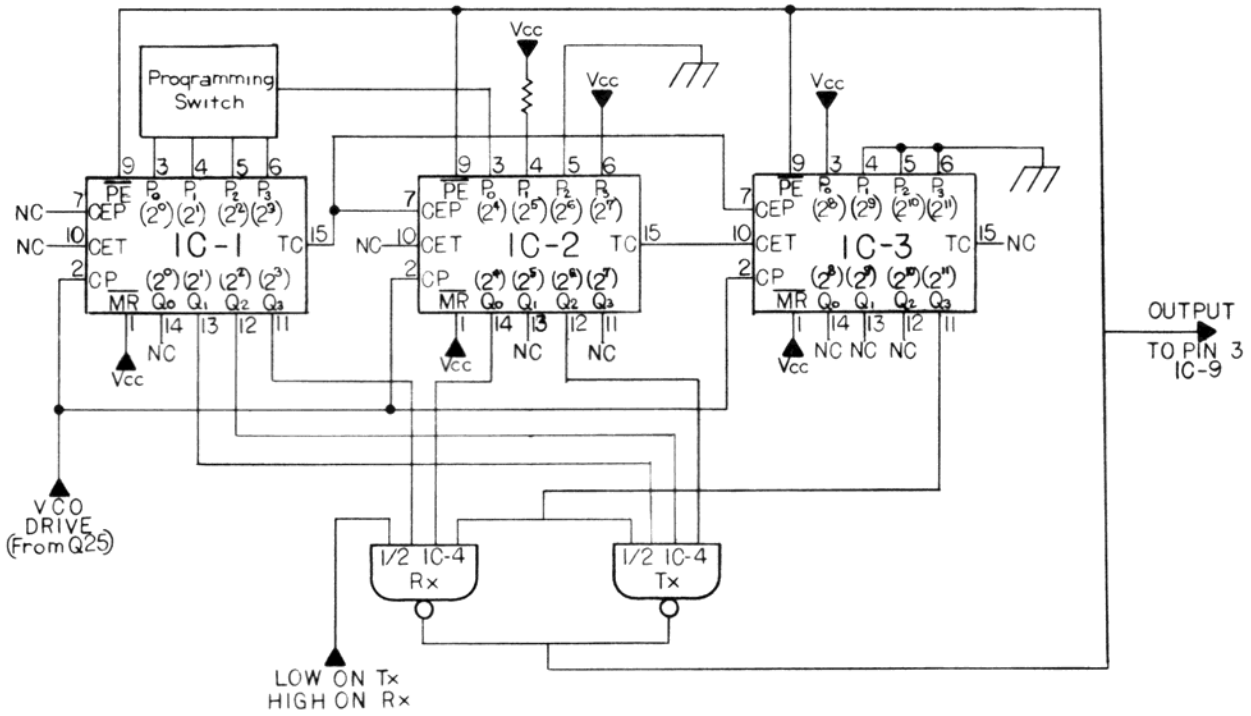


FIG. 4.4-3 PROGRAMMABLE DIVIDER LOGIC DIAGRAM



PROGRAMMABLE DIVIDER CIRCUIT DESCRIPTION

General

The programmable divider consists of four integrated circuits, I.C. 1, I.C. 2, I.C. 3 and I.C. 4. The purpose of this circuit is to provide a division of the voltage controlled oscillator output, such that when the oscillator is operating at the proper frequency, the programmable divider's output will be equal in frequency and phase to the output of the reference divider.

The V.C.O. must operate at a total of 46 different frequencies. This necessitates that the division ratio of the programmable divider be changeable so that all desired V.C.O. frequencies will result in the proper output frequency from the divider.

A complete description of the internal operation of the programmable divider is beyond the scope of this manual. However, a basic description of the operation of the counter follows and should be of assistance to those wishing to study further the operation of programmable dividers.

Circuitry

The programmable divider of the SBE-26CB consists of a three stage circuit employing Fairchild 9316 or Texas Instruments 74163 integrated circuits. These I.C.s are four-bit binary counters with programming capability.

The normal operation of a conventional, non-programmable four-bit binary counter stage is as follows: The internal circuitry of the counter always starts at zero. Each input pulse from the source raises the internal count of the counter by one. When this count reaches 15 in a four-bit divider (counting zero, this is 16 total cycles of the input signal), an output pulse occurs.

The programmable divider operates in the same fashion with the exception of the fact that the programmable divider does not necessarily always start counting at zero. It is possible, via external programming inputs, to pre-set the counter to any desired number. This allows the number of cycles of the input frequency for each output pulse to be changed. Therefore, the division ratio of the counter is effectively changeable or programmable. This method of changing the division ratio by presetting the counters to start at a number other than zero, is a method used in the Formula D for programming the channel frequency.

With counters of this nature, it is also possible to decode any particular internal count by means of the four binary outputs available. This means that it is possible to stop the count and provide an output pulse to the next counter at a count less than 15. Doing this requires the use of external gates to sense the condition of the counters. This method is referred to as changing the terminal count, and is used on the Formula D to change the division ratio by 46 between transmit mode and receive mode. This is done by enabling one of two nand gates used to sense the terminal count. Each of these gates is connected to selected binary outputs of the counters. When all inputs to a given nand gate are high, terminal count is sensed and an output pulse appears at the gate output.

This output pulse resets all the counters to the preset value set by the channel selector and also is the counter chain's output to the phase detector.

The terminal count sense gate used in the receive mode is connected to sense a terminal count of 2072. The transmit mode senses a count of 2118. Since the receive mode gate senses an earlier count, it will control the divider when both gates are active. In the transmit mode, the receive mode gate is disabled by bringing one input low. (Connected by D13 to the 9 volt receive bus, which is grounded on transmit.) This allows the transmit mode gate to control the divider.

REFERENCE OSCILLATOR CIRCUIT DESCRIPTION

General Description

The reference oscillator is a crystal controlled stage consisting of Q9, X1 and frequency control circuitry including D14, Q10 and the delta tune control. The normal output of this oscillator is 10.240 MHz on receive and 10.2381 MHz on transmit.

Circuit Description

The oscillator (Q9) is of the common collector variety with the output taken from the emitter. D14 is forward biased in the transmit mode and reverse baised in the receive mode. This results in an increase in capacitance in the transmit mode, which results in a frequency shift to 10.2381 MHz when L11 has been properly adjusted in the transmit mode. The reverse bias on D14 is made variable by the action of the delta tune control and its associated amplifier, Q10. This variation in bias on the cathode of D14 is sufficient to cause approximately 700-800 hertz of frequency shift above and below a center value of 10.240 MHz in the receive mode. The delta tune control is disabled in the transmit mode, as its power source, the 9 volt receive bus is shorted to ground during transmit.

REFERENCE DIVIDER CIRCUIT DESCRIPTION

General

The reference divider consists of I.C.'s 5, 6 and 7, plus one section of I.C. 8. Its purpose is to provide a fixed division ratio of 1,024 to 1 on the output of the reference oscillator, Q9.

Circuit Description

The signal from Q9 emitter is coupled through R607 and C521 to the base of Q24, the reference divider driver. The purpose of this common emitter amplifier is to provide a sufficiently large peak to peak voltage swing to insure that the reference divider input switches fully from logical 1 to logical 0 during each input cycle. The output of Q24 is coupled directly to the "A input" of I.C. 5, a type 7493 four-bit binary counter. This counter performs a division of 16 to 1 on the input signal. In other words, the output of I.C. 5 will have a frequency 1/16 that of the input (640 KHz on receive). The output of I.C. 5 is coupled directly to the input of I.C. 6. This stage is identical to the previous one and performs another division of 16 to 1 on the input signal (40 KHz output). The output of this stage is coupled to I.C. 7, a type 7474 (dual D-type) edge triggered flip-flop. Each half of this I.C. divides by 2. The two sections are connected in series for a total division ratio of 4 to 1. Therefore, the input signal at 40 KHz is divided by 4 to result in an output frequency of 10 KHz. (All frequencies noted are true on receive only. Transmit values are slightly lower, due to reference oscillator frequency shift.)

I.C. 7 actually has two outputs in the form of square waves, 180° out of phase. The ideal input for the phase detector (I.C. 9) is a negative going spike, of fast rise time. To obtain this, both outputs of I.C. 7 are acted upon by a nand gate (part of I.C. 8) in the following manner: Each output of I.C. 7 is coupled to an input of the nand gate. However, one output has a .01 capacitor (C517) across it to ground. This capacitor slows the rise time of the output to which it is connected sufficiently so that the inputs to the nand gate are slightly out of phase. Therefore, for a very short period of time, both inputs are high to the nand gate. During this period, a short negative spike appears at the nand gate output. This is the drive to the reference input of I.C. 9, the phase detector.

OUT-OF-LOCK DETECTOR CIRCUIT DESCRIPTION

General Description

The "out-of-lock detector" section of the synthesizer serves the purpose of providing a disabling voltage to the mixers of the transmitter and receiver to insure against off frequency operation, should phase lock be lost.

The circuit consists of Q18, Q19, D25 and three nand gates which are part of I.C. 8.

Circuit Description

One of the "two-input nand gates" in I.C. 8 has each of its inputs coupled to one output of the phase detector. Please remember that the output of a nand gate is low only during the time when both inputs are high. If either input should go low, the output will go high. The output of this nand gate is capacitively coupled to a half wave shunt detector (D25). The output of this detector is negative going and is used to control the gate of Q19, which is a junction F.E.T. This F.E.T. operates as a depletion mode device. Due to the fact that no external bias is provided, this F.E.T. is saturated unless sufficient negative bias is provided from the detector (D25).

The output at the drain of Q19 is coupled to an inverter formed by connecting both inputs of one section of I.C. 8 together. The output of this inverter is coupled to a third section of I.C. 8, which is used as a nand gate. The other input of this nand gate is connected to a pull-up resistor connected to V.C.C. and one contact of the channel selector switch.

The output of this nand gate is coupled directly to the base of Q18, which functions as an output emitter follower for the out of lock disable circuit.

Normal Operation

A positive going spike will appear on the output of the first nand gate driving the out of lock detector every 100 microseconds. Under phase locked conditions, these output pulses will be very narrow, resulting in a small amount of detected DC at the output of D25. However, should out of lock conditions exist, either the leading or lagging output of the phase detector will have a much wider pulse on its output. Therefore, the positive going spikes at the output of the nand gate will be much wider and the detected DC voltage will be greater in value. Component values in the coupling network between the detector and Q19 are chosen so that when out of lock conditions prevail, sufficient DC voltage is provided to reverse bias Q19. This allows its drain voltage to rise sufficiently to cause an inverter connected to its output to switch to the low output state. This will drive one input of the third nand gate low, which will result in a high voltage on its output. This will raise the base voltage on Q18 and cause it to conduct, creating a positive pull-up voltage (approximately 3 volts) on the emitter of Q18. This voltage disables the transmit and receive mixers by pulling their source voltage up sufficiently to reverse bias them to cut-off.

The third "nand gate" also serves the purpose of sensing when the channel selector switch is set to the blank position. This is done by providing a contact on the channel selector switch which grounds the second input to this nand gate. This, of course, results in a disable output in the same manner an out of phase lock condition would do.

SECTION 5
SERVICING

5.1 TEST INSTRUMENTS REQUIRED

General

The test equipment required for citizens band servicing includes a number of the items commonly found in service shops specializing in entertainment electronics repair. However, for economical and expedient repair of citizens band equipment, certain items of test gear not normally found in entertainment electronics service shops are required.

Four items of test equipment indispensable to citizens band servicing are a calibrated signal generator, a wide band oscilloscope, an accurately calibrated wattmeter, and a frequency counter. In the following discussions the required characteristics for each of these units will be delineated and desired features will be discussed.

Signal Generator

The signal generator used for alignment and testing of citizens band receivers must adhere to considerably more precise specifications than "service type" generators commonly found in service shops.

Stability is an important factor in signal generators used for alignment of citizens band transceivers. The fact that C.B. transceivers are inherently narrow band receivers, combined with the fact that they

are crystal controlled, makes this specification an important one. Accurate alignment of citizens band receivers requires that the frequency of the generator remains stable to within a few hundred hertz over a period of several minutes. This is beyond the capability of most service type generators at a frequency of 27 MHz.

Frequency calibration accuracy is another useful feature in a signal generator for citizens band service. However, if sufficient output is available from the signal generator, a frequency counter may be used to set the generator frequency to excellent accuracy. This makes accurate frequency calibration a nice, but unnecessary, feature.

Reasonably well calibrated modulation capability with the modulation level either variable or preset at 30%, is required for A.M. transceiver alignment. The preferred modulation frequency is 1,000 hertz. However, 400 hertz is satisfactory.

Output calibration is the last and most critical specification of the signal generator. The generator should be capable of signal outputs of .5 microvolts or less. The output calibration should be in the form of a dial or a meter and be accurately readable (±20%) at these levels. The output of the signal generator should be continuously variable up to at least 500,000 microvolts.

The generator preferably should be capable of output on the I.F. frequencies used in C.B. receivers as well as at the 27 MHz R.F. input frequency range. The most common of these frequencies are 10.7 MHz, 7.8 MHz, and 455 KHz.

OSCILLOSCOPE

The servicing techniques we have developed at the SBE Factory over the last several years make heavy use of a high quality wide band oscilloscope for trouble-shooting. This philosophy is reflected in the very considerable use made of oscilloscope wave-forms in this manual.

Taking advantage of the considerable capability of the oscilloscope to shorten and simplify service procedures, requires that certain basic minimum specifications be adhered to in selection of an oscilloscope for C.B. servicing.

Bandwidth is the single most important consideration. We consider the minimum 3db bandwidth for a suitable oscilloscope to be 25 MHz. This specification is considerably beyond that required for most other electronics servicing.

A bandwidth of this magnitude allows inspection of the signal wave-form throughout the entire transmitter. This ability to observe both carrier levels and modulation envelopes throughout the various points in the transmitter is critical to quick and easy analysis of transmitter failures. Although a 25 MHz bandwidth is sufficient for basic oscillosocpe functions, a wider bandwidth in the area of 50 MHz is preferable. This is due to the fact that specifications for bandwidth are made at the so called 3db point. Essentially, this means that in a 25 MHz oscilloscope, signals with a frequency of 25 MHz will be displayed with approximately seven tenths the apparent amplitude of a low frequency signal. This means that if an oscillosocpe is used at anything more than 50% of its rated bandwidth, a correction factor must be applied to the reading for all but relative measurements. Oscilloscopes used in the SBE service facility all have a bandwidth of 35 MHz or greater.

Another important consideration to successful use of the oscilloscope in servicing is the sensitivity of the vertical amplifier. Because of the necessity of using a 10X low capacity probe for most oscilloscope measurements (all wave-forms taken in this manual were made with a 10X probe), the effective sensitivity of the vertical amplifier is reduced by a factor of 10. We have found that a sensitivity of 50 millivolts per division with a 10X probe is the minimum satisfactory sensitivity for C.B. transceiver servicing.

This means a basic oscilloscope sensitivity of 5 millivolts per division at its input jack. Calibration of the vertical input of the oscilloscope is necessary for easy trouble-shooting. We find that the best form of step attenuator uses the 1-2-5 sequence of sensitivity steps.

An oscilloscope having a vertical bandwidth as described above will generally have sufficient horizontal sweep capabilities for proper display of the signal. Two factors are important in the oscilloscope's horizontal sweep capability: The first of these is a sufficient number of calibrated horizontal sweep speeds. These should preferably range in a 1-2-5 sequence over one second or longer to 1/10 microsecond or less per division. The second factor is triggering capability. Triggered sweep capability is important in general servicing and absolutely indispensable in digital servicing. A good triggered sweep system offers the advantage of allowing a repetitive wave-form of any frequency to be displayed as a stable trace on the oscilloscope at any sweep speed. This allows the calibrated capabilities for amplitude and frequency measurement to be used to their fullest advantage.

Additional features are useful but not indispensable to the C.B. servicing oscilloscope. These features include: dual trace, delaying sweep, and trigger hold-off. Although not necessary, these additional features should be considered, especially with digital synthesizer servicing in mind.

WATTMETER

Wattmeters of professional class only should be considered for citizens band servicing. This limits the choice to two brands that are nationally distributed. These are Bird and Sierra.

The most important specification in selecting a wattmeter for citizens band servicing is calibration accuracy. The wattmeter you choose should specify this figure to 5% or better at the frequency of operation.

FREQUENCY COUNTER

Four specifications are of importance when considering the purchase of a frequency counter for citizens band servicing. These include frequency range, resolution, time base accuracy and sensitivity.

A range of 5 Hz to 30 MHz is generally satisfactory for citizens band servicing, however, a slightly wider range counter (5 Hz to 50 MHz) can be useful in the servicing of certain radios which utilize crystal oscillators operating above the citizens band.

The resolution of a frequency counter, in practical terms, is basically set by the number of digits in the readout. Generally speaking, a six digit counter provides sufficient resolution for the purposes of citizens band servicing.

The accuracy of the time base oscillator is usually specified in at least two of three different forms: These include overall accuracy over a period of time (usually a year), ageing rate and temperature stability. The first method of specification is the easiest to interpret as it includes all temperature and ageing factors. Typical values for a satisfactory counter would be in the range of + or - 20 parts per million per year. A good specification for maximum ageing rate would be 10 parts per million per year or 1 part per million per month. A satisfactory figure for temperature stability would be + or - 10 parts per million over a range of 0-40° C.

Specification for the sensitivity of the counter input must include consideration of two factors: The input sensitivity in volts and the impedence of the input line. The preferable input impedence for a citizens band counter is 1 megohm shunted by 20 pfd or less. This allows the use of standard 10X oscilloscope probes for counting frequencies in sensitive circuits where a direct connection with coaxial

FIG. 5.1-2 AUDIO TEST BOX

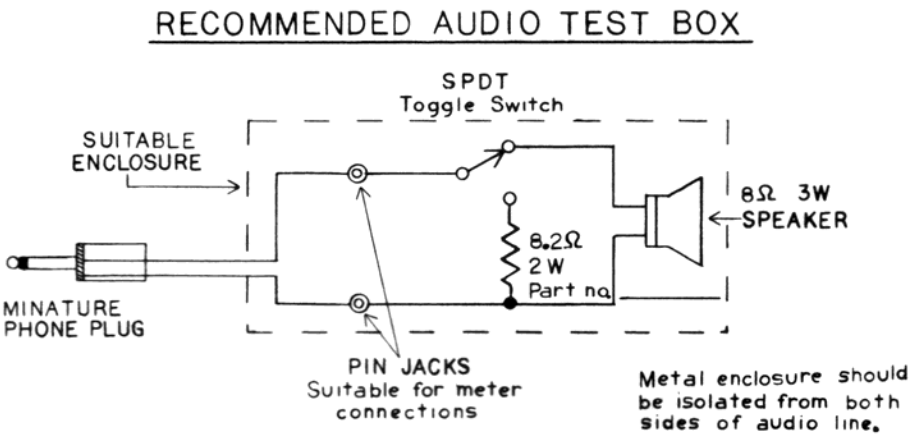


FIG. 5.1-3 MODULATOR TEST BOX

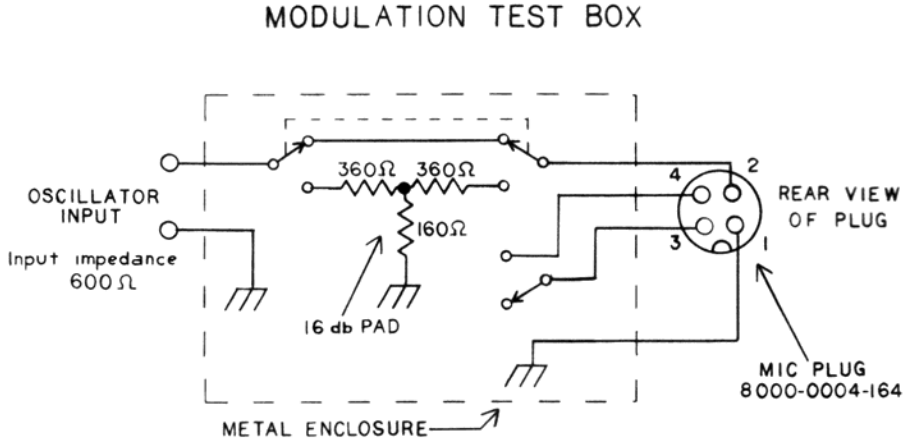
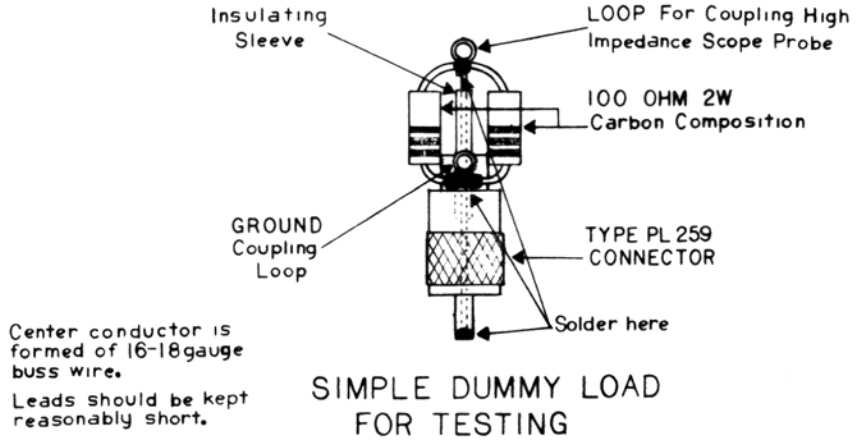


FIG. 5.1-4 SIMPLE DUMMY LOAD



cable will usually upset the circuit. The necessity of using 10X probes to reduce capacitive and resistive loading on the circuitry being tested, requires that the sensitivity of the counter be excellent. 10 millivolts R.M.S. is a satisfactory sensitivity specification for a citizens band servicing counter.

TABLE 5.1-1
RECOMMENDED TEST INSTRUMENTS

TEST INSTRUMENT	REQUIRED SPECIFICATIONS	USE	RECOMMENDED INSTRUMENT TYPE
R.F. Signal Generator	Output frequency: 26.965 to 27.255 MHz. Output level calibrated from .1 microvolts to 500,000 microvolts. Internal modulation capability of 30% minimum at 1 KHz. (Calibrated)	Receiver service and alignment.	Hewlett-Packard Model 606A or B. Wavetek Model 3000.
Oscilloscope	Vertical bandwidth of 25 MHz or greater at 3db point. Triggered sweep capability.	Transmitter and receiver test and alignment.	Tektronics Model T932. Tektronics Model 465. Hewlett-Packard Model 180. Phillips Model PM3260E.
Frequency Counter	Frequency range DC to 30 MHz. Sensitivity: 10mv R.M.S. at 30 MHz. Overall timebase accuracy ±.002%, 6 digit resolution.	Transmitter frequency check and synthesizer troubleshooting.	Heath-Schlumburger Model SM118A
Wattmeter	5 watts full scale into 50 ohm load ±5% accuracy.	Measure power output and S.W.R.	Bird Model 43 with type 5A element. (May be terminated with antenna load described in Figure 5-1-4.)
AC VTVM	-40 to +20db range.	Measure audio output.	Heath Model IM-21.
Audio Oscillator	400 Hz to 4000 Hz output: Adjustable level, 0-1 volt output impedence 600 ohm.	Audio and modulator tests.	Hewlett-Packard Model 204C. Heath Model SG18A.
DC Power Supply	13.8 volt DC ±10% at 2 amperes.	Primary supply voltage for servicing.	Heath Model SP2720 (SBE Model SBE-1AC may be used if available.)
Audio Test Box	8 ohm speaker and resistive load with switching provisions.	Receiver tests and alignment.	Refer to Figure 5.1-2 for fabrication details.
Modulator Test Box	16db 600 ohm pad (switchable), plus keying switch.	Transmitter and modulator checks.	Refer to Figure 5.1-3 for fabrication details.

5.2 PERFORMANCE VERIFICATION

RECEIVER

Step 1. Connect unit to 13.8 volt DC supply.

Step 2. Set generator frequency to 27.115 MHz with 30% modulation at 1 KHz. Connect the signal generator to the antenna jack of the transceiver.

Step 3. Set channel selector switch to channel 13, the DIS/LOC switch to distance position, CB/PA switch to CB position, noise limiter switch to NL position and delta tune to mid-position.

Step 4. Set signal generator output at 1 microvolt and verify 5 volts AC audio across external speaker jack using 8 ohm resistive load.

Step 5. Adjust the test equipment as in Step 4 above. Turn off the signal generator modulation and verify a 10db or greater reduction in audio output.

Step 6. Increase generator output to 100 microvolts. Check for "S" meter indication of approximately "S9".

Step 7. Observe meter lamp and channel selector lamp to insure that both are operational.

Step 8. Reset generator output to 1 microvolt. Rotate delta tune control to both extremes, verify a slight decrease in audio output and "S" meter reading at both extremes, return delta tune to center position.

Step 9. Increase signal generator output to 200 microvolts. Rotate squelch knob fully clockwise and verify full squelch of the receiver with an input of 200 microvolts (tight squelch may be adjusted with VR8).

Step 10. Decrease generator output to 1 microvolt, adjust squelch control to the point that the receiver is just muted. Increase signal generator output by ½ microvolt and verify that the squelch opens.

Step 11. Set CB/PA switch in the PA position. Connect an external speaker or 8 ohm load across PA jack and observe the audio output while speaking into the microphone.

TRANSMITTER

Step 1. Connect the unit to 13.8 volt DC supply. Set channel selector to channel 13, CB/PA switch to CB position. Connect standard microphone to the microphone input jack. Connect wattmeter and dummy load to antenna jack. Key the transmitter and check that the transmit lamp comes on. Observe an output of 3 watts or greater on the wattmeter. Observe a nominal internal R.F.O. meter reading of approximately 2/3 scale. (R.F.O. may be adjusted by VR6.)

Step 2. Whistle into microphone with transmitter keyed and verify that 80% positive and 90% negative modulation capability is obtained.

Step 3. Connect counter through 10X probe to wattmeter load and check the transmit frequencies on all channels.

SYNTHESIZER

Step 1. Check the voltage at the emitter of Q18. If high, (approximately 3 volts) go to section 5.3. If low, (less than .5 volts) go to step 2.

Step 2. Check wave-form at the collector of Q23 (refer to wave-form no. 9 on the synthesizer schematic.) If wave-form is not present or is substantially reduced in amplitude, go to section 5.3. If wave-form appears normal, go to step 3.

Step 3. Monitor the output frequency of the synthesizer at the collector of Q23 (coupled to the counter with the 10X oscilloscope probe) in both transmit and receive modes. Check to see that the output frequency on each channel agrees with the frequencies listed in the programming chart (figure 5.2 1). If the output frequencies are wrong in either mode, on any channel, refer to section 5.3.

If the three above tests are passed by the synthesizer, it may be assumed that any problems in the receiver or transmitter are limited to failures external to the synthesizer. Refer to section 5.4 for receiver problems, section 5.5 for transmitter problems.

FIG. 5-2.1 PROGRAMMING CHART

		BINARY PRESET (5 Least Significant Digits Only)						
V.C.O. Frequency		I.C. 2	I.C. 1				Channel	
Transmit MHz	Receive MHz	Pin 3	Pin 6	Pin 5	Pin 4	Pin 3	No.	Frequency
16.727	16.270	1	1	1	1	0	1	26.965
16.737	16.280	1	1	1	0	1	2	26.975
16.747	16.290	1	1	1	0	0	3	26.985
16.767	16.310	1	1	0	1	0	4	27.005
16.777	16.320	1	1	0	0	1	5	27.015
16.787	16.330	1	1	0	0	0	6	27.025
16.797	16.340	1	0	1	1	1	7	27.035
16.817	16.360	1	0	1	0	1	8	27.055
16.827	16.370	1	0	1	0	0	9	27.065
16.837	16.380	1	0	0	1	1	10	27.075
16.847	16.390	1	0	0	1	0	11	27.085
16.867	16.410	1	0	0	0	0	12	27.105
16.877	16.420	0	1	1	1	1	13	27.115
16.887	16.430	0	1	1	1	0	14	27.125
16.897	16.440	0	1	1	0	1	15	27.135
16.917	16.460	0	1	0	1	1	16	27.155
16.927	16.470	0	1	0	1	0	17	27.165
16.937	16.480	0	1	0	0	1	18	27.175
16.947	16.490	0	1	0	0	0	19	27.185
16.967	16.510	0	0	1	1	0	20	27.205
16.977	16.520	0	0	1	0	1	21	27.215
16.987	16.530	0	0	1	0	0	22	27.225
17.017	16.560	0	0	0	0	1	23	27.255

5.3 SYNTHESIZER SERVICING

Three basic forms of defect occur in the digital synthesizer of the Formula D.

1. LOSS OF PHASE LOCK

Under these conditions, the voltage controlled oscillator, Q21, is no longer under control of the phase lock loop system. There are several possible causes for this. A break anywhere in the loop, causing a loss of one of the inputs to the phase detector, a defect in the oscillator control circuitry including I.C. 9, Q20 and associated circuitry, (this of course, is also a break in the loop, in effect), a division ratio so far from correct in one of the divider chains that it is not possible for the oscillator to pull far enough in frequency to phase lock under these conditions.

A quick test to determine whether or not the V.C.O. will operate at the correct frequency, is to clamp test point 3 with a variable power supply voltage. By varying this voltage, in the area of 1-4 volts, it should be possible to obtain the full range of normal oscillator frequencies. With the voltage at approximately 2.5 volts, it should be possible to tune L14 for an oscillator frequency of approximately 16.5 MHz. If this is not true, it may be assumed that D26 or one of the other associated frequency determining components is defective, including C509, C511 and C510.

If phase lock is lost, or if the unit is operated with the channel selector in the blank position, the "out of lock disabler" circuit will become active. This circuit is a handy reference to determine if the synthesizer is in phase lock. If the circuit is working normally, the emitter of Q18 will be pulled up to approximately 2½ to 3 volts whenever phase lock is lost.

2. NO OUTPUT OR LOW OUTPUT

The general symptom is insufficient or nonexistent output at the collector of Q23. This is the easiest and most conventional fix. It is simply a question of checking the oscillator and its two buffers to determine where the defective component may be. The oscillator may be treated as a conventional L.C. oscillator, and the two buffers as common emitter amplifiers.

3. WRONG DIVISION RATIO

The third group of possible defects is when the oscillator frequency is wrong but phase locking is obtained. In this case, generally the error in frequency will be some multiple of 10 KHz, 20 KHz, 40 KHz, 80 KHz or 160 KHz. Reference to the programming defects chart will help to isolate problems in the programming (channel selector) switch. If the pattern of defects is the same as that specified in one of the conditions on the chart, you may safely assume that either the switch section noted, the pull-up resistor noted, or the I.C. involved, is defective. Although problems of this nature are generally found in the programmable divider, occasionally defects causing a wrong frequency output will be found in the reference divider. Defects in the reference divider circuit may be easily isolated by comparing the input and output frequencies of the various I.C.'s with those specified on the synthesizer circuit diagram. PLEASE NOTE: The use of a sensitive counter and a 10X 10 megohm input oscilloscope probe is recommended to avoid loading the inputs and outputs, which may cause erroneous readings.

On occasion, internal defects in I.C. 9 may result in excessively wide output pulses at either pin 2 or pin 13 of I.C. 9. Under these conditions, the synthesizer will appear to operate normally and oscillator frequency will be normal, however, the "out of lock disabler" circuit will be active. It is normal for the output pulses at pins 2 and 13 of I.C. 9 to be negative going and of very short duration when the synthesizer is in phase lock. If, however, one of these pulses should, due to a defect internal to I.C. 9, become excessively wide, this will cause the out of lock detector, D25, to detect sufficient average negative voltage to cause Q19 to be turned off, which will allow the gating circuits to turn on Q18 and disable the transmit and receive mixers. This defect can also be caused by internal problems in I.C.

8, therefore it's recommended that when the disabler circuit appears to be operating without cause, the following procedures should be followed: First, one lead of C502 should be removed, if this allows the disabler circuit to turn off and the transmitter and receiver to operate normally, with phase lock being maintained, probably either I.C. 8 or I.C. 9 is defective. The simplest approach is to replace I.C. 8. If this does not solve the problem, then replacing I.C. 9 should do so.

A condition where the transmit or receive frequency of the synthesizer is off by 460 KHz will sometimes occur in the synthesizer. This can generally be narrowed down to either an open D13, an open R530 or a defective I.C. 4. The voltage at pin 10 of I.C. 4 should be approximately 7/10 of a volt in the transmit mode and approximately 4 volts in the receive mode. If these conditions are present and yet the frequency is still off by 460 KHz in one mode or in the other, I.C. 4 can be assumed to be defective.

Locating a defect in the programmable divider which results in an incorrect division frequency, should consist of the following procedure: First, the programming defects chart should be compared with the actual frequency differential present to determine if the defects on the programming input lines may be the problem.

The next step is to assess whether the division ratio defect is present both on transmit and receive or is present only in one of the two modes. Defects present in only one of the two modes will almost always be due to D13, R530 or I.C. 4. In rare cases, a defect in the binary outputs of one of the counters (Q_0 through Q_3) can also cause this effect, however, the above mentioned components should always be checked or replaced first.

Generally, defects in I.C. 1 will account for 10 KHz to 80 KHz errors in divider output. Defects in the programming inputs to I.C. 2 or 3 or internal defects in I.C. 2 or 3 will almost always cause a loss of phase lock due to a very large change in the total division ratio, resulting in a desired oscillator frequency far beyond the capability of the oscillator.

A simple way to determine the approximate division ratio is to note the oscillator frequency. (The oscillator frequency may be set to some convenient value by grounding test point 3 and adjusting L14 to a suitable frequency or driving test point 3 with a variable 1-4 volt power supply output to set it to approximately the correct frequency.) After this is done, the output frequency of the divider may be measured and the approximate division ratio determined. The scale of the error in division will indicate which chip is likely to be causing the problem. Small errors are usually the result of defects in I.C. 1, larger errors in I.C. 2, and extremely large errors in I.C. 3.

The division ratio of I.C. 3 is unchanging at 7 to 1, therefore, when the output of the divider circuit is 10 KHz, the input to I.C. 3 is always 70 KHz.

NOTE: Division ratio equals input frequency divided by output frequency, for example: channel 13 receive division ratio is 1,642.

$$\frac{16{,}420\ \text{KHz}}{10\ \text{KHz}} = 1{,}642$$

4. T.T.L. LOGIC LEVELS

The microcircuits used in the programmable divider of the SBE-26CB utilize a form of logic circuitry known as T.T.L. (an acronym for Transistor-Transistor Logic). In general, T.T.L. circuitry is direct coupled. This means that DC levels as well as AC voltage swings are important in determining whether or not an input or output of a T.T.L. gate is satisfactory. All T.T.L. logic is designed with standard compatible inputs and outputs so that gates may be interconnected without external interface devices.

The operational states of an input or output in a T.T.L. system, operating normally, have two possible conditions. The first of these is "logical zero", "low" or simply "zero". In standard T.T.L. logic this is defined as an input or output gate having a voltage less than +.8 volts relative to ground. In other words, when an output of one T.T.L. gate drives another gate to less than .8 volts relative to ground, you can be sure that the input gate recognizes the signal as a logical zero or low input. Conversely, a "logical one", "high" or simply "one" is defined as a voltage on any input or output greater than +2 volts relative to ground. In other words, whenever an input is driven to greater than 2 volts relative to ground, it will always recognize this as the logical one state.

The above specifications for the two logic states are "worst case" conditions. This merely means that under the worst possible conditions of external noise, tolerances in power supply voltage and extremes of temperature (within ratings), any input gate will always recognize inputs meeting the above specifications.

Therefore, under optimum operating conditions (25°C temperature, exactly 5 volts supply voltage and no problems with external noise) these limits for logical zero and logical one can usually be exceeded somewhat. Generally, one can expect a T.T.L. gate to recognize anything from about 1.1 volts or lower as a logical zero and anything from about 1.6 volts or higher as a logical one. Of course, it is generally preferable to stay within the worst case conditions for input voltages to insure that the best possible performance under all operating conditions can be met.

From the above it can be seen that the most important point to assess when determining if a drive signal to a T.T.L. gate is satisfactory, is to determine whether the positive and negative peaks of the drive signal are driving the gate input to sufficiently high and low levels, to meet worst case conditions.

Occasionally, if drive is marginal to a T.T.L. gate, for instance if the drive from Q25 to the programmable divider chain is marginal, operation may be normal while the unit is cool and abnormal after the temperature rises due to normal heating of the transceiver in operation. Again, under these marginal conditions, a variation in supply voltage within normal specifications may result in improper operation under certain conditions when T.T.L. drive levels are only being marginally met.

It is important to realize that many symptoms that may appear to be intermittent due to a loose connection or an otherwise mechanically induced malfunction, may in fact be due to marginal drive to the divider circuitry, resulting in intermittent operation.

LOSS OF PHASE LOCK

1. Check for 5 volts ±10% at the emitter of Q26.	Voltage OK: Go to Step 2. Wrong voltage: D27, Q26, C528 or R529 defective or excessive loading on 5 volt line. (Disconnect loads in turn and check for shorts.)
2. Check the wave-form at the collector of Q24.	Normal wave-form: Go to Step 4. Abnormal wave-form: Go to Step 3.
3. Check the wave-form at the emitter of Q9 (Reference Oscillator).	Normal wave-form: Q24 or associated circuitry defective, or excessive loading from I.C. 5. Abnormal wave-form: Q9 or associated circuitry defective.
4. Check the wave-form at the emitter of Q21.	Normal wave-form: Go to Step 5. Q21 oscillator circuit including D26, L14, C509, R508, etc.
5. Check the wave-form at the emitter of Q25.	Abnormal wave-form: Q25 or associated components defective or excessive loading from I.C. 1, 2 or 3. NOTE: Excessive loading from the I.C.'s may be checked by carefully de-soldering pin 2 of each I.C. in turn, thus removing the loading.
6. Check the wave-form at pin 1 of I.C. 9.	Wave-form greatly distorted or not present: Defect in I.C.'s 5-8. Locate individual I.C. at fault by measuring input and output wave-forms and frequencies of each I.C. in turn. (An I.C. with the correct input and wrong output may be assumed defective.)
7. Measure wave-form at pin 3 of I.C. 9.	Normal wave-form: Go to Step 8. Wave-form distorted or absent: I.C.'s 1-4 defective.
8. Clamp V.C.O. with +2.5 volts DC at TP-3. (Either a highly regulated supply or a battery should be used.) Adjust L14 for 17 MHz. Varying the clamp voltage between 2 and 3 volts should produce an oscillator frequency shift of more than 1 MHz.	No response or wrong frequency range: D26, Q21 or associated circuitry defective. Test OK: Problem is in I.C. 9, Q20 or associated circuitry.

PROGRAMMING DEFECT SYMPTOMS

PROGRAMMING DEFECT	CHANNELS AFFECTED	SYMPTOM
S_0 Stays Low	2, 5, 7, 8, 10, 13, 15, 16, 18, 21, 23	10 KHz High
S_0 Stays High	1, 3, 4, 6, 9, 11, 12, 14, 17, 19, 20, 22	10 KHz Low
S_1 Stays Low	1, 4, 7, 10, 11, 13, 14, 16, 17, 20	20 KHz High
S_1 Stays High	2, 3, 5, 6, 8, 9, 12, 15, 18, 19, 21, 22, 23	20 KHz Low
S_2 Stays Low	1, 2, 3, 7, 8, 9, 13, 14, 15, 20, 21, 22	40 KHz High
S_2 Stays High	4, 5, 6, 10, 11, 12, 16, 17, 18, 19, 23	40 KHz Low
S_3 Stays Low	1, 2, 3, 4, 5, 6, 13, 14, 15, 16, 17, 18, 19	80 KHz High
S_3 Stays High	7, 8, 9, 10, 11, 12, 20, 21, 22, 23	80 KHz Low
S_4 Stays Low	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12	160 KHz High
S_4 Stays High	13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23	160 KHz Low

Defects resulting in incorrect programming inputs to the first two integrated circuits of the programmable divider (I.C. 1, I.C. 2) will result in characteristic failure symptoms. The possible failures and their associated failure symptoms are charted above.

If the transmit and receive frequency is high or low by one of the amounts stated above on certain channels, check to see if the channels affected correlate with one of the groups shown on the chart above. A correlation between the symptom chart and the actual defect in the radio can, in this way, narrow down a failure to a specific section of the channel selector switch, its associated pull up resistor, and the I.C. to which it is connected.

5.4 RECEIVER SERVICING

Unless otherwise noted, the front panel controls should be set as follows: Set the LOC/DIS switch on the front panel to the distance position and adjust the volume control to maximum, clockwise, set the delta tune control to the center position, set the CB/PA switch in the CB position, set the noise limiter switch in the off position, turn the squelch control fully counterclockwise, set the channel selector on channel 13. Connect the transceiver to a 13.8 volt DC power supply.

No Receive

1. Connect the signal generator to the entenna jack. Inject a high level modulated signal at the channel frequency. (Approximately 10,000 microvolts.) Check for "S" meter deflection.

   "S" meter deflects: Go to Step 2.
   "S" meter does not deflect: Go to Step 8.

2. Check internal speaker by plugging in an external unit. Check for audio while the signal generator is set up as in Step 1.	If audio from the test speaker is normal, the internal speaker or R215 is open.
3. With the signal generator set up as in Step 1, check for audio at test point 4 (transmitter).	Good audio at test point 4 indicates a probable defective relay, CB/PA switch, external speaker jack or associated wiring. No audio at test point 4, go to Step 4.
4. Check the emitter voltage of Q14.	Approximately 2 volts, go to Step 5. If the result is approximately 3.2 volts, the problem is in the squelch circuit. (Refer to section 4.1, Squelch.)
5. Set the CB/PA switch to the PA position. Connect an external speaker to the P.A. jack, plug in the standard microphone. Key the microphone and determine if the P.A. system is working normally. NOTE: The microphone gain control should vary the output in the P.A. mode.	P.A. function OK. Probable receiver fault is in the detector A.N.L. or tone control circuit. Go to Step 6. No P.A. function. Problem is in audio amplifier chain. Go to Step 7.
6. Locate defect in the audio detector, A.N.L. or tone control circuit by signal tracing through the circuitry with the signal generator connected as in Step 1.	
7. Check for defect in audio amplifier chain by either signal tracing with an oscilloscope with the generator connected as in Step 1, monitoring the audio output while injecting audio from a test oscillator, or making DC tests and comparing voltages to those listed on the schematic.	Defect is probably Q14, Q15, Q16, Q17 or associated components.
8. Check receive bus at cathode of D5 (9 volts ±10%).	If voltage is low or zero, suspect shorted D5, C123 or C114. Open R701 or excessive bus loading. If 9 volt line is OK, go to Step 9.
9. Check the voltage at test point 1 with no signal. (Approximately .7 volts)	If voltage is zero, suspect open R107, shorted C126, or open Q1. If test point 1 voltage is normal, go to Step 2.

Weak Receive

NOTE: If any evidence of tampering with the unit is found, perform the alignment procedure as outlined in section 6.1.

1. Refer to receiver injection chart and isolate weak stage by injecting at detector and pro-

gressing back through the receiver chain to the front end.

NOTE: Although the synthesizer performance verification indicates normal output from the reference oscillator and synthesizer output buffer, injection to the mixers should be verified.

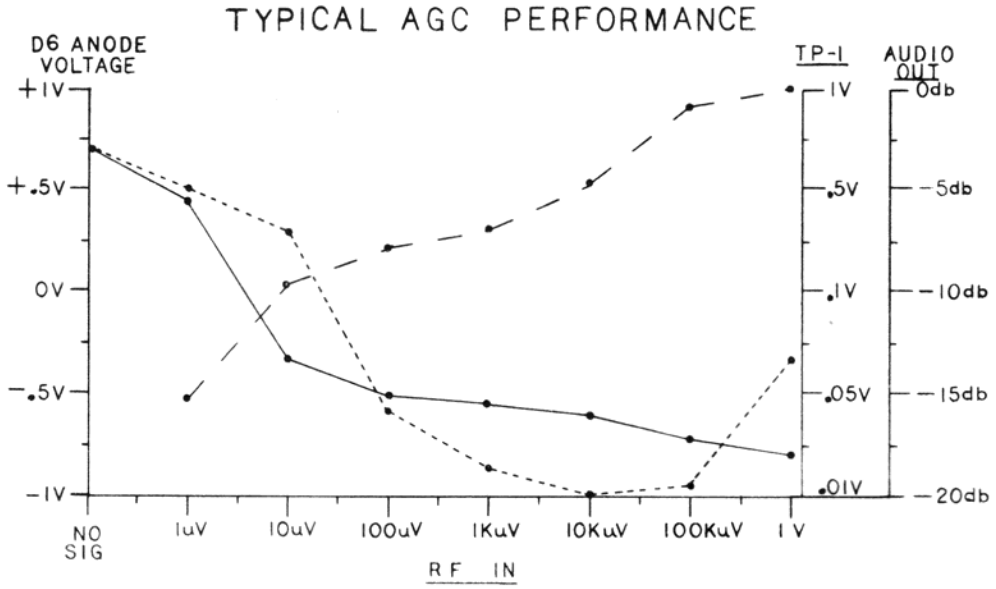
FIG. 5.4-1 RECEIVER INJECTION CHART

The following injection signals should produce approximately four volts audio output. All signals are modulated with 1 KHz @ 30% (audio output is terminated in 8 ohms).

Squelch is fully counter-clockwise, volume is at maximum, LOC/DIS switch is in distance position, and tone control is at mid-position.

INJECTION POINT	INJECTION LEVEL	FREQUENCY
Anode of D2	2 microvolts	Channel Frequency
Collector of Q1	60 microvolts	Channel Frequency
G_2 of Q2	40 microvolts	Channel Frequency
Drain of Q2	600 microvolts	10.695 MHz
TP2	100 microvolts	10.695 MHz
Base of Q3	40 microvolts	455 KHz
Collector of Q3	.01 volts	455 KHz
Base of Q4	700 microvolts	455 KHz
Collector of Q4	.7 volts	455 KHz
Anode of D9	1 volt	455 KHz

FIG. 5.4-2 AGC PERFORMANCE GRAPH



5.5 TRANSMITTER SERVICING

No Carrier

1. Check for relay action with keying.	If relay fails to pull in, check or replace microphone, check relay and associated circuitry.
2. Check for approximately 13 volts at test point 4.	13 volts missing, check D19 and T9 secondary for opens.
3. Perform synthesizer performance verification. (Section 5.2)	If synthesizer performance is verified as normal, continue with **Weak Carrier** section of the Transmitter Service Procedure.

Weak Carrier

NOTE: If there is any evidence of misalignment, perform the alignment procedure as outlined in Section 6.2 before continuing with this procedure.

1. Check DC voltages on Q5, Q6, Q7 and Q8 in the transmit mode.	If any voltages are substantially abnormal, make further checks in the stage involved.

2. Refer to the wave-form keys on the schematic. Check the transmitter wave-forms to isolate the defective stage.	Check Q5 through Q8.

NOTE: Tuned impedence matching networks couple R.F. between transmitter stages. Substantial "de-tuning" of one of these stages can result in very low or no output. Defects causing this effect can include shorts, opens or severe value changes in either the series or shunt reactances.

A wave-form with abnormally high peak to peak value often indicates a defect in the following stage or the intercoupling network.

Remember that low stage gain can also be caused by open bypass capacitors such as C405, C409 or C410.

A good method for discovering de-tuned, nonresonating coupling circuits, is to tune the associated coils through their normal range, if no "peak" is found, you may probably assume that the circuit is not resonating. Remember that "Q" of many of these stages is fairly low. Therefore, the peak may be rather broad, especially, in the output coupling network.

FIG. 6.1-1

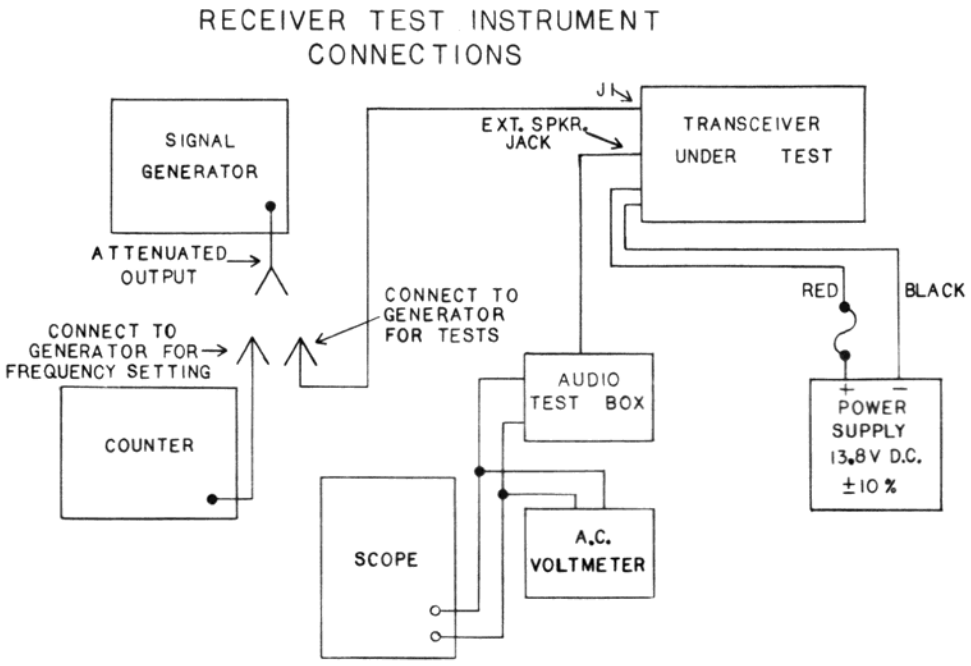
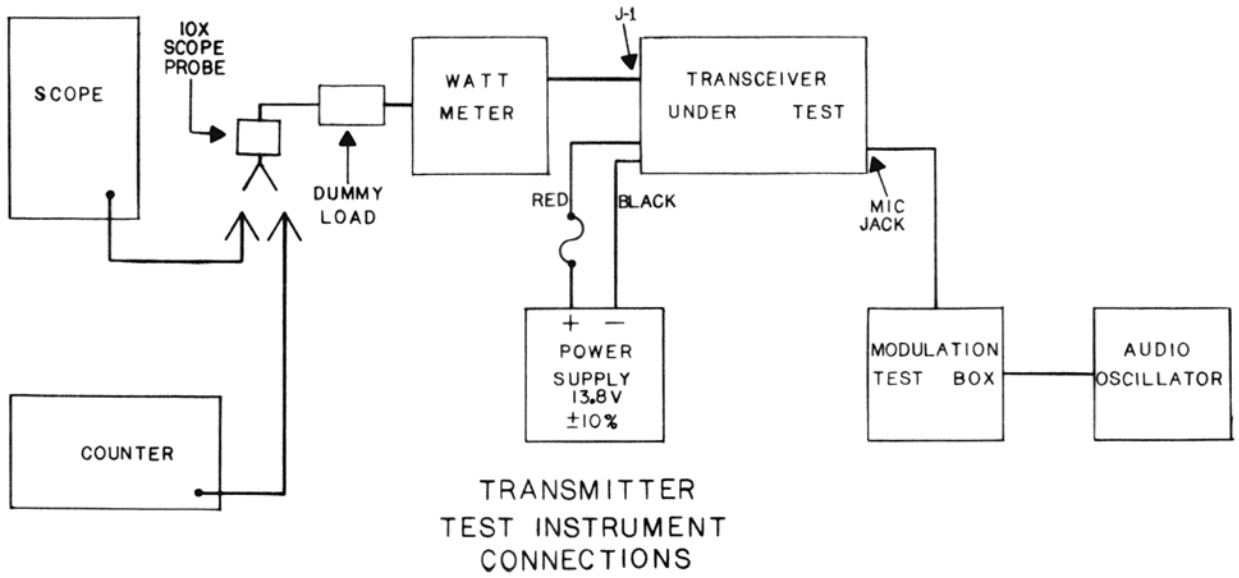


FIG. 6.2-1



SECTION 6
ALIGNMENT

RECEIVER ALIGNMENT PROCEDURE

INITIAL SET-UP

Connect the test equipment to the unit as shown in figure 6.1-1. Set the local-distance switch on the front panel to the distance position. Adjust the volume control to maximum, clock-wise. Set the delta tune control to the center position. Set the CB/PA switch in the CB position. Set the noise limiter switch in the off position. Turn the squelch control fully counter clock-wise. Set the channel selector on channel 13.

STEP 1

Set the output level of the signal generator to a level sufficient to provide 3 volts of audio as measured on the audio voltmeter. Adjust in turn the following: T1, L1, T2-1, T2-2, T3, T4, T5, and T6 for maximum indication on the voltmeter. If at any time during the alignment procedure the audio level increases to more than 5 volts, reduce the generator output level to result in an audio output level of 3 volts.

STEP 2

Repeat the above procedure until a nominal 5 volts or more is available at the audio output with an input of 1 microvolt.

STEP 3

Adjust the audio output level with the volume control to result in a reading of 0db on the voltmeter. Adjust the slug of T1 counter-clockwise for a reduction of 1db in audio output. Remove the generator input from J1. Adjust the volume control to obtain a useable reading of the background noise level. On the voltmeter, switch the channel selector to channel 1 and note the noise level. Switch to channel 23. The noise level should be within 2db of the channel 1 reading. If the difference between 1 and 23 is greater than 2db, adjust L2, slightly to reduce the differential.

STEP 4

Set the generator output to 100 microvolts. Adjust VR7 for a reading of "9".

STEP 5

Rotate squelch control fully clockwise. Increase generator output to 300 microvolts. Squelch should break. If squelch fails to break, adjust VR8 to break squelch at 300 microvolts.

FIG. 6-1 ALIGNMENT LAYOUT

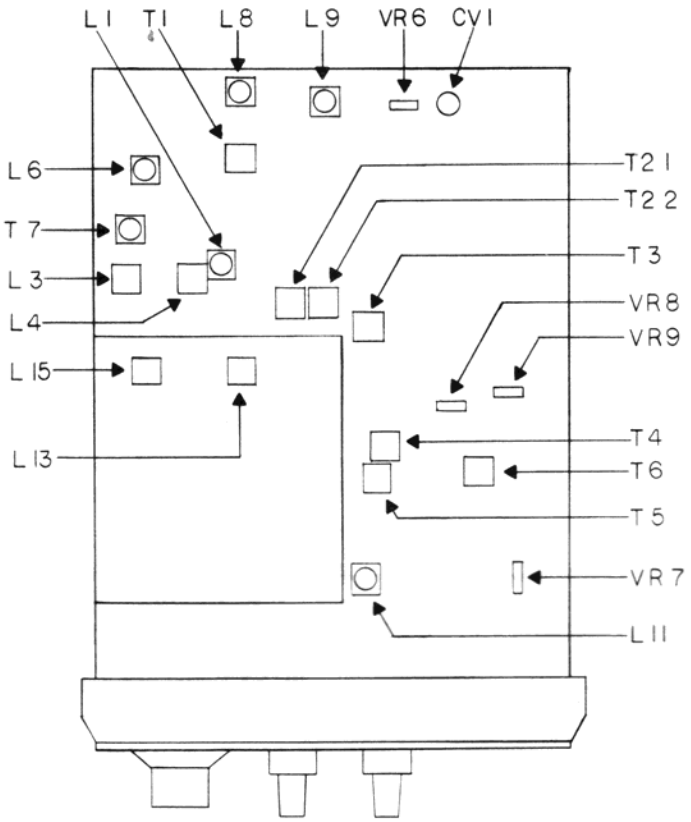
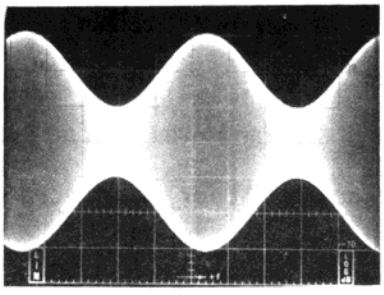
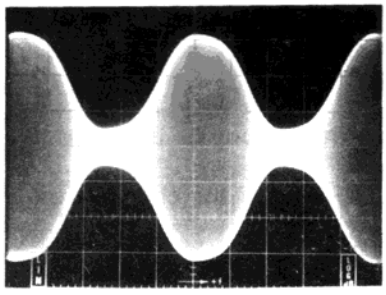


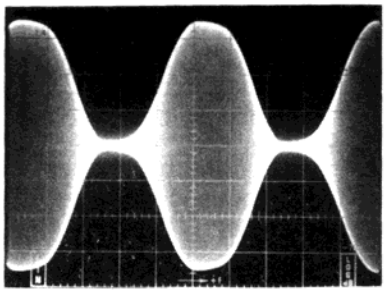
FIG. 6.2-2 TRANSMITTER ALIGNMENT WAVEFORMS



50% MODULATION



80% POSITIVE AND NEGATIVE MODULATION (SLIGHT DISTORTION ON PEAKS, AS IN STEP 2)



80% POSITIVE, 90% NEGATIVE MODULATION

TRANSMITTER ALIGNMENT PROCEDURE

INITIAL SET-UP

Connect the test equipment to the unit as shown in figure 6.2-1. Set the delta tune control to the center position. Set the CB/PA switch in the CB position. Set the channel selector to channel 13.

STEP 1

With no modulation, key the transmitter and adjust coils and transformers L3, L4, T7, L6, L8, L9 and L13 for maximum power output.

STEP 2

With the transmitter keyed, observe the output envelope on the oscilloscope. Turn on the audio oscillator and set its output frequency to 1 KHz. Increase oscillator output while observing the modulation envelope on the oscilloscope. Set the audio oscillator output to a level that results in slight distortion of the positive peaks of the modulation, (see figure 6.2-2).

STEP 3

Adjust L6 counterclockwise until approximately 90-95% negative modulation is seen on the oscilloscope wave-form, (see figure 6.2-2).

MODULATION LIMITER

Switch the modulation test box to the 16db attenuation position and adjust the output of the audio oscillator for 50% modulation, (see figure 6.2-2). Switch the modulation test box to the zero attenuation position and adjust VR9 for 100% negative modulation.

R.F.O. METER

The R.F.O. meter indication is relative. It should be adjusted to approximately 2/3 scale with VR6.

OUTPUT FREQUENCY

Connect the frequency counter to the output of the transceiver. Key the transmitter with no modulation and note the frequency.
If the frequency is more than 500 Hz from the channel frequency, adjust L11 for the correct channel frequency.

SECOND HARMONIC TRAP

This trap is adjusted at the Factory. Its intent is to reduce the second harmonic of the transmitted signal.

CAUTION: Do not tamper with this adjustment unless there is some question of T.V. interference, if so, proceed as follows.

Turn on a nearby T.V. set and set it to channel 2. Key the transmitter and adjust CV1 for minimum interference on the television receiver.

SECTION 7
SBE - 26 CB FORMULA D PARTS LIST

SYMBOL NO.	PART NO.	DESCRIPTION
C101	8000-00004-016	Capacitor, 20 pfd, Mica
C102	8000-00004-007	Capacitor, 10pfd, Mica
C103	8000-00004-001	Capacitor, 0.01mfd, Cer.
C104	8000-00004-001	Capacitor, 0.01mfd, Cer.
C105	8000-00004-001	Capacitor, 0.01mfd, Cer.
C106	8000-00004-001	Capacitor, 0.01mfd, Cer.
C107	8000-00012-011	Capacitor, 30pfd, N330, Cer.
C108	8000-00004-001	Capacitor, 0.01mfd, Cer.
C109	8000-00004-021	Capacitor, 47pfd, Mica
C110	8000-00011-008	Capacitor, 10pfd, Mica
C111	8000-00004-001	Capacitor, 0.01mfd, Cer.
C112	8000-00004-001	Capacitor, 0.01mfd, Cer.
C113	8000-00011-012	Capacitor, 1pfd, Mica
C114	8000-00004-003	Capacitor, 0.04mfd, Mylar
C115	8000-00004-041	Capacitor, 150pfd, Mica
C116	8000-00011-012	Capacitor, 1pfd, Mica
C117	8000-00004-003	Capacitor, 0.04mfd, Mylar
C118	8000-00004-003	Capacitor, 0.04mfd, Mylar
C119	8000-00004-007	Capacitor, 10pfd, Mica
C120	8000-00038-015	Capacitor, 4.7mfd, 25V, Elect.
C121	8000-00004-018	Capacitor, 0.1mfd, Mylar
C122	8000-00004-003	Capacitor, 0.04mfd, Mylar
C123	8000-00004-044	Capacitor, 220mfd, 16V, Elect.
C124	8000-00004-001	Capacitor, 0.01mfd, Cer.
C125	8000-00004-003	Capacitor, 0.04mfd, Mylar
C126	8000-00038-015	Capacitor, 4.7mfd, 25V, Elect.
C127	8000-00004-018	Capacitor, 0.1mfd, Mylar
C128	8000-00004-011	Capacitor, 0.001mfd, Cer.
C129	8000-00004-011	Capacitor, 0.001mfd, Cer.
C130	8000-00004-011	Capacitor, 0.001mfd, Cer.
C131	8000-00004-203	Capacitor, 0.02mfd, Mylar
C132	8000-00004-045	Capacitor, 0.22mfd, Elect.
C201	8000-00006-072	Capacitor, 0.047mfd, Mylar
C202	8000-00006-072	Capacitor, 0.047mfd, Mylar
C203	8000-00038-015	Capacitor, 4.7mfd, 25V, Elect.
C204	8000-00004-011	Capacitor, 0.001mfd, Cer.
C205	8000-00004-001	Capacitor, 0.01mfd, Cer.
C206	8000-00004-009	Capacitor, 47mfd, 16V, Elect.
C207	8000-00024-087	Capacitor, 1mfd, 50V, Elect.
C208	8000-00004-018	Capacitor, 0.1mfd, Mylar
C209	8000-00004-044	Capacitor, 220mfd, 16V, Elect.
C210	8000-00011-007	Capacitor, 0.005mfd, Mylar
C211	8000-00011-007	Capacitor, 0.005mfd, Mylar
C212	8000-00004-001	Capacitor, 0.01mfd, Cer.
C213	8000-00024-087	Capacitor, 1mfd, 50V, Elect.
C214	8000-00004-009	Capacitor, 47mfd, 16V, Elect.

SYMBOL NO.	PART NO.	DESCRIPTION
C215	8000-00004-001	Capacitor, 0.01mfd, Cer.
C216	8000-00004-001	Capacitor, 0.01mfd,Cer.
C217	8000-00004-045	Capacitor, 0.22mfd, Elect.
C218	8000-00004-047	Capacitor, 10mfd, 16V, Elect.
C219	8000-00004-001	Capacitor, 0.01mfd, Cer.
C220	8000-00004-001	Capacitor, 0.01mfd, Cer.
C301	8000-00004-011	Capacitor, 0.001mfd, Cer.
C302	8000-00004-001	Capacitor, 0.01mfd, Cer.
C303	8000-00024-087	Capacitor, 1mfd, 50V, Elect.
C304	8000-00024-087	Capacitor, 1mfd, 50V, Elect.
C305	8000-00004-047	Capacitor, 10mfd, 16V, Elect.
C401	8000-00004-002	Capacitor, 15pfd, Mica
C402	8000-00004-021	Capacitor, 47pfd, Mica
C403	8000-00004-283	Capacitor, 78pfd, Mica
C404	8000-00004-001	Capacitor, 0.01mfd, Cer.
C405	8000-00004-001	Capacitor, 0.01mfd, Cer.
C406	8000-00004-024	Capacitor, 30pfd, Mica
C407	8000-00004-017	Capacitor, 500pfd, Mica
C408	8000-00004-026	Capacitor, 40pfd, Mica
C409	8000-00004-001	Capacitor, 0.01mfd, Cer.
C410	8000-00004-001	Capacitor, 0.01mfd, Cer.
C411	8000-00038-012	Capacitor, 130pfd, Mica
C412	Not Used	
C413	8000-00004-001	Capacitor, 0.01mfd, Cer.
C414	8000-00004-006	Capacitor, 24pfd, Mica
C415	8000-00004-020	Capacitor, 100pfd, Mica
C416	8000-00004-001	Capacitor, 0.01mfd, Cer.
C417	8000-00004-021	Capacitor, 47pfd, Mica
C418	8000-00004-001	Capacitor, 0.01mfd, Cer.
C419	8000-00004-027	Capacitor, 220pfd, Mica
C420	8000-00038-013	Capacitor, 160pfd, Mica
C421	8000-00011-012	Capacitor, 1pfd, Mica
C501	8000-00004-203	Capacitor, 0.02mfd, Mylar
C502	8000-00004-011	Capacitor, 0.001mfd, Cer.
C503	8000-00004-001	Capacitor, 0.01mfd, Cer.
C504	8000-00006-072	Capacitor, 0.047mfd, Mylar
C505	8000-00004-045	Capacitor, 0.22mfd, Elect.
C506	8000-00004-203	Capacitor, 0.02mfd, Mylar
C507	8000-00004-042	Capacitor, 1.0mfd, Elect.
C508	8000-00004-001	Capacitor, 0.01mfd, Cer.
C509	8000-00030-006	Capacitor, 20pfd, N750, Cer.
C510	8000-00004-020	Capacitor, 100pfd, Mica
C511	8000-00038-014	Capacitor, 47pfd, N470, Cer.
C512	8000-00011-008	Capacitor, 5pfd, Mica
C513	8000-00004-001	Capacitor, 0.01mfd, Cer.
C514	8000-00011-008	Capacitor, 5pfd, Mica
C515	8000-00004-020	Capacitor, 100pfd, Mica
C516	8000-00004-001	Capacitor, 0.01mfd, Cer.
C517	8000-00004-001	Capacitor, 0.01mfd, Cer.
C518	8000-00004-001	Capacitor, 0.01mfd, Cer.
C519	8000-00004-001	Capacitor, 0.01mfd, Cer.
C520	8000-00004-001	Capacitor, 0.01mfd, Cer.
C521	8000-00004-021	Capacitor, 47pfd, Mica
C522	8000-00004-001	Capacitor, 0.01mfd, Cer.

SYMBOL NO.	PART NO.	DESCRIPTION
C523	8000-00004-001	Capacitor, 0.01mfd, Cer.
C524	8000-00004-003	Capacitor, 0.04mfd, Mylar
C525	8000-00004-003	Capacitor, 0.04mfd, Mylar
C526	8000-00004-024	Capacitor, 30pfd, Mica
C527	8000-00032-003	Capacitor, 470mfd, 16V, Elect.
C528	8000-00004-046	Capacitor, 100mfd, 16V, Elect.
C529	8000-00004-044	Capacitor, 220mfd, 16V, Elect.
C530	8000-00004-001	Capacitor, 0.01mfd, Cer.
C531	8000-00004-001	Capacitor, 0.01mfd, Cer.
C532	8000-00004-003	Capacitor, 0.04mfd, Mylar
C534	8000-00004-011	Capacitor, 0.001mfd, Cer.
C535	8000-00004-001	Capacitor, 0.01mfd, Cer.
C536	8000-00004-001	Capacitor, 0.01mfd, Cer.
C537	8000-00004-003	Capacitor, .04mfd, Mylar
C601	8000-00004-041	Capacitor, 150pfd, Mica
C602	8000-00006-061	Capacitor, 330pfd, Mica
C603	8000-00004-003	Capacitor, 0.04mfd, Mylar
C604	8000-00004-041	Capacitor, 150pfd, Mica
C605	8000-00004-002	Capacitor, 15pfd, Mica
C701	8000-00004-049	Capacitor, 1000mfd, 16V, Elect.
C702	8000-00004-048	Capacitor, 0.001mfd, Feed Thru
C703	8000-00004-018	Capacitor, 0.1mfd, Mylar
C704	8000-00004-003	Capacitor, 0.04mfd, Mylar
C705	Not Used	
C706	8000-00004-001	Capacitor, 0.01mfd, Cer.
C707	8000-00004-003	Capacitor, 0.04mfd, Mylar
C708	8000-00004-001	Capacitor, 0.01mfd, Cer.
C709	8000-00004-001	Capacitor, 0.01mfd, Cer.
C801	8000-00011-008	Capacitor, 5pfd, Mica
C802	8000-00024-087	Capacitor, 1mfd, 50V, Elect.
C803	8000-00024-087	Capacitor, 1mfd, 50V, Elect.
C901	8000-00004-001	Capacitor, 0.01mfd, Cer.
C902	8000-00004-018	Capacitor, 0.1mfd, Mylar
C903	8000-00011-002	Capacitor, 2.2mfd, 16V, Elect.
C904	8000-00011-002	Capacitor, 2.2mfd, 16V, Elect.
C905	8000-00004-001	Capacitor, 0.01mfd, Cer.
C906	8000-00004-001	Capacitor, 0.01mfd, Cer.
CV-1	8000-00004-204	Capacitor, Var., 10pfd, Trimmer, Cer.
D1	8000-00038-008	Diode, WG713
D2	8000-00038-008	Diode, WG713
D3	8000-00011-046	Diode, 1S1007S
D4	8000-00038-009	Diode, 1N60FM
D5	8000-00011-043	Diode, BZ090
D6	8000-00038-009	Diode, 1N60FM
D7	8000-00038-008	Diode, WG713
D8	8000-00038-009	Diode, 1N60FM
D9	8000-00038-009	Diode, 1N60FM
D10	8000-00004-064	Diode, 1S84
D11	8000-00038-009	Diode, 1N60FM
D12	8000-00038-009	Diode, 1N60FM

SYMBOL NO.	PART NO.	DESCRIPTION
D13	8000-00038-008	Diode, WG713
D14	8000-00004-248	Diode, 1S352M
D15	8000-00038-009	Diode, 1N60FM
D16	8000-00038-009	Diode, 1N60FM
D17	8000-00004-060	Diode, 1N34A
D18	8000-00011-045	Diode, 1S1211
D19	8000-00030-010	Diode, 1N4002
D20	8000-00011-043	Diode, BZ090
D21	8000-00038-008	Diode, WG713
D22	8000-00030-010	Diode, 1N4002
D23	8000-00038-008	Diode, WG713
D24	8000-00038-008	Diode, WG713
D25	8000-00038-008	Diode, WG713
D26	8000-00038-010	Diode, MV201
D27	8000-00004-239	Diode, 1S331
D901	8000-00038-009	Diode, 1N60 FM
D902	8000-00038-009	Diode, 1N60 FM
FIL-1	8000-00004-139	Ceramic Filter, LFB-6, 455 KHz
IC1	8000-00038-003	Integrated Circuit, F9316PC
IC2	8000-00038-003	Integrated Circuit, F9316PC
IC3	8000-00038-003	Integrated Circuit, F9316PC
IC4	8000-00038-005	Integrated Circuit, 74H22/9H22
IC5	8000-00038-006	Integrated Circuit, 7493/9393
IC6	8000-00038-006	Integrated Circuit, 7493/9393
IC7	8000-00038-007	Integrated Circuit, F7474PC
IC8	8000-00038-004	Integrated Circuit, 7400/9N00
IC9	8000-00038-002	Integrated Circuit, MC 4044P
J1	8000-00004-069	Connector, Ant., SO-239
J2	8000-00030-021	Jack, External Speaker
J3	8000-00030-021	Jack, PA
J4	8000-00004-070	Jack, Microphone
L1	8000-00038-016	Coil, 508SB1
L2	8000-00004-054	Choke Coil, 3.3uh
L3	8000-00038-017	Coil, C354N
L4	8000-00038-017	Coil, C354N
L5	8000-00030-011	Choke Coil, RF, 2.5uh
L6	8000-00004-078	Coil, C046ZD
L7	8000-00004-055	Choke HF, 0.65uh
L8	8000-00004-077	Coil, C045ZD
L9	8000-00004-077	Coil, C045ZD
L10	8000-00004-059	Choke Coil, 0.85uh
L11	8000-00038-022	Coil, Z353ZZ
L12	8000-00004-057	Choke Coil, 150uh
L13	8000-00038-017	Coil, C354N
L14	8000-00038-023	Coil, Z355N
L15	8000-00030-012	Transformer, K-10
M1	8000-00030-029	Meter, A-36

SYMBOL NO.	PART NO.	DESCRIPTION
PL1	8000-00004-142	Lamp, 16V, 40ma
PL2	8000-00004-142	Lamp, 16V, 40ma
PL3	8000-00011-056	Lamp, 14V, 75ma
Q1	8000-00011-047	Transistor, 2SC710C
Q2	8000-00011-053	Transistor, 3SK45L
Q3	8000-00011-047	Transistor, 2SC710C
Q4	8000-00011-047	Transistor, 2SC710C
Q5	8000-00011-053	Transistor, 3SK45L
Q6	8000-00011-047	Transistor, 2SC710C
Q7	8000-00006-278	Transistor, 2SC495T
Q8	8000-00038-001	Transistor, 2SC1306
Q9	8000-00011-047	Transistor, 2SC710C
Q10	8000-00030-007	Transistor, 2SC403C
Q11	8000-00030-007	Transistor, 2SC403C
Q12	8000-00030-007	Transistor, 2SC403C
Q13	8000-00030-007	Transistor, 2SC403C
Q14	8000-00030-009	Transistor, 2SD187R or Y
Q15	8000-00030-007	Transistor, 2SC403C
Q16	8000-00004-087	Transistor, 2SC1014C1
Q17	8000-00004-087	Transistor, 2SC1014C1
Q18	8000-00030-007	Transistor, 2SC403C
Q19	8000-00010-017	Transistor, 2SK30GR
Q20	8000-00011-049	Transistor, 2SC458LGD
Q21	8000-00011-047	Transistor, 2SC710C
Q22	8000-00011-047	Transistor, 2SC710C
Q23	8000-00011-047	Transistor, 2SC710C
Q24	8000-00011-047	Transistor, 2SC710C
Q25	8000-00011-047	Transistor, 2SC710C
Q26	8000-00011-050	Transistor, 2SC1061C
Q901	8000-00011-047	Transistor, 2SC710C
Q902	8000-00011-047	Transistor, 2SC710C
R214	8000-00004-091	Resistor, Fixed, 1 ohm, 1 watt, Oxide Film
RL1	8000-00030-022	Relay, HTC-12VDC
S1	8000-00038-032	Switch, Slide, D.P.D.T.
S2	8000-00038-032	Switch, Slide, D.P.D.T.
S3	8000-00038-032	Switch, Slide, D.P.D.T.
S4	Part of VR-1	
S5	8000-00038-044	Switch, Rotary, 24 Pos.
SP1	8000-00038-036	Speaker, 8 ohm
T1	8000-00038-018	Transformer, C294DD
T2-1	8000-00038-019	Transformer, F3571 (PINK)
T2-2	8000-00038-020	Transformer, F001AS (BLUE)
T3	8000-00030-018	Transformer, A088AT

SYMBOL NO.	PART NO.	DESCRIPTION
T4	8000-00012-034	Transformer, EIA117B
T5	8000-00012-034	Transformer, EIA227B
T6	8000-00038-021	Transformer, A293AP
T7	8000-00030-016	Transformer, C042DD
T8	8000-00030-019	Transformer, A-31
T9	8000-00012-037	Transformer, E-03
VR1 and VR2	8000-00004-098	Res., Var., 10K x 10K ohm, w/sw
VR3 and VR4	8000-00004-256	Res., Var., 10K x 10K
VR5	8000-00030-002	Res., Var., 5K ohm
VR6	8000-00004-094	Resistor, Var., 100K ohm
VR7	8000-00004-096	Resistor, Var., 10K ohm
VR8	8000-00004-094	Resistor, Var., 100K ohm
VR9	8000-00011-082	Resistor, Var., 1K ohm
X1	8000-00038-011	Crystal, HC25U, 10.240 MHz
Miscellaneous	8000-00030-022	Relay, HTC-12VDC
	8000-00038-024	Heat Sink, 2SC1306
	8000-00038-025	Cabinet
	8000-00038-027	Front Bezel, Less Overlay
	8000-00038-028	Mounting Bracket
	8000-00030-023	Feed Through Bracket (For C702)
	8000-00038-031	Front Panel Overlay
	8000-00038-033	SBE Jewel
	8000-00038-034	Tx Lamp Jewel
	8000-00030-028	Channel Plate Knob w/skirt
	8000-00038-037	Knob Outside (Tone or Mic Gain)
	8000-00011-119	Knob Inside (Volume or Squelch)
	8000-00038-035	Knob Delta Tune
	8000-00030-031	Pwr Cord Clamp
	8000-00004-152	Fuse, 2A
	8000-00004-151	Fuse Holder
	8000-00038-038	Foam (Meter Mounting)
	8000-00038-039	Grommet
	8000-00004-172	Channel Window Plate
	8000-00004-153	Microphone, Complete
	8000-00038-040	Styrofoam, Packing
	8000-00038-041	Display Box
	8000-00038-042	Speaker Mounting Ring
	8000-00038-043	Model Label (Rear Panel)
	8000-00030-053	Bolt, Mounting Bracket
	8000-00030-054	Washer, Mounting Bracket
	8000-00038-045	Channel Window Ring

SECTION 8

ADDENDA

8.1 MODIFICATIONS

The following is a list of modifications made during production of the SBE model 26CB. Any radios received for service should be checked to insure that these modifications have been performed. Any modifications that have not been performed, should be installed as part of the normal service procedure.

C119, original value 10pfd – change to 5 pfd

R121, original value 100K ohm – change to 220K ohm

R202, original value 4.7K ohm – change to 1K ohm

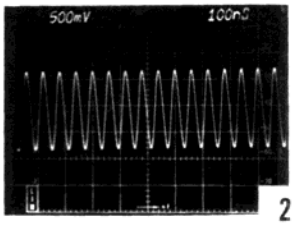
R518, original value 47K ohm – change to 6.8K ohm

R528, original value 33K ohm – change to 6.8K ohm

The source lead of Q19 passes through a ground foil on the component side of the synthesizer circuit board, and is soldered to a ground foil on the bottom of the board. Early production units have this lead soldered only to the bottom foil. On these units, the ground foil on the component side should also be soldered to the source lead.

TRANSCEIVER WAVEFORMS

1



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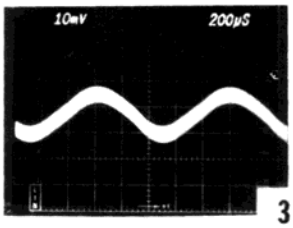

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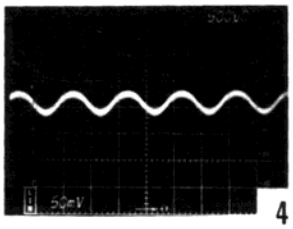

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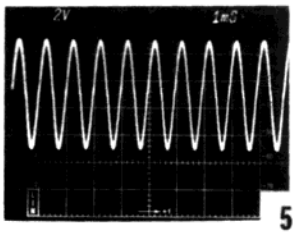

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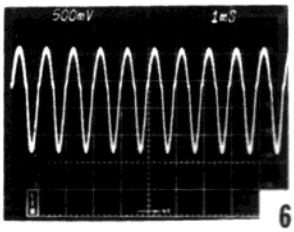

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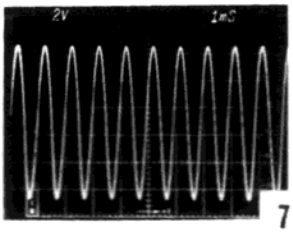

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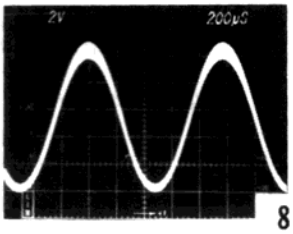

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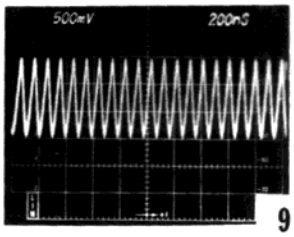

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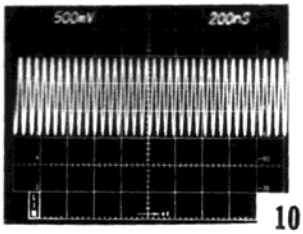

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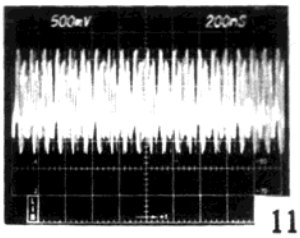

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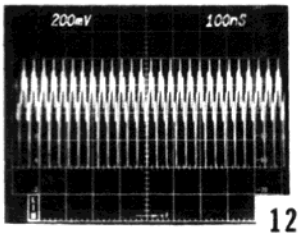

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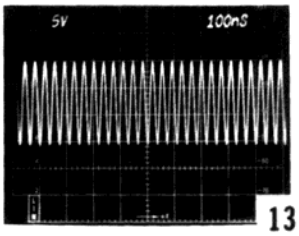

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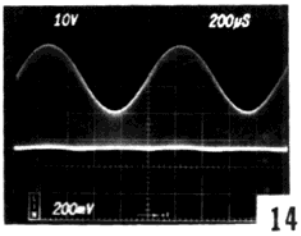

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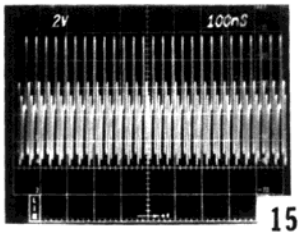

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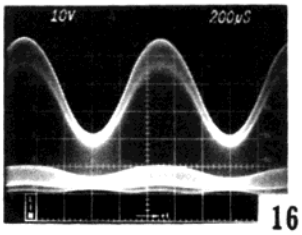

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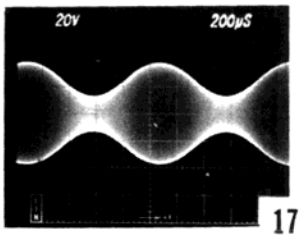
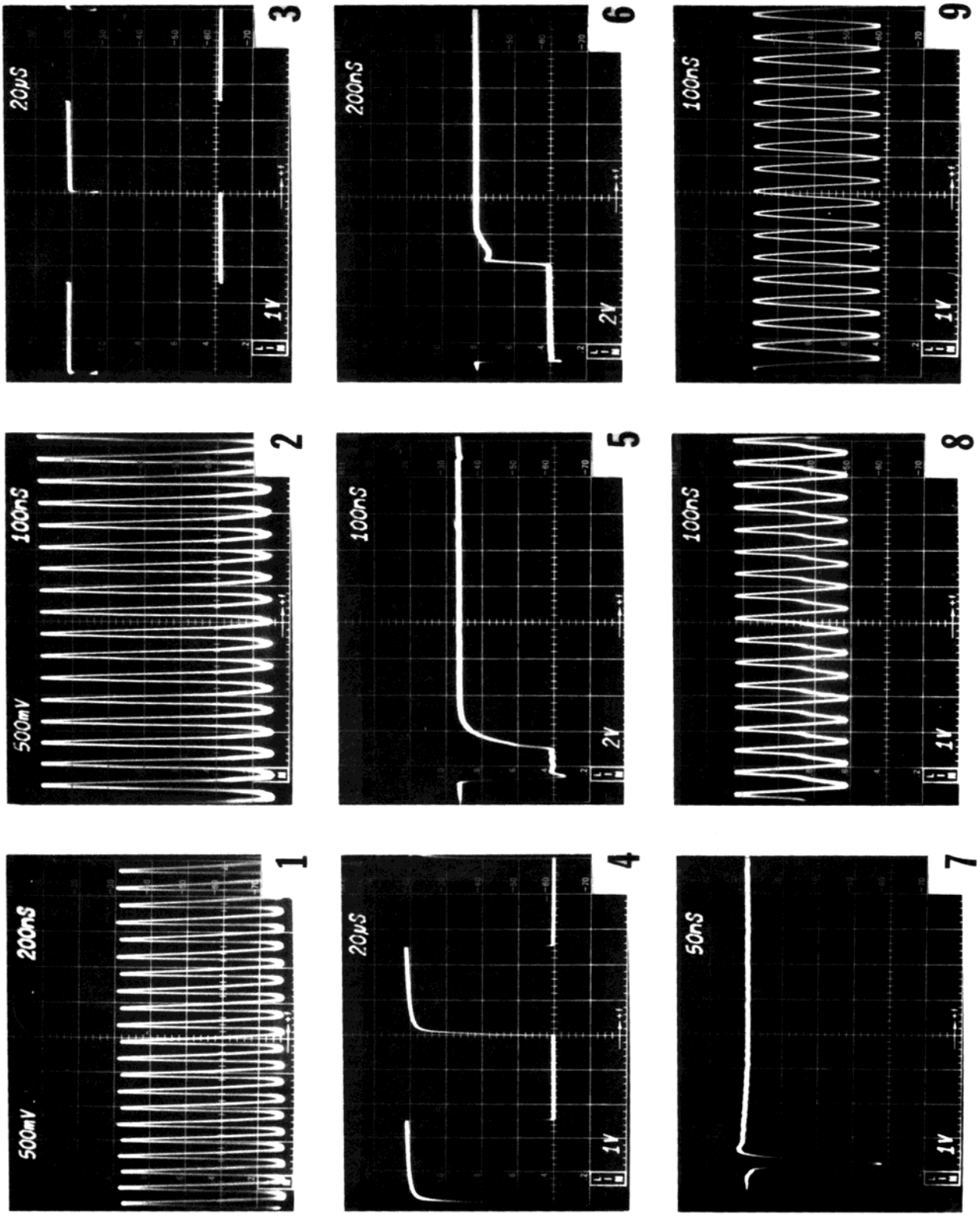
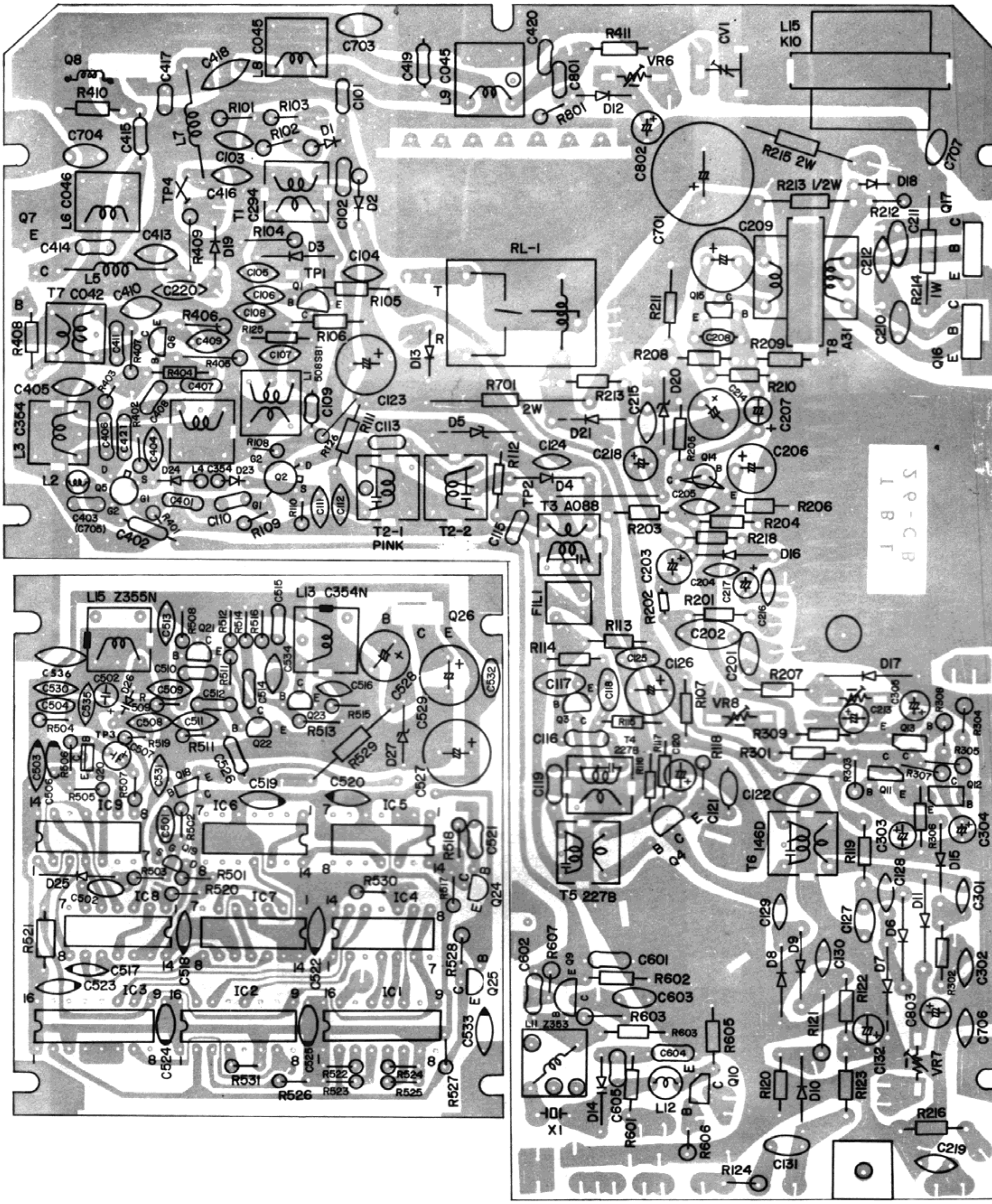


17

SYNTHESIZER WAVEFORMS




Q8
R410
C417
C418
L8 C045
C703
C419
L9 C045
C420
R411
CV1
L15
K10
VR6
C801
D12
R801
C101
R101
R103
R102
D1
C704
C415
L7
C103
C802
R215 2W
C707
L6 C046
TP4
C416
T1 C294
C102
D2
R213 1/2W
D18
C701
R212
Q17
Q7
E
R409
D19
R104
D3
C414
C413
C104
C209
C211
C
B
C
L5
C105
TP1
RL-1
C212
C220
Q1
T
R214 1W
E
B
T7 C042
C410
C106
R105
C108
R211
Q15
R406
R408
C411
R407
Q6
C409
R125
R106
C208
R209
C210
C
B
E
Q16
R405
C107
L1 508SBT
D13
R
R208
T8 A31
C405
R403
R404
C407
R213
R210
L3 C354
R402
C408
C406
C421
C109
C123
R701
2W
C215
D20
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C404
R108
R111
C113
D5
D21
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Q14
C218
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L2
D24
L4
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D23
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D4
Q5
G2
G1
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C112
T2-1
T2-2
TP2
C205
R206
C403
(C706)
C402
R401
C110
R109
PINK
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T3 A088
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R204
R218
D16
C203
C204
C217
L15 Z355N
C513
R508
Q21
R512
R514
R516
C515
L13 C354N
Q26
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R202
R201
C216
C202
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C510
R511
C334
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R113
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R114
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T5 227B
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IC3
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D7
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R603
R121
C706
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C525
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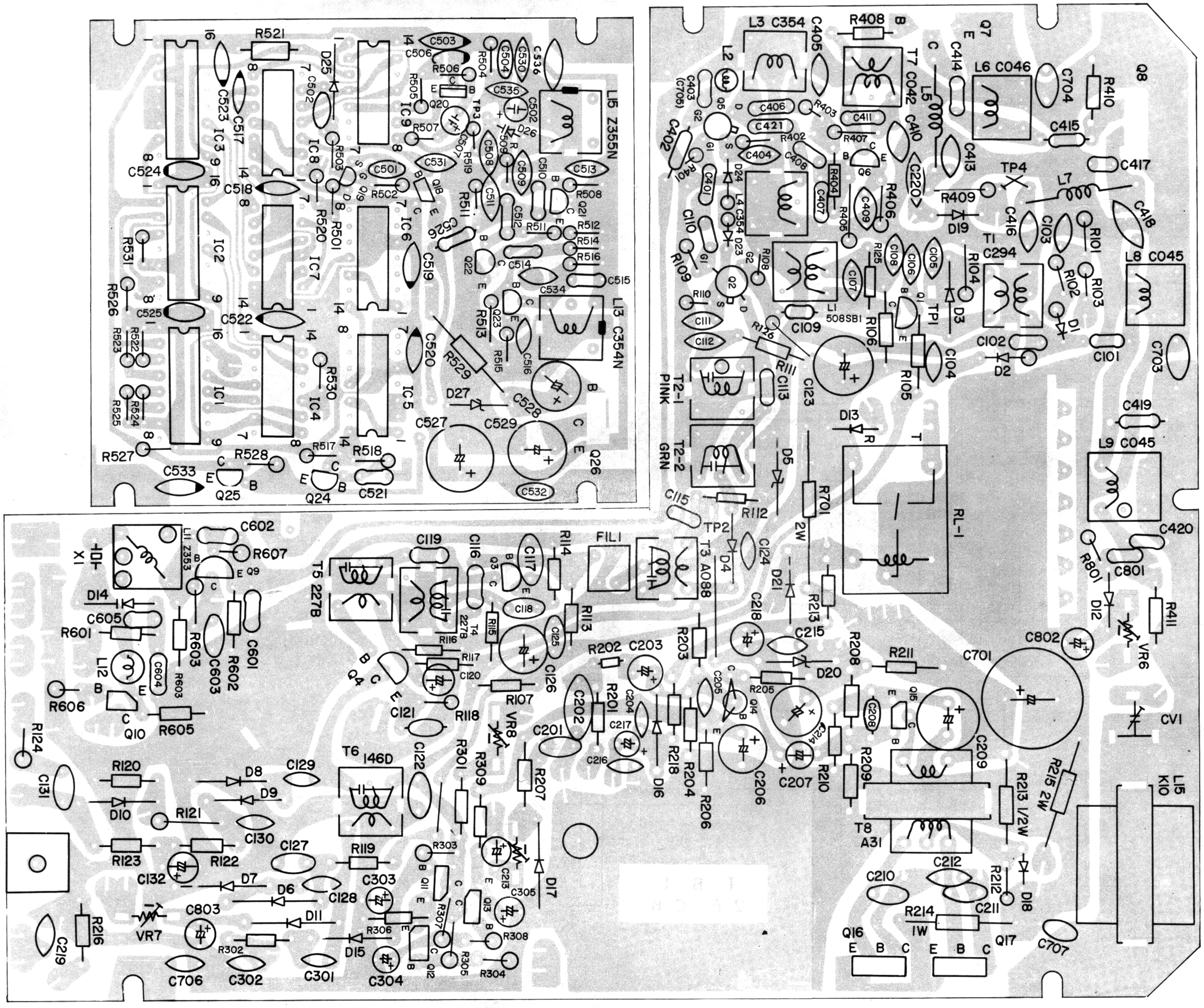

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C207
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R215 2W
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D10
R121
C130
R213 1/2W
T8 A31
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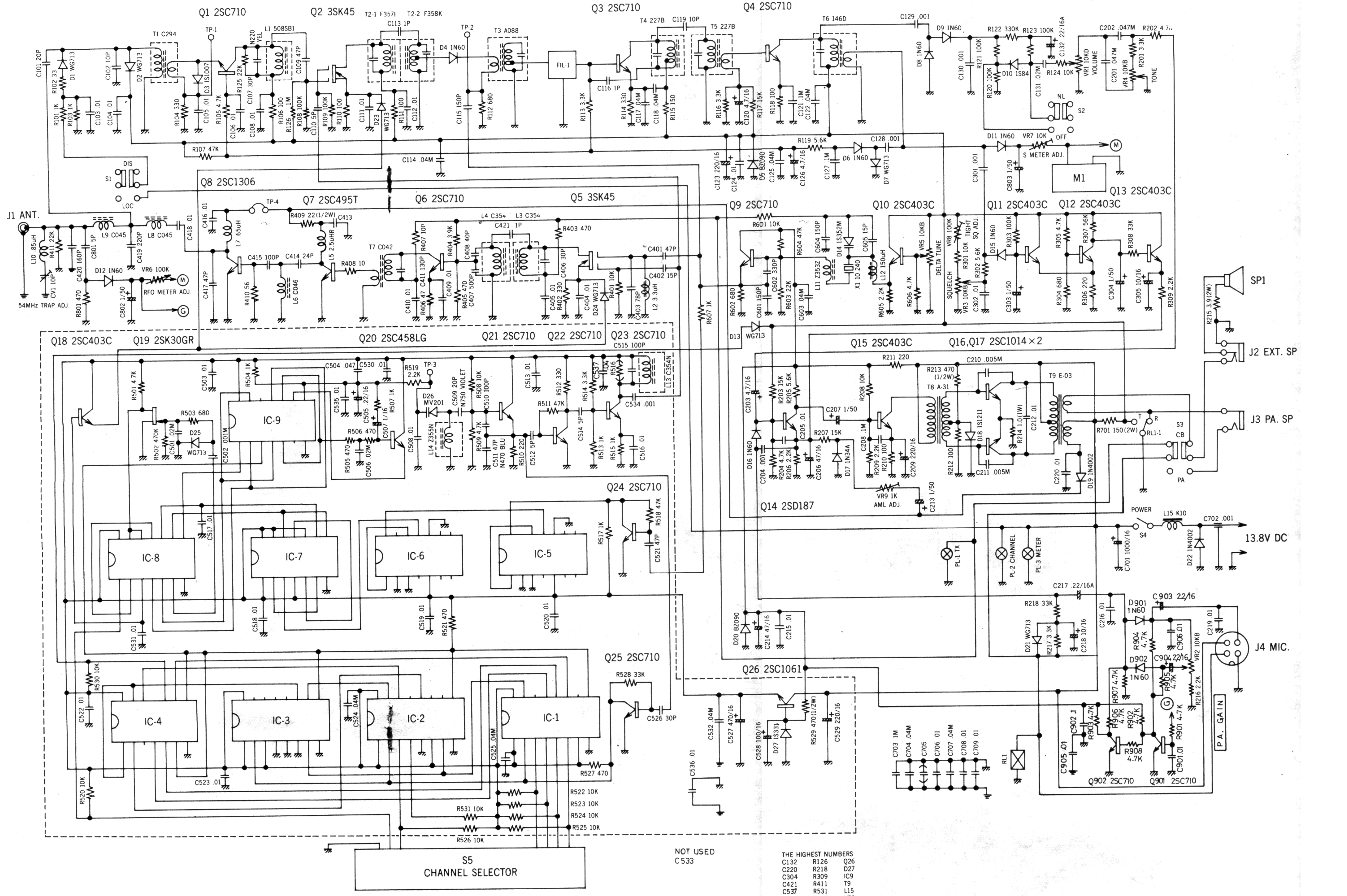
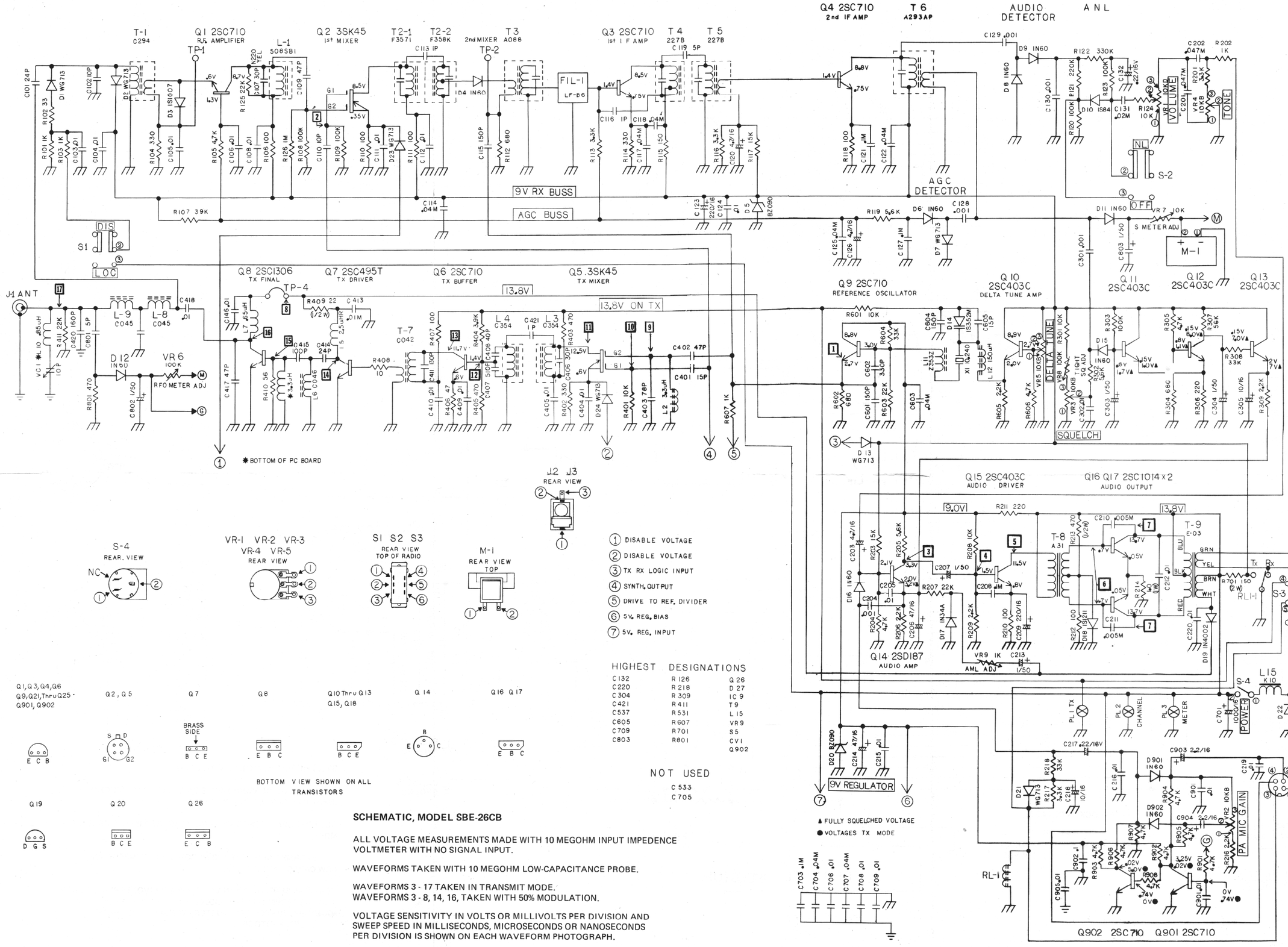
R304



NOT USED
C533

THE HIGHEST NUMBERS

C132	R126	Q26
C220	R218	D27
C304	R309	IC9
C421	R411	T9
C537	R531	L15
C605	R607	VR9
C709	R701	S5
C803	R801	CV1



SCHEMATIC, MODEL SBE-26CB

ALL VOLTAGE MEASUREMENTS MADE WITH 10 MEGOHM INPUT IMPEDENCE VOLTMETER WITH NO SIGNAL INPUT.

WAVEFORMS TAKEN WITH 10 MEGOHM LOW-CAPACITANCE PROBE.

WAVEFORMS 3 - 17 TAKEN IN TRANSMIT MODE.
WAVEFORMS 3 - 8, 14, 16, TAKEN WITH 50% MODULATION.

VOLTAGE SENSITIVITY IN VOLTS OR MILLIVOLTS PER DIVISION AND SWEEP SPEED IN MILLISECONDS, MICROSECONDS OR NANOSECONDS PER DIVISION IS SHOWN ON EACH WAVEFORM PHOTOGRAPH.

Q18 2SC403C
DISABLE DRIVER

Q19 2SK30GR
"OUT-OF-LOCK"
DETECTOR

Q20 2SC458LG

Q21 2SC710
VCO

Q22 2SC710
1st VCO BUFFER

Q23 2SC710
2nd VCO BUFFER

L 13
C354M

5V BUSS

IC 9
MC 4044

TP-3

D26
MV201

L14 Z355N

Q24 2SC710
DRIVER

10KHZ

40KHZ

640KHZ

10.24MHZ

IC-8
7400/9N00

IC-7
7474PC

IC-6
7493/9393

IC-5
7493/9393

10 KHZ 70KHZ

70KHZ

IC-4
74H22/9H22

IC-3
9316/74163

IC-2
9316/74163

IC-1
9316/74163

Q25 2SC710
DRIVER

Q26 2SC71061
5 VOLT
REGULATOR

P.C. BOARD
GROUND

CHASSIS
GROUND

■ OUT-OF-LOCK VOLTAGE

NOTE 1. R516 MAY OR MAY NOT BE IN CIRCUIT. IF IN CIRCUIT RESISTANCE VARIES.

S-5
CHANNEL SELECTOR

IC-1 IC-2 IC-3

VCC TC Q_3 Q_2 Q_1 Q_0 CET PE

MR CP P_3 P_2 P_1 P_0 CEP

IC-4

IC-5 IC-6

IC-7

Clear
Preset
Clock
D
Q

IC-8

IC-9

PHASE DETECTOR
CHARGE PUMP
INV' AMP
REF IN
LAG OUT
VCO IN
PD
nc
GND

S-5
CHANNEL SWITCH

CONNECT TO B5
CONNECT TO PIN 3 IC-1
CONNECT TO PIN 2 IC-1
INDEX MARKER

CONNECT TO A5, C5 and C4
CONNECT TO PIN 5 IC-1
CONNECT TO PIN 4 IC-1

NO CONNECTION
CONNECT TO C5 and P.C. BOARD GROUND
CONNECT TO B5
CONNECT TO PIN 1 IC 8
CONNECT TO PIN 3 IC 2
NO CONNECTION

SYNTHESIZER, MODEL SBE-26CB

ALL VOLTAGE MEASUREMENTS TAKEN WITH 10 MEGOHM INPUT IMPEDENCE VOLTMETER.

ALL FREQUENCIES SHOWN WERE MEASURED IN THE RECEIVE MODE.

WAVEFORMS TAKEN WITH 10 MEGOHM INPUT IMPEDENCE, LOW CAPACITANCE PROBE.

VERTICAL SENSITIVITY IN VOLTS OR MILLIVOLTS PER DIVISION AND SWEEP SPEEDS IN MILLISECONDS, MICROSECONDS OR NANOSECONDS PER CENTIMETER, ARE SHOWN ON EACH WAVEFORM PHOTOGRAPH.

SBE, INC.
220 AIRPORT BLVD.
WATSONVILLE, CA 95076

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