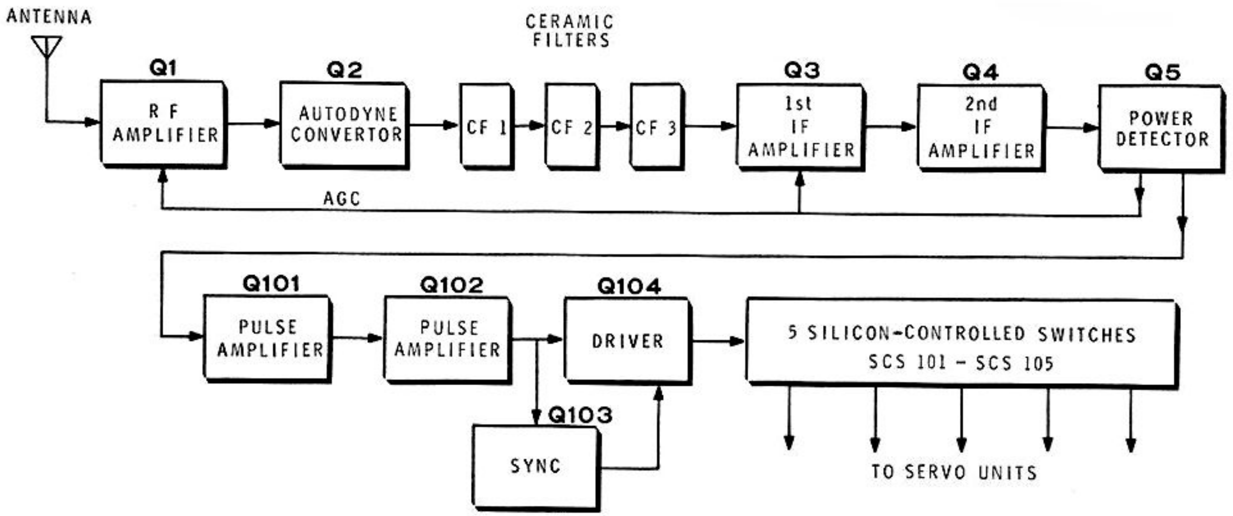
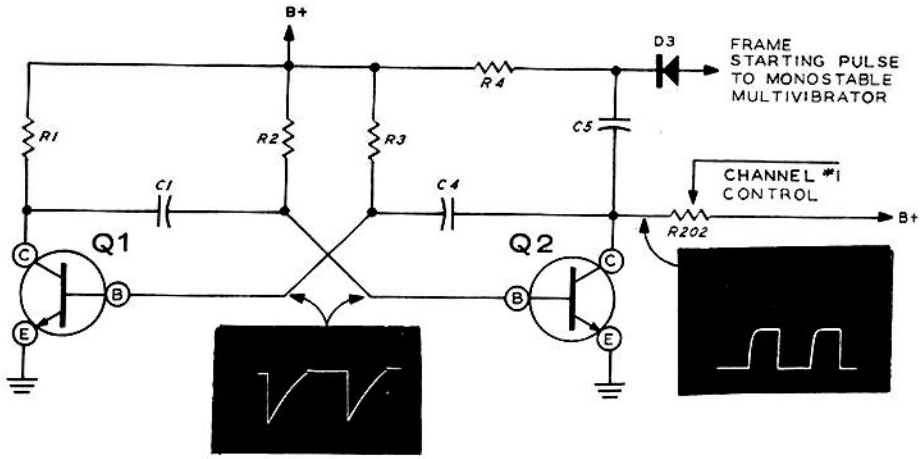
RECEIVER BLOCK DIAGRAM





FREE-RUNNING MULTIVIBRATOR

Figure 6-4

CIRCUIT DESCRIPTION

TRANSMITTER

A number series has been assigned to each of the two circuit boards and to the cabinet in the Transmitter. These number series are used on the Schematic Diagram and in this Circuit Description to help you identify and locate circuits and parts. The part numbers are grouped as follows:

1- 99	Parts mounted on the encoder circuit board.
101-199	Parts mounted on the RF transmitter circuit board.
201-299	Parts mounted on the cabinet.

Pulses that are used to modulate the RF carrier of the Transmitter originate in the circuits of the encoder circuit board. These circuits include a free-running multivibrator, five monostable timers, and a monostable multivibrator. The RF circuit board contains a crystal-controlled oscillator and an RF output on the 27 and 53 MHz bands. The 72 MHz RF circuit board contains a crystal-controlled oscillator, doubler, and RF output stage. Each circuit of the Transmitter will be described separately in the following paragraphs.

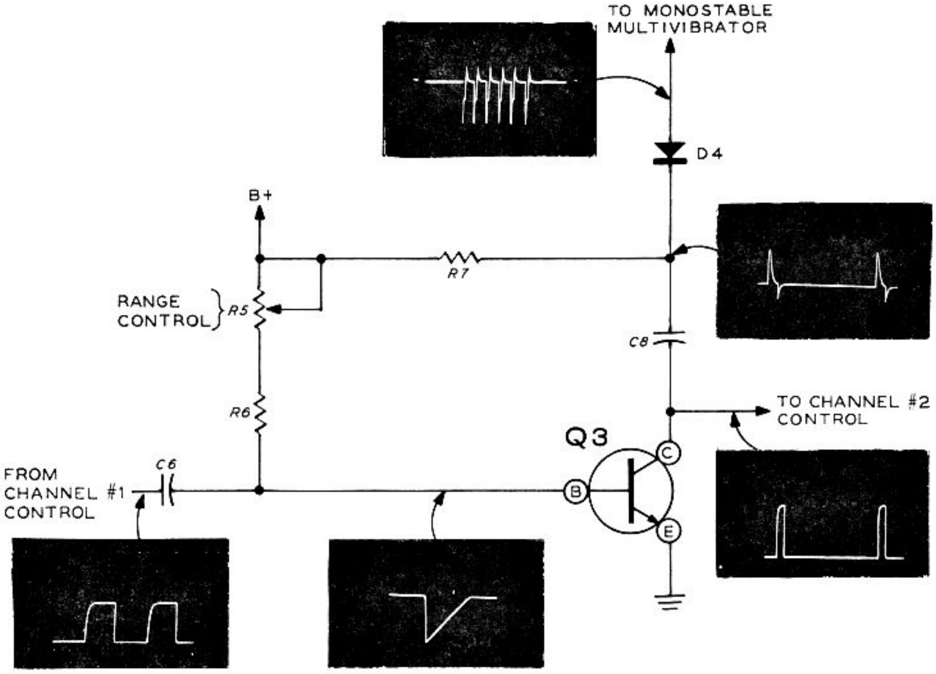
Refer to the Block Diagram on Page 103 and to the Schematic Diagram (fold-out from Page 109), while you read this Circuit Description. Several partial schematics are included with the text to help describe individual circuits.

FREE-RUNNING MULTIVIBRATOR

Transistors Q1 and Q2 are connected in a circuit that operates as a free-running multivibrator. See Figure 6-4. Alternately, one of these transistors conducts while the other is cut off.

Assume that transistor Q1 conducts first when power is applied to the circuit. The voltage at the collector of Q1 is reduced, causing capacitor C1 to start charging through resistor R2 from the power supply. During the charging of C1, the voltage to the base of Q2 increases sufficiently to cause Q2 to conduct, reducing its collector voltage to near zero. This applies a negative voltage through C4 to the base of Q1 and stops Q1 from conducting. Now C4 begins to charge through R3. During the charging of C4, the voltage to the base of Q1 rises in a positive direction and Q1 again conducts.

The time required to charge C1 through R2, and C4 through R3, determines the period of the multivibrator. The values of these resistors and capacitors are chosen to turn each transistor on and off every 16,000 microseconds. This multivibrator period of 16,000 microseconds produces the starting pulse for each frame, and this frame starting pulse is coupled through capacitor C5 and diode D3 to transistor Q8 of the monostable multivibrator circuit. The pulse also passes through Channel #1 Stick Control R202 to a series of monostable timers which produces the other five pulses for channel information and will be described next.



MONOSTABLE TIMER

Figure 6-5

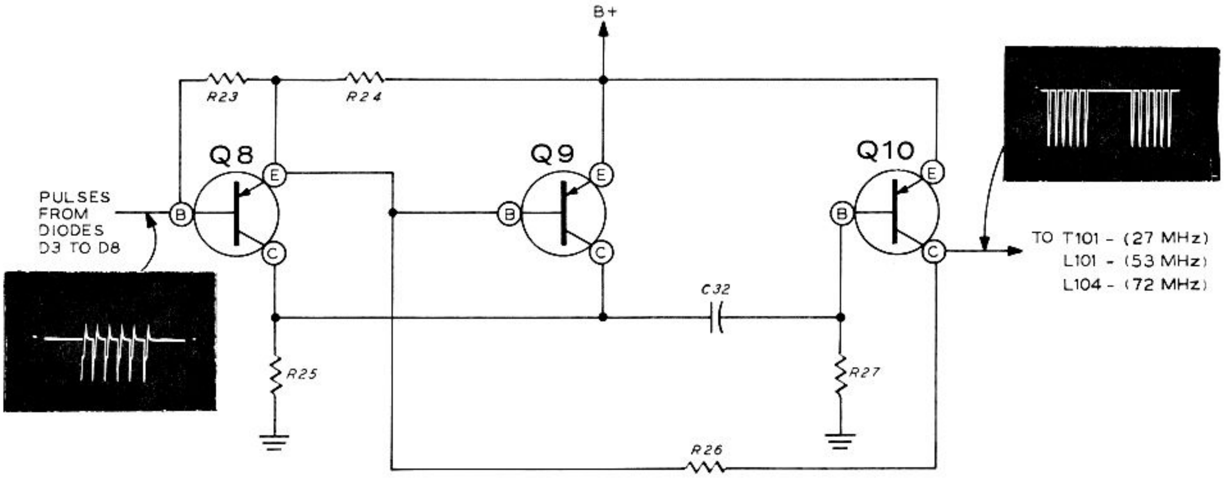
MONOSTABLE TIMERS

Transistors Q3 through Q7 are connected in five identical monostable timer circuits. Each frame-starting pulse from the free-running multivibrator begins a chain reaction through the monostable timers. Since these circuits are identical, only the operation of Q3 will be described. See Figure 6-5.

Transistor Q3 is biased through Channel #1 Range control R5 and resistor R6 so that it is normally conducting and its collector voltage is near zero. The negative frame-starting pulse from transistor Q2 is coupled from the arm of stick control R202, through capacitor C6, to the base of Q3. This pulse drives the base of Q3 negative by an amount that depends on the setting of R202, cutting off the transistor.

As soon as the negative frame-starting pulse is fed to the base of Q3, the voltage at this base begins to rise again due to the positive voltage through R5 and R6. When the base reaches +.6 volts, Q3 again conducts. The time required for the base to reach +.6 volts is affected by the time constant of R5, R6, and C6, as well as by the amplitude of the pulse that is passed through control R202. Thus, control R202 provides manual control of the pulse amplitude, which controls the length of time that transistor Q3 is cut off.

Control R5 adjusts the effective range of control R202 by altering the charging time of capacitor C6. (NOTE: The charge curve of C6 is the trailing edge of the pulse at the base of Q3.) As C6 charges up to +.6 volts more slowly, for example, due to a larger resistance value of R5, a wider range of pulse widths is available from the collector of Q3. When the resistance of R5 is decreased, a smaller range of pulse widths is available from Q3.



MONOSTABLE MULTIVIBRATOR

Figure 6-6

When transistor Q3 again conducts, a negative-going pulse appears at its collector. This pulse is passed through Channel #2 Control R203 to the next monostable timer circuit, which operates in the same manner as the circuit of Q3. Note that only the negative-going portion of the pulse will trigger this stage.

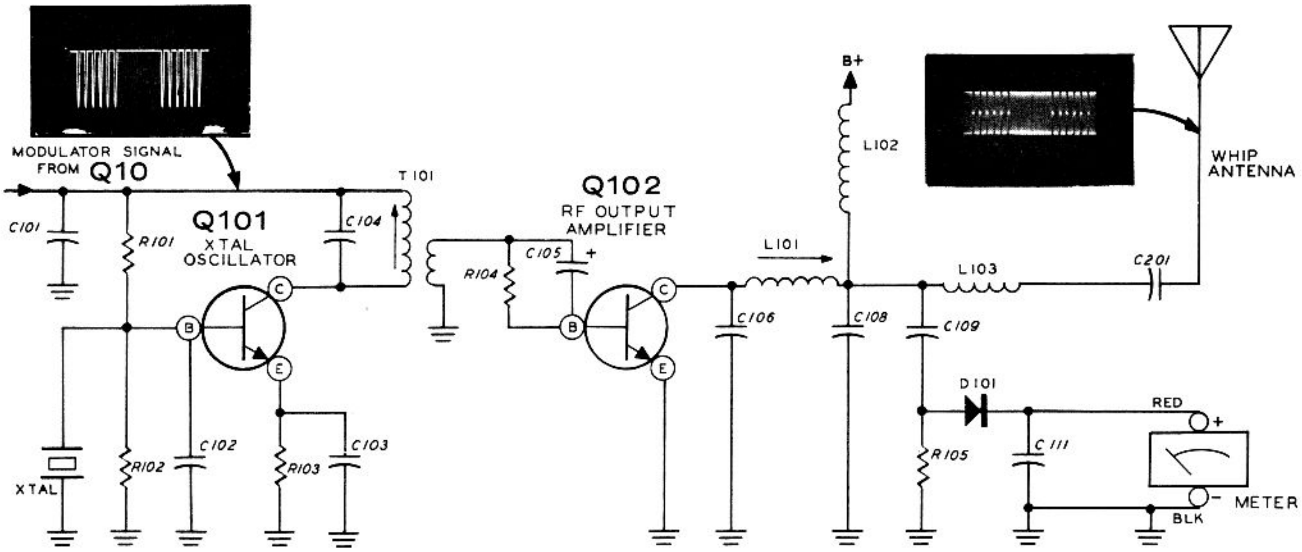
The channel #1 controlling pulse from Q3 is coupled through C8 and D4 to the monostable multivibrator circuit Q8, Q9, and Q10. Diodes D5, D6, D7, and D8 couple the other controlling pulses to the monostable multivibrator.

MONOSTABLE MULTIVIBRATOR

Transistors Q8, Q9, and Q10 are connected to operate as a monostable, 350 microsecond multivibrator (see Figure 6-6). Its purpose is to cause each frame-starting pulse and controlling pulse to modulate the transmitter's RF carrier for only 350 microseconds during each pulse.

Diodes D3 through D8 allow only the negative-going portion of the pulse from the monostable timers and the multivibrator to be applied to the base of transistor Q8. Since the emitter of Q8 is direct coupled to the base of Q9, this negative-going pulse causes Q8 and Q9 to conduct and produce a positive pulse at the collector of Q9. This positive pulse is coupled through capacitor C32 to the base of Q10, causing Q10 to cut off. The time constant of C32 and R27 holds transistor Q10 cut off for a period of 350 microseconds after each pulse is applied to its base. Resistor R26 provides positive DC feedback from the collector of Q10 to the base of Q9. This feedback insures that Q9 continues to conduct during the 350 microsecond cutoff period of the monostable multivibrator.

From the collector of transistor Q10, power is supplied to the crystal oscillator circuit on the 27 and 53 MHz bands, and to the doubler circuit on the 72 MHz band. Since Q10 normally conducts, and is cut off during the presence of pulses, this transistor turns the crystal oscillator (on 27 and 53 MHz) or frequency doubler (on 72 MHz) off and on like a switch and thereby modulates the RF signal.



OSCILLATOR AND RF
OUTPUT AMPLIFIER CIRCUITS
27 MHz BAND

Figure 6-7

27 MHz BAND RF TRANSMITTER CIRCUITS

The crystal-controlled oscillator and RF output amplifier circuits are contained on the small RF Transmitter circuit board. These circuits generate and amplify the radio frequency carrier signal that is modulated by the controlling pulses from the multivibrator. See Figure 6-7.

Crystal oscillator transistor Q101 operates as a grounded-base Colpitts oscillator. The primary winding of transformer T101, which is in parallel with capacitor C104, tunes the circuit to the frequency of the crystal.

During the intervals between pulses from the monostable multivibrator circuit, while transistor Q10 conducts, power is applied through the primary winding of T101 to the collector of Q101, causing the oscillator to operate. Since the oscillator stops when the power is cut off during a pulse, the oscillator's output signal is negative-modulated by the pulse signals.

The secondary winding of transformer T101 couples the modulated oscillator signal to the base of final RF amplifier transistor Q102 through capacitor C105. Q102 conducts on the positive peaks of the RF carrier which charges C105 to the polarity shown. R104 provides a return path for the negative voltage on the base of Q102 and provides proper bias. This bias is determined by the time constant of R104 and C105.

Transistor Q102 operates as a tuned collector amplifier. The pi network of C106, C108, and L101 tunes the amplifier output to the crystal frequency and provides a proper impedance match between Q102 and the antenna. Coil L103 is the antenna loading coil, and capacitor C201 prevents the DC supply voltage from reaching the antenna. B+ voltage is supplied through choke L102.

A portion of the RF signal is taken from the pi network through C109 and rectified by diode D101 to operate the meter, which indicates relative carrier strength. Resistor R105 provides a DC return path for the diode while capacitor C111 filters the diode's rectified output.

The pulse-modulated RF signal is radiated from the collapsible whip antenna to be received and detected by the Receiver.

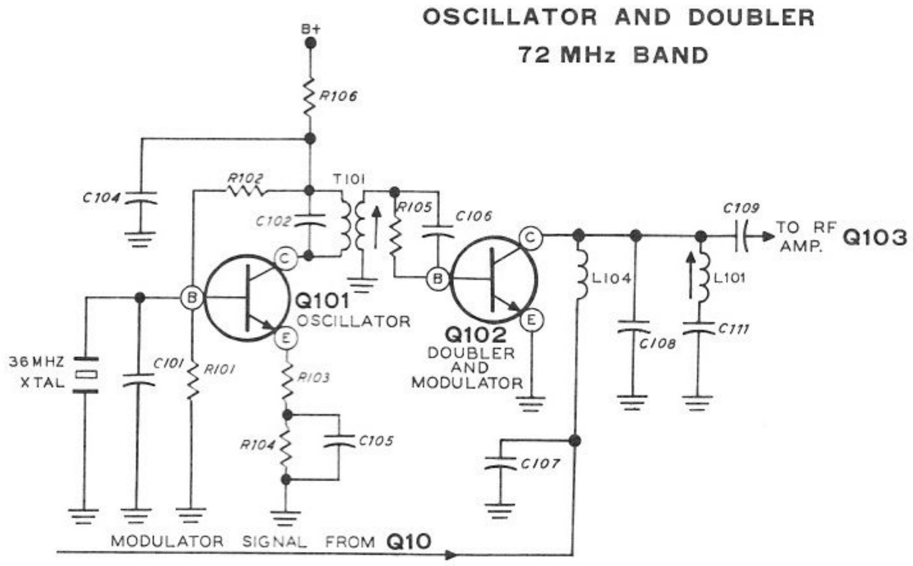


Figure 6-8

53 MHz BAND RF TRANSMITTER CIRCUITS

The 53 MHz band RF transmitter circuits are similar in operation to the 27 MHz band circuits. The circuits differ the most by the addition of the tuned circuit, C105 and L102, which is tuned to the oscillator frequency and used to drive RF amplifier Q102. The tap on L102 is for impedance matching. See the Schematic Diagram (fold-out from this Page.)

72 MHz BAND RF TRANSMITTER CIRCUITS

The 72 MHz band oscillator operates just like the oscillators for the other bands, except that it oscillates at a frequency that is one-half of the final transmitted frequency. The secondary winding of transformer T101 couples the oscillator signal through C106 to the base of Q102. Q102 conducts on the positive peaks of the oscillator signals. See Figure 6-8.

The output of Q102 (C108, C111, and L101) is tuned to the second harmonic of the oscillator frequency. This appears as a low impedance to ground for the fundamental oscillator frequency and, at the same time, resonates at a high impedance for the second harmonic.

Coil L104 couples DC to the collector of Q102 from multivibrator Q10 and, at the same time, isolates Q10 from the RF at Q102. The DC from Q10 causes Q102 to operate normally until a negative pulse arrives at the collector of Q102. Then Q102 cuts off for the duration of the pulse, modulating the RF.

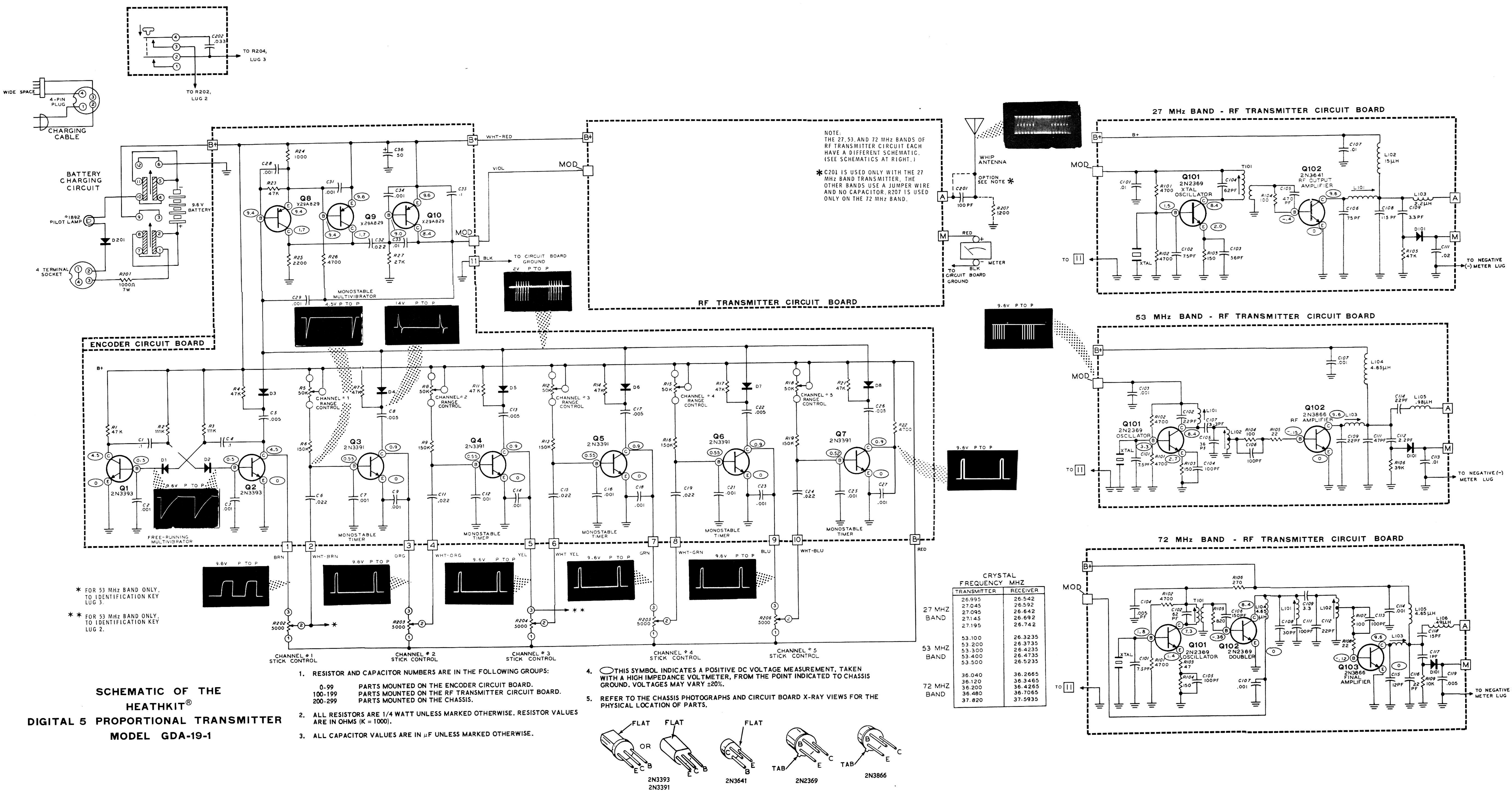
The doubled and modulated signal is then coupled from Q102 to RF amplifier Q103, amplified, and coupled to the antenna in the same manner as the signals of the other two bands.

POWER SUPPLY

Power for the Transmitter circuits is supplied by a self-contained, rechargeable 9.6 volt nickel-cadmium battery. When the Power switch is in the Off position, the Battery is connected to a charging circuit which operates in the following manner.

The Receiver's battery is connected, by means of the charging cable, in series with D201 and the pilot lamp, through the ON-OFF switch, to the negative (-) lead of the Transmitter Battery. R201 connects to the positive (+) lead of the Transmitter Battery through the ON-OFF switch. When the charging cable is connected between the 4-pin connector and a 120 volt AC outlet, the series circuit charges both the Receiver Battery and the Transmitter Battery at the same time.

Diode D201 rectifies the AC line voltage and resistor R201 limits the charging current to a safe value. The pilot lamp indicates when the batteries are being charged. Since the Off position of the power switch removes all connections between the Battery and the Transmitter circuits, the danger of shock from the charging circuit is eliminated.



NOTE:
THE 27, 53, AND 72 MHz BANDS OF RF TRANSMITTER CIRCUIT EACH HAVE A DIFFERENT SCHEMATIC. (SEE SCHEMATICS AT RIGHT.)

* C201 IS USED ONLY WITH THE 27 MHz BAND TRANSMITTER, THE OTHER BANDS USE A JUMPER WIRE AND NO CAPACITOR. R207 IS USED ONLY ON THE 72 MHz BAND.

CRYSTAL FREQUENCY MHZ

	TRANSMITTER	RECEIVER
27 MHZ BAND	26.995	26.542
	27.045	26.592
	27.095	26.642
	27.145	26.692
	27.195	26.742
53 MHZ BAND	53.100	26.3235
	53.200	26.3735
	53.300	26.4235
	53.400	26.4735
	53.500	26.5235
72 MHZ BAND	36.040	36.2665
	36.120	36.3465
	36.200	36.4265
	36.480	36.7065
	37.820	37.5935

* FOR 53 MHz BAND ONLY, TO IDENTIFICATION KEY LUG 3.

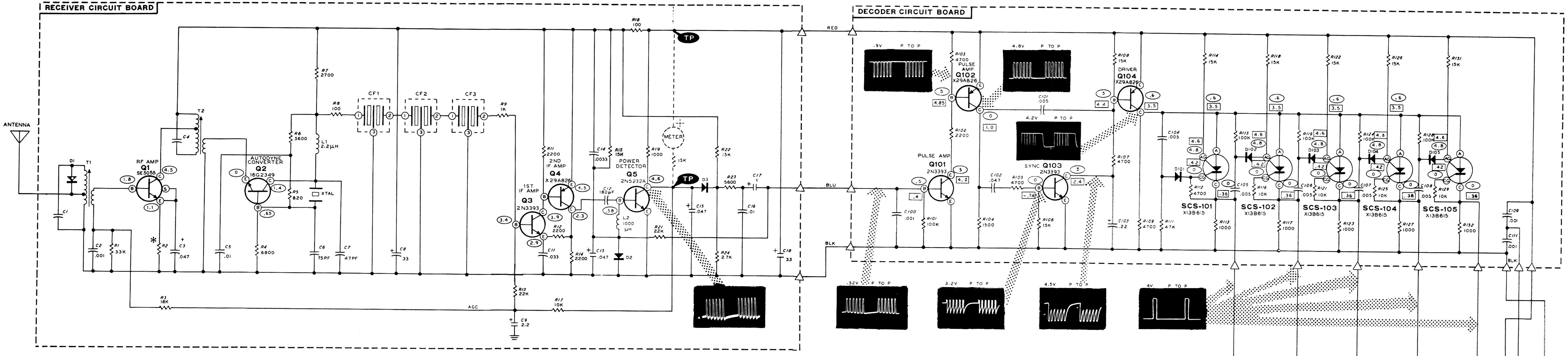
** FOR 53 MHz BAND ONLY, TO IDENTIFICATION KEY LUG 2.

SCHEMATIC OF THE HEATHKIT® DIGITAL 5 PROPORTIONAL TRANSMITTER MODEL GDA-19-1

1. RESISTOR AND CAPACITOR NUMBERS ARE IN THE FOLLOWING GROUPS:

0-99	PARTS MOUNTED ON THE ENCODER CIRCUIT BOARD.
100-199	PARTS MOUNTED ON THE RF TRANSMITTER CIRCUIT BOARD.
200-299	PARTS MOUNTED ON THE CHASSIS.

2. ALL RESISTORS ARE 1/4 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K = 1000).
3. ALL CAPACITOR VALUES ARE IN µF UNLESS MARKED OTHERWISE.
4. ○ THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT, TAKEN WITH A HIGH IMPEDANCE VOLTMETER, FROM THE POINT INDICATED TO CHASSIS GROUND. VOLTAGES MAY VARY ±20%.
5. REFER TO THE CHASSIS PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.



	C1	C4
27 MHZ	47PF	47PF
53-72 MHZ	27PF	27PF

SCHEMATIC OF THE
HEATHKIT®
DIGITAL 5 PROPORTIONAL RECEIVER
MODEL GDA-19-2

1. RESISTOR AND CAPACITOR NUMBERS ARE IN THE FOLLOWING GROUPS:

   0-99 PARTS MOUNTED ON THE RECEIVER CIRCUIT BOARD.
   100-199 PARTS MOUNTED ON THE DECODER CIRCUIT BOARD.

2. ALL RESISTORS ARE 1/4 WATT UNLESS MARKED OTHERWISE. RESISTOR VALUES ARE IN OHMS (K=1,000).

3. ALL CAPACITOR VALUES ARE IN μF UNLESS MARKED OTHERWISE.

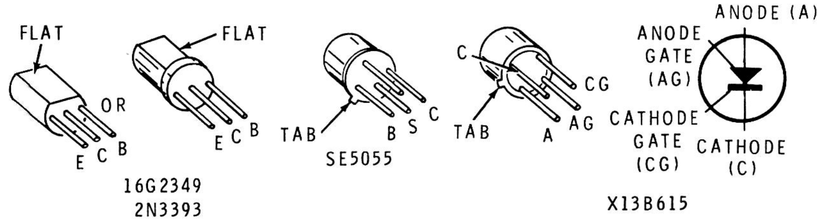
4. ⬭ THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT WITH NOTSIGNAL BEING RECEIVED.

5. ▭ THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT WITH SIGNAL BEING RECEIVED.

6. ALL VOLTAGES ARE MEASURED WITH A HIGH IMPEDANCE VOLTMETER. FROM THE POINT INDICATED TO COMMON GROUND. VOLTAGES MAY VARY ±20%.

7. REFER TO THE CIRCUIT BOARD X-RAY VIEWS FOR THE PHYSICAL LOCATION OF PARTS.

8. * 470Ω RESISTOR FOR 27 MHz OPERATION. 1000Ω RESISTOR FOR 53 MHz OR 72 MHz OPERATION.

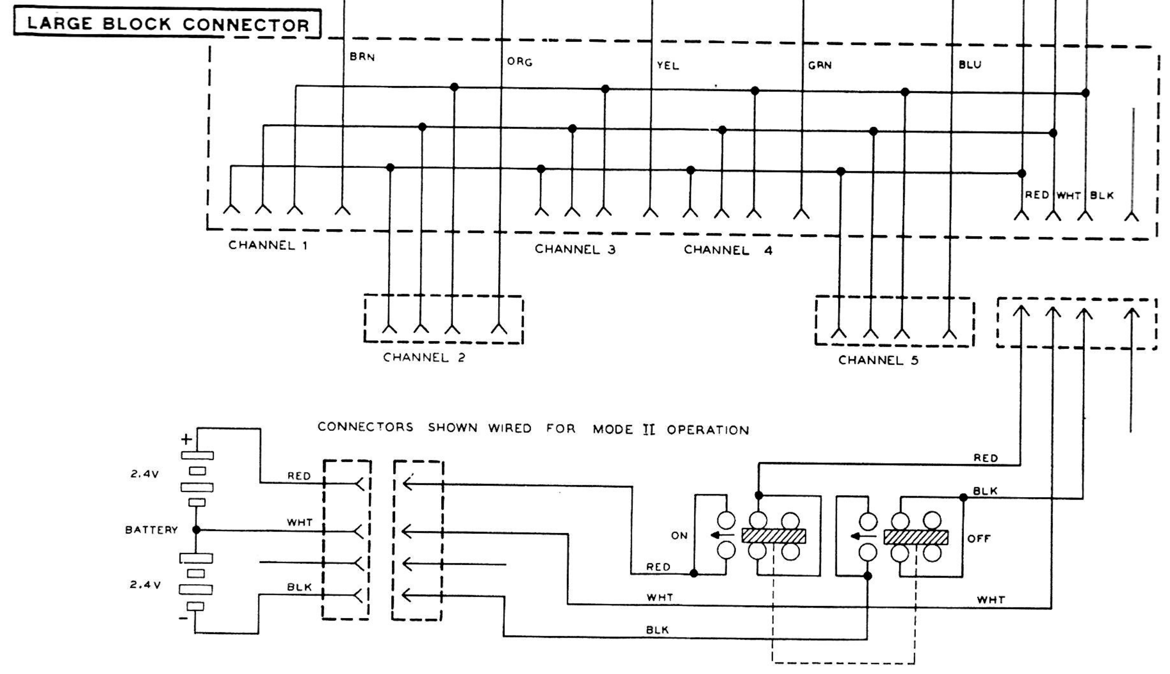


16G2349
2N3393
X29A826
2N5232A

X13B615

CRYSTAL FREQUENCY MHZ

	TRANSMITTER	RECEIVER
27 MHZ BAND	26.995	26.542
	27.045	26.592
	27.095	26.642
	27.145	26.692
	27.195	26.742
53 MHZ BAND	53.100	26.3235
	53.200	26.3735
	53.300	26.4235
	53.400	26.4735
	53.500	26.5235
72 MHZ BAND	36.040	36.2665
	36.120	36.3465
	36.200	36.4265
	36.480	36.7065
	37.820	37.5935



RECEIVER

GENERAL

A number series has been assigned to each of the two circuit boards used in this Receiver. This number series is used on the Schematic Diagram and in this Circuit Description to help you identify and locate circuits and parts. The part numbers are grouped as follows:

1- 99	Parts mounted on the receiver circuit board.
101-199	Parts mounted on the decoder circuit board.

The Receiver circuit board contains a conventional crystal-controlled superheterodyne receiver with a power detector and an integrator circuit. The decoder circuit board contains a pulse amplifier, sync and driver circuits, and five silicon-controlled switch circuits.

Refer to the Schematic Diagram (fold-out from this page) and to the Block Diagram (fold-out from Page 104) while you read this Circuit Description.

RECEIVER CIRCUIT BOARD

The transmitted RF signal is picked up by the antenna and fed to the tuned circuit of T1 and C1. T1 and C1 are tuned to the transmitted signal frequency, and their values are selected for each band of frequencies.

From the secondary of T1, the signal is coupled to the base of RF amplifier Q1. The amplified signal from Q1 is applied to the tuned circuit of C4 and T2, which are also tuned to the transmitted signal frequency. T2 is tapped to provide an impedance match to the collector of Q1. From the secondary of T2, the signal is coupled to the emitter of autodyne converter Q2.

Regenerative feedback through the receiver crystal causes the autodyne converter circuit to oscillate at a frequency that is 453 kHz from the incoming frequency. This will be at the crystal's fundamental frequency on the 27 MHz band, or at its second harmonic on the 53 and 72 MHz bands. The input signal and oscillator signal beat together in transistor Q2 to produce a 453 kHz difference signal that is passed through coil L1 and resistor R8 to the first ceramic (IF) filter, CF1. Capacitor C7 tunes with L1 near the crystal oscillator frequency.

The ceramic filters are made up of one ceramic disc in each filter. As the IF signal is applied to the disc, it vibrates at that frequency. The ceramic filters will vibrate at and pass only the frequency to which they are tuned; in this case the 453 kHz IF frequency.

The IF signal is coupled through CF1, CF2, CF3, and resistor R9 to the base of the first IF amplifier, Q3. The amplified IF signal from Q3 is further amplified by second IF transistor Q4 and coupled through capacitor C12 to the base of the power detector, Q5. Diode D2 is forward biased by resistor R15 so that about .5 volt is applied to the base of Q5 through L2, which will hold Q5 at cutoff. Since Q5 requires about .6 volt at its base to conduct, the additional .1 volt is supplied by the positive portion of the IF signal. Thus, transistor Q5 conducts only on the positive peaks of the IF signal.

When receiving an IF signal, Q5 is conducting. Then when a transmitted pulse is received, which temporarily stops the RF carrier, there is no IF signal to make Q5 conduct. Therefore, Q5 stops conducting and its collector voltage rises. This then produces a positive pulse from Q5 that is equivalent to the pulses in the Transmitter.

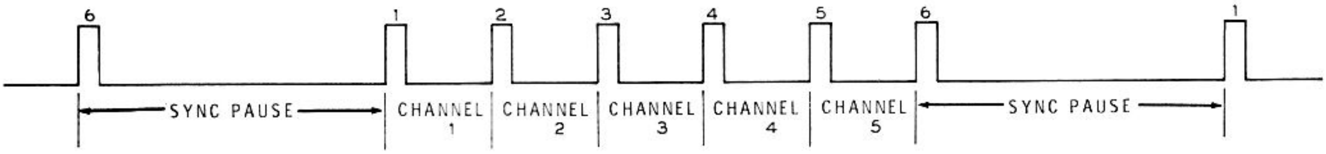


Figure 6-9

Capacitor C15 bypasses the IF frequency to ground and leaves a train of audio frequency pulses that are coupled through D3, R23, and C17 to the base of the pulse amplifier Q101 on the decoder circuit board. Diode D3 and resistors R22 and R24 eliminate noise pulses under strong signal conditions, and integrator network resistor R23 and capacitor C16 prevent noise from interfering under weak signal conditions.

An automatic gain control (AGC) circuit that consists of resistors R17, R13, R3, and R1 with capacitor C9, feeds back part of the Q5 collector voltage to the base circuits of transistors Q1 and Q3. The stronger the received signal, the more transistor Q5 conducts, lowering the voltage at its collector. This voltage is applied through R17, R13, and R3 to reduce the gain of Q1 and Q3. This AGC action prevents the IF amplifier and detector circuits from overloading and producing improper pulses when strong signals are received.

The output signal from the Receiver is a series of positive pulses that are spaced like the modulation pulses of the Transmitter. See the waveform in Figure 6-9. These signal pulses are coupled to the decoder circuit, which will be described next.

DECODER CIRCUIT BOARD

Pulse amplifier transistors Q101 and Q102 further increases the amplitude of the pulses from Q5 on the receiver circuit board. Q101 and Q102 are normally cut off until the pulses reach a high enough amplitude to turn them on, thus providing further noise immunity and producing clear sharp pulses at the collector of Q102.

The signal pulses from the collector of Q102 are coupled through C102 and R105 to the base of sync transistor Q103, and through C101 to the base of driver transistor Q104. Transistor Q104 is used to supply anode voltage to the five SCS's (silicon-controlled switches: SCS-101 through SCS-105). Q104 is normally cut off, removing the anode voltage from these five SCS's. Q103 is also normally cut off, but it conducts during each signal pulse from Q102. This controls the charge and discharge of capacitor C103 which, in turn controls Q104 during the sync pause time.

When Q103 is cut off during the sync pause time, capacitor C103 begins to charge through resistors R108 and R107, and the base emitter junction of Q104. The resulting voltage drop across R107 holds Q104 on until the charging current decreases and C103 becomes charged. Then Q104 returns to its normally cutoff condition.

Transistor Q103 conducts during each positive pulse it receives from Q102 and discharges capacitor C103 (see the waveform at the collector of Q103 on Figure 6-10). The six pulses of each train occur in such rapid succession that C103 cannot obtain a charge sufficient enough to turn Q104 off. However, during the sync pause time, Q103 is cut off long enough to permit C103 to charge up to the voltage which stops Q104 from conducting.

The first pulse following the sync pause turns on Q103, discharging capacitor C103 and allowing Q104 to conduct again. During the time that Q103 holds Q104 on, pulses are coupled from Q102 to the base of Q104 through C101. These positive pulses momentarily turn Q104 off, interrupting the anode voltage from the SCS's for a short instant. This is necessary for proper operation of the SCS's.

Each SCS acts like a transistor with an additional "latching" junction. With the correct biasing conditions, the SCS can be made to conduct from anode to cathode by applying a positive pulse to its cathode gate, or a negative pulse to its anode gate. The SCS continues to conduct until its anode voltage is interrupted. After the anode voltage is restored, another pulse is required at one of its gates before the SCS will turn on again. The SCS circuits operate in the following manner. See Figure 6-11.

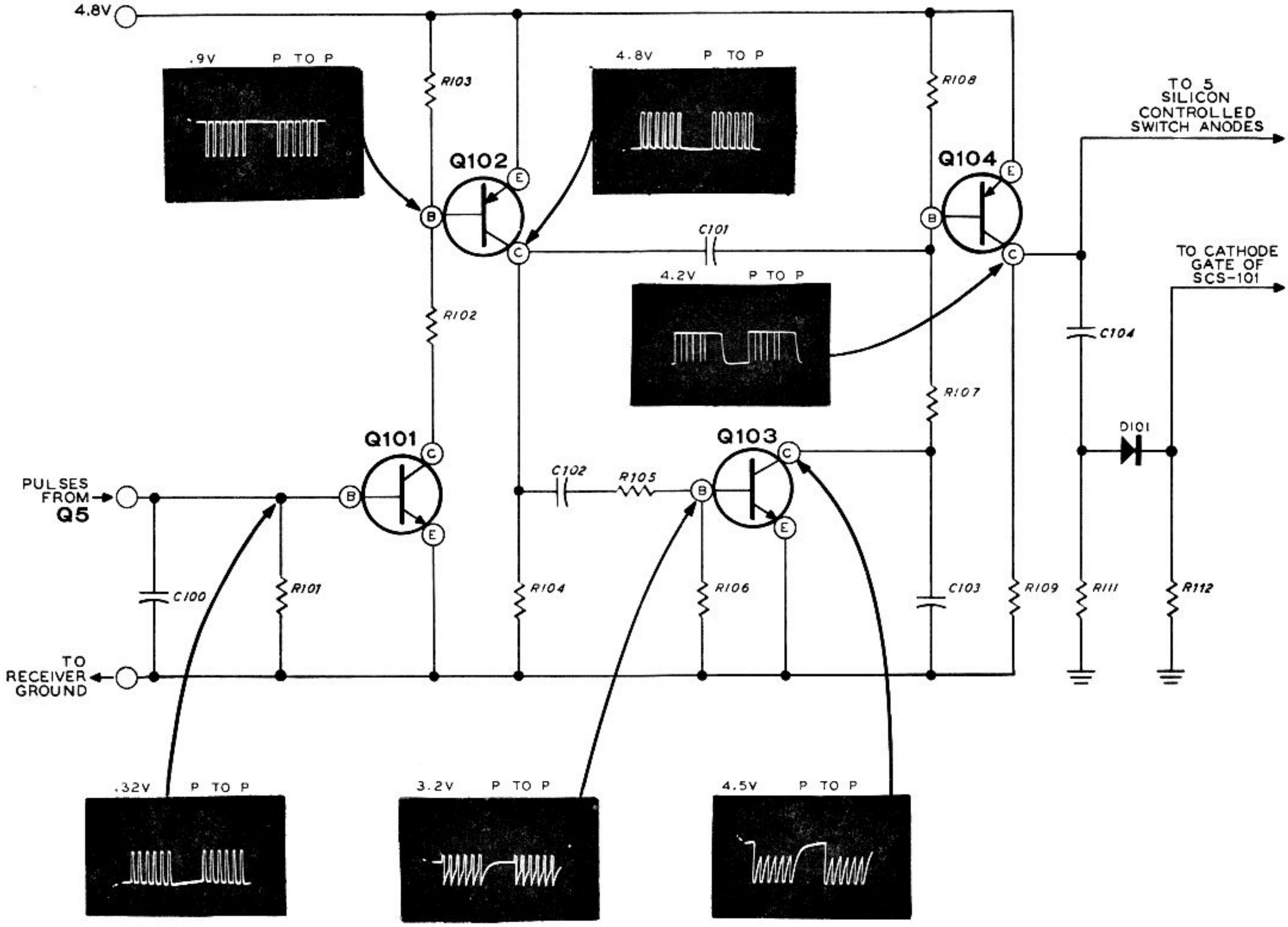


Figure 6-10

The sync pause time of the voltage waveform at the collector of Q104 stops all five SCS circuits from conducting. The positive-going portion of the first pulse, which is applied to all SCS anodes, prepares them to conduct. At the same time, this first positive pulse is applied through the differentiating network of C104 and R111, and through diode D101, to the cathode gate of SCS-101. This turns on SCS-101, passing current to the first (channel #1) Servo unit.

The second pulse momentarily cuts off the SCS anode voltage and turns off SCS-101. When SCS-101 turns off, its cathode presents a negative-going trailing edge which is coupled through C105 and D102 as a negative pulse to the anode gate of SCS-102, turning on this SCS. Now SCS-101 is turned off, removing current from the first Servo, while SCS-102 conducts and passes current to the second Servo.

Each SCS conducts only during the interval between two pulses. The first pulse in each train starts SCS-101 conducting and the second pulse stops it. As SCS-101 stops conducting, it starts SCS-102. The third pulse stops SCS-102, and SCS-102 in turn starts SCS-103, etc. Each SCS passes current to its own servo unit only during the interval that was initially determined by a control position at the Transmitter.

Each Servo unit translates the pulse-time interval into motor revolutions. The operation of the Servo unit is described next.

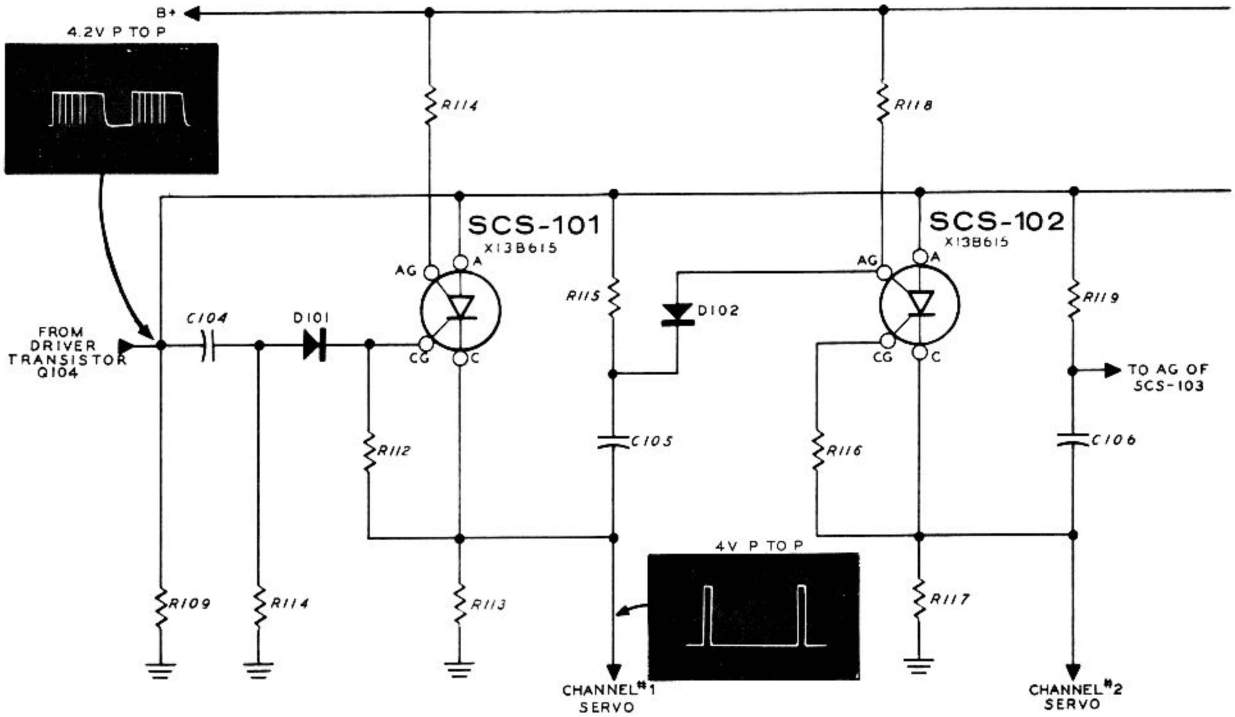
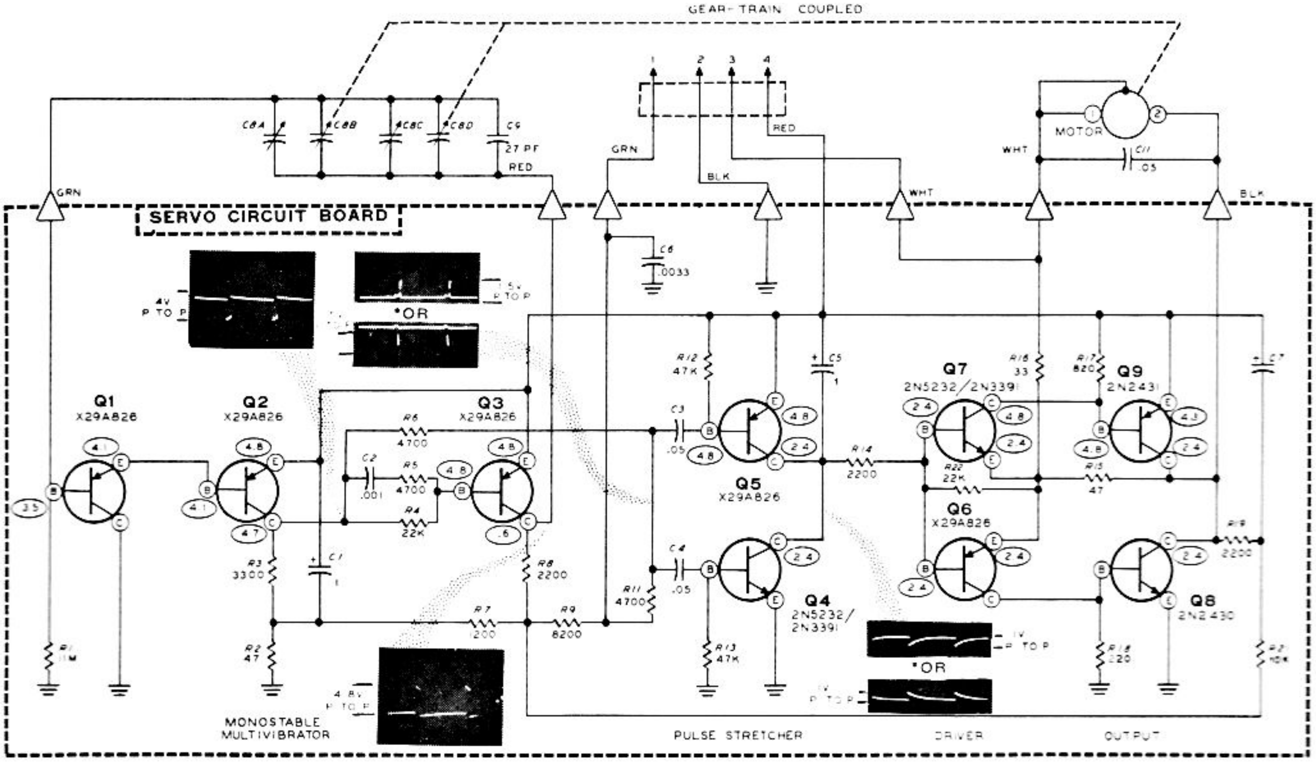
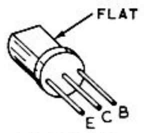


Figure 6-11

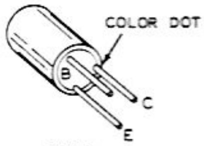


SCHEMATIC OF THE HEATHKIT® DIGITAL PROPORTIONAL SERVO MODEL GDA-19-4

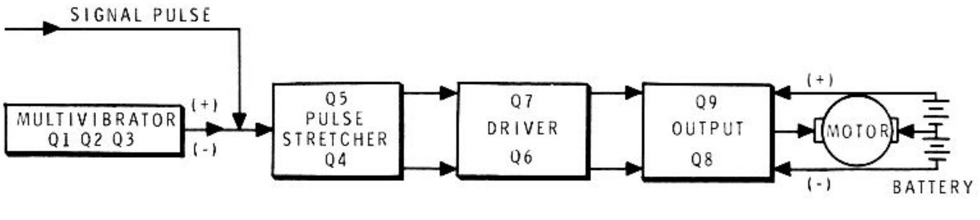
1. ALL RESISTORS ARE 1/4 WATT.
   RESISTOR VALUES ARE IN OHMS (K = 1,000, MEG = 1,000,000).
2. ALL CAPACITOR VALUES ARE IN µF UNLESS MARKED OTHERWISE.
3. ⬭ THIS SYMBOL INDICATES A POSITIVE DC VOLTAGE MEASUREMENT WITH NO SIGNAL BEING RECEIVED.
4. ALL VOLTAGES ARE MEASURED WITH A HIGH IMPEDANCE VOLTMETER, FROM THE POINT INDICATED TO COMMON GROUND. VOLTAGES MAY VARY ±20%.
5. REFER TO THE SERVO PHOTOGRAPHS AND CIRCUIT BOARD X-RAY VIEW FOR THE PHYSICAL LOCATION OF PARTS.
6. * THESE WAVEFORMS SHOW THE DRIVE SIGNALS FOR BOTH DIRECTIONS.



2N5232/2N3391
X29A826



2N2430
2N2431



SERVO BLOCK DIAGRAM

SERVO

The Servo unit translates the pulses that come from the Receiver into positive or negative voltages, and these voltages operate a motor that moves a control surface of a model. The signal pulses and the battery voltages are coupled from the Receiver to the Servo through a multi-pin connector. The miniature circuit board in the Servo contains a monostable multivibrator circuit, a pulse stretcher circuit, a driver circuit, and an output circuit. Each of these circuits will be described separately in the following paragraphs. Refer to the Block Diagram and to the Schematic Diagram (fold-out from this Page) while you read this Circuit Description.

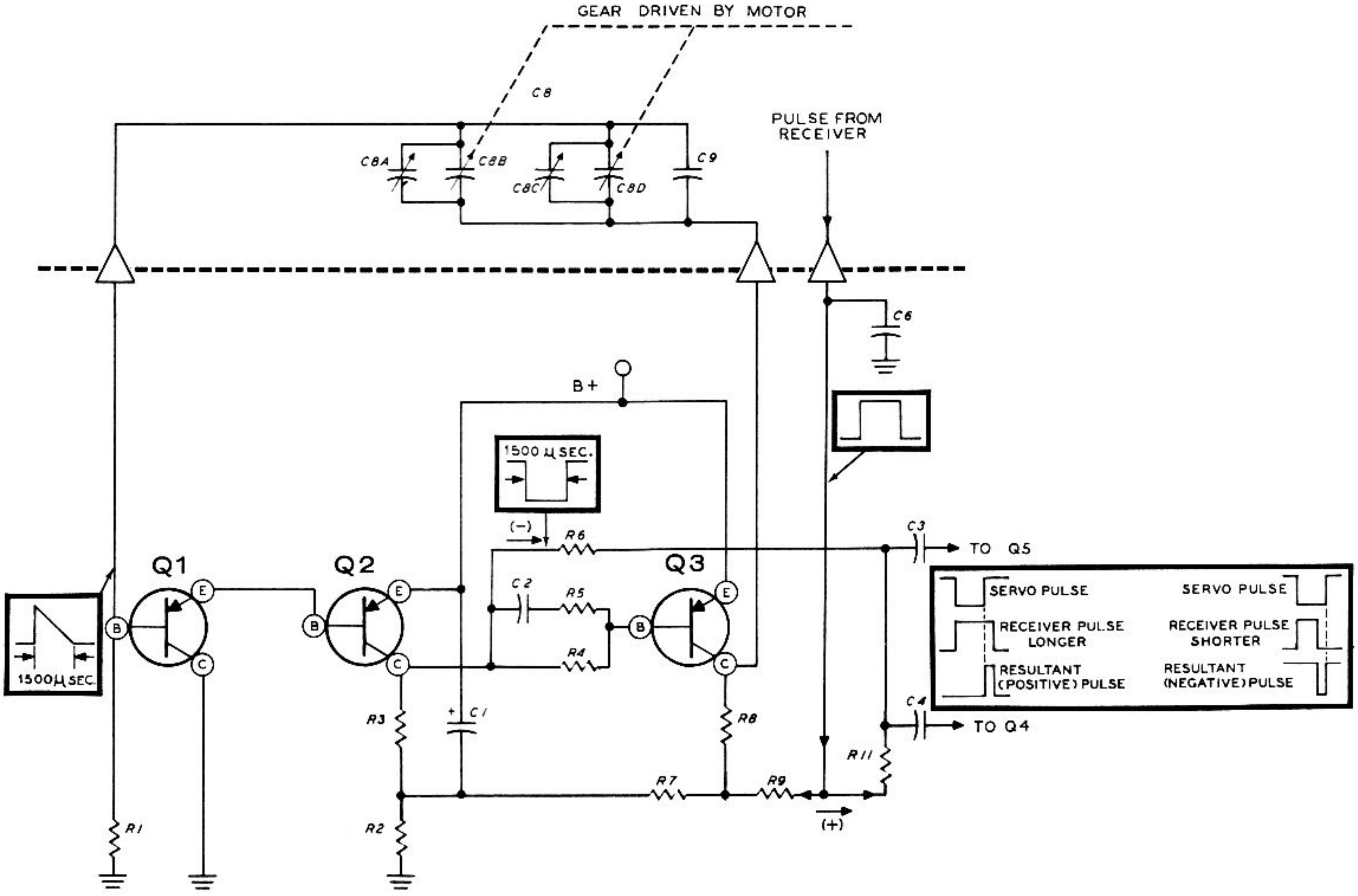
MULTIVIBRATOR CIRCUIT

Transistors Q1, Q2 and Q3 form a monostable (one-shot) multivibrator. See Figure 6-12. In this multivibrator circuit, transistors Q1 and Q2 normally conduct while Q3 is normally cut off. When a positive signal pulse from the Receiver is applied through R8 and R9 to the collector circuit of Q3, the conditions are reversed and Q3 conducts while Q1 and Q2 are cut off. The circuit remains in the reversed condition for a definite period of time and then returns to the normal condition.

The length of time that the multivibrator will remain reversed (normally 1500 microseconds) depends on the RC (resistor-capacitor) time constant set by resistor R1 and capacitors C8 and C9. Capacitor C8 consists of two variable sections, B and D, and two trimmer capacitors, A and C. These parallel capacitors are connected between the base of Q1 and the collector of Q3.

Each positive signal pulse from the Receiver passes through the green wire of the Servo and resistors R9 and R8 to the collector of Q3. This positive signal voltage also passes through capacitors C8 and C9 to the base of Q1, causing Q1 to cut off. Since the emitter of Q1 is direct-coupled to the base of Q2, Q2 also cuts off producing a negative pulse at its collector. This negative pulse, which is coupled through R4 to the base of Q3, causes Q3 to conduct. The circuit remains in this condition until capacitors C8 and C9 charge sufficiently through R1 to raise the base voltage of Q1 and cause it to conduct. Then the circuit reverts to its normal condition.

The variable sections of capacitor C8 are gear-driven by the servo motor. With the capacitor in its midposition, the period of the multivibrator is approximately 1500 microseconds. Thus, the negative pulse from the collector of Q2 lasts for 1500 microseconds, and is coupled through resistor R6 to the junction of capacitors C3 and C4. The positive signal pulse from the Receiver is passed through R11 to the same junction of C3 and C4. If the duration of the positive signal pulse equals the duration of the negative multivibrator pulse, the pulses cancel and the voltage at the junction of C3 and C4 is zero. A signal pulse that is longer than the multivibrator pulse results in a proportionately positive voltage pulse at the junction of C3 and C4, while a shorter signal pulse leaves a proportionately negative voltage pulse at this junction.



MONOSTABLE MULTIVIBRATOR

Figure 6-12

PULSE STRETCHER CIRCUIT

Capacitors C3 and C4 couple any difference pulses to transistors Q4 and Q5. See Figure 6-13. These transistors are connected in series between the supply voltage and ground. Without a difference pulse at the base of Q4 or Q5, neither transistor conducts. The voltage at their common collectors is then approximately half of the voltage between the supply and ground. Capacitor C5 is then charged to this voltage at the collectors.

When a positive difference pulse results from comparing the signal pulse with the multivibrator pulse, transistor Q4 conducts and reduces its collector voltage to zero, causing C5 to charge to the battery voltage. Since this collector is coupled through R14 to the common bases of Q6 and Q7, these bases become more negative. If the difference pulse at the junction of C3 and C4 is negative, transistor Q5 conducts discharging C5, making its collector and the bases of Q6 and Q7 more positive.

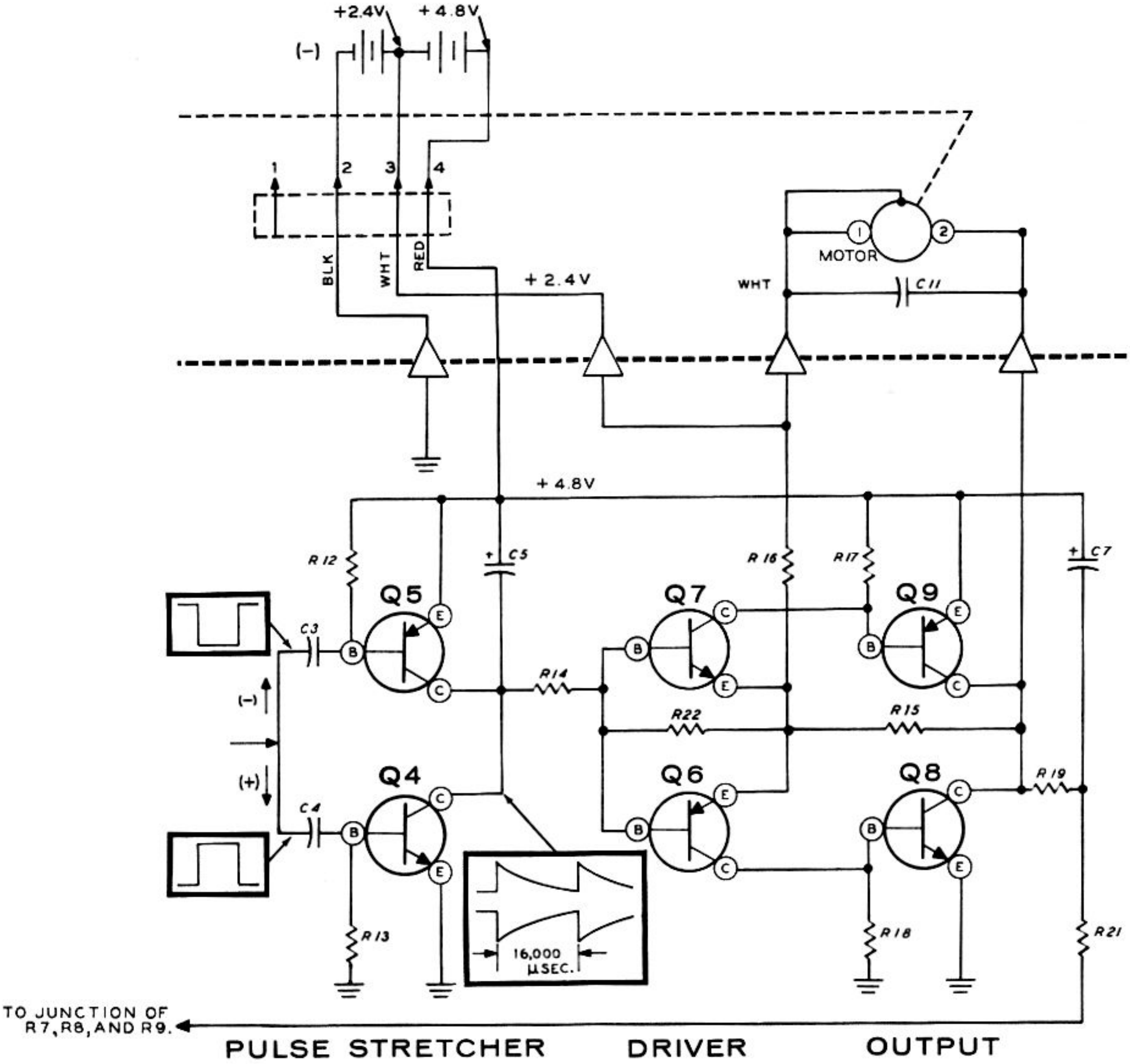


Figure 6-13

As the difference pulse may be very narrow due to only slight differences in the receiver pulse and the multivibrator pulse, and since it is only repeated once every 16,000 microseconds, very little average current would be fed to the motor. Therefore, C5 is used to stretch out this pulse at the collectors of Q4 and Q5 to hold this voltage there for a much longer period of time. This will give the motor greatly increased average current and power.

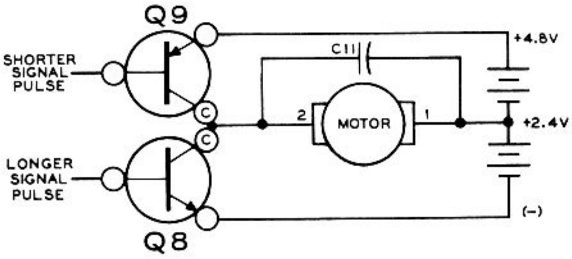


Figure 6-14

DRIVER AND OUTPUT CIRCUITS

The collector of Q6 is direct coupled to the base of Q8, and the collector of Q7 is direct coupled to the base of Q9. The common emitters of Q6 and Q7 are supplied through R16 from the center tap of the battery. When transistor Q6 is made to conduct as the result of a longer signal (positive difference) pulse from the Receiver, Q8 also conducts and shorts its collector to ground. A shorter signal (negative difference) pulse, on the other hand, causes Q9 to conduct and shunts its collector to the 4.8 volt supply. Resistor R15 feeds back a portion of the output to increase the stability of the amplifier, and resistors R19 and R21, along with capacitor C7, form a feedback network to prevent overshoot.

Number 1 pole of the reversible motor is connected to the center tap of the battery as shown in the simplified schematic of Figure 6-14. The motor runs in one direction when number 2 pole is connected to the positive end of the battery, and reverses when this pole is connected to the negative (ground) end of the battery. Transistors Q6 and Q7 are the drivers that operate Q8 and Q9 to perform the battery switching that drives the motor.

The collectors of Q8 and Q9 are common to the number 2 pole of the motor. With a signal pulse from the Receiver that is longer than the multivibrator pulse, transistors Q4, Q6, and Q8 conduct, making the number 2 pole of the motor negative, and driving the motor in one direction. When the signal pulse from the Receiver is shorter than the multivibrator pulse, transistors Q5, Q7, and Q9 conduct. This places the number 2 pole of the motor at the positive end of the battery supply, and the motor runs in the opposite direction. Capacitor C11 is used to filter out motor brush noise.

The length of the multivibrator period is determined by the RC time constant of resistor R1 and variable capacitors C8 and C9. The rotor plates of C8B and C8D are gear-driven by rotation of the servo motor. When a signal pulse length differs from the multivibrator pulse length, the motor turns in one direction and rotates the variable capacitor plates. When the capacity of C8B and C8D change enough to make the multivibrator pulse length equal to the signal pulse length, these pulses cancel and no longer produce the difference pulse that is required to turn on either Q4 and Q5. This absence of a pulse length difference keeps the driver and output transistors turned off and the motor remains stopped. In this way, each different pulse length input to the Servo is represented by a different portion of the variable capacitor and the output wheel and coupling tabs.

The motor gear train turns the variable capacitor rotor plates while it drives a pair of rack gears. The rack gears can be driven approximately 5/8 inch. These rack gears are mechanically connected to one of the control devices in the model so that the Servo unit operates the device.

PULSE STRETCHER CIRCUIT

Capacitors C3 and C4 couple any difference pulses to transistors Q4 and Q5. See Figure 6-13. These transistors are connected in series between the supply voltage and ground. Without a difference pulse at the base of Q4 or Q5, neither transistor conducts. The voltage at their common collectors is then approximately half of the voltage between the supply and ground. Capacitor C5 is then charged to this voltage at the collectors.

When a positive difference pulse results from comparing the signal pulse with the multivibrator pulse, transistor Q4 conducts and reduces its collector voltage to zero, causing C5 to charge to the battery voltage. Since this collector is coupled through R14 to the common bases of Q6 and Q7, these bases become more negative. If the difference pulse at the junction of C3 and C4 is negative, transistor Q5 conducts discharging C5, making its collector and the bases of Q6 and Q7 more positive.

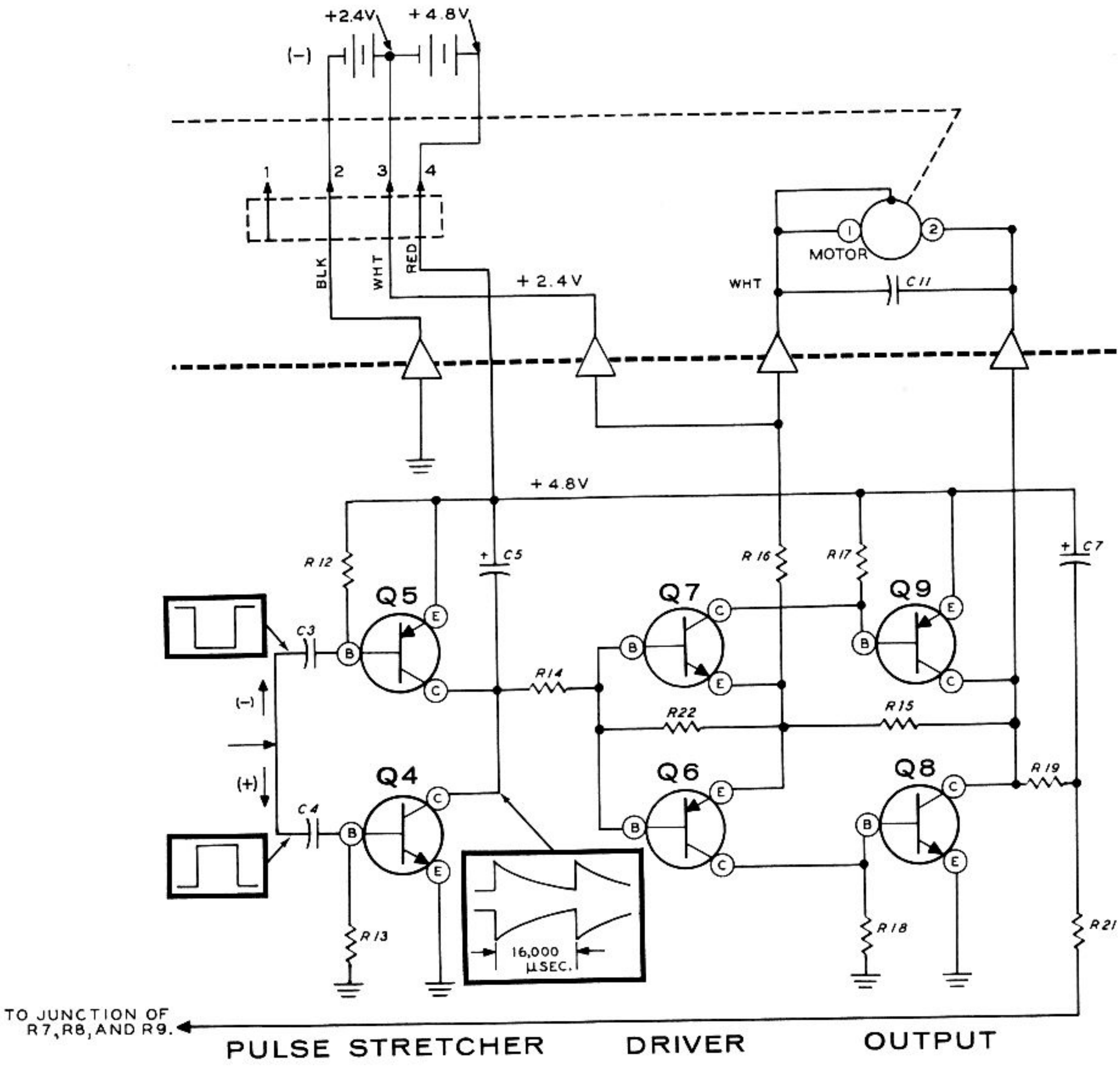


Figure 6-13

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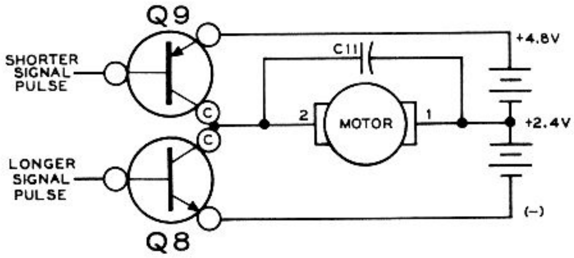

Figure 6-14

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The length of the multivibrator period is determined by the RC time constant of resistor R1 and variable capacitors C8 and C9. The rotor plates of C8B and C8D are gear-driven by rotation of the servo motor. When a signal pulse length differs from the multivibrator pulse length, the motor turns in one direction and rotates the variable capacitor plates. When the capacity of C8B and C8D change enough to make the multivibrator pulse length equal to the signal pulse length, these pulses cancel and no longer produce the difference pulse that is required to turn on either Q4 and Q5. This absence of a pulse length difference keeps the driver and output transistors turned off and the motor remains stopped. In this way, each different pulse length input to the Servo is represented by a different portion of the variable capacitor and the output wheel and coupling tabs.

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