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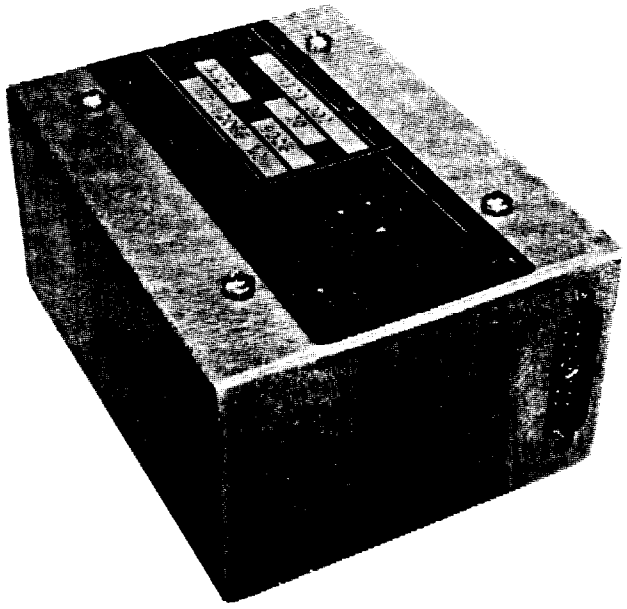
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Efratom Division

DESCRIPTION AND OPERATION MANUAL



SUBMINIATURE RUBIDIUM OSCILLATOR
MODEL FRS

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Ball Corporation, Efratom Division, will be happy to answer any application or usage questions which will enhance your use of this unit. Please address your requests or correspondence to: **Ball Corporation, Efratom Division**, 3 Parker, Irvine, California 92718-1605, Attention: Sales Department, or call (714) 770-5000, Fax: (714) 770-2463.

European customers may contact: **Ball Efratom Elektronik GmbH**, Fichtenstr 25, 8011 Hofolding, West Germany, Telephone: 08104/90 40; Telex 529701; Fax: 08104/99 18.

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CHAPTER 1

INTRODUCTION AND SPECIFICATIONS

1-1. INTRODUCTION.

The Efratom Model FRS Rubidium Standard is a sub-miniature, atomic resonance-controlled oscillator that provides an extremely stable signal of 2.048 MHz TTL, 5 MHz, or 10 MHz (TTL or sinusoidal). The FRS-C is designed for instruments and equipment requiring an extremely stable and precise frequency operating in commercial/industrial environmental conditions. The FRS-N is designed primarily for use in high-performance communication and navigation systems with more stringent environmental conditions.

1-2. SCOPE.

This manual contains information regarding the operation and field maintenance of the FRS. Chapters 1 and 2 contain general information concerning the unit. It is recommended that these chapters be read prior to attempting operation of the unit. Chapter 3 presents a general theory of operation for a technician or engineer who requires a better understanding of the unit's operation. Outline and assembly drawings, parts lists and schematic diagrams are contained in the Appendix.

1-3. CONNECTIONS.

All necessary connections for input and output signals are externally accessible. Output signal, power, frequency adjustment, and built-in-test (BIT) functions are provided by a Cannon connector that mates with Cannon P/N DAM11W1S and DM 53740-5000.

1-4. ELECTRICAL PROTECTION.

The unit is protected against reverse polarity input power by both an internal fuse and diode. The output signal is short-circuit protected.

1-5. AVAILABLE OPTIONS.

Optional output frequencies include the following: 5 MHz at 1.5 Vrms into a 50 ohm load, 2.048, 5 or 10 MHz TTL.

1-6. SPECIFICATIONS.

The FRS 1 day stability (1E-10) assumes an ambient temperature of 25 (±3)°C and a warm-up time of forty-eight hours minimum, preceded by a maximum off time of seventy-two hours; or a warm-up time of three days with an off time of one month. After seven days of continuous operation, the one day stability is 4E-11. Table 1-1 lists the specifications for the FRS Model C. Table 1-2 lists the specifications for the FRS Model N.

TABLE 1-1. SPECIFICATIONS, FRS-C

ELECTRICAL

Output:

FRS-C

EXAMPLE PART NUMBER
FRS-C-1A8A4C

MODEL	BASEPLATE	COVER	CONNECTOR	OUTPUT	OPTIONS	TEMP RANGE
FRS-C	4-40 THD 1	STANDARD A	CANNON DAM11W1S 8	10 MHZ SINE A	TTL LOCK MONITOR 4	-5°C TO +65°C C
	M2.5 THD 2			10 MHZ TTL E		
				2.048 MHZ TTL F		
				5 MHZ SINE G		

Amplitude (Sine):	0.5 Vrms +30/-10% into 50 ohm resistive load
Amplitude (TTL):	Low: 0 to +0.8V, High: +3.5 to +5.5V, into 50 Ohm resistive load.
Accuracy Setting at Shipment:	±5E-11 (25°C) (Accuracy after 1 year): 1E-9/Year
Input Voltage Range:	22 to 30 Vdc
Power-steady State:	12 W @ 24 Vdc at 25°C Base Plate
At turn on:	2.0 A peak
Input Voltage Sensitivity:	5E-11 (for ±10% Vdc)
Warm-up Characteristics:	
Time to lock:	≤ 4 minutes
Minutes/Freq @ 25°C:	6 minutes/1E-9
Long Term Drift:	≤ 5E-11/Mo*, ±5E-10/Yr
1-Day Stability:	1E-10/day**
Short-Term Stability: (5 & 10 MHz outputs only)	
1.0 Second (Allan Var.)	1E-10
10 Sec. (Allan Var.)	3.16E-11
100 Sec. (Allan Var.)	1E-11
Phase Noise (SSB 1 Hz BW) :	-70dBc/√Hz at 1Hz, -110dB c/√Hz at 100Hz, -130 dBc/√Hz at 1 KHz
Harmonic/Non-Harmonic Distortion:	10 MHz = -40 dBc (sine)/ -70 dBc; 5 MHz = -40 dBc/-60 dB
Frequency Trim Range:	±1E-9 minimum
Frequency Retrace:	5E-11
Setting Resolution:	1E-11
Magnetic Field Sensitivity:	≤ 4E-13/A m^{-1} (worst case)
Electrical Protection:	Internal diode protects against reverse polarity connection. Rf output/BIT short-circuit protected.

ENVIRONMENTAL

Operating Temperature:	≤ 3E-10 from -5°C to +55°C Amb. (65°C Max baseplate)
Storage Temperature (non-ops):	-55°C to +85°C
Humidity:	≤ 95 % RH
Altitude, Vibration, Shock:	MIL-T-28800 Type III, Class 5

PHYSICAL

Size (inches h/w/d):	2.0 x 3.0 x 4.0 (5.1 x 7.6 x 10.2 cm)
Weight:	1.2 lbs (0.55 kg)
Connectors:	Mate with Cannon Series DAM11W1S
Baseplate Threads:	(STD) 4-40 (M2.5 option)
Warranty:	12 months

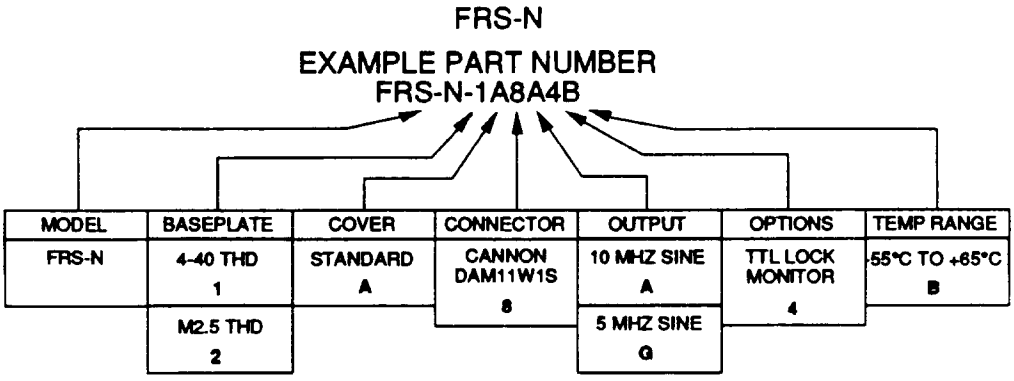
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* After 1 month of continuous operation
** Refer to Section 1-6.

TABLE 1-2 SPECIFICATIONS, FRS-N

ELECTRICAL

Output:



Amplitude (Sine):	0.5 Vrms +30/-10% into 50 ohm resistive load
Amplitude (TTL):	Low: 0 to +0.8V, High: +3.5 to +5.5V, into 50 Ohm resistive load.
Accuracy Setting at Shipment:	±5E-11 (25°C) (Accuracy after 1 year): 1E-9/Year
Input Voltage Range:	24 Vdc nominal (22-29.5 Vdc) (RTCA DO-160B, CAT A for voltage levels and spikes)
Power-steady State:	12 W @ 24 Vdc at 25°C Base Plate
At turn on:	2.0 A peak
Steady state:	21 W @ 24 Vdc (circulated air, Base Plate ~45°C)
Input Voltage Sensitivity:	5E-11 (for ±10% Vdc)
Warm-up Characteristics:	
Time to lock @ 25°C:	4 minutes
@ -55°C	8 minutes
Minutes/Freq @ 25°C:	6 minutes/1E-9
Long Term Drift:	≤ 5E-11/Mo*, ±5E-10/Yr
1-Day Stability:	1E-10/day**
Short-Term Stability: (5 & 10 MHz outputs only)	
1.0 Second (Allan Var.)	5E-11
10 Sec. (Allan Var.)	1.58E-11
100 Sec. (Allan Var.)	5E-12
Phase Noise (SSB 1 Hz BW) :	-70dBc/√Hz at 1Hz, -110dBc/√hz at 100Hz, -130 dBc/√Hz at 1 KHz
Harmonic/Non-Harmonic Distortion:	10 MHz = -40 dBc/ -65 dBc; 5 MHz = -40 dBc/-60 dB
Frequency Trim Range:	±1E-9 minimum

Frequency Retrace:	5E-11
Setting Resolution:	1E-11
Magnetic Field Sensitivity:	$\leq$ 4E-13/A m^{-1} (worst case), (3E-11/gauss), CAT. A
Electrical Protection:	Internal diode/fuse protects against reverse polarity connection. Rf output/BIT short-circuit protected

ENVIRONMENTAL CONDITIONS (per RTCA DO-160B)

Temperature / Altitude:	CAT. E1
Operating Temperature:	-5°C ambient to +65°C baseplate ($5E^{-}10$) 25°C + 25°C ambient ($\pm1E^{-}10$)
Storage Temperature:	-55°C to +85°C
Altitude:	$\leq$ 70,000 ft. (21,300 m)
Magnetic Field:	$\leq$ 4E-13/AM^{-1} (3E-11/0.1 millitesla)
Temperature Variations:	CAT. B, (5°C per minute minimum)
Humidity:	CAT. A, (95 RH)
Shock Operational:	6 g, 11 ms
Crash Safety:	12 g, 11 ms
Vibration (sinewave):	Curves M, N, O 1.5 g to 500 Hz 1.0 g to 1000 Hz
Explosion:	CAT. E
Waterproofness:	CAT. X
Fluids Susceptibility:	CAT. X
Sand and Dust:	CAT. X
Fungus:	CAT. X
Salt Spray:	CAT. X
Magnetic Effect:	CAT. A
Power Input:	CAT. A for steady state voltage levels and voltage spikes CAT. B for ripple susceptibility
Voltage Spike:	CAT. A
Audio Frequency Conducted:	CAT. B
Susceptibility - Power Input:	
Induced Signal Susceptibility[1]	CAT. A
Radio Frequency Susceptibility[1]	CAT. A
Emission of Radio Frequency[1]	CAT. A

PHYSICAL CHARACTERISTICS

Size (inches, h / w / l):	2.0 x 3.0 x 4.0 (5.1 x 7.6 x 10.2 cm)
Weight:	lbs/inches cubed: 1.2 / 24 kg/cm cubed: 0.55 / 395
Connectors :	Mate with Cannon Series DAM11W1S
Baseplate Threads:	(STD) 4-40 (M2.5 option)
Warranty:	12 months

---

* After 1 month of continuous operation

** Refer to Section 1-6.

CHAPTER 2

INSTALLATION AND OPERATION

2.1 INTRODUCTION. This chapter of the manual contains information regarding the installation and operation of the Efratom Model FRS. It is recommended that this chapter be read carefully prior to attempting operation of the unit.

2.2 SHIPPING AND RECEIVING INFORMATION. The Model FRS is packaged and shipped in a foam-packed container. The unit is inspected mechanically and electrically prior to shipment. Upon receipt of the unit, a thorough inspection should be made to ensure that no damage has occurred during shipping. If any damage is discovered, contact Ball Corp., Efratom Division, 3 Parker, Irvine, CA. 92718. Telephone 714/770-5000; Telex 685-635; FAX 714/770-2463. If reshipment of the unit is necessary, the original container and packing should be used. If the original container is not available, a suitable container with foam-packing is recommended.

2.3 MOUNTING. The unit should be mounted with the thermal baseplate in contact with a flat metal surface (.005 inches rms or better). Mounting screws (4-40) must not be allowed to penetrate the baseplate more than 0.2 inches (5mm). It is recommended that the mounting surface be designed to permit free access to the unit's frequency adjust potentiometer.

The heat transfer characteristics of the mounting surface must be adequate to limit the rise of the unit's baseplate to $< +65°C$. The allowable environmental temperature (Ta), for this mounting is:

	Ta	= 65° C - Vs, Is, Rk
	Vs	= Supply Voltage in volts
Where:	Is	= Supply Current in amperes
	Rk	= Thermal Resistance between unit and ambient, °C/watt).

2.4 POWER REQUIREMENTS. The Model FRS requires an external power source capable of providing between +22 and +30 Vdc, with a minimum of 2.5 ampere output. The positive input voltages for the unit is to pins 9 (electronics) and 6 (heater) with the negative return voltage on pin 10 of the connector.

In order to obtain the cleanest output signal close to the carrier, the maximum ac ripple on the supply voltage must be less than 1 mV peak-to-peak. If non-harmonics at the supply ripple frequency (50, 60, or 400 Hz) are not a consideration, the ripple can be higher, but in no case should the supply voltage AC +/- peak exceed the upper or lower input power limit of the unit.

2.5 INSTALLATION CONSIDERATIONS. Some consideration must be given to the operating location of the unit, regardless of its application. To minimize frequency offsets and/or non-harmonic distortion, the unit should not be installed near equipment generating strong magnetic fields such as generators, transformers, etc.

> **CAUTION**
> Care must be taken to ensure that the maximum operating temperature is not exceeded, (+65°C as measured at the unit's baseplate).

2-6. SIGNAL INPUTS AND OUTPUTS. Figure 2-1, illustrates the Model FRS Cannon connector J1, and presents a functional description of the pin connections.

PIN	DESCRIPTION
Coax	RF Out/Shield
1	Lock Monitor
2	External Frequency Adjust (wiper of potentiometer)*
3	External Frequency Adjust (ground for potentiometer)
4	Lamp Monitor*
5	Not Used
6	Heater Power +24 Vdc
7	Crystal Monitor (crystal control voltage)*
8	External Frequency Adjust (regulator monitor - positive for potentiometer)
9	Regulated Input Voltage (+24 Vdc)
10	Power Return

*Refer to Appendix B

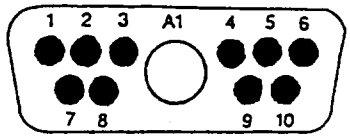


FIGURE 2-1. Cannon connector J1 Pin Arrangement

2-7. NORMAL OPERATION. When 24 Vdc is applied to pins 9 and 6(+) and 10(-), the unit will immediately begin generating a 10 MHz signal from the crystal oscillator. Within approximately 4 to 6 minutes after application of input power, the unit will "lock". The crystal is now stabilized by the atomic resonant frequency.

2-8. FUNCTIONAL OPERATION TEST EQUIPMENT. The equipment required to functionally test the unit is listed in Table 2-1. Test equipment other than those items listed may be used provided that the performance equals or exceeds the MINIMUM USE CHARACTERISTICS as stated in Table 2-1.

TABLE 2-1. Functional Operation Test Equipment

Para. No.	ITEM	MINIMUM USE CHARACTERISTICS	TEST EQUIP.
2.1	DC Power Supply	Output Voltage: +22 to +30 Vdc	Hewlett-Packard 6433B
2.2	DMM (Digital Multimeter)	Voltage Range: 0 to 30 Vdc Accuracy ±1.25% - Resistance Range: 0 to 150 ohm.	Fluke 8020A or 8000A
2.3	Freq. & Time Interval Analyzer	Ref. Freq. 10 MHz Resolution: 1E-10	Hewlett-Packard 5371A
2.4	Optional External Freq. Ref.	Output Frequency: 10 MHz Accuracy: ±5E-12 Stability: Parts in 10^{12}, or as req.	Cesium standard

NOTE

Throughout the test procedures in this manual the FRS will be referred to as the UUT (Unit Under Test). In addition, connections described or illustrated pertain to the Cannon connector.

2.9 OPERATIONAL FREQUENCY ACCURACY TEST.

a) Connect the equipment as shown in Figure 2-2.

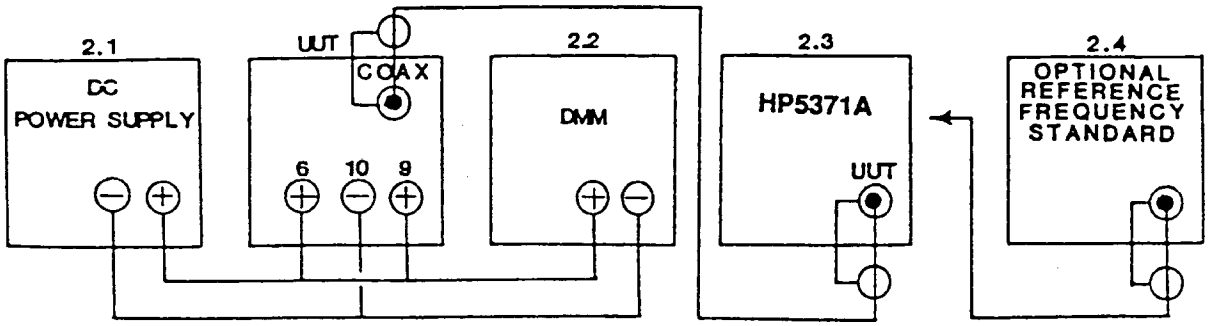


Figure 2-2. Operational Frequency Accuracy Test Setup.

b) Adjust the DC power supply controls to obtain a 24 ± 1.4 Vdc indication on the DMM. Allow sufficient time for equipment to stabilize.

NOTE

The UUT requires 4 minutes (@ 25°C) to stabilize for the following frequency accuracy: ±1E-9 (after 1 yr operation) of the final frequency (calibrated frequency), or the frequency before turn off, (providing turn off was within 24 hours). If the unit has been calibrated recently, the maximum frequency offset after 1 hour operation would be ±2E-11 warmup accuracy, ±2E-11 retrace. This assumes the last calibration was at the same ambient temperature.

c) Begin the test (refer to Frequency & Time Analyzer or HP5371A manuals).

d) Allow sufficient time for the test set to indicate the UUT OFFSET for the data you require. Verify that the UUT frequency offset is within the tolerance stated in the NOTE following Step 2-9b.

2.10 SHORT TERM STABILITY TEST (ALLAN VARIANCE)

NOTE

If steps 2-9 through 2-9d have been completed, and the Allan Variance indications (as displayed on the HP-5371A) are of the required averaging times, the test results as indicated are valid. If 2-9 was not performed, continue with 2-10.

a) With the equipment connected as shown in Figure 2-2, and the required stabilization time allowed, (refer to NOTE following 2-9b), begin the test.

b) Allow sufficient time for the test set to display the data for the averaging times required, and verify that the UUT Allan Variance is within the tolerance listed in Table 1-1, SPECIFICATIONS.

c) If no other tests are necessary, disconnect the test set-up.

CHAPTER 3

THEORY OF OPERATION

3.1 INTRODUCTION. This chapter of the manual contains a general theory of operation and circuit analysis of the Model FRS Rubidium Standard. Schematic diagrams are included in the Appendix to help clarify the text.

3.2 GENERAL THEORY. The FRS generates a stable 10 MHz output frequency from a 20 MHz Voltage Controlled Crystal Oscillator (VCXO), whose frequency is locked to the atomic-standard "resonance frequency" of the rubidium atom (rubidium reference frequency). Figures 3-1 and 3-2 show how the standard works.

A microwave signal that is derived from the VCXO tuneable oscillator is applied to rubidium vapor contained within a heated glass cell. Light from a rubidium lamp is passed through the cell and illuminates a photo detector causing current to flow in the detector. As the applied microwave signal approaches the frequency that corresponds to the ultrastable rubidium atomic resonance frequency, the rubidium light entering the glass cell is absorbed by the rubidium vapor to an increased extent causing a decrease in the photo detector current. This "darkening" effect is used to generate an error signal which permits continuous regulation of the quartz crystal oscillator output frequency, thereby locking it to the atomic-standard frequency.

RUBIDIUM REFERENCE FREQUENCY. The atomic-standard frequency (f_{Rb}) used for reference is provided by the 6.834 GHz ground-state hyperfine transition of ^{87}Rb (rubidium) atoms. The VCXO is locked to this frequency by means of a microwave signal (f_c), generated from the 20 MHz VCXO output, having a frequency in the vicinity of f_{Rb}. The frequency synthesis and multiplication scheme is designed so that the VCXO frequency is exactly 20 MHz when the microwave frequency (f_c) is equal to the rubidium reference frequency, f_{Rb}. The microwave signal excites vapor phase ^{87}Rb atoms that are contained in the heated glass cell within the microwave cavity (resonator) (see Figure 3-2).

RUBIDIUM LAMP. Light from the rubidium lamp is generated by an rf-excited plasma discharge. Rubidium in the lamp is heated to a vapor state (approximately 106°C) and subjected to a high-energy rf field. This rf field causes a plasma discharge which produces rubidium light of the proper wavelength. The light passes through rubidium vapor contained in the resonance cell, where some of the light is attenuated. The remaining light is incident upon a silicon photo detector (photocell) within the resonator cavity. When the applied microwave frequency (f_c) is equal to the hyperfine frequency, f_{Rb}, the rubidium atoms resonate with the microwave field in the cavity, causing the light reaching the photo detector to decrease. This decrease in light intensity is made possible by the simultaneous interaction of rubidium light and microwave energy, a process called "Optical Pumping". (This behavior is illustrated by the V-shaped curve in Figure 3-3.)

The darkening effect described above is used to generate the error signal that is processed by the servo (control) circuits to correct the VCXO frequency, maintaining a "locked" condition when the applied microwave frequency (f_c) is equal to the hyperfine frequency f_{Rb}. Figure 3-1 is a block diagram of this process.

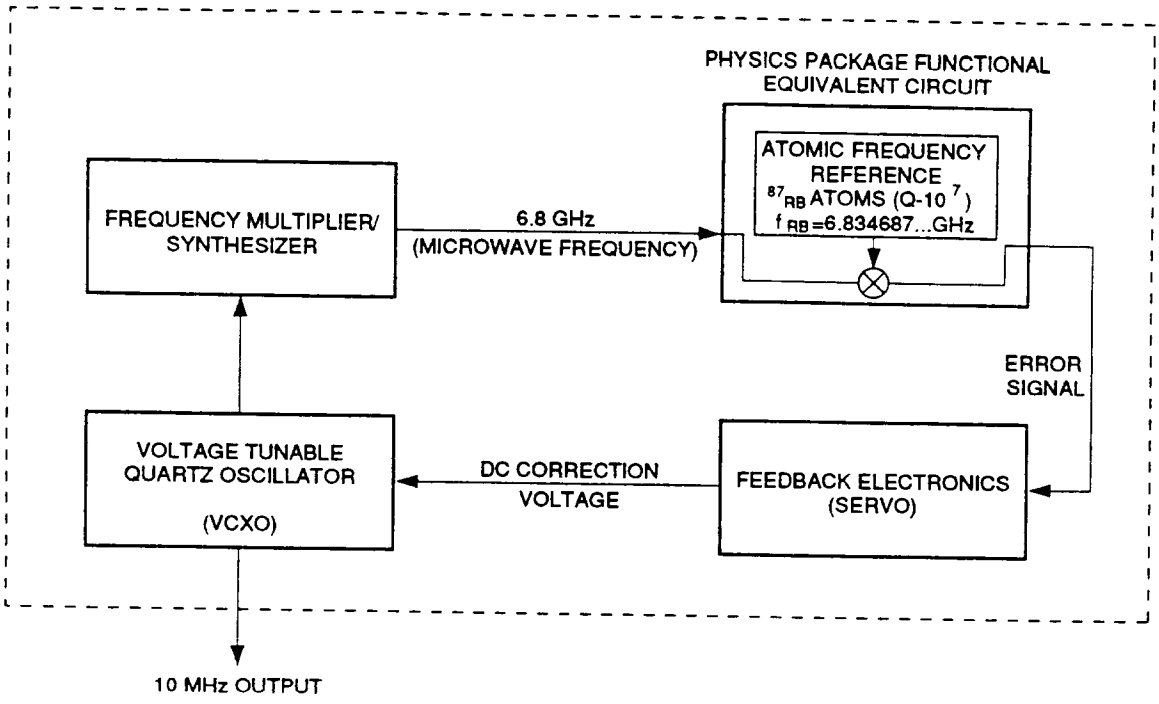


Figure 3-1. Simplified Block Diagram of Rubidium Atomic Standard

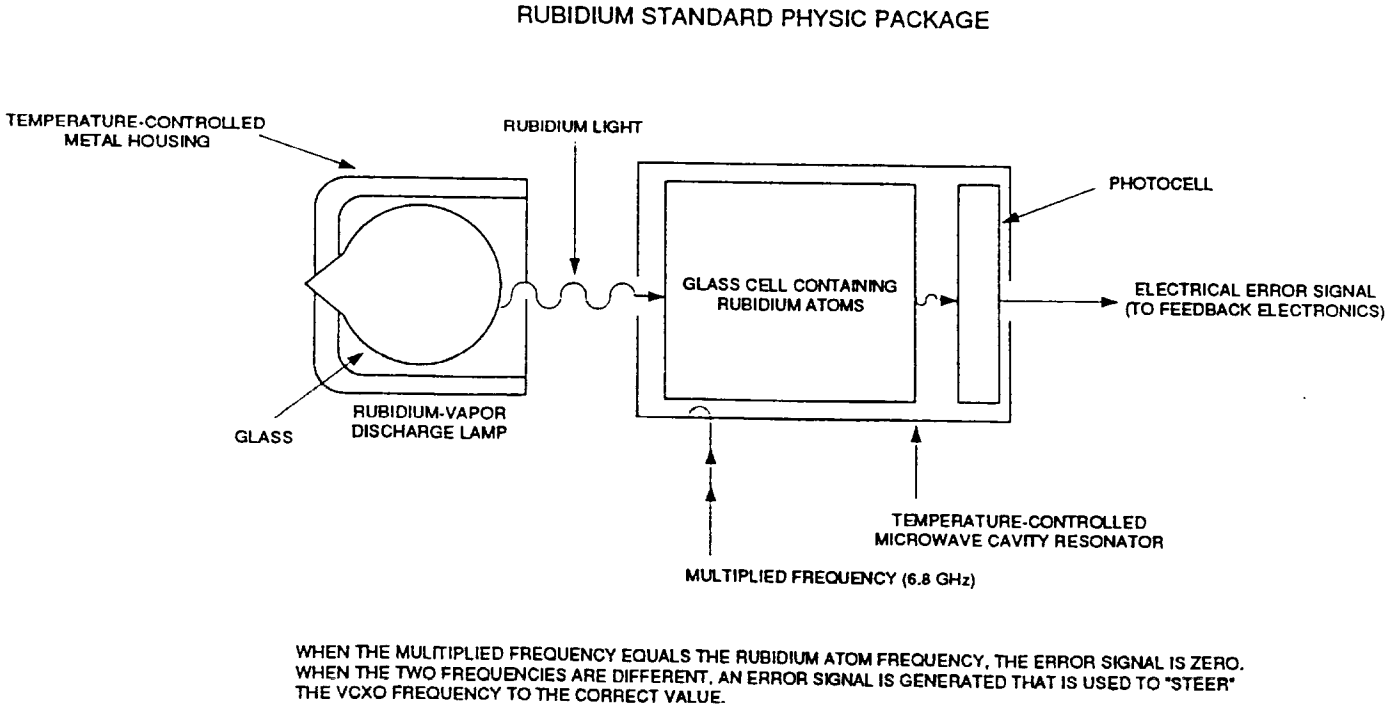


Figure 3-2. Simplified Block Diagram of Physics Package

OPTICAL PUMPING. The rubidium oscillator is a passive device in that the atoms themselves do not produce a self-sustaining microwave oscillation. The atomic resonance is detected passively by optical means and involves a process by which atoms are raised to a higher energy state through the absorption of light energy.

To understand how the optical darkening effect occurs, it is necessary to understand the atomic physics phenomenon called "Optical Pumping".

According to Planck's theory, when radiation is absorbed or emitted by an atom, the energy is absorbed or emitted in whole packets, or quanta, called photons. Atoms therefore exist only at specific energy levels.

For rubidium the lowest two energy levels are called the ground-state hyperfine levels and are denoted by A and B in Figure 3-4. The rubidium atoms will ordinarily be equally divided between these two levels (Figure 3-4-I). If the atoms are irradiated with microwave energy at the hyperfine frequency, then the atoms at level A will make a transition to level B and vice-versa, without changing the overall distribution between the two levels (Figure 3-4-II). This transition takes place at the hyperfine frequency of rubidium, (f_{Rb}). The hyperfine frequency is related to the hyperfine energy level separation by a fundamental equation of physics:

$$E_{Rb} \text{ (joules)} = h\, f_{Rb},$$

where h = Plank's Constant = 6.626 E-34 joules/Hz.

A third and much higher energy state, level C, also exists which is normally vacant. Level C is excited by infrared light energy of the proper wavelength from the rubidium lamp (Figure 3-4-III). Transitions to level C are known as "optical transitions" and can occur from either of the two hyperfine energy levels A or B. After a short time (~25 nsec), the atoms which were raised to the C level will emit a photon of approximately the same wavelength as the original photon. They then return to the ground state hyperfine level, redistributing themselves approximately equally between levels A and B (Figure 3-4-IV).

If the spectral wavelength corresponding to only one of the hyperfine levels is introduced, level A for example, only the atoms at that hyperfine level will make the transition to level C (Figure 3-4-V). This condition is generated by filtering out the spectral wavelength corresponding to the other hyperfine level, B. In rubidium oscillators manufactured by EFRATOM, an isotope of rubidium ^{85}Rb, mixed with the ^{87}Rb in the resonance cell, performs the filtering function.

As the filtered light energy passes through the resonance cell, level A to C transitions occur so that the rubidium atoms excited to the C level emit photons and return to the ground state redistributing themselves equally between levels A and B (Figure 3-4-VI). The atoms which return to level A will again absorb light and be raised to level C, where they will remain for a short time before emitting a photon and again redistributing themselves between the two levels A and B. As this process continues, eventually there will be no atoms left at level A to be excited to level C (Figure 3-4-VII). The atoms will stay at level B because the filtered

light is not the proper wavelength to excite them to level C. By this process all of the atoms are pumped to hyperfine level B, producing a population difference between the two hyperfine levels, A and B.

Once all the atoms are pumped to level B, and in the absence of the correct microwave energy, light is no longer absorbed and passes unattenuated through the resonance cell.

When a microwave field with frequency corresponding to the hyperfine frequency is applied, the atoms at level B make the transition to level A and vice-versa. However, due to optical pumping, when the atoms from level B make the transition to level A they are also available for excitation to level C by the light beam. Since each excitation of an atom at level A is accompanied by the absorption of a light photon, the net effect of applying the microwave field at the hyperfine frequency is to cause continued attenuation of the light beam. (It should be mentioned that when Rb atoms absorb photons and subsequently make C ---> A or C ---> B transitions, the re-emitted photons are emitted with equal probability in all directions so that most of these photons never reach the photo detector. Thus, a photon originally removed from the light beam is replaced by a photon that, in most cases, is not detected.) Figure 3-4 illustrates the Optical Pumping process.

ELECTRONIC ANALOGUE. The operating behavior of the physics package can be viewed in its simplest form as a high-Q series-resonant tank circuit that is resonant at the hyperfine frequency (6.8 GHz). (See Figure 3-5.) The voltage source driving the tank is the microwave frequency (f_c) derived from the 20 MHz VCXO, and the LCR components are the rubidium atoms contained in the optical package. Figure 3-5 includes the effects of modulation, which are described below.

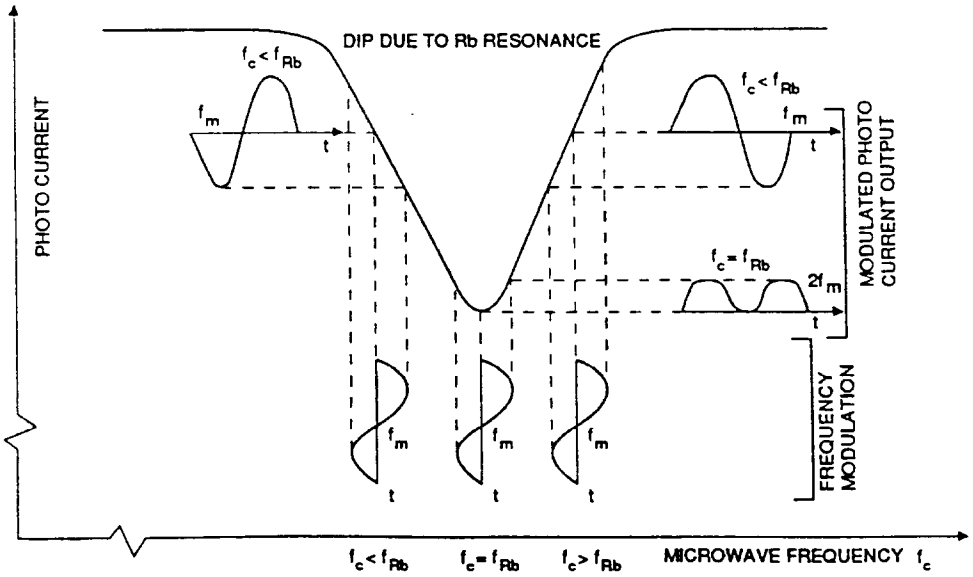


Figure 3-3. Derivation of Modulation Signal

FREQUENCY MODULATION. Because of the small changes in detected light intensity ($\leq$0.1%) that are associated with locking the VCXO to the rubidium reference frequency, an ac detection scheme is used. The advantage of an ac detection scheme compared to a dc

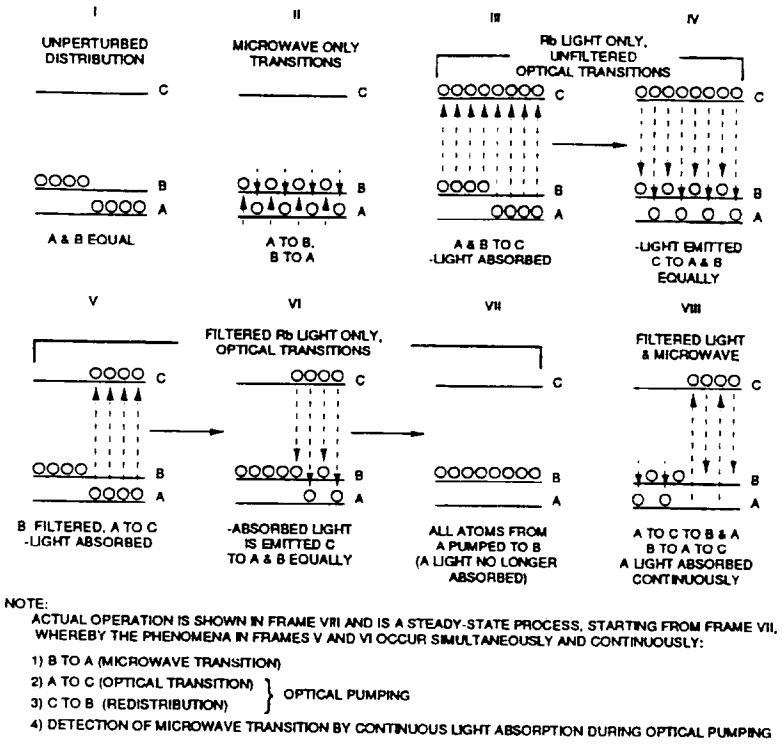


Figure 3-4. Optical Pumping Process.

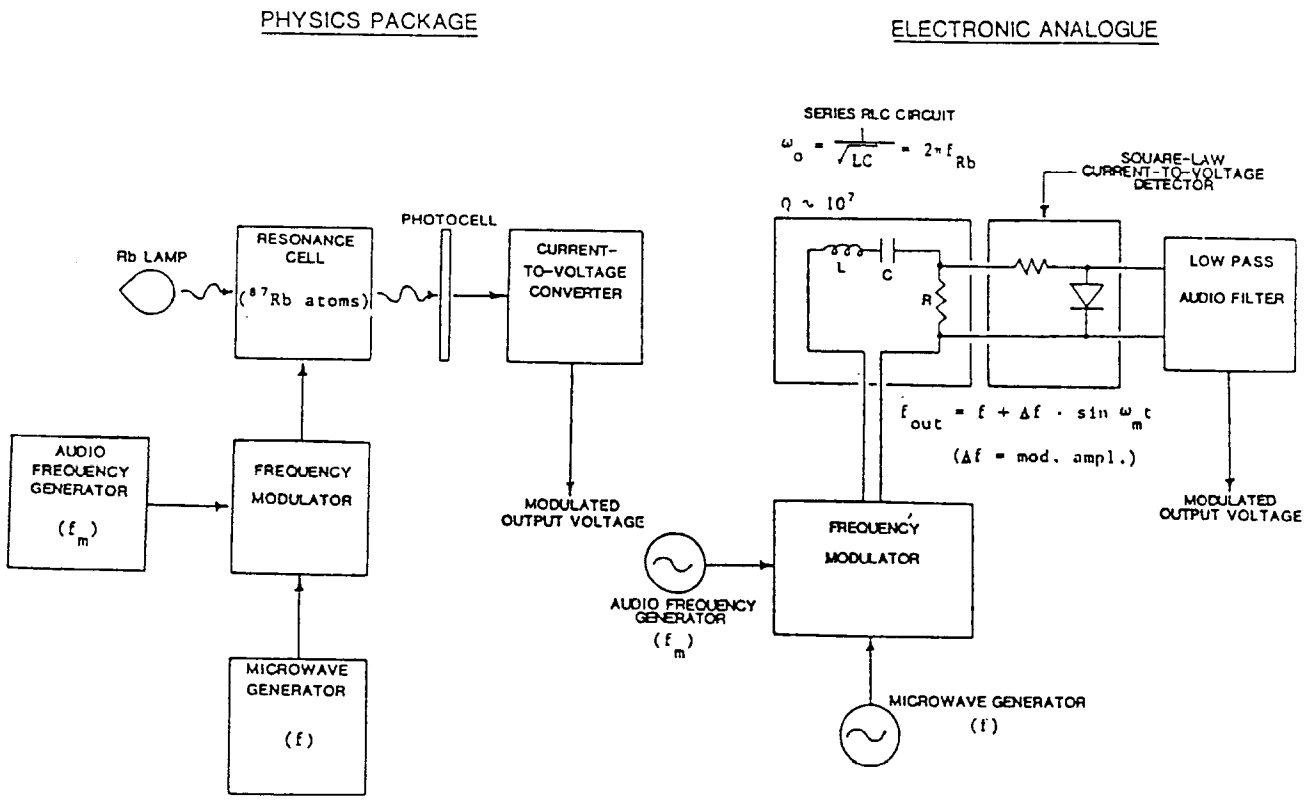


Figure 3-5. Electrical Analogue of Physics Package.

detection scheme is that small signal changes are not obscured by dc drifts. In order to generate the ac error signal for VCXO frequency correction, the microwave signal is frequency modulated. As the modulated microwave frequency approaches the hyperfine frequency, the light from the rubidium lamp varies in intensity at the modulation rate. The variation in the light intensity is very small, only about 0.1% of the overall intensity of the light. The photocell within the cavity detects the small variation in light intensity and a preamp circuit on the resonator board amplifies the signal and sends it to the servo circuits.

RESONANT SIGNAL. By modulating the microwave signal injected into the resonator at 127 Hz, the light striking the photocell, and therefore the output current, varies at 127 Hz as the microwave frequency approaches the hyperfine frequency (Figure 3-2). The servo circuits use this signal to generate a continuous correction signal for the VCXO.

When the microwave frequency (f_c) in the resonator is exactly equal to the hyperfine frequency (f_{Rb}), the 127 Hz modulation varies the microwave signal around the center of the absorption curve, resulting in a modulation of the photocell current at twice the modulation frequency, or 254 Hz (Figure 3-3). It is this 254 Hz signal which is used to generate the lock indicator signal. The lock indicator signal is the primary indicator that the unit is operating normally. If the microwave signal, f_c, which is synthesized from the 20 MHz VCXO, drifts off the hyperfine frequency, f_{Rb}, the photocell output reverts to the fundamental 127 Hz rate. The phase of the 127 Hz indicates if f_c is above or below f_{Rb} and this phase information is used to move the VCXO frequency in the proper direction until f_c again equals f_{Rb}.

3.3 DETAILED CIRCUIT DESCRIPTIONS. Figure 3-6 (and the interconnect/wiring diagram in Appendix A) illustrate the interconnections of the flex board, physics package and the associated circuitry and circuit board assemblies that comprise the rubidium frequency standard.

The two main assemblies of the FRS are the PHYSICS PACKAGE assembly and the FLEX BOARD assembly. The Flex Board interconnects four printed circuit boards (PCBs): the SERVO BOARD, the CRYSTAL OSCILLATOR BOARD, the MULTIPLIER BOARD and the POWER SUPPLY BOARD (refer to the interconnect wiring diagram in the Appendix).

3.3.1 THE PHYSICS PACKAGE. The function of the Physics Package is to provide the standard frequency reference and the error signal. The error signal is processed by the servo board to stabilize the frequency of the crystal oscillator.

The Physics Package has two main sub-assemblies: the LAMP ASSEMBLY and the RESONATOR ASSEMBLY. The entire physics package is enclosed in a mu-metal container to shield the resonant cell from magnetic fields.

THE LAMP ASSEMBLY (A2 & A7). The function of the Lamp Assembly is to generate rubidium light that contains the desired spectral lines of Rb necessary for the process of interrogating the atomic standard frequency. The lamp circuits ignite the Rb lamp and thermostatically control the lamp housing temperature at approximately 106° C (223° F), which is required to maintain the proper Rb vapor pressure in the lamp envelope.

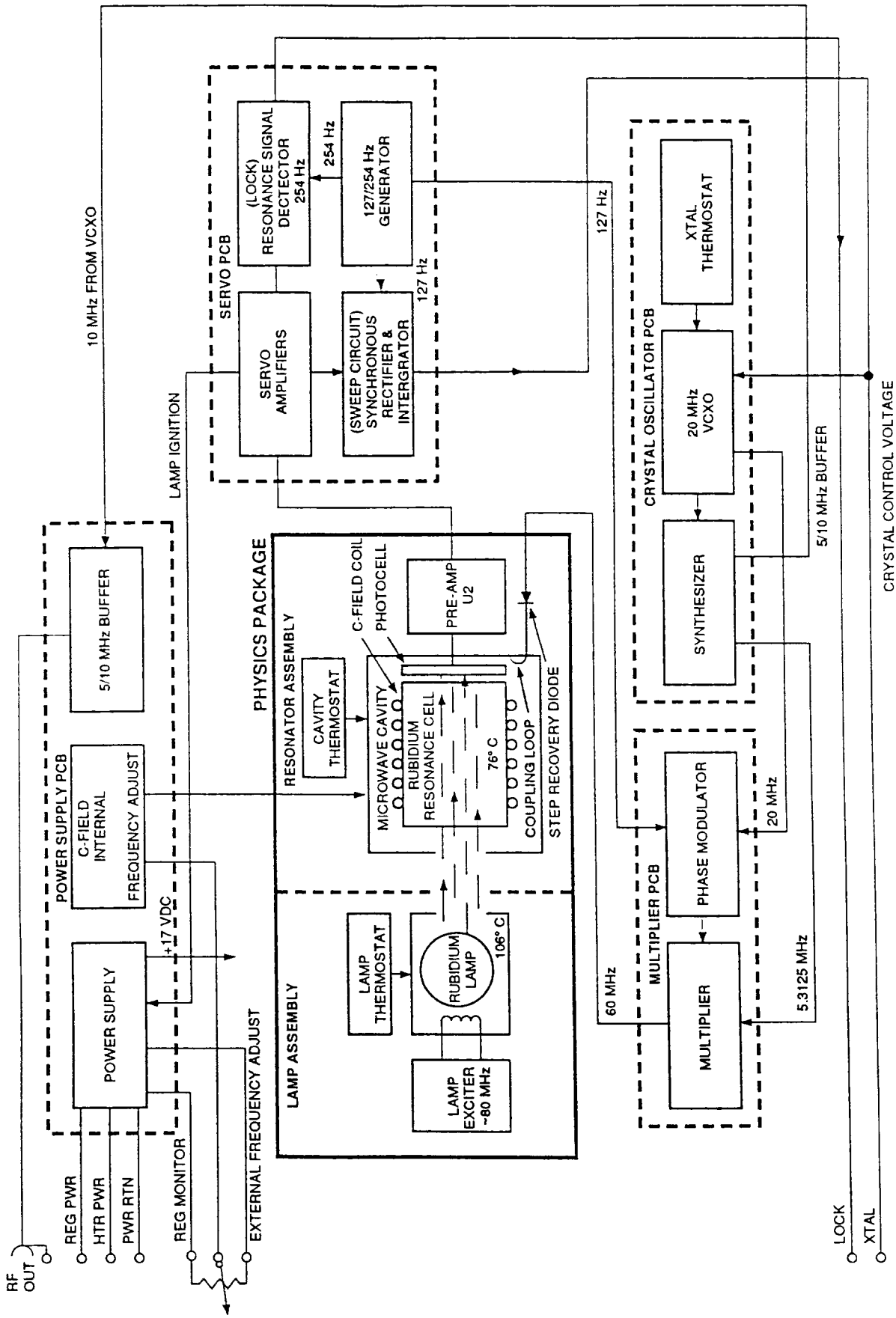


Figure 3-6. Detailed Block Diagram, FRS.

a. The Rb lamp oscillator circuit on the A2 and A7 boards is an adjustable 70 to 100 MHz modified Colpitts oscillator and rf transistor Q3 is the active element. CR1 provides temperature compensation for the ac biasing of Q3. R10 and R11 set the oscillator bias and R12 provides dc bias stabilization. C11 is adjusted to tune the circuit to the desired output frequency, while C7, C8 and C9 are rf bias caps. L5 is a frequency determining element. The remaining passive elements provide rf filtering for the power input.

The lamp oscillator ignites and maintains an electrode-less plasma gas discharge in the rubidium lamp that is mounted in the oscillator's tank circuit, C11 and L6. L6 is a step-up auto-transformer that provides a high voltage for rapid lamp ignition at turn-on.

b. The Rb lamp is mounted in a temperature-controlled housing. Q1 is mounted on the housing and acts as the heating element. Thermistor RT1 is the temperature sensor embedded in the housing and with R1 forms one side of a bridge circuit. R2 and R3 form the other side. U1 is the amplifier that senses the bridge balance and controls the heater Q1 accordingly. Q2 senses the voltdrop across R9 and limits Q1 current flow by reducing base current. R1 selects the desired operating temperature. See section d. RESONATOR HEATER CIRCUIT below for a more detailed analysis of heater controller operation.

THE RESONATOR ASSEMBLY (A6). The Resonator assembly consists of the Resonator board and the Resonator cavity. The cavity is constructed of mu-metal and contains the resonant cell and C-field coil. A heater ring surrounds the cavity and provides its mounting. The lid assembly on the cavity contains the photocell, step recovery diode, and a feed-through capacitor. Cavity temperature of about 74° C is maintained by the resonator heater control circuit. (See Figure 3-4).

a. THE PHOTOCELL PREAMP. The resonant signal is detected by the photocell CR2 which provides a variable current signal to the preamplifier U2 on the Resonator board. The signal is routed through the "flex" board to the Servo circuits that use this signal to correct the VCXO. This "lamp volts" signal also controls the power supply voltage.

b. STEP RECOVERY DIODE (CR1 - refer to Multiplier [A5] schematic) . The step recovery diode is a varactor (voltage variable capacitance) diode designed for frequency multiplication. When the diode is forward-biased and is switched to reverse bias, most of the stored charge is released as a high pulse of reverse current, producing a steep waveform rich in harmonics.

A 60 MHz signal from the multiplier and a 5.3125 MHz signal from the VCXO are mixed on the multiplier board and then are applied to CR1 within the cavity. When CR1 conducts, it produces the harmonics of the 60 MHz and 5.3125 MHz mixed signals. The resonator cavity and loop are tuned to select the 114th harmonic which corresponds to the resonant frequency of the rubidium.

c. RESONATOR COIL (A6). The resonator "mag field"coil is wound on the rubidium cell and provides a magnetic field (the C-field) within the resonator cavity. This magnetic field functions as a fine tuning mechanism by changing the hyperfine transition frequency through what is called the "Zeeman effect"; the splitting of a spectrum line of light into several symmetrical components, which occurs when the source of light is placed in a static magnetic field. The "C-field" strength is determined by the current through the coil. The current is summed from the following sources:

FIXED: R13 on the Power Supply board (A3) supplies current directly to the coil.

MANUALLY-CONTROLLED: R14 on the Power Supply board supplies an adjust able voltage which is fed to U1 and R20 on the Resonator board. External (remote) frequency adjustment is possible by applying a 0 to 5 Vdc voltage source to P1, pin 2. (See the Power Supply schematic in the Appendix).

COMPENSATION: The Resonator heater (A6 assembly) current varies inversely with the ambient temperature. This condition is used to provide compensation for frequency shifts that occur due to ambient temperature changes. The voltdrop across R19 in the resonator heater circuit is used to detect the changes and is processed thru U1 and R27, or thru R12, into a temperature variable current. This current adjusts the magnetic field to compensate for the ambient temperature changes. The current is passed thru Power Supply board select-in-test resistor A3 R12 for accessibility to change the current magnitude as necessary. Positive compensation is achieved through U1 and R27 and negative compensation is achieved through R12.

d. RESONATOR HEATER CIRCUIT (A6). The operation of the resonator heater and its control circuits is typical of the other heater circuits in the unit. The heating elements are Q1 and Q2 which are mounted on the heater ring that surrounds the resonator cavity. The temperature sensing element, thermistor A6 R21, is embedded in the heater ring. Its resistance drops from about 10K Ohms at room temperature to less than 1K Ohm at 74°C. The remaining circuitry is mounted on the Resonator and Power Supply circuit boards.

U1 is an Op Amp with a resistive bridge network on its inputs. On one side of the bridge are fixed resistors R2 and R3. On the other side of the bridge are the thermistor R21, resistor R22 and select-in-test resistor A3 R15 on the Power Supply board, which adjusts the temperature of the Resonator.

When power is turned on the bridge is unbalanced causing the Op Amp U1 output to turn Q2 on full. This causes the voltage at the collector of Q2 to drop, turning Q1 on full. Q3 functions as a current limiter for the heater circuit. The current thru Q1 and Q2 passes thru R19 causing a voltdrop. When the voltdrop exceeds the Q3 base to junction voltage, Q3 turns on. Some of the current from the Op Amp is now diverted thru the Q3 collector to ground instead of thru the base of Q2, thus limiting the Q1 and Q2 current flow.

By selecting the resistance value of A3 R15, the Op Amp will drive the resonator heaters until the desired temperature is attained. At this point, the voltage at the R21 and R22 junction will equal the voltage at the R2 and R3 junction and the bridge will be balanced.

With the bridge balanced, the circuit regulates the power to the heater transistors, thereby maintaining the resonator at the temperature selected by A3 R15. In order to control temperature overshoot, a portion of U1, pin 1 output is fed back to the input. This slows down the rate of change sensed at the input during rapid transitions by reducing the U1 pin 2-3 difference. U1 pin 6 senses the current through the heater by detecting the voltage drop across R19 for temperature compensation as outlined in c. above. The R7, R8 divider limits the heater current when higher input voltages are present to keep the maximum heater power relatively constant.

3.3.2 SERVO BOARD ASSEMBLY (A1). The primary function of the servo circuits is to process the error signal received from the resonator preamp at J1 pin 3 to provide the crystal control voltage for the 20 MHz VCXO at J1 pin 4. The control voltage is derived by comparing the phase of the 127 Hz modulation signal with the phase of the photocell signal at J1 pin 3. The secondary function is to provide the atomic resonance lock signal at J1 pin 8.

a) 127 AND 254 Hz REFERENCE SIGNALS. The CMOS oscillator/divider U4 on the servo board provides the 127 and 254 Hz reference signals. The oscillator frequency of 8.128 Khz is determined by C22, R13 and select-in-test resistor R12. The divider portion of U4 divides the oscillator frequency into the required 127 and 254 Hz signals. The 127 Hz reference signal is routed from U4 pin 4 to pin 9 of synchronous demodulator U3; and to the input of U2, pin 2 through the RC network R36, C38. The RC network R36, C38 in addition to the feedback network R37, C37 and the output RC filters (R41, R42, and C41 on the servo board; R8, C7, and C8 on the synthesizer board) serve to waveshape the 127 Hz signal into the sinewave which is coupled to the synthesizer to modulate the rf.

The 254 Hz reference signal is routed from U4 pin 5 to pin 10 of synchronous demodulator U3. The 254 and 127 Hz reference signals control the timing of analog switches in the synchronous demodulator.

b. MODULATION ERROR SIGNAL. The modulation error signal received at the photocell is preamplified on the resonator board (see Figures 3-2 and 3-7) and received at the servo (A1) input J1, pin 3. The signal is then routed through three capacitively coupled amplifier stages (U1 in pin 13, out pin 14; U1 in pin 9, out pin 8). The resultant signal is then routed to U3, pin 3 and also U1, pin 6 where it is further amplified and output from pin 7 to U3, pin 2.

c. SYNCHRONOUS DEMODULATION. The amplified modulation signal received at U3, pin 3 is subsequently demodulated at a 127 Hz rate. See Figure 3-3, f_m. The resulting demodulated output (U3, pin 4) can be observed at TP1 on the flex board. See Figure 3-7. The TP1 output signal is the result of synchronous demodulation and contains both phase and amplitude information, indicating whether above, below or "on" the rubidium frequency. The further amplified signal received at U3, pin 2 is demodulated at a 254 Hz rate. See Figure 3-2, $2f_m$. The resulting output (U3, pin 15) is a positive 1/2 cycle of the 254 Hz, $2f_m$

signal received when "on frequency" during normal operation. This "lock" signal is used as input to the second harmonic lock circuit.

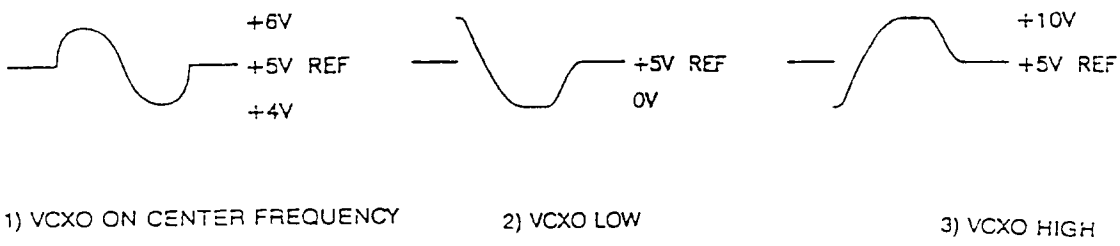


FIGURE 3-7. TP1 Phase and Amplitude Indications.

d. INTEGRATOR U5. U5 Functions as an integrator whose output voltage fluctuates at a rate proportional to the input voltage. As an example, an input differential of 1000 mV causes an output voltage change of 500 Mv per second. The changes will continue until the differential input is nullified by bringing the crystal back to center frequency, or until the Op Amp reaches its maximum or minimum output voltage. The output of integrator U5 is the crystal control voltage used to control the frequency of the VCXO via a varactor diode (crystal oscillator CR1). A portion of the integrator output is also routed to the sweep control circuit at U1, pin 3.

e. SWEEP CONTROL CIRCUIT. U1, pins 1, 2, and 3 is a high hysteresis switch and controls the sweep range. Its output is either low (about 0.5 Vdc) or high (about 10.5 Vdc). When no "lock" signal is present (+10 Vdc on U3, pin 11), the output of U1, pin 1 is routed to the integrator input (U3 pin 14) via U3, pin 13. Diode CR2 clamps the U1 output to the 5 Vdc reference voltage resulting in a slow down sweep of the crystal control voltage of about 250 mV per second. When the output of U1 goes low, the differential voltage on the integrator is about 5 Vdc, resulting in an up sweep of about 2.5 V/sec. The hysteresis of U1 pins 1, 2 and 3 is set by R23, R24 and the reference voltage on pin 2. The switch changes state when the voltage on pin 3 goes higher or lower than the reference voltage on pin 2. The upper threshold is set at about 12 Vdc crystal control voltage, the lower at about 1 Vdc.

When the crystal volts signal reaches approximately 12 volts, U1, pin 1 is driven high (+10.5 V). This voltage however, is limited by the R25, CR2 clamping circuit to approximately 5.5 volts. The integrator will sense about 500 mV differential and sweep down at about 250 mV/sec. When it reaches below the 1 volt low switch level of U1, the U1 output switches low and the crystal control voltage will sweep up at about 2.5 V/sec completing the cycle. Sweeping continues until "Lock" occurs. (U3, pin 11 becomes low).

f. LOCK CIRCUITS. The lock circuit uses the positive 1/2 cycle (254 Hz) lock loop signal by integrating it through R29, C32 to a DC level. If the second harmonic is of significant amplitude (approximately 200 mv peak-to-peak), U6, pin 7 will drive low.

This low signal discharges C30 thru R28 to produce a low at U3, pin 11. "Lock" then disables the sweep circuit by disconnecting U3, pins 13 and 14 and connecting U3 pins 12 and 14.

This switching places the integrator under fundamental loop control.

A long range (1 Hz) capture circuit functions in much the same way as the lock circuit. When the integrator is in a down sweep, the first detection of atomic resonance will be a very high positive 1/2 cycle VCXO signal. This TP1 signal is integrated by R27, C31 to a DC level. If the fundamental is of sufficient amplitude (approximately 200 mV peak-to-peak), U6, pin 1 will drive low and the lock will function as explained in the preceding paragraph.

The lock amplifier (output U2, pin 7) is designed to allow jumpers for selection of "high" or "low" lock output signals at J1 pin 8. This signal is then routed thru the buffer stage of the power supply to the external connector.

3.3.3 CRYSTAL OSCILLATOR (A4) (VCXO). The main elements of the VCXO are the crystal Y1, the oscillator IC U1 and the varactor diode CR1. The board also contains a thermostat circuit and a frequency divider/synthesizer. The 20 MHz AT Cut 3rd overtone crystal is temperature controlled by the thermostat circuit. Q3 functions as the heater element, RT1 as the temperature sensor, Q4 as the gain element. Q2 limits the maximum heater current during turn on.

The 20 MHz signal from the oscillator IC U1 is buffered by Q1 and converted from a TTL compatible signal to a sine wave. This signal drives the multiplier.

The complimentary 20 MHz signal from U1 (HC 320) is fed to the divider IC U2. A 5 or 10 MHz signal from U2 (HCT 393) is selected and fed to the output buffer located at the power supply PCB. The standard configuration of the oscillator PCB is for a 10 MHz output. In this case, no jumpers (JP1, 2 and 3) are needed.

For the 10 MHz sine output signal, L4 and C17 suppress sub-harmonics generated by the divider IC.

The 5 MHz and 312.5 KHz signals from the divider are added by an "exclusive OR" gate, U3 (HC 86), to provide the 5.3125 MHz synthesis signal for the multiplier output. To provide maximum isolation between the oscillator and the synthesizer IC's, two separate 5 volt regulators VR1 and VR2 are used.

3.3.4 MULTIPLIER (A5). The multiplier utilizes the 20 MHz sinewave signal from the VCXO to generate a 60 MHz signal for the resonator. The 5.3125 MHz signal is summed into the final stage. These summed signals are routed to a step recovery diode in the resonator where they are in turn mixed and multiplied to the 6.834 MHz signal (f_c). A tripler consisting of Q1 and Q2 multiplies the 20 MHz signal to a 60 MHz signal. Q1 wave shapes the 20 MHz sinewave into a specific positive pulse. These pulses are amplified by Q2 to ring the tuned (60 MHz) collector tank. The DC voltage at the Q2 emitter provides DC bias for Q1 and maintains constant amplitude.

A second stage (CR1, T1 and associated circuitry) forms a modulator for the 127 Hz modulation signal from the servo. This sinewave signal is routed to CR1 (a varicap diode). This diode capacitance varies at the fundamental 127 Hz rate and forms a tuned tank with the primary of T1. The tank reactance then phase modulates the 60 MHz which is then coupled to the driver stages. The 60 MHz drivers consist of two (Q4 and Q5) capacitively coupled amplifier stages, tuned to 60 MHz. The output stage tank (Q5), is a step-down impedance matching transformer tuned to 60 MHz.

The 5.3125 MHz signal synthesized from the crystal board is received through R28 and C21 into the L6, C22 tank which is tuned to 5.3125 MHz. The resulting sinewave signal is then coupled through C23 and L7 and summed into the 60 MHz output of the multiplier.

MULTIPLIER AGC. The step recovery diode produces a dc bias voltage through rectification of the rf across its terminals in the process of generating harmonics. This dc bias voltage is adjusted by R30, which helps to tune the diode circuit to produce the optimum resonance in the resonator cavity. The step recovery voltage across R30 is monitored by U1 and compared to the reference voltage set by R25, R27 and the pot R24 for automatic gain control (AGC) of the Q4 stage. The output of U1 changes the bias of Q4 to keep the step recovery voltage constant. The initial setting of the multiplier is done with the AGC inoperative by installing jumper TP1 to TP2 and by turning R24 fully counter clockwise.

3.3.5 POWER SUPPLY. An internal power supply provides the unregulated, filtered voltages for the Rb lamp heaters, oscillator heater and resonator heaters; in addition to providing the filtered and regulated voltage for unit operation. The power supply board also houses the RF output buffer and the lock indicator buffer. The input voltage line is fuse and diode protected against reverse polarity inputs.

a. +17 VDC REGULATED POWER SUPPLY. The +17 Vdc power supply consists of Q1, Q2 and U1 along with the components in their respective circuitry mounted on the power supply board. Pass transistor Q1 is heat sinked to the baseplate. Refer to drawing No. 814-144 for a pictorial view of pass transistor Q1.

b. POWER SUPPLY OPERATION. After power is initially applied, Q1 receives sufficient voltage from Q2 (FET) to go to forward bias. Its output then rises toward the input supply and supplies power to U1. CR5 is reversed biased as the +17V line increases, until it achieves zener operation. The +17 V forces U1, pin 7 high and is applied to Q2 which increases voltage to Q1. As +17V is approached, CR5 regulates to a 6.4V reference and R5, R6 divider senses any input error for regulation. R6 sets the regulated voltage.

c. LAMP SWITCHING CIRCUIT. The power supply board accepts the +22 to +32 Vdc input voltage at P1 pin 9, and provides +22 Vdc until the Rb lamp lights, at which time the power supply is switched to +17 Vdc. The switching occurs when U1, pin 3 receives a lamp voltage (P1 pin 9) exceeding the 6.4 V reference on pin 2. The output of U1, pin 1 is high if lamp ignition is normal. The positive voltage reverse biases CR5, and this effectively removes R7 from the circuit. This sets the condition for the power supply output to be lowered to the +17 Vdc required for the internal circuits of the unit by the R5, R6 voltage

divider. Improper lamp ignition grounds CR4 which in turn places R7 parallel to R6. R7 now selects +22V as the regulator output.

d. RF OUTPUT BUFFER. The Q3 circuit is an RF output buffer designed to accept 5 or 10 MHz TTL inputs. Tabulated values are selected for sine output or TTL square wave output. The RF output signal is referenced to chassis ground.

e. LOCK SIGNAL BUFFER. The Q4 circuit buffers the lock signal from the servo board lock amplifier output at A1, U2, pin 7 and provides a TTL output high or low to the external connector P1, pin 1. The output is high or low when the unit is locked depending on the jumper selection at the servo board A1, U2, inputs 6 and 7.

f. C-FIELD TUNING. The power supply PCB contains select resistor R13 that sets the C-Field bias current. This current is fixed and should only be changed if the physics package is replaced, or if after years of operation it is necessary to recenter the C-Field tuning range.

The ten-turn potentiometer, R14, allows fine tuning of the output frequency over a range of ±1E-9. The output frequency can also be controlled by means of an external 1Kohm potentiometer. The power supply schematic shows the connection of this external potentiometer to main connector pins 2, 3, and 8. This potentiometer overrides the internal pot R14. The trim range of the external potentiometer is similar to the internal trim range; resolution depends on the potentiometer used.

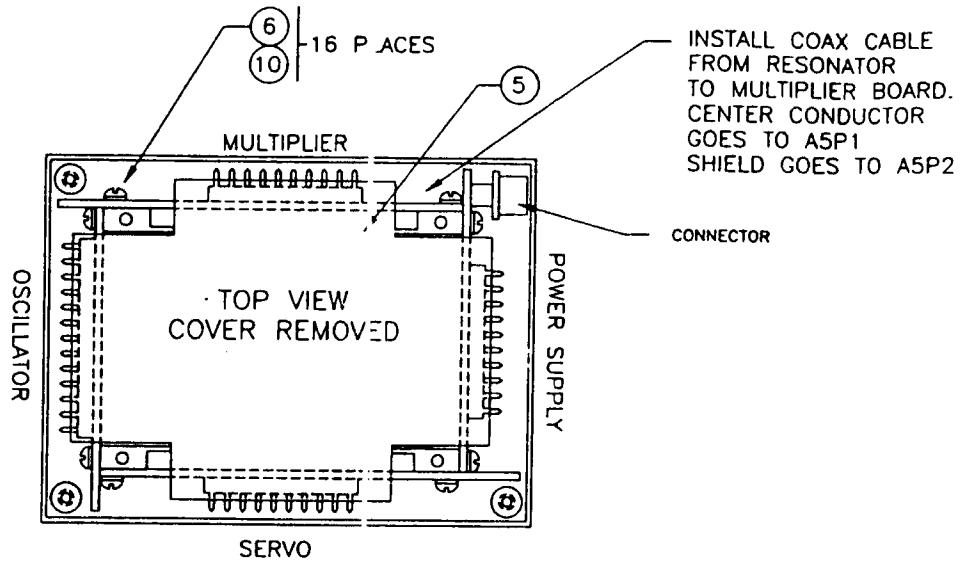
APPENDIX A

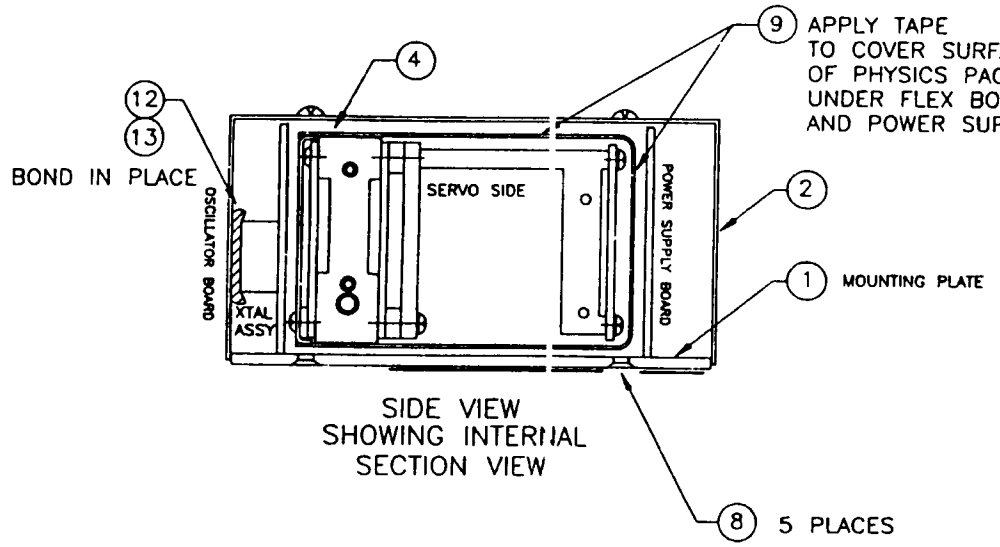
FRS ASSEMBLY DRAWINGS, SCHEMATICS, & PARTS LISTS

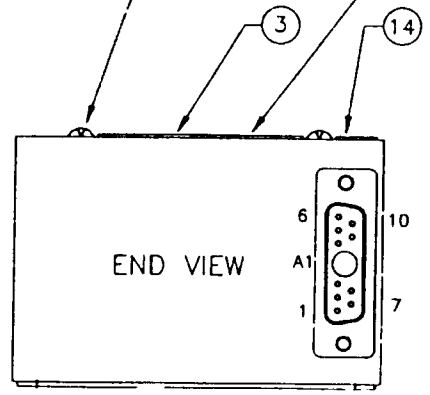
APPENDIX

LIST OF FRS DRAWINGS

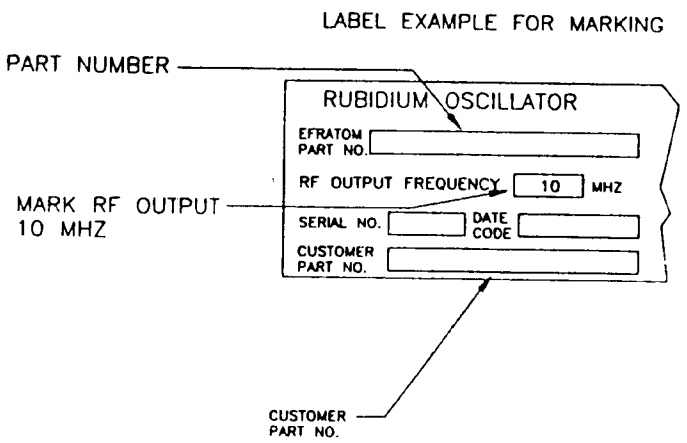
DWG NO.	ASSY.	DESCRIPTION	PAGE NO.
100318		FINAL ASSEMBLY	A-2
		PARTS LIST, FINAL ASSEMBLY	A-3
100308		OUTLINE/MOUNTING DRAWING	A-4
100339	A8	ASSEMBLY, FLEX BOARD	A-5
		PARTS LIST, FLEX BOARD ASSEMBLY	A-6
814-133		INTERCONNECT WIRING DIAGRAM	A-7
814-112	A2/A7	ASSEMBLIES, LAMP/SUPPORT BOARDS	A-8
814-114		SCHEMATIC, LAMP BOARD	A-9
PL814-113		PARTS LIST, LAMP BOARD ASSEMBLY	A-10
PL814-112		PARTS LIST, SUPPORT BOARD ASSEMBLY	A-11
814-122	A6	ASSEMBLY, RESONATOR BOARD	A-12
814-123		SCHEMATIC, RESONATOR BOARD	A-13
PL814-122		PARTS LIST, RESONATOR BOARD ASSEMBLY	A-14
814-144-3	A3	ASSEMBLY, POWER SUPPLY BOARD	A-15
814-142		SCHEMATIC, POWER SUPPLY BOARD	A-16
PL814-144-3		PARTS LIST, POWER SUPPLY BOARD ASSEMBLY	A-17,-18
814-145-2	A1	ASSEMBLY, SERVO BOARD	A-19
814-140		SCHEMATIC, SERVO BOARD	A-20
PL814-145-2		PARTS LIST, SERVO BOARD ASSEMBLY	A-21, -22
814-192	A4	ASSEMBLY, OSCILLATOR BOARD	A-23
814-201		SCHEMATIC, OSCILLATOR BOARD	A-24
PL814-192		PARTS LIST, OSCILLATOR BOARD ASSEMBLY	A-25
814-167	A5	ASSEMBLY, MULTIPLIER BOARD	A-26
814-168		SCHEMATIC, MULTIPLIER BOARD	A-27
PL814-167		PARTS LIST, MULTIPLIER BOARD ASSEMBLY	A-28, -29







LABEL EXAMPLE FOR MARKING



TABULATION FOR PARTS SELECTION					
PRODUCTION ASSEMBLY NO.	MODEL PART NO.	BASEPLATE ITEM-1	SIZE REF	FLEX BOARD ASSY ITEM-5	FREQUENCY RF OUTPUT
100318-001	FRS-_-1A8A4_	814-104-1	4-40	100339-001	10MHZ SINE
100318-002	FRS-_-2A8A4_	814-104-2	M2.5	100339-001	10MHZ SINE
100318-003	FRS-_-1A8E4_	814-104-1	4-40	100339-002	10MHZ TTL
100318-004	FRS-_-2A8E4_	814-104-2	M2.5	100339-002	10MHZ TTL
100318-005	FRS-_-1A8F4_	814-104-1	4-40	100339-003	2.048MHZ TTL
100318-006	FRS-_-2A8F4_	814-104-2	M2.5	100339-003	2.048MHZ TTL
100318-007	FRS-_-1A8G4_	814-104-1	4-40	100339-004	5MHZ SINE
100318-008	FRS-_-2A8G4_	814-104-2	M2.5	100339-004	5MHZ SINE

"A" OR "C"

"B" OR "C"

USE TEST PROCEDURE NO. ATP814-100
OR TEST PROCEDURE NO. 100309
WHEN REVISED OR AVAILABLE.

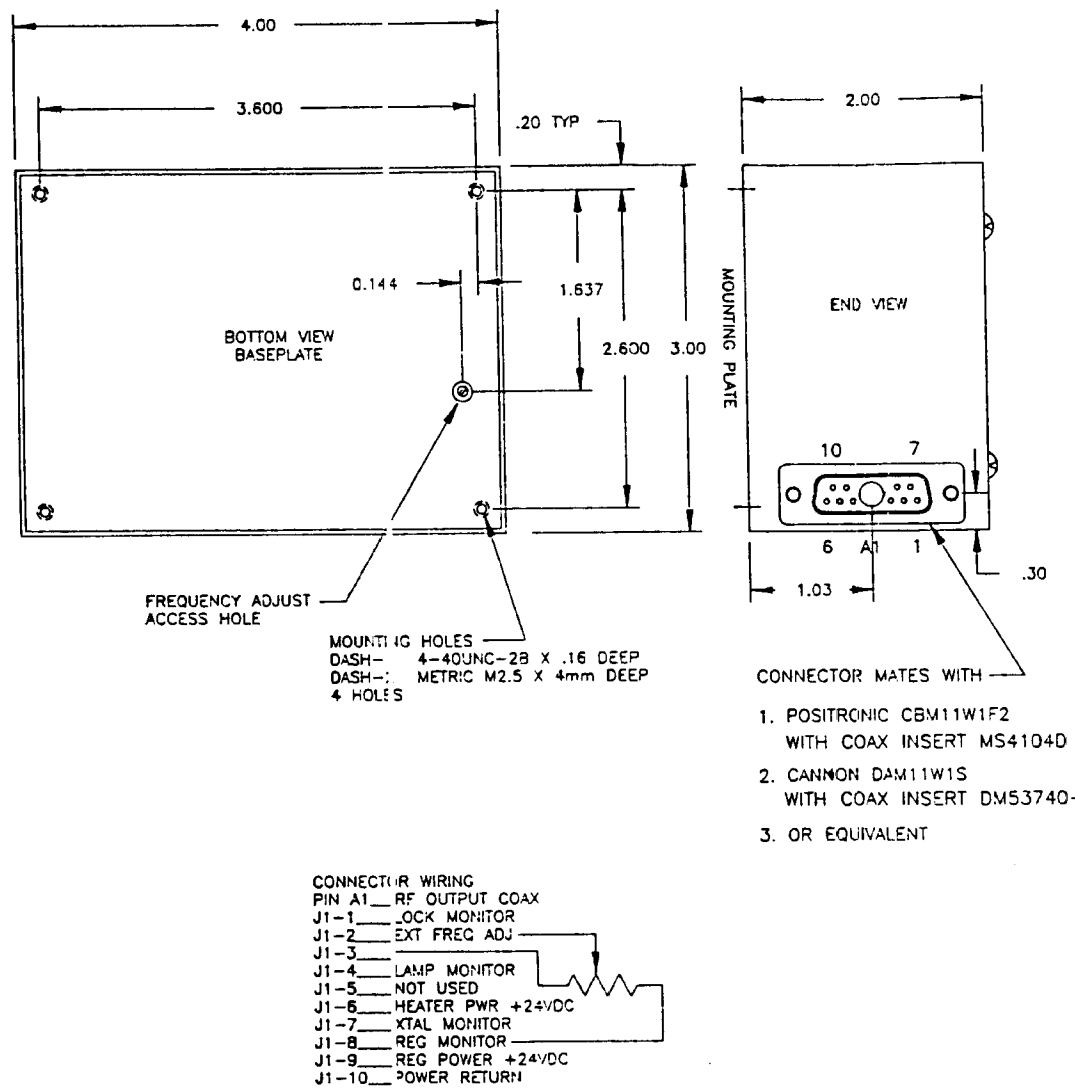
NOTES-UNLESS OTHERWISE SPECIFIED

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 100318-001 REVISION LTR. B
REVISION DATE 91-5-15

TITLE: PARTS LIST, FINAL ASSEMBLY, FRS

SHEET 2

FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	SEE TAB ON SHT 2		BASEPLATE 4-40 THREAD		
2	1	814-105		COVER		
3	1	100141-001		LABEL, NAMEPLATE		
4	1	814-110		PHYSICS PACKAGE ASSEMBLY		
5	1	SEE TAB ON SHT 2		FLEX BOARD ASSEMBLY		
6	16	MS51957-2		SCREW, PAN HD 2-56x3/16		2821424
7	4	MS51957-13		SCREW, PAN HD 4-40x1/4		2821417
8	5	MS24693C2		SCREW, FLAT HD 4-40x1/4		2821353
9	A/R	70423-3		TAPE, MYLAR (1" WIDE)		
10	16	MS35338-134		WASHER, LOCK NO. 2		2821390
11	4	MS35338-135		WASHER, LOCK NO. 4		2821391
12	1	814-127-1		INSULATOR, MYLAR		
13				NOT USED		
14	1	713-040		WARRANTY LABEL		



FRS-C EXAMPLE PART NUMBER
FRS-C-1A8A4C

MODEL	BASEPLATE	COVER	CONNECTOR	OUTPUT	OPTIONS	TEMP RANGE
FRS-C	4-40 THD 1	STANDARD A	SEE NOTE ON FACE OF DRAWING 8	10 MHZ SINE A	TTL LOCK MONITOR 4	-5 C TO +65 BP C
	M2.5 THD 2			10 MHZ TTL E		
				2.048 MHZ TTL F		
				5 MHZ SINE G		

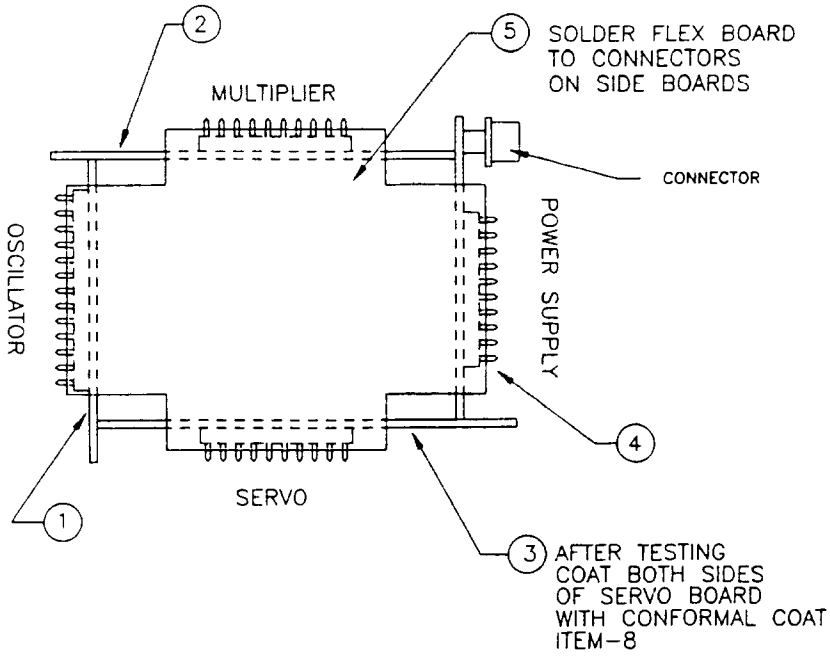
FRS-N EXAMPLE PART NUMBER
FRS-N-1A8A4B

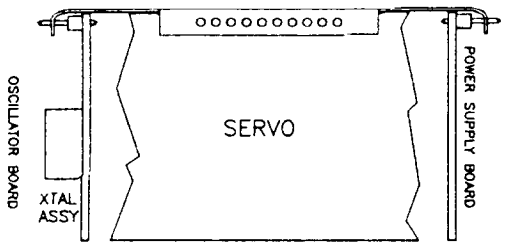
MODEL	BASEPLATE	COVER	CONNECTOR	OUTPUT	OPTIONS	TEMP RANGE
FRS-N	4-40 THD 1	STANDARD A	SEE NOTE ON FACE OF DRAWING 8	10 MHZ SINE A	TTL LOCK MONITOR 4	-55 C TO +65 BP B
	M2.5 THD 2			5 MHZ SINE G		

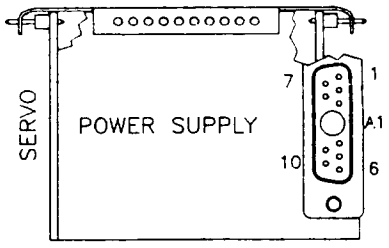
FRS
CATALOG PART NUMBER MATRIX

PART NUMBER \ OPTIONS	10 MHZ SINE	10 MHZ TTL	2.048 MHZ TTL	5 MHZ SINE	BP 4-40	BP M2.5	TEMP -5C	TEMP -55C
FRS-C-1A8A4C	X				X		X	
FRS-C-2A8A4C	X					X	X	
FRS-C-1A8E4C		X			X		X	
FRS-C-2A8E4C		X				X	X	
FRS-C-1A8F4C			X		X		X	
FRS-C-2A8F4C			X			X	X	
FRS-C-1A8G4C				X	X		X	
FRS-C-2A8G4C				X		X	X	
FRS-N-1A8A4B	X				X			X
FRS-N-2A8A4B	X					X		X
FRS-N-1A8G4B				X	X			X
FRS-N-2A8G4B				X		X		X

OUTLINE & MOUNTING DWG, FRS (100308/REV A)







TABULATION FOR PARTS SELECTION					
FLEX BOARD ASSY NO.	FREQUENCY RF OUTPUT	OSCILLATOR ITEM-1	MULTIPLIER ITEM-2	SERVO BD. ITEM-3	POWER SUPPLY ITEM-4
100339-001	10MHZ SINE	814-192-1	814-167-1	814-145-2	814-144-2
100339-002	10MHZ TTL	814-192-2	814-167-1	814-145-2	814-144-3
100339-003	2.048MHZ TTL	814-192-3	814-167-1	814-145-2	814-144-3
100339-004	5MHZ SINE	814-192-4	814-167-1	814-145-2	814-144-4
100339-005	13MHZ TTL	101243-001	814-167-2	814-145-2	814-144-3

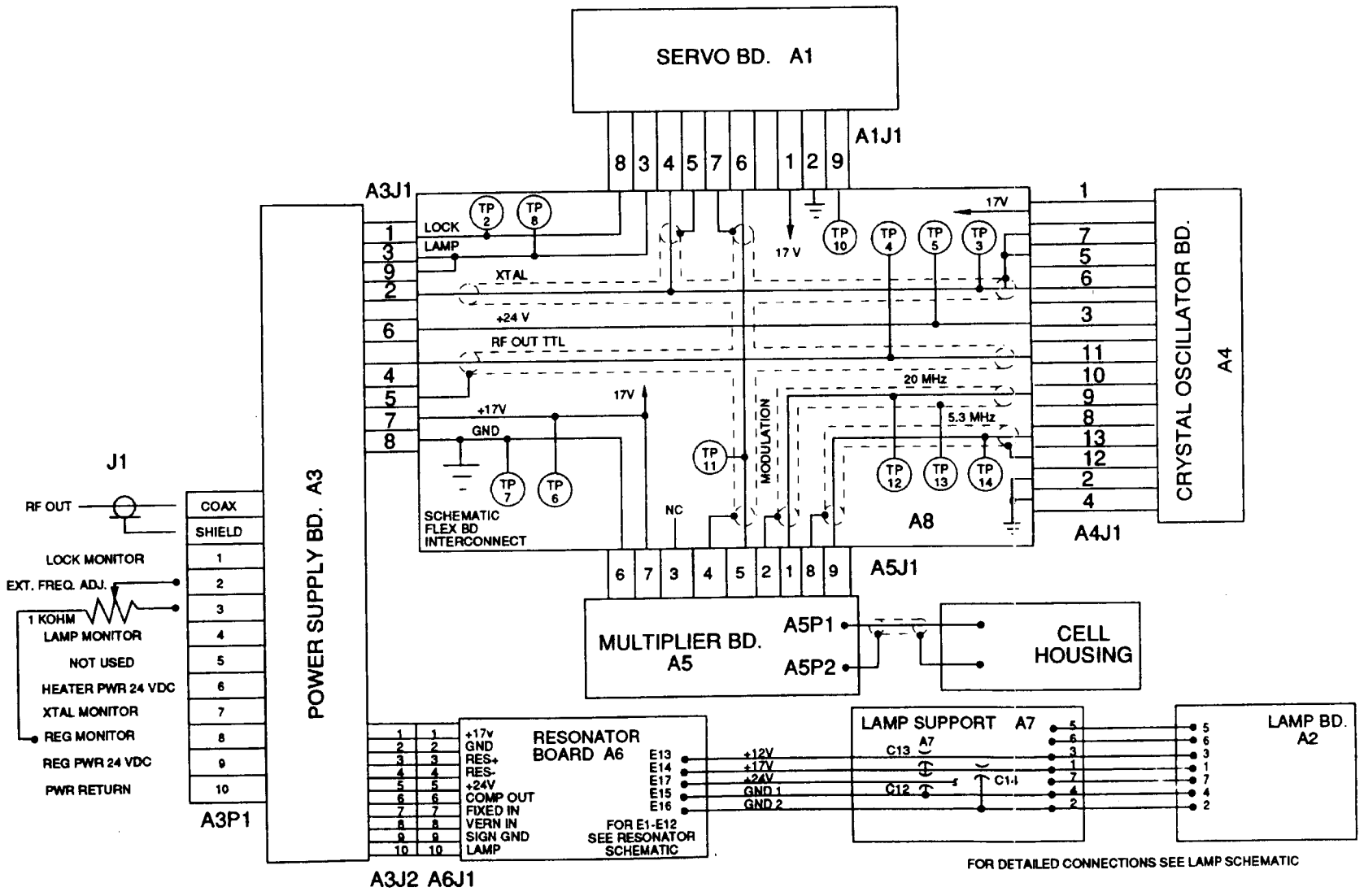
ASSEMBLY, FLEX BOARD (100339/REV B)

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 100339-00X REVISION LTR. B.
REVISION DATE 5-15-91

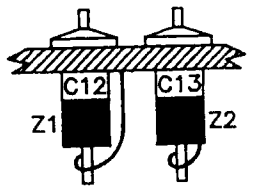
TITLE: PARTS LIST, FLEX BOARD ASSY, RUBIDIUM FREQ.

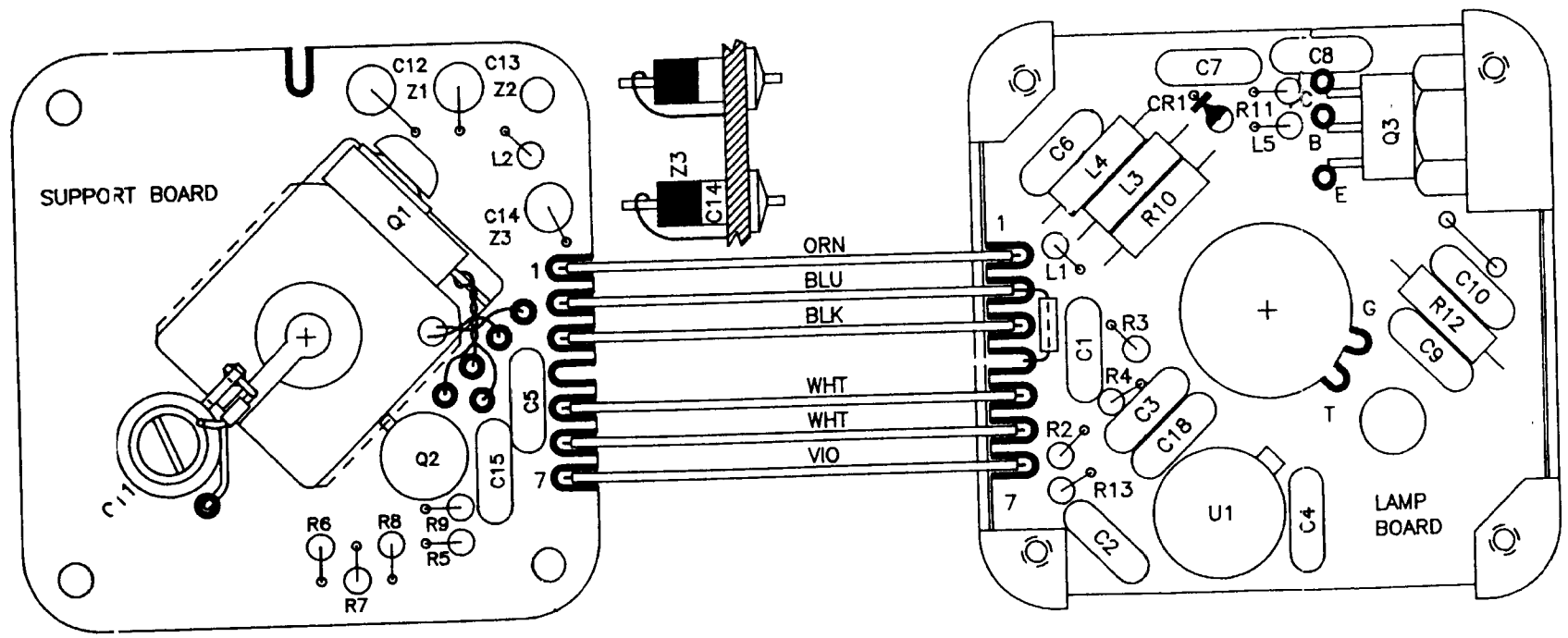
SHEET 2

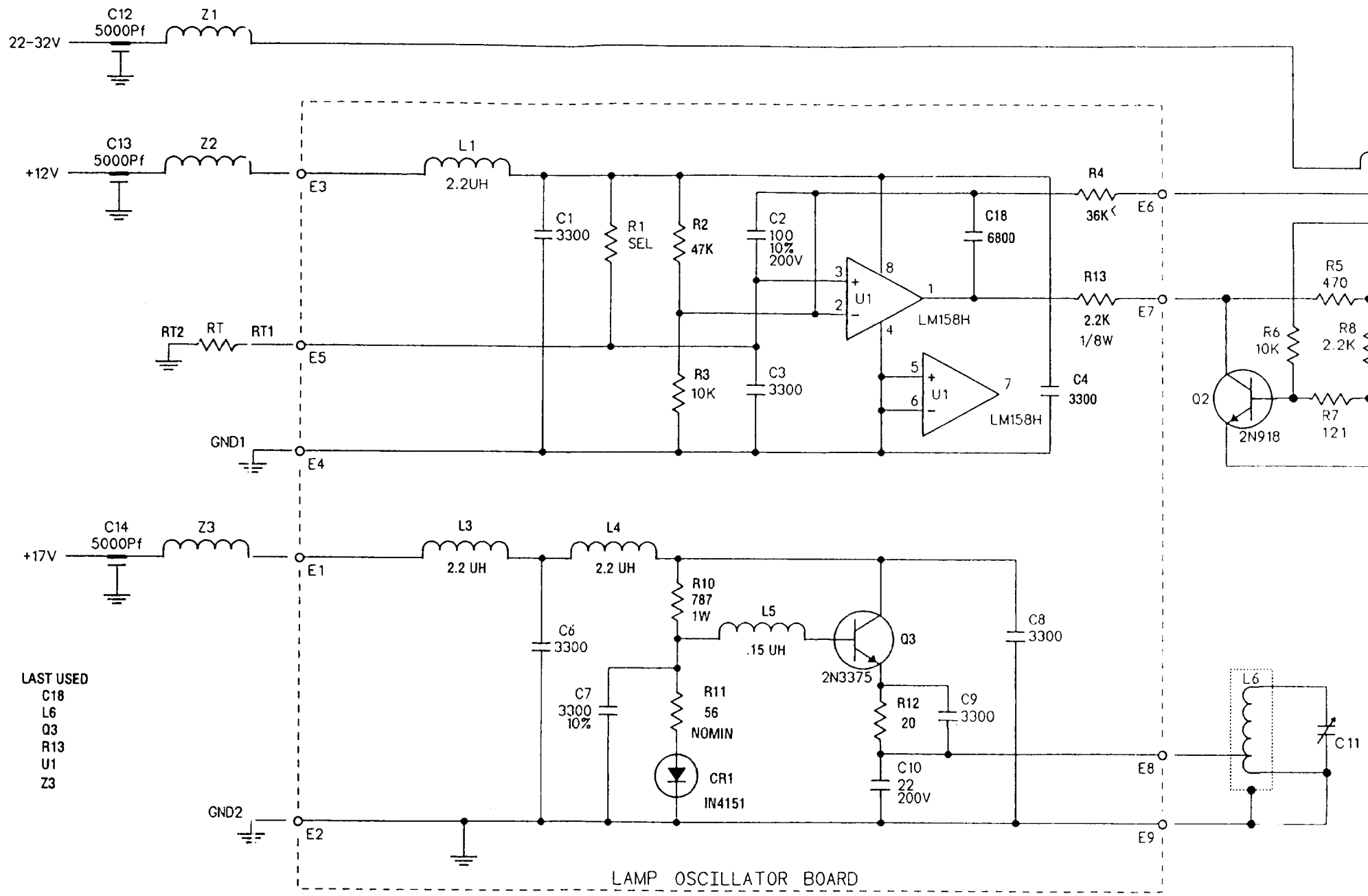
FIND No.	QTY REQ	PART OR IDENTIFYING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	SEE TAB ON SHT 2		OSCILLATOR/SYNTHESIZER ASSEMBLY		
2	1	SEE TAB ON SHT 2		MULTIPLIER ASSEMBLY		
3	1	SEE TAB ON SHT 2		SERVO BOARD ASSEMBLY		
4	1	SEE TAB ON SHT 2		POWER SUPPLY ASSEMBLY		
5	1	814-134-2		FLEX BOARD(KAPTON)		
6				NOT USED		
7	A/R	SN63WRMAP3		SOLDER		
8				NOT USED		



INTERCONNECT WIRING DIAGRAM (184-133/REV D)


C12
C13
Z1
Z2


C12
Z1
C13
Z2
L2
Z3
C14
SUPPORT BOARD
Q1
C14
Z3
C5
Q2
C15
C11
R6
R8
R9
R5
R7
1
7
ORN
BLU
BLK
WHT
WHT
VIO
C7
C8
CR1
R11
L5
B
E
Q3
C6
L4
L3
R10
L1
R3
R4
C1
C3
C18
R2
R13
U1
C4
C2
G
T
C10
R12
C9
LAMP
BOARD



2. RESISTANCE VALUES ARE OHMS,+/-1%,1/10W.

1. CAPACITANCE VALUES ARE PICOFARADS,+/-5%,50V.

NOTES: UNLESS OTHERWISE SPECIFIED.

SCHEMATIC, LAMP BOARD (814-123/REV F)

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-113 REVISION LTR. L
REVISION DATE 91-5-13

TITLE: PARTS LIST, LAMP BOARD ASSY

SHEET 2

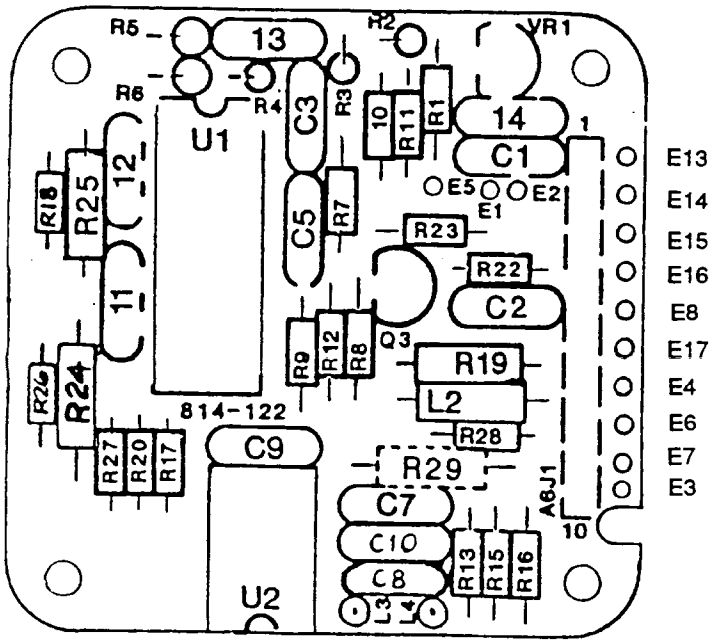
FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	814-115		P.W.B.		814-115
2	1	MK1 2.21K	*2	RESISTOR, MF, 2.21K OHM, 1/8 W	R13	4703035
3	1	MK1 10K	*2	RESISTOR, MF, 10K OHM, 1/8 W	R3	4703029
4	1	MK1 36K	*2	RESISTOR, MF, 36K OHM, 1/8 W	R4	4703314
5	1	MK2 56.2	*3,4	RESISTOR,MF, 56 OHM, 1/4W NOM	R11	4701286
6				NOT USED		
7	1	RWR81S7870FR		RESISTOR 1 W WIREWOUND 787 OHM	R10	4702028
8	1	RWR80S20R0FR		RESISTOR 2 W WIREWOUND 20 OHM	R12	4701967
9	1	EDPT 22 PF NPO		CAPACITOR, CERAMIC 22 PF NPO	C10	1500742
10	1	CKR05BX101KSV		CAPACITOR, CERAMIC 100 PF	C2	1500685
11	7	C322C332K1G5CA	KEMET	CAPACITOR, CERAMIC 3300 pf NPO	C1,3,4,6-9	1500580
12	1	MS75083-3	*4	INDUCTOR 0.15UH	L5	1801443
13	3	MS75084-4		INDUCTOR 2.2UH	L1,3,4	1801448
14	1	1N4151		DIODE	CR1	4800084
15	1	LM158H		INTEGRATED CIRCUIT	U1	3130993
16				NOT USED		
17	1	MK1 47.5K	*2	RESISTOR, MF, 47K OHM, 1/8 W	R2	4703014
18	1	CKR05BX682KSV		CAPACITOR 6800PF	C18	1500695
19	1	705-142	*4 MOTOROLA	TRANSISTOR 2N3375	Q3	705-142
20	1	814-117-1		LAMP SPACER		
21	2	MS51957-4		SCREW, 2-56x5/16 CRES PAN HD		2821434
22	A/R	70411		THERMAL JOINT COMPOUND		70411
23	A/R	MIL-W-16878 TYPE E		WIRE, 24 AWG STRANDED		
0			NOTES:	*1. ALL STANDUP COMPONENTS TO HAVE		
0				0.02 MIN. CLEARANCE ABOVE THE P.C.B.		
0				*2. MAY USE RCR05GXXXJR		
0				*3. MAY USE RCR07GXXXJR		
0				*4. TO USE ALTERNATE TSTR (2N3375)		
0				MADE BY THOMPSON(LOGO"ST") MUST USE		
0				RESISTOR R11(75 OHM),MK2) AND INDUCTOR		
0				L5(0.12UH,MS75083-2). SEE TAB ON LAMP		
0				ASSY AND SCHEMATIC LAMP CIRCUIT.		

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-112 REVISION LTR. V
REVISION DATE 91-5-13

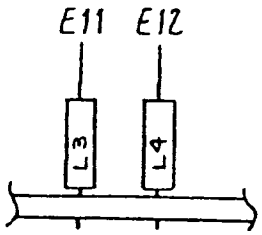
TITLE: PARTS LIST, LAMP ASSEMBLY

SHEET 2

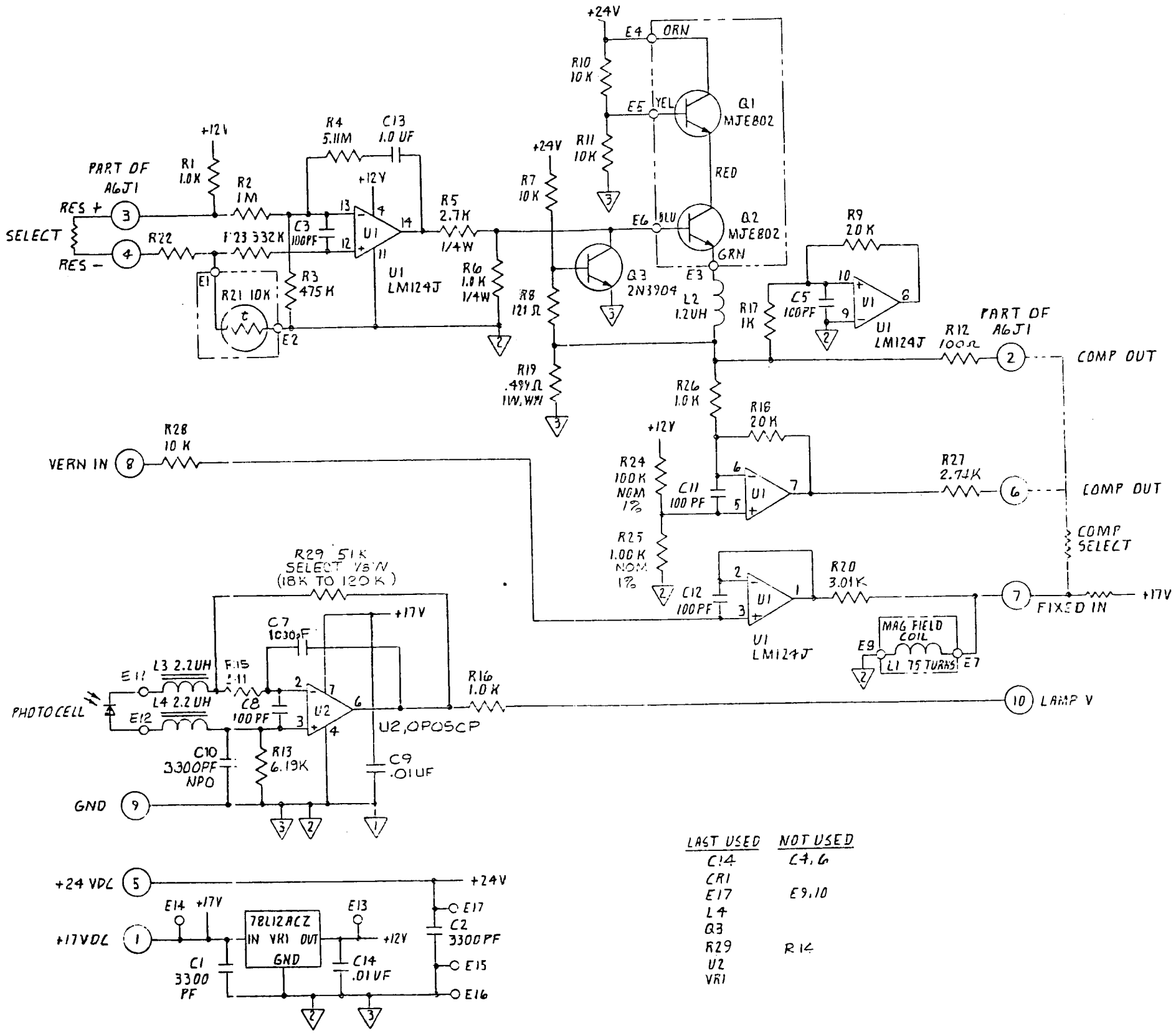
FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	814-116		LAMP SUPPORT BOARD		
2	1	814-117-2		LAMP SPACER		
3	6	MS51957-3		SCREW, 2-56x1/4 CRES PN HD		2821428
4	A/R	LOCKTITE #222		COMPOUND, THREAD LOCKING		
5	A/R	MIL-W-16878E		WIRE, 28 AWG STRANDED		
6	A/R	SN63WRMAP3		SOLDER		
7	A/R	704-215-1		WIRE, 26AWG, 99.9%SILVER,SPRING TEMPER	L6(9 TURNS)	
8	1	100299-001		LAMP HOUSING ASSEMBLY		
9	A/R	70424-12		ADHESIVE RTV, BLACK		
10	A/R	70424-7		ADHESIVE RTV 108		
11	1	100297-001		COIL FORM		
12	3	1126-1115-502AD	CDI	CAPACITOR, FEED THRU	C12-14	1500032
13	1	8053		CAPACITOR, VARIABLE 1.5-14PF	C11	
0	1	B57232-A1103-M		*1 THERMISTOR (M85)	RT	5301106
15	A/R	AMS-3655		TUBING, TEFLON 30 AWG	LEADS OF RT	
16				NOT USED		
17	1	814-113		LAMP BOARD ASSEMBLY		
18	1	814-120-2		LAMP, FILLED		
19	A/R	AMS-3655		TUBING TEFLON 26 AWG		
20				NOT USED		
21	1	MJE802		TRANSISTOR	Q1	4801151
22				NOT USED		
23				NOT USED		
24	1	B52200F006		WASHER #4 BELLEVILLE		2820531
25	1	MS51957-14		SCREW, PAN HD 4-40x5/16		2821418
26				NOT USED		
27				NOT USED		
28				NOT USED		
29	A/R	70411		THERMAL JOINT COMPOUND		
30	1	814-158		PLUG-LAMP COIL		
31	3	2643000101		FERRITE BEAD	Z1-3	1850160
32	1	MS75084-4		INDUCTOR 2.2UH	L2	1801448
33	1	2N918		TRANSISTOR	Q2	4800210
34	1	C322C332K1G5CA	KEMET	CAPACITOR 3300PF NPO	C5	1500580
35	1	CKR05BX682KS		CAPACITOR 6800 PF	C15	1500695
36	1	MK1 121	*2	RESISTOR, MF, 121 OHM, 1/8 W	R7	4703010
37	1	MK1 475	*2	RESISTOR, MF, 475 OHM, 1/8 W	R5	4703358
38	1	MK1 10K	*2	RESISTOR, MF, 10K OHM,1/8 W	R6	4703029
39	1	RWR81S1R40FR		RESISTOR 1.40 ohm WW	R9	4702014
40	1	43-77-1	THERMALLOY	INSULATOR (THERMALFILM)	XQ1	1002594
41	1	MK1 2.21K	*2	RESISTOR, MF, 2.21K OHM, 1/8 W	R8	4703035
42				NOT USED		
43	1	250-169		MICA WINDOW		
0			NOTE:	*1 MAY USE THERMOMETRICS BR55KB103-L		
0				1.8 LONG		
0				*2. MAY USE RCR05GXXXJR		



R29 IS MOUNTED ON SOLDER SIDE DURING TEST



ASSEMBLY A6, RESONATOR BOARD (814-122/REV R)



LAST USED	NOT USED
C14	C4, 6
CR1	
E17	E9, 10
L4	
Q3	
R29	R14
U2	
VR1	

SCHEMATIC, RESONATOR BOARD (814-123/REV P)

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-122 REVISION LTR. T
REVISION DATE 91-4-3

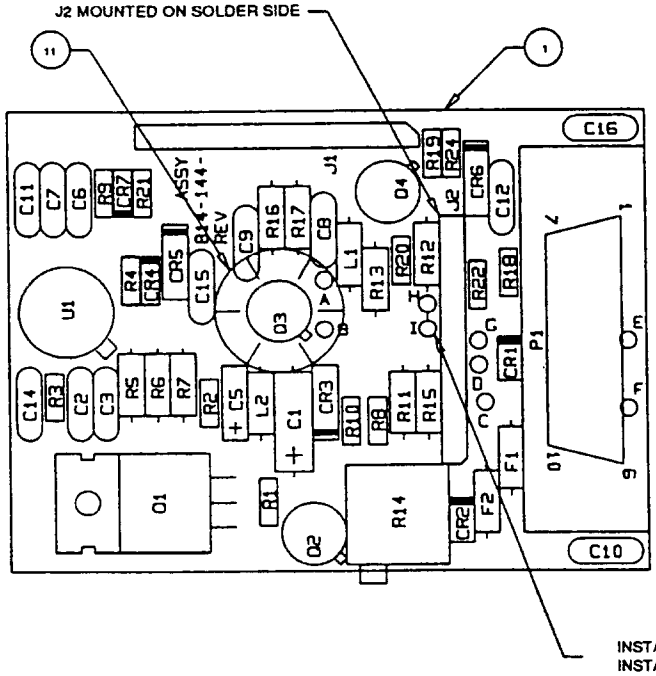
TITLE: PARTS LIST, RESONATOR BOARD ASSEMBLY

SHEET 2

FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	814-124		P.C.B.		
2	1	BBL-110-G-F	SAMTEC	CONNECTOR	A6J1	2100542
3	A/R	SN63WRMAP3		SOLDER		
4				NOT USED		
5	2	MS75804-4		INDUCTOR 2.2 uH	L3,4	1801448
6	1	RWR81SR499FR		RESISTOR 1W, WW .499 ohm	R19	4702034
7	1	MS75084-1		INDUCTOR 1.2 uH	L2	1801444
8	1	RCR07G102JR		RESISTOR 1/4 W CARBON 1.0K	R6	4701686
9	1	RCR05GXXXJR	SELECT IN TEST	RESISTOR 1/8 W CARBON, SIT	R29	
10	1	RCR07G272JR		RESISTOR 1/4 W CARBON 2.7K	R5	4701715
11	1	MK2 100K		RESISTOR, METAL FILM 100K	R24	4701170
12	1	MK2 1.00K		RESISTOR, METAL FILM 1.00K	R25	4701153
13	1	2N3904		TRANSISTOR NPN	Q3	4800197
14	1	CK06BX105KSV		CAPACITOR, CERAMIC 1.0UF	C13	1500697
15	5	C320C101K2G5CA		CAPACITOR, CERAMIC 100PF NPO	C3,5,8,11,12	1500565
16	2	RCR05G101JR		RESISTOR 100 ohm 1/8 W CARBON	R12,15	4701599
17	3	C322C332K1G5CA	KEMET	CAPACITOR, CERAMIC 3300pF NPO	C1,2,10	1500580
18	3	CKR05BX103KSV		CAPACITOR CERAMIC .01 uF	C7,9,14	1500687
19	1	RCR05G334JR		RESISTOR 1/8 W CARBON 330K	R23	4701642
20	4	RCR05G102JR		RESISTOR 1/8 W CARBON 1.0K	R17,26,1,22	4701600
21	1	RCR05G272JR		RESISTOR 1/8 W CARBON 2.7K	R27	4701634
22	1	RCR05G622JR		RESISTOR 1/8 W CARBON 6.2K	R13	4701661
23	4	RCR05G103JR		RESISTOR 1/8 W CARBON 10K	R10,11,7,28	4701601
24	2	RCR05G203JR		RESISTOR 1/8 W CARBON 20K	R9,18	4701623
25	1	RCR05G474JR		RESISTOR 1/8 W CARBON 470K	R3	4701652
26	1	RCR05G105JR		RESISTOR 1/8 W CARBON 1.0M	R2	4701604
27	1	RCR05G515JR		RESISTOR 1/8 W CARBON 5.1M	R4	4701655
28	1	RCR05G121JR		RESISTOR 1/8 CARBON 120 ohm	R8	4701526
29	1	LM124J		INTEGRATED CIRCUIT	U1	3130985
30	1	OP05CP	PMI ONLY	INTEGRATED CIRCUIT	U2	3130018
31	1	78L12ACZ		VOLTAGE REGULATOR	VR1	4002225
32	1	RCR05G302JR		RESISTOR 3.0 K	R20	4701637

TABULATION CHART

COMPONENT VALUES FOR RF OUTPUT		COMPONENT VALUES FOR TTL OUTPUT
ASSEMBLY 814-144-2 10 MHz SINE	ASSEMBLY 814-144-4 5 MHz SINE	ASSEMBLY 814-144-3 10 MHz TTL
L1= 8.8UH	L1= 15UH	L1= OMIT
L2= 15UH	L2= 47UH	L2= REPLACE WITH R23 130 OHM, 1W, RWR81
R16= 910 OHM NOM	R16= 910 OHM NOM	R16= 100 OHM NOM
R17= 1.0K NOM	R17= 1.0K NOM	R17= 270 OHM NOM 1/4W
R18= 1.0K	R18= 1.0K	R18= OMIT
C8= 47PF NOM	C8= 82PF NOM	C8= JUMPER
C9= 6800PF NOM	C9= 6800PF NOM	C9= 0.47UF NOM
C16= 0.1UF	C16= 0.1UF	C16= JUMPER
C17= 240PF NOM NPO	C17= 240PF NOM NPO	C17= OMIT
		INSTALL JUMPER A-B
		INSTALL HEATSINK (ITEM 11) ON Q3



NOTES: UNLESS OTHERWISE SPECIFIED.

1. WORKMANSHIP SHALL BE PER MIL-STD-454K REQUIREMENT 9. (NO CERTIFICATIONS REQUIRED)
2. ALL SOLDERING, WIRING AND COMPONENT MOUNTING SHALL MEET THE REQUIREMENTS OF IPC-S-815 CLASS III.
3. LEADS SHOULD BE PARTIALLY CLINCHED OR SWAGED FOR PART RETENTION PRIOR TO SOLDERING. (FOR REF. ONLY SEE MIL-P-46843B TYPE II OR TYPE III).
4. AFTER SOLDERING, CLEAN ASSEMBLY TO REMOVE ALL FLUX RESIDUE.
5. IDENTIFY WITH ASSY DASH No. AND PARTS LIST REV. LETTER.
6. LEAD PROJECTION BELOW BOARD SURFACE SHALL BE .020 MIN .060 MAX.
7. FOR SCHEMATIC DIAGRAM SEE DRAWING NUMBER 814-142

-4	SEE SEPARATE PARTS LIST PL814-144-4
-3	SEE SEPARATE PARTS LIST PL814-144-3
-2	SEE SEPARATE PARTS LIST PL814-144-2
-1	NOT USED

ASSEMBLY NUMBER	CAGE CODE	PART OR IDENTIFYING No.	SPECIFICATION OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	HCI CODE	REFERENCE DESIGNATOR	UNITS No.
PARTS LIST							

ASSEMBLY A3, POWER SUPPLY BOARD (814-144/REV P)

NOTES: UNLESS OTHERWISE SPECIFIED

1. RESISTORS ARE 1/8W F.C., VALUES ARE IN OHMS.
2. CAPACITORS ARE 50V MIN. 10% FIXED CERAMIC, VALUES ARE IN UF.
3. USE MK-2 OR RN55B FOR SIT RESISTORS
4. USE EQPT OR CKO5 FOR SIT CAPACITORS

(5) P.C.B. LAYOUT FOR R17 MUST BE SIZED FOR 1\4 W RESISTOR

(6) FOR UNITS WITH SINGLE +24V SUPPLY INSTALL JUMPER C-D

(7)

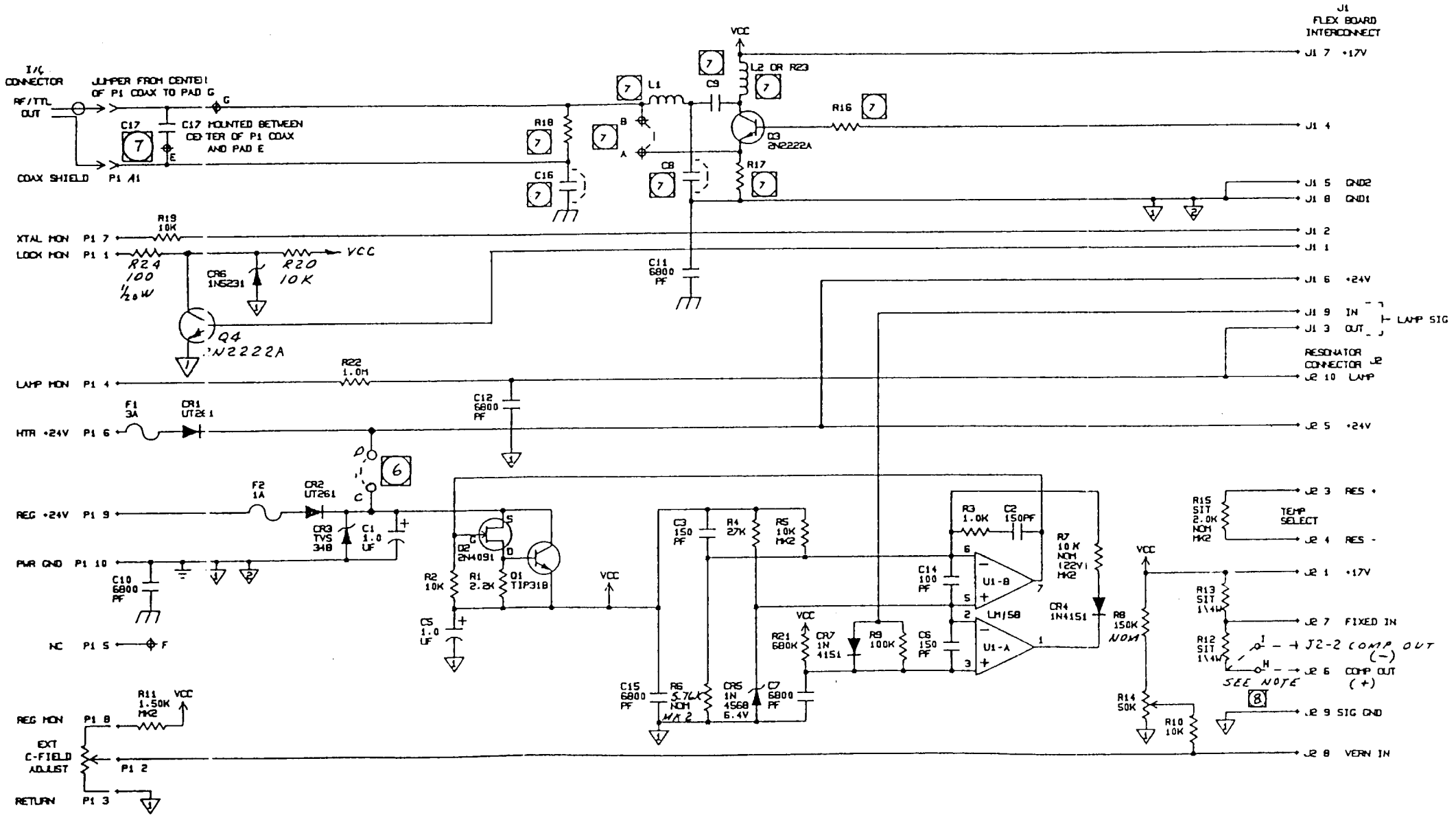
COMPONENT VALUES FOR RF OUTPUT		COMPONENT VALUES FOR TTL OUTPUT
ASSEMBLY 814-144-2 10 MHz SINE	ASSEMBLY 814-144-4 5 MHz SINE	ASSEMBLY 814-144-3 10 MHz TTL
L1= 6.8UH	L1= 15UH	L1= OMIT
L2= 15UH	L2= 47UH	L2= REPLACE WITH R23 130 OHM, 1W, RWR81
R16= 910 OHM NOM	R16= 910 OHM NOM	R16 = 100 OHM NOM
R17= 1.0K NOM	R17= 1.0K NOM	R17 = 370 OHM NOM 1/4W
R18= 1.0K	R18= 1.0K	R18 = OMIT
C8= 47PF NOM	C8= 82PF NOM	C8= JUMPER
C9= 6800PF NOM	C9= 6800PF NOM	C9= 0.47UF NOM
C16= 0.1UF	C16= 0.1UF	C16 = JUMPER
C17= 240PF NOM NPO	C17= 240PF NOM NPO	C17 = OMIT INSTALL JUMPER A-B

POWER CHART		
DEVICE NO.	GND PIN	+VCC PIN
U1	4	8

LAST USED	NOT USED
C17	C4,C13
CR7	
F2	
L2	
Q4	
R24	
U1	

(8)

TEMP COMPENSATION	R12 CONNECTION
NEGATIVE COMPENSATION	TO PAD I (J2-7 TO J2-2)
POSITIVE (NORMAL) COMPENSATION	TO PAD H (J2-7 TO J2-6)



SCHEMATIC, POWER SUPPLY BOARD (814-142/REV T)

BALL, EFRATOM DIVISION CONTRACT NO. CAGE CODE 55761 PL 814-144-3 REVISION LTR. K
REVISION DATE 91-4-3

TITLE: PARTS LIST, POWER SUPPLY ASSY

SHEET 2

FIND NO.	QTY	PART OR IDENTIFYING NO.		SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS NO.
1	1	814-143		EFRATOM	PRINTED WIRING BOARD		
2	1	814-148		EFRATOM	HEAT SINK		
3	2	4750-5		RAF	SCREW, JACK SOCKET		
4	1	MS51957-14			SCREW, PAN HD, 4-40x5/16 LG		2821418
5	1	5607-45		SEASTROM	WASHER, SHOULDER		2820391
6	3	MS35338-135			WASHER, LOCK #4		2821391
7	1	NAS620C4L			WASHER, FLAT #4		2821462
8	1	KFS2-440		PEM	NUT, CAPTIVE		2820954
9	2	NAS671C4			NUT, HEX, #4		2821486
11	1	TXC20B		IERC	HEATSINK	XQ3	2602125
12	1	3223-07FR-54		AAVID	INSULATOR	XQ1	3100241
13	3	7717-133N		THERMALLOY	INSULATOR TO-18	XQ2,XQ3,XQ4	2102218
14	A/R	704-232		LOCTITE	COMPOUND, THREAD LOCKING		
15	A/R	M16878		MIL-W-16878	WIRE, 28 AWG STRANDED TYPE E		
17	A/R	SN63WRMAP3		QQ-W-371	SOLDER		
20	1	CKR05BX101KS		MIL-C-39014	CAPACITOR, CERAMIC 100 PF	C14	1500685
21	3	CKR05BX151KS		MIL-C-39014	CAPACITOR, CERAMIC 150 PF	C2,3,6	1500689
23	5	CKR05BX682KS		MIL-C-39014	CAPACITOR, CERAMIC 6800 PF	C7,10-12,15	1500695
24	6	CKR05BX682KS		MIL-C-39014	CAPACITOR, CERAMIC 6800 PF	C9,7,10-12,15	1500695
26	1	C320C474M5U5CA		KEMET	CAPACITOR, CERAMIC 0.47 UF	C9	1503032
27	1	173D105X9050V		SPRAGUE	CAPACITOR, TANTALUM 1.0 UF	C5	1500072
28	1	CSR13G105K	*2	MIL-C-39003	CAPACITOR, TANTALUM 1.0 UF	C1	1500708
29	2	1N4151			DIODE	CR4,CR7	4800084
30	1	1N4568			DIODE	CR5	4800085
31	1	1N5231B			DIODE, ZENER	CR6	4800090
32	1	TVS348	*5		DIODE	CR3	4802259
33	2	UT261	*3		DIODE	CR1,CR2	4802136
34	1	251001		LITTELFUSE	FUSE 1A	F2	4300180
35	1	251003		LITTELFUSE	FUSE 3A	F1	4302506
36	1	CA-S09-20T-40-125		CA CORP	CONNECTOR	J1	2102502
37	1	SS-110-G-2		SAMTEC	CONNECTOR	J2	2102090

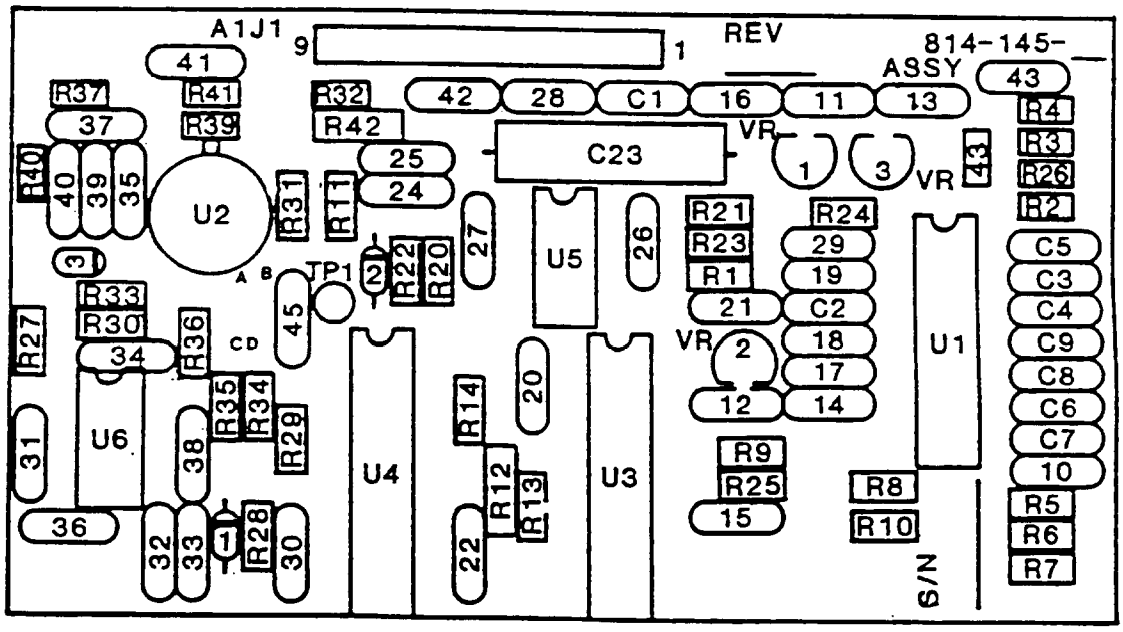
BALL, EFRATOM DIVISION CONTRACT NO. CAGE CODE 55761 PL 814-144-3 REVISION LTR. K
REVISION DATE 91-4-3

TITLE: PARTS LIST, POWER SUPPLY ASSY

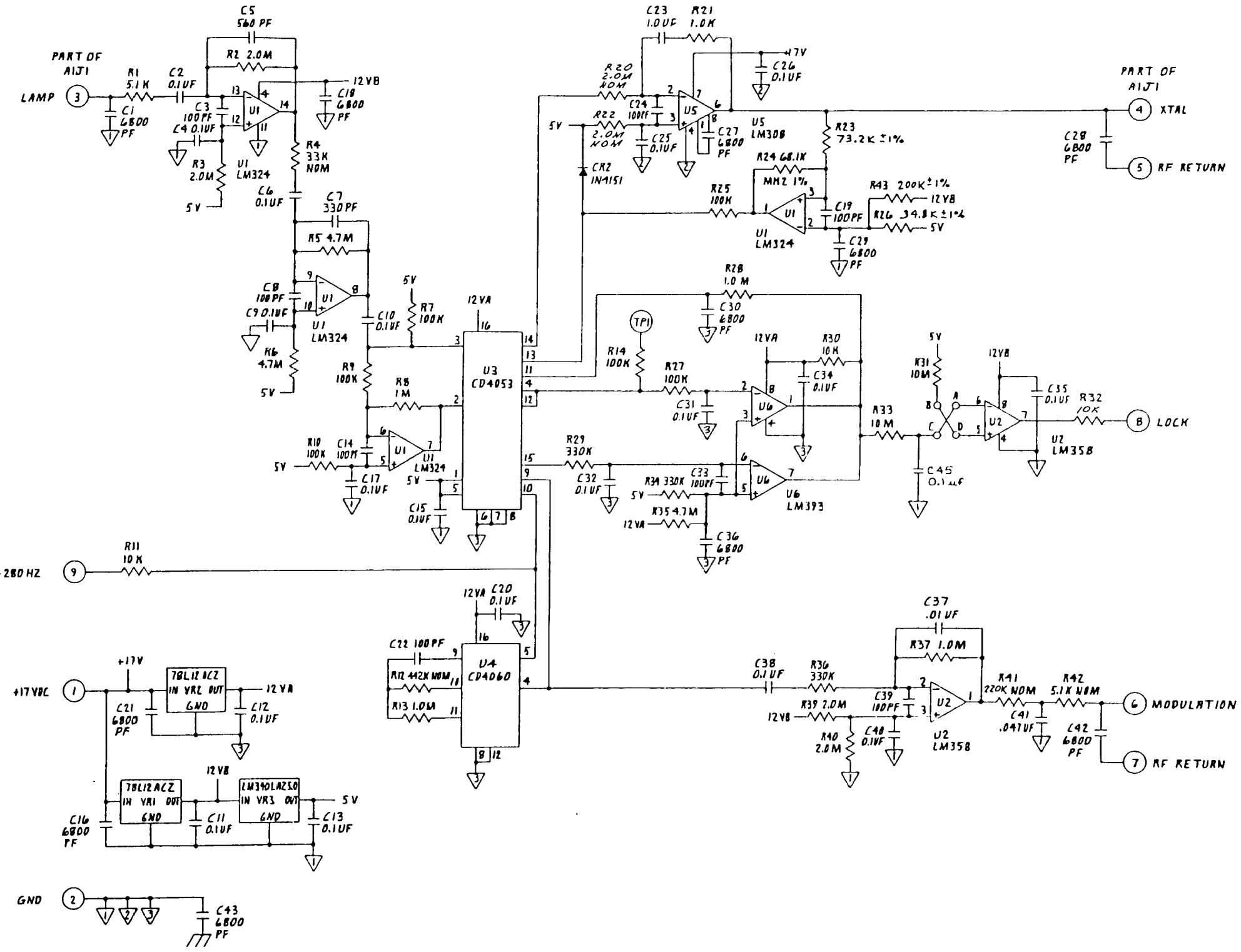
SHEET 3

FIND NO.	QTY	PART OR IDENTIFYING NO.		SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS NO.
42	1	CBD11W1M3S000-867.0		POSITRONIC	CONNECTOR (WITH PINS)	P1	2102722
43	1	FDS4201D	*7	POSITRONIC	CONTACT, COAX	P1A1	2103287
44	2	2N2222A			TRANSISTOR	Q3,4	4800188
45	1	2N4091			TRANSISTOR	Q2	4800199
46	1	TIP31B			TRANSISTOR	Q1	4802114
47	1	MK1 100 OHM	*4		RESISTOR MF 1/8W 100 OHM NOM	R16	4703031
48	1	RNC50H1000FR		MIL-R-55182	RESISTOR MF 1/20W 100 OHM	R24	4703027
49	1	RWR81S1300FR	*6	MIL-R-39007	RESISTOR WW 1W 130 OHM	R23 (L2 LOC)	4701969
50	1	MK2 274 OHM			RESISTOR MF 1/4W 274 OHM NOM	R17	4701223
55	1	MK2 1.5K			RESISTOR MF 1/4W 1.5K	R11	4701161
56	1	MK2 2K			RESISTOR MF 1/4W 2K NOM SEL	R15	4701193
57	1	MK1 2.2K	*4		RESISTOR MF 1/8W 2.21	R1	4701628
58	1	MK2 5.76K			RESISTOR MF 1/4W 5.76K NOM	R6	4701280
59	4	MK1 10K	*4		RESISTOR MF 1/8W 10K	R2,10,19,20	4701601
60	2	MK2 10K			RESISTOR MF 1/4W 10K NOM	R7,5	4701167
61	1	MK1 27 K	*4		RESISTOR MF 1/8W 27K	R4	4701635
62	1	3299P-1-503		BOURNS	RESISTOR, VARIABLE 50K	R14	4750245
63	1	MK1 100K	*4		RESISTOR MF 1/8W 100K	R9	4701602
64	1	MK1 150K	*4		RESISTOR MF 1/8W 150K NOM	R8	4701615
65	1	RCR05G684JR		MIL-R-39008	RESISTOR FC 1/8W 680K	R21	4701664
66	1	RCR05G105JR		MIL-R-39008	RESISTOR FC 1/8W 1MEG OHM	R22	4701604
67	2	MK2 SIT			RESISTOR MF 1/4W NOM (OPEN)	R12,13	
68	1	LM158H			I.C. OP AMP	U1	3130993
69	1	MK1 1K	*4		RESISTOR MF 1/8W 1K	R3	4703171

NOTES: REF *2 _____ MAY USE M39003/01-2596
REF *3 _____ MAY USE SEMTECH JSM2
REF *4 _____ MAY USE RCR05GXXXJS
REF *5 _____ USE P6KE56A-GEN'L INST OR MOT
REF *6 _____ 814-144-3 HAS NOTE L2 LOCATION
REF *7 _____ MAY USE DM121073-201,CANNON,CONTACT COAX



(A1) ASSEMBLY, SERVO BOARD (814-145/REV G)



SCHEMATIC, SERVO BOARD (814-140/REV K)

A20

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-145-2 REVISION LTR. U
REVISION DATE 91-4-3

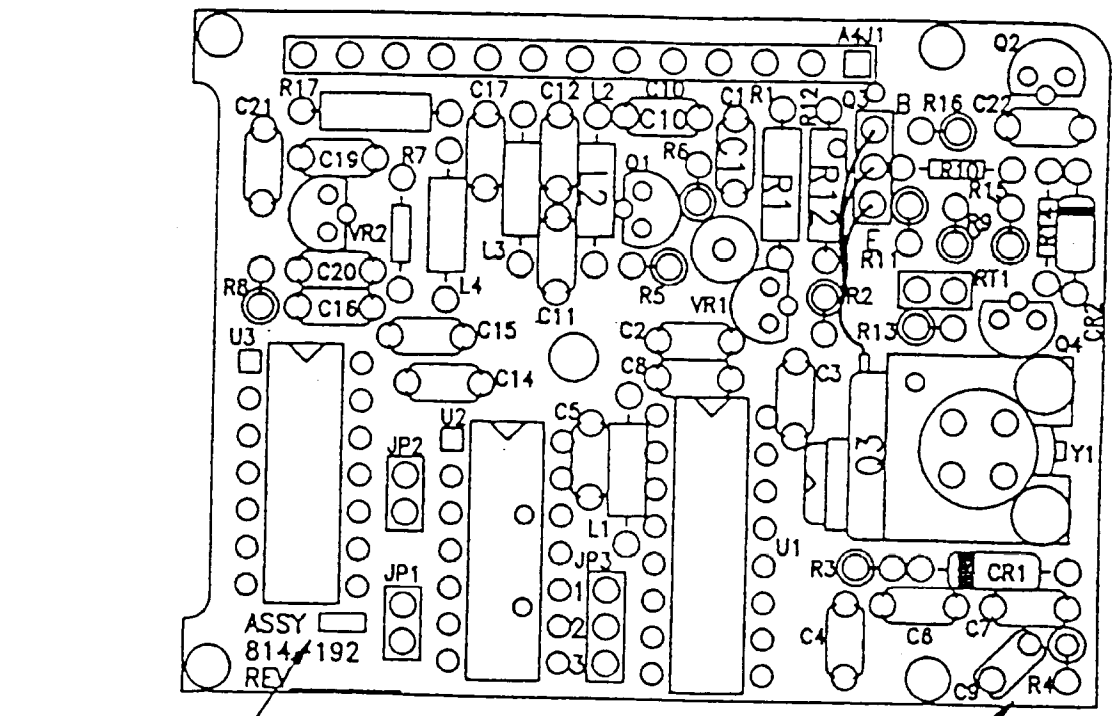
TITLE: PARTS LIST, SERVO BOARD ASSEMBLY

FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	814-141		P.C.B.		814-141
2	1	CA-S09-20T-40-125	CIRCUIT ASSY	CONNECTOR		2102502
3	1	70416-2		TERMINAL	TP1	70416-2
4				NOT USED		
5	1	MK2 5.11K		RESISTOR 1/4W M.F. 5.11K NOM	R42	4701276
6	1	MK2 442K		RESISTOR 1/4W M.F. 442K	R12	4702688
7	1	RNC55H7322FR		RESISTOR 73.2K +/-1%	R23	4702357
8	1	MK2 68.1K		RESISTOR 1/4 W M.F. 68.1K	R24	4701295
9				NOT USED		
10	1	RCR05G102JR		RESISTOR 1/8W CARBON 1.0K	R21	4701600
11	1	RCR05G512JR		RESISTOR 1/8W CARBON 5.1K	R1	4701653
12	3	MK1 10K		RESISTOR 1/8W 10K M.F.	R11,30,32	4701601
13	1	RCR05G333JR		RESISTOR 1/8W CARBON 33K	R4	4701641
14				NOT USED		
15	1	RCR05G224JR		RESISTOR 1/8W CARBON 220K	R41	4701629
16				NOT USED		
17	6	RCR05G104JR		RESISTOR 1/8W CARBON 100K R7,9,10,14,25,27		4701602
18				NOT USED		
19	3	RCR05G334JR		RESISTOR 1/8W CARBON 330K	R36,34,29	4701642
20	2	RCR05G205JR		RESISTOR 1/8W CARBON 2.0M NOM	R20,22	4701625
21	4	RCR05G105JR		RESISTOR 1/8W CARBON 1.0M	R13,28,37,8	4701604
22	4	RCR05G205JR		RESISTOR 1/8W CARBON 2.0M	R2,3,39,40	4701625
23	3	RCR05G475JR		RESISTOR 1/8W CARBON 4.7M	R5,6,35	4701605
24	2	RCR05G106JR		RESISTOR 1/8W CARBON 10M	R31,33	4701605
25	1	RNC50H2003FR		RESISTOR 200K +/-1%	R43	4701784
26	1	RNC50H3482FR		RESISTOR 34.8K +/-1%	R26	4701801
27				NOT USED		
28				NOT USED		
29				NOT USED		
30	7	CKR05BX101KSV		CAPACITOR, CERAMIC 100pf C3,8,14,19,24,33,39		1500685
31	1	CKR05BX331KSV		CAPACITOR, CERAMIC 330pf	C7	1500691
32	1	CKR05BX561KSV		CAPACITOR, CERAMIC 560pf	C5	1500694

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-145-2 REVISION LTR. U
REVISION DATE 91-4-3

TITLE: PARTS LIST, SERVO BOARD ASSEMBLY SHEET 3

FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
33	11	CKR05BX682KSV		CAPACITOR, CERAMIC 6800pf C1,16,18,21,27-30,36,42,43		1500695
34	1	CKR05BX103KSV		CAPACITOR, CERAMIC .01uf	C37	1500687
35	1	CKR05BX473KSV		CAPACITOR, CERAMIC .047uf	C41	1500693
36	20	CKR05BX104KSV		CAPACITOR, CERAMIC 0.1uf C2,4,6,9-13,15,17,20,25,26,31,32,34,35,45,38,40		1500688
37	1	C320C101K2G5CA		CAPACITOR, CERAMIC 100pf NPO	C22	1500565
38	1	MKC18601.0/63		CAPACITOR, CERAMIC 1.0uf	C23	1501323
39				NOT USED		
40				NOT USED		
41				NOT USED		
42	1	1N4151		DIODE	CR2	4800084
43				NOT USED		
44				NOT USED		
45	1	LM340LAZ5.0		VOLTAGE REGULATOR 5V	VR3	4001007
46	2	78L12ACZ		VOLTAGE REGULATOR 12V	VR1,2	4001022
47	1	LM158H		INTEGRATED CIRCUIT	U2	3130993
48	1	LM106J-8		INTEGRATED CIRCUIT	U5	3130982
49	1	LM124J		INTEGRATED CIRCUIT	U1	3130985
50	1	LM393J		INTEGRATED CIRCUIT	U6	3131012
51	1	CD4053BF		INTEGRATED CIRCUIT	U3	3130668
52	1	CD4060BF		INTEGRATED CIRCUIT	U4	3130670
0			NOTE:	1. MK-1 RESISTORS MAY BE USED IN PLACE		
0				OF RCR05GXXXJS		
0				2. CR1 & CR3 ARE NOT USED		



3.

LOCATE C9 & R4 AS SHOWN.

5.

TABULATION		
PRODUCTION ASSY NO	RF OUTPUT	BOARD MODIFICATION
814-192-1	10 MHz SINE	AS SHOWN, NO JUMPERS
814-192-2	10 MHz TTL	REPLACE R7 WITH JUMPER, DO NOT INSTALL L4 OR C17
814-192-3	2.048 MHz TTL	CUT AT U2-11 JUMPER U2-9 TO R7 JP3-1 TO JP3-3 CUT AT U2-10 JUMPER U2-9 TO U3-9 JP1 CUT AT U2-4 JUMPER U2-3 TO U3-10 JP2 REPLACE R7 WITH JUMPER
814-192-4	5 MHz SINE	CUT AT U2-11 JUMPER U2-10 TO R7 JP3-1 TO JP3-2 REPLACE R7 WITH JUMPER, DO NOT INSTALL L4 OR C17

5. SLEEVE STAND-UP RESISTORS R3, R4, R9, R13 USING CLEAR HEATSHRINK TUBING (ITEM 43). R4 MUST BE FACED AWAY FROM C4 DURING SOLDERING.

4. BOND INSULATOR FOAM (ITEM 41) TO CRYSTAL ASSY (ITEM 2) USING RTV ADHESIVE (ITEM 42) AS SHOWN.

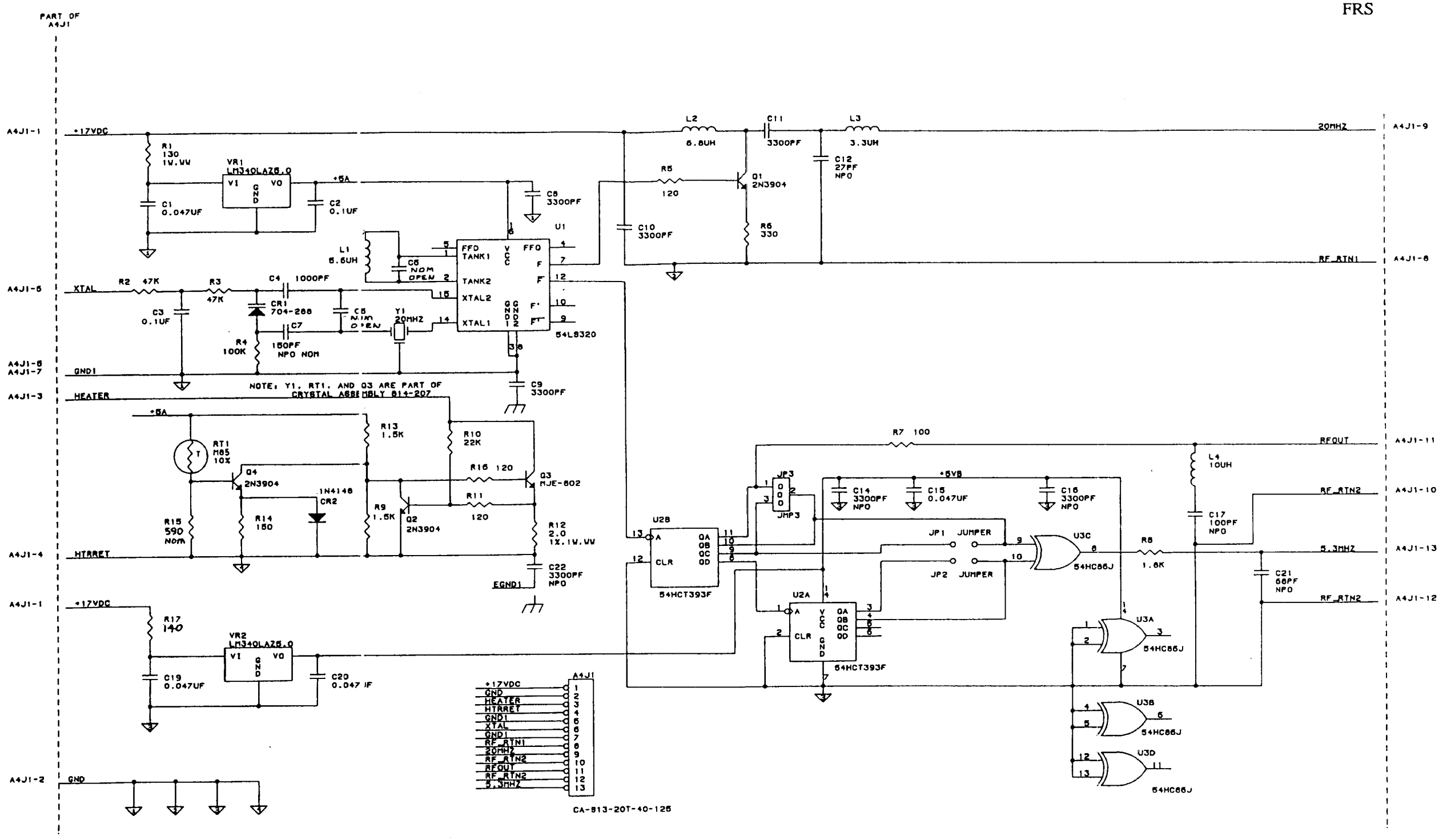
3. IDENTIFY WITH ASSEMBLY DASH NUMBER AND REVISION LETTER.

2. FOR SCHEMATIC SEE 814-201.

1. PART ATTACHMENT, WIRING, SOLDERING, CLEANING AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH IPC-S-815 CLASS III.

NOTES: UNLESS OTHERWISE SPECIFIED.

ASSEMBLY A4, OSCILLATOR BOARD (814-192/REV T)



ASSEMBLY	OUTPUT	DESCRIPTION
814-192-1	10 MHZ SINE	AS SHOWN. NO JUMPERS
814-192-4	5 MHZ SINE	CUT AT U2-11. JUMPER FROM U2-10 TO R7 (JP3.1-2) REPLACE R7 WITH JUMPER DO NOT INSTALL L4 OR C17
814-192-3	2.048 MHZ TTL	CUT AT U2-11. JUMPER FROM U2-9 TO R7 (JP3.1-3) CUT AT U2-10. JUMPER FROM U2-9 TO U3-9 (JP1) CUT AT U2-4. JUMPER FROM U2-3 TO U3-10 (JP2) REPLACE R7 WITH JUMPER
814-192-2	10 MHZ TTL	REPLACE R7 WITH JUMPER DO NOT INSTALL L4 OR C17

LAST USED	NOT USED
R17	
C22	C13
L4	C18
CR2	
Q4	
VR2	
U3	
RT1	
Y1	

SCHEMATIC, OSCILLATOR BOARD (814-201/REV B)

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 ASSEMBLY No. 814-192 REVISION LTR. –

TITLE: PARTS LIST, PRINTED WIRING ASSY CRYSTAL OSCILLATOR REVISION DATE 9-10-90

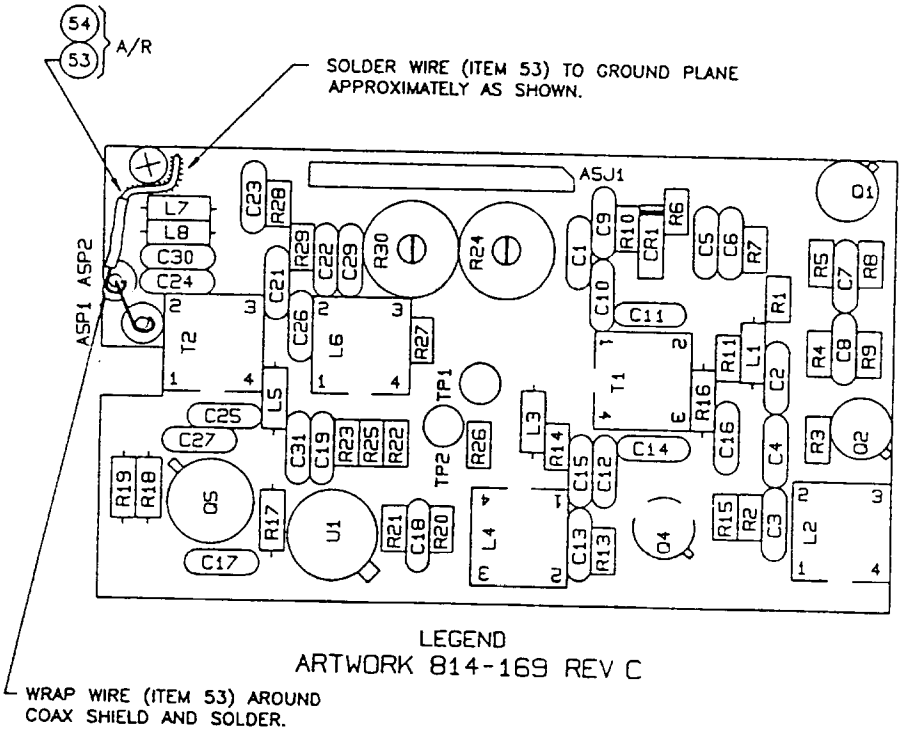
SHEET 1.002

FIND No.	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10	CAGE CODE	PART OR IDENTIFYING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	HCI CODE	REFERENCE DESIGNATOR	UNIS No.
1	1	1	1	1								814-202	EFRATOM	PRINTED WIRING BOARD			
2	1	1	1	1								814-207	EFRATOM	CRYSTAL ASSEMBLY		Y1	
3	1	1	1	1								CA-S13-20T-40-125		CONNECTOR		J1	2102503
4	1	1	1	1							*1	MK1 150		RESISTOR,150 OHM,1/8W		R14	4702868
5	1	1	1	1							*1	MK1 590		RESISTOR,590 OHM,1/8W,NOMINAL		R15	4702938
6	2	2	2	2							*1	MK1 1.5K		RESISTOR,1.5K OHM,1/8W		R9,13	4702867
7	1	0	0	0							*1	MK1 100		RESISTOR,100 OHM,1/8W		R7	4703031
8	3	3	3	3							*1	MK1 120		RESISTOR,120 OHM,1/8W		R5,11,16	4701525
9	1	1	1	1							*1	MK1 330		RESISTOR,330 OHM,1/8W		R6	4701539
10	1	1	1	1							*1	MK1 1.8K		RESISTOR,1.8K OHM,1/8W		R8	4701617
11	1	1	1	1							*1	MK1 22K		RESISTOR,22K OHM,1/8W		R10	4702268
12	2	2	2	2							*1	MK1 47K		RESISTOR,47K OHM,1/8W		R2,3	4701651
13	1	1	1	1							*1	MK1 100K		RESISTOR,100K OHM,1/8W		R4	4701651
14	1	1	1	1								PWR81S2R00FR		RESISTOR,2.00 OHM,1W,WW		R12	4702814
15	1	1	1	1								RWR81S1300FR		RESISTOR,130 OHM,1W,WW		R1	4701969
16	1	1	1	1								MK2 140		RESISTOR,140 OHM		R17	4701181
17	1	1	1	1								EDPT 27PF NPO		CAPACITOR,27PF,NPO		C12	1500743
18	1	1	1	1								EDPT 68PF NPO		CAPACITOR,68PF,NPO		C21	1500753
19	1	0	1	0								EDPT 100PF NPO		CAPACITOR,100PF,NPO		C17	1500764
20	1	1	1	1								C315C151K1G5CA		CAPACITOR,150PF,NPO,NOMINAL		C7	1503024
21	7	7	7	7								C322C332K1G5CA		CAPACITOR,3300PF,NPO		C9-11,14,16,22	1500580
22	2	2	2	2								EDPT NPO		CAPACITOR,SELECT,NOMINAL,OPEN		C5,6	
23	1	1	1	1								CKR05BX102KSV		CAPACITOR,1000PF		C4	1500704
24	4	4	4	4								CKR05BX473KSV		CAPACITOR,0.047UF		C1,15,19,20	1500693
25	2	2	2	2								CKR05BX104KSV		CAPACITOR,0.1UF		C2,3	1500688
26	1	1	1	1								MS75084-6		INDUCTOR,3.3UH		L3	1802933
27	1	1	1	1								MS75084-9		INDUCTOR,5.6UH		L1	1801449
28	1	1	1	1								MS75084-10		INDUCTOR,6.8UH		L2	1801445
29	1	0	1	0								MS75084-12		INDUCTOR,10UH		L4	1801446
30	1	1	1	1								704-288		DIODE,HYPER ABRUPT		CR1	4800197
31	1	1	1	1								1N4148		DIODE		CR2	4001007
32	3	3	3	3								2N3904		TRANSISTOR		Q1,2,4	3132071
33	2	2	2	2								LM340LAZ5.0		VOLTAGE REGULATOR,5V		VR1,2	3131127
34	1	1	1	1								54LS320J	TI	IC,54LS320J		U1	2821428
35	1	1	1	1								54HCT393F	ECA	IC,54HCT393F		U2	
36	1	1	1	1								54HC36J	TI	IC,54HC86J		U3	
37	2	2	2	2								MS51957-3		SCREW,PAN HD,2-56 X 1/4 LG			
38	AR	AR	AR	AR								271	LOCKTITE	ADHESIVE			
39	AR	AR	AR	AR								70424-19	LOCKTITE	ADHESIVE,TAK-PAK			
40	0	1	1	1								30.300X0.125T24	SQUIRES ELEC.	JUMPER WIRE,PRESLEEVED		(R7)	
41	1	1	1	1								814-184		INSULATOR FOAM			
42	A/R	A/R	A/R	A/R								70424-7		ADHESIVE, RTV 108			
43	A/R	A/R	A/R	A/R								70422-3		SLEEVING, HEATSHRINK, CLEAR			

NOTES: *1 MAY USE RCR05GXXXJS

NOTES; UNLESS OTHERWISE SPECIFIED.

1. WORKMANSHIP SHALL BE PER MIL-STD-454K REQUIREMENT 9. (NO CERTIFICATIONS REQUIRED)
2. ALL SOLDERING, WIRING AND COMPONENT MOUNTING SHALL MEET THE REQUIREMENTS OF IPC-S-815 CLASS III.
3. LEADS SHOULD BE PARTIALLY CLINCHED OR SWAGED FOR PART RETENTION PRIOR TO SOLDERING. (FOR REF. ONLY SEE MIL-P-46843B TYPE II OR TYPE III).
4. AFTER SOLDERING, CLEAN ASSEMBLY TO REMOVE ALL FLUX RESIDUE.
5. IDENTIFY ASSEMBLY WITH ASSEMBLY NUMBER (AND DASH NO. IF REQ'D), REVISION LETTER AND SERIAL NUMBER.
6. LEAD PROJECTION BELOW BOARD SURFACE SHALL BE .020 MIN .060 MAX.
7. FOR SCHEMATIC DIAGRAM SEE DRAWING NUMBER 814-168
8. INSTALL ITEM 52 (TERMINALS) 3 PLACES (TP1, TP2, ASP1) FUNNEL SWAGE CIRCUIT SIDE PRIOR TO SOLDERING.
9. VIEW SHOWN IS FOR PCB 814-169 REV C ONLY



LEGEND
ARTWORK 814-169 REV C

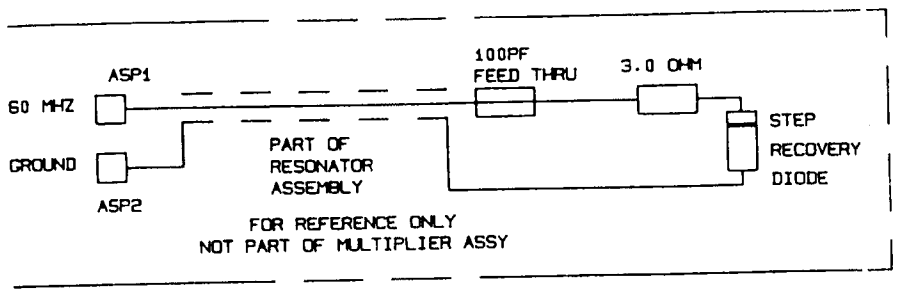
WRAP WIRE (ITEM 53) AROUND COAX SHIELD AND SOLDER.

TABULATION	
FRS	PARTS LIST
10MHz TTL	814-167-1
13MHz TTL	814-167-2

ASSEMBLY A5, MULTIPLIER BOARD (814-167/REV E)

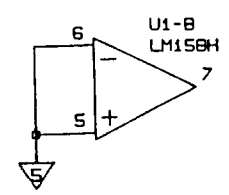
NOTES: UNLESS OTHERWISE SPECIFIED.

1. RESISTORS ARE 1/8 WATT, 5% COMPOSITION, VALUES ARE IN OHMS.
2. CAPACITORS ARE CERAMIC, VALUES ARE IN MICRO FARADS.
3. FOR ASSEMBLY DRAWING SEE DRAWING 814-167

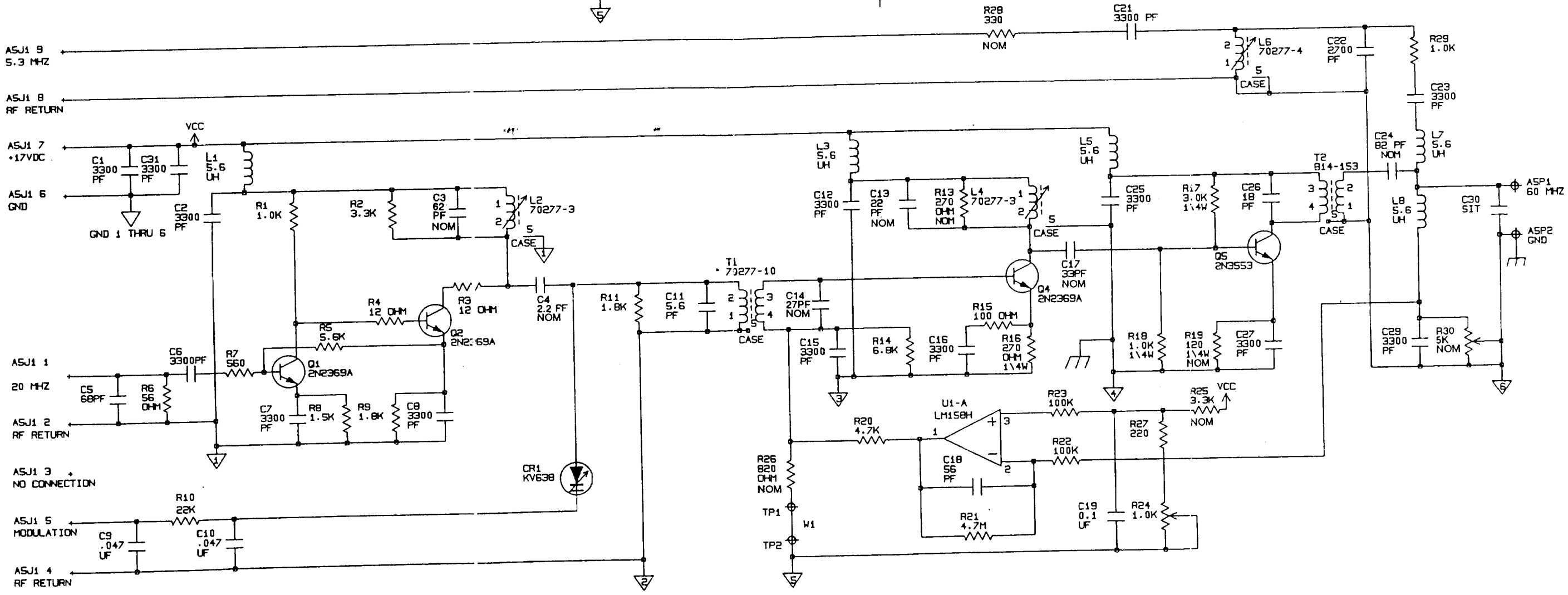


POWER AND GROUND CHART

DEVICE	+17V PIN NUMBER	GND PIN NUMBER
LM158	8	4



LAST USED	NOT USED
C31	C20, C28
L8	
Q5	Q3
R30	R12
T2	
U1	
W1	
CR1	



SCHEMATIC, MULTIPLIER BOARD (814-168/REV F)

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-167-2 REVISION LTR. -
REVISION DATE 91-05-21

TITLE: PARTS LIST, 13MHZ MULTIPLIER BD ASSEMBLY SHEET 2

FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
1	1	814-169	EFRATOM	P.W.B. FABRICATION		
2	A/R	SN63WRMAP3	QQ-S-571	SOLDER		
3	1	CA-S09-20T-40-125	CIRCUIT ASSY	CONNECTOR, 9 PIN	A5J1	2102502
4	1	EDPT 2.2 PF NPO	STETTNER	CAPACITOR, CER 2.2PF NOM	C4	1503020
5				NOT USED		
6	2	EDPT 22 PF NPO	STETTNER	CAPACITOR, CER 22 PF NOM	C14,C26	1500742
7				NOT USED		
8	1	EDPT 12 PF NPO	STETTNER	CAPACITOR, CER 12 PF NOM	C13	1500738
9	1	EDPT 27 PF NPO	STETTNER	CAPACITOR, CER 27 PF NOM	C17	1500743
10				NOT USED		
11	1	EDPT 56 PF NPO	STETTNER	CAPACITOR, CER 56 PF	C18	1500753
12	1	EDPT 68 PF NPO	STETTNER	CAPACITOR, CER 68 PF	C5	1500758
13	1	EDPT 82 PF NPO	STETTNER	CAPACITOR, CER 82 PF NOM	C24	1500760
14	1	EDPT 820 PF Y5P		CAPACITOR, CER 820 PF NOM	C22	1500796
15	14	C322C332K1G5CA		CAPACITOR, CER 3300 PF		1500580
				C1,2,6-8,12,15,16,21,23,25,27,29,31		
16	2	CKR05BX473KS	MIL-C-11015	CAPACITOR, CER .047uF	C9,10	1500693
17	1	CKR05BX104KS	MIL-C-11015	CAPACITOR, CER 0.1uF	C19	1500688
18	1	EDPT (SELECT)	STETTNER	CAPACITOR, CER SELECT	C30	
19	1	KV638		DIODE, VARACTOR	CR1	4800966
20	5	MS75084-9		INDUCTOR, 5.6UH	L1,L3,L5,L7-8	1801449
21	2	70277-3	EFRATOM	INDUCTOR, VARIABLE	L2,L4	
22	1	70277-4	EFRATOM	INDUCTOR, VARIABLE	L6	
23	3	2N2369A		TRANSISTOR, NPN	Q1,Q2,Q4	4800190
24	1	2N3553		TRANSISTOR, NPN	Q5	4800195
25	2	RCR05G120JR		RESISTOR, 1/8W 5% 12 OHM	R3,R4	4701525
26	1	RCR05G560JR		RESISTOR, 1/8W 5% 56 OHM	R6	4701656
27	1	RCR05G101JR		RESISTOR, 1/8W 5% 100 OHM	R15	4701599
28	1	RCR05G271JR		RESISTOR, 1/8W 5% 270 OHM NOM	R13	4701632
29	1	RCR05G221JR		RESISTOR, 1/8W 5% 220 OHM	R27	4701627
30				NOT USED		
31	1	RCR05G561JR		RESISTOR, 1/8W 5% 560 OHM	R7	4702263
32	3	RCR05G102JR		RESISTOR, 1/8W 5% 1.0K	R1,R28,R29	4701600
33	1	RCR05G152JR		RESISTOR, 1/8W 5% 1.5K	R8	4701527

BALL, EFRATOM DIVISION CONTRACT No. CAGE CODE 55761 814-167-2 REVISION LTR. -
REVISION DATE 91-05-21

TITLE: PARTS LIST, 13MHZ MULTIPLIER BD ASSEMBLY

SHEET 3

FIND No.	QTY REQ	PART OR IDENTIFING No.	SPEC. OR MANUFACTURER	NOMENCLATURE OR DESCRIPTION	REFERENCE DESIGNATOR	UNIS No.
34	2	RCR05G182JR		RESISTOR, 1/8W 5% 1.8K	R9,R11	4701617
35	2	RCR05G332JR		RESISTOR, 1/8W 5% 3.3K	R2,(R25 NOM)	4701640
36	1	RCR05G472JR		RESISTOR, 1/8W 5% 4.7K	R20	4702265
37	1	RCR05G562JR		RESISTOR, 1/8W 5% 5.6K	R5	4701657
38	1	RCR05G682JR		RESISTOR, 1/8W 5% 6.8K	R14	4702604
39	2	RCR05G104JR		RESISTOR, 1/8W 5% 100K	R22,R23	4701602
40	1	RCR05G223JR		RESISTOR, 1/8W 5% 22K	R10	4702268
41	1	RCR05G475JR		RESISTOR, 1/8W 5% 4.7M	R21	4701550
42	1	RCR07G121JR		RESISTOR, 1/4W 5% 120 OHM NOM	R19	4701691
43	1	RCR07G271JR		RESISTOR, 1/4W 5% 270 OHM	R16	4701714
44	1	RCR07G102JR		RESISTOR, 1/4W 5% 1.0K	R18	4701686
45	1	RCR07G302JR		RESISTOR, 1/4W 5% 3.0K	R17	4701716
46	1	RCR05G821JR		RESISTOR, 1/8W 5% 820 OHM	R26	4702264
47	1	3386P-1-102	BOURNS	RESISTOR, VAR 1.0K	R24	4750253
48	1	70277-10	EFRATOM	TRANSFORMER	T1	
49	1	814-153	EFRATOM	TRANSFORMER	T2	
50	1	LM158H	NATIONAL	I.C. OP-AMP	U1	3130993
51	1	CCR05CG470JR		CAPACITOR CER 47 PF NOM	C3	1502522
52	3	M55155/30-09	MIL-T-55155	TERMINAL	TP1,TP2,A5P1	2101101
53	A/R	QQ-W-343S24SIT	QQ-W-343	WIRE, 24AWG, BUSS		
54	A/R	24GATWTFL		SLEEVING, 24AWG, AMS-3655		
55				NOT USED		
56	1	3339P-1-502		RESISTOR, VAR, 5K NOM	R30	4750249
57	3	7717-46N		PAD, TRANSISTOR	XQ1,2,4	2102342
58	1	5203-11		PAD, TRANSISTOR	XQ5	3100370
0			*NOTE:	1.USE MK1 RES IF RCR05GXXXJR UNAVAIL.		
0				2.USE MK2 RES IF RCR07GXXXJS UNAVAIL.		

APPENDIX B

FRS MONITORS AND ADJUSTMENTS AT CONNECTOR J1

Lamp Voltage Monitor,
Crystal Control Voltage Monitor,
and External Frequency Adjustments

Lamp Voltage Monitor

When the FRS unit is assembled its lamp voltage is set at the factory to ~14 volts. Over the first year of operation this voltage level will decay by 2 to 3 volts. After the first year of operation this decay becomes much less. The decay can go as low as 6 volts before the operation of the unit is affected.

Lamp voltage levels also vary depending on the state of the unit. When a FRS is first powered up the lamp voltage is between 1.5 to 3 volts. Once the rubidium lamp ignites, lamp voltage rises to between 14 to 9 volts in a working unit, depending on its operating duration. This voltage change is used to switch the FRS internal regulated power supply from 22 to 17 Vdc. The lamp requires 22 volts to ignite, but after ignition only 17 volts is required to maintain operation.

Functionally, the lamp monitor circuit measures the lamp voltage through a 1 megOhm resistor (that protects the lamp circuit). The reading will change depending on the input impedance of the voltage measuring device. The higher the input impedance, the more accurate the measurement will be. The resistor and the input impedance for a voltage divider that reduces the measured voltage.

NOTE:

The lamp voltage monitor is for factory use and reference only, and is not intended as customer use. If there is a special requirement that makes it necessary to monitor the lamp voltage level in the field, the customer should contact Efratom's Marketing or Customer Service groups so that Efratom's technical staff can evaluate these needs and make recommendations.

Crystal Voltage Monitor

The crystal voltage controls the crystal oscillator output frequency through the error signal, slaving the oscillator output to the atomic frequency. As the unit warms up the crystal voltage sweeps the oscillator frequency to detect the atomic frequency signal. The voltage range of these sweeps is between 1.5 and 12 volts dc. Upon detecting the atomic frequency the unit locks and the monitor circuit automatically controls the crystal voltage at the level necessary to lock the output signal to the atomic frequency. Generally, this is any voltage from 2 to 10 volts (but typically 4 to 8 volts), depending on conditions.

The lock monitor is normally used by Efratom as an indication that the output frequency is locked to the atomic frequency. In this use, the lock monitor signal supercedes both the lamp voltage and crystal voltage as a failure indication.

NOTE:

The crystal voltage monitor is for factory use and reference only, and is not intended as customer use. If there is a special requirement that makes it necessary to monitor the crystal voltage level in the field, the customer should contact Efratom's Marketing or Customer Service groups so that Efratom's technical staff can evaluate these needs and make recommendations.

External Frequency Adjustment

The external frequency adjustment feature allows the user to change the output frequency of the FRS over a range of ±1 to ±1.5 x 10E-9 using a customer supplied 1000 Ohm potentiometer, or placing 0 to +5 volts across the external connector pins (from a customer supplied source). When a potentiometer is used, pins 2 (wiper), 3 and 8 (ends) are connected. For 0 to +5 volts, pins 2(+) and 3 (gnd) are used.

When either of these two methods are used, they will override the setting of the internal frequency adjustment.

The following figures show simple schematics of the external frequency adjustment connections.

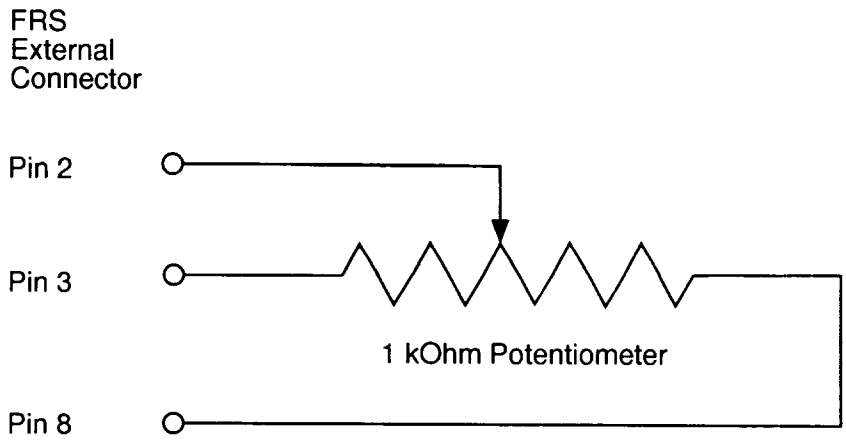


Figure B1. Potentiometer Connections

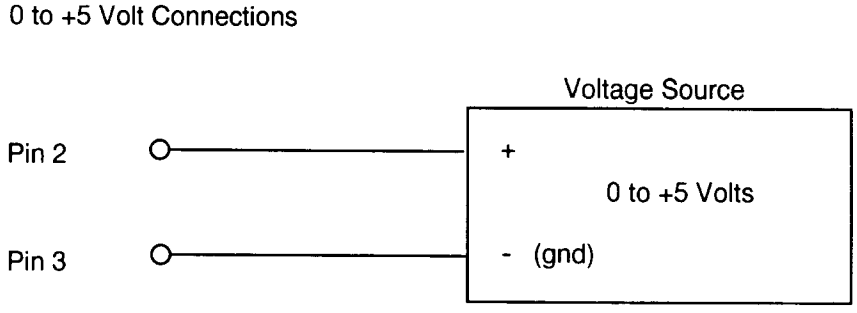


Figure B2. 0 to +5 Volt Connections

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