AIR-GROUND RADIO
PRIVATE SYSTEMS
ECHO-FOX UHF RADIO SYSTEM
DESCRIPTION
OVERALL SYSTEM

CONTENTS PAGE

1. GENERAL

1.01 This section describes the Echo-Fox UHF Radio System used by the United States Government for the transmission of analog voice signals between airborne and ground-based customers.

Note: The Echo-Fox system was originally supplied with a wide-band digitally coded mode which is no longer in use. However, reference is made to wideband in the alignment sections of this BSP series where adjustment of wideband components could affect alignment of the transmitters or receivers.

1.02 This section supersedes Section 406-199-100 LL.

2. CHARACTERISTICS

2.01 The Echo-Fox radio system is comprised of Bell System dedicated land line facilities and air-ground radio links. The land line facilities terminate at radio stations that are remotely controlled to provide UHF FM radio links to customer provided equipment (CPE) installed in Government aircraft. The ground radio stations are deployed throughout the continental United States to provide contiguous coverage (Table A). Intercontinental circuits connecting to the Bell System network provide world-wide coverage.

2.02 The transmission facilities are designed to carry analog voice signals. All stations are equipped for narrowband operation only.

2.03 All land line facilities converge in the Washington area and selection of any ground station is controlled by the customer from a centrally located radio select console (CROWN CONTROL). These locations are designated as control offices Washington 1 and Arlington 2.

2.04 A typical transmission circuit (Fig. 1) consists of the following major items:

(a) Airborne terminal (CPE)

(1) Telephone

(2) Supervisory unit

(3) Radio transmitter and receiver

(b) Ground radio station (Fig. 2)

(1) Radio transmitter and receiver

(c) Land line facilities

(d) Control office—telephone company

(e) Customer location

(1) Radio select console

(2) PBX

2.05 As shown in Fig. 1, the interface equipment is used between the radio facilities and the land line facilities. The units in the interface equipment group also provide the following control and test functions:

(a) Translate radio receiver carrier-operated relay operation into M lead information through the RC1 lead

(b) Translate E lead information to radio transmitter keying information through the TC1 lead

(c) Enable RF loopback testing through the data auxiliary set 806A3

3. OPERATION

3.01 All calls are routed through CROWN CONTROL where the most suitable ground radio station is selected. Normally, the ground transmitter closest to the flight path of the aircraft is manually selected. The RF signal from the aircraft transmitter is received by one or more of the ground receivers and routed via land line facilities to CROWN CONTROL. The first signal arriving at CROWN CONTROL ("race" operation) is automatically selected. Manual override permits CROWN CONTROL to reject the automatic selection and select an alternate station.

3.02 Since ground receivers and transmitters can be operated independently of each other, diverse (split) receiving and transmitting paths may exist at any instant during a call.

A. Air-to-Ground Call

3.03 To establish a call from an aircraft in flight, the airborne transmitter is keyed to signal CROWN. CROWN acknowledges the call and completes the circuit to the called party and communication ensues (Fig. 1).

3.04 The signal from the aircraft operates a squelch relay in the ground receiver. As noted in 2.05 (a), relay operation is translated into M lead information (battery) to signal CROWN CONTROL through the E3B single frequency (SF) signaling system (Fig. 3). As the aircraft moves out of radio range, received signal strength decays and the receiver squelch relay releases. Simultaneously, signal strength in the adjacent area of radio coverage in the flight path will have increased and operated the associated ground receiver squelch relay. In

this manner, circuit continuity (handover) is maintained from one area of coverage to another.

3.05 The FM radio link to the calling aircraft is established by CROWN CONTROL by selecting the ground transmitter closest to the flight path of the aircraft. Ground transmitters are selected along the flight path as needed to maintain the 2-way circuit. Normally, the transmitter of the receiving station is used.

B. Ground-to-Air Call

3.06 In a ground-to-air call, the CROWN switchboard operator serving the calling party initiates the call supervised by CROWN CONTROL. The CROWN CONTROL operator selects a ground transmitter within radio range of the aircraft. The aircraft transmitter acknowledges the call, and a ground receiver is selected as in 3.01 to establish the 2-way circuit. If the flight path of the aircraft is unknown, CROWN CONTROL may have to try several transmitter locations before contact with the aircraft is established.

REMOTE TESTING

3.07 As noted in 2.05 (c), equipment is provided to enable loopback tests on any ground station and to sectionalize circuit troubles.

A. RF Loopback

3.08 All ground stations are equipped with a data auxiliary set 806A3 and an oscillator-converter (with associated antennas) to provide RF loopback capability (Fig. 4). RF loopback tests may be performed by CROWN CONTROL and the control office. The RF loopback test simulates operating conditions at the system's maximum radio range.

3.09 The oscillator-converter simulates an airborne radio terminal by detecting, heterodyning, and retransmitting the base transmitter signal. The reradiated signal is at the base receiver operating frequency. The path loss is adjusted so that the signal input to the receiver is at a level 6 dB above that required to open receiver squelch. Subsequently, a 6 dB loss of transmitted power, low receiver sensitivity, excess loss in the antenna system, or off-frequency operation results in failure of the loopback test.

3.10 To initiate an RF loopback test, the testing office sends a 2400-Hz tone to the data auxiliary set 806A3 at the ground station under test. The set responds to the signal and turns on the oscillator-converter (Fig. 4). The station transmitter is then keyed through the SF signaling unit. A 1000-Hz test tone or voice signals are used to determine loopback quality.

B. Land Line Loopback

3.11 At some unattended stations, a data auxiliary set 806A2 (Fig. 1) provides loopback functions for the line. The data auxiliary set 806A2 operates on a frequency of 2800 Hz.

4. CIRCUIT FUNCTIONS

GROUND RADIO EQUIPMENT

4.01 The ground radio equipment operates in the UHF radio spectrum as a single channel, full duplex, remotely controlled station. It is crystal controlled and utilizes phase modulation for analog voice signals. A tuned multicavity diplexer (duplexer) couples the transmitter and receiver to a common antenna.

A. Base Transmitter

4.02 The base transmitter uses phase modulation for the voice input. Optimum power output is 200 watts (+53 dBm).

B. Base Receiver

4.03 The base receiver has one audio output available through output circuits.

4.04 When no RF signal is present, the voice output is muted by a carrier/noise, antiflutter squelch circuit.

C. Antenna System

4.05 The antenna system includes a diplexer, an RF transmission line, and a station antenna.

4.06 The diplexer is a tuned multicavity device designed to permit simultaneous transmission and reception of RF signals over a common station antenna. The transmitter output and the receiver input are connected to two ports on one end of

the device. A third port connects to the antenna through a low-loss pressurized transmission line.

4.07 Two types of station antennas are used. A high-gain antenna is used in stations originally equipped for both wideband and narrowband operation. A unity gain antenna is specified for narrowband-only stations.

D. Oscillator-Converter

4.08 As noted in 3.08, an oscillator-converter in the base station provides RF loopback capability to test the operation of the station receiver, the transmitter, the antenna system, and the land line facilities.

4.09 The oscillator-converter is equipped with two loopback antennas (receive and transmit), line attenuators, and remote control circuitry (Fig. 4). In operation, RF radiated by the regular station antenna is sampled by the loopback receive antenna. This sample is fed to the converter where it is heterodyned to the Echo-Fox receive frequency and reradiated by the loopback transmit antenna. The signal is picked up by the station antenna and fed to the Echo-Fox receiver to complete the loop back. Test signals transmitted to the ground station are returned on the receive line to the location conducting the test.

4.10 Attenuators in the RF line of the oscillator-converter permit adjustment of the path loss to simulate path loss at maximum radio range. Simulated path loss is adjusted so that the signal level at the Echo-Fox receiver is 6 dB above that required to open receiver squelch.

E. Station Guardian

4.11 All base radio stations are equipped with a Station Guardian designed to detect abnormal conditions in the transmitter and antenna systems. The unit monitors RF power output, reflected power, and voltage standing wave ratio (VSWR).

4.12 The Station Guardian is described in Section 406-116-101; however, basically, it consists of two sensitive dc differential amplifiers adjusted to detect abnormal changes over preset levels. Directional couplers installed in the input (TRANSMITTER) and output (ANTENNA) lines of the diplexer sample both forward and reflected power in each line. The Station Guardian input circuits may be switched to either directional coupler to measure output and reflected power before or after the diplexer (Fig. 5). In operation, an abnormal change in either output or reflected power will be detected by the differential amplifiers and the condition signaled through a visual or audible alarm.

INTERFACE EQUIPMENT GROUP

4.13 The interface equipment group includes functions necessary for signaling and signal processing.

4.14 The voice interface group consists of a single-frequency (2600-Hz) signaling unit, a resistance hybrid, two amplifiers, three pads, a relay, and a data auxiliary set 806A3.

A. SF Signaling Unit

4.15 The SF signaling unit converts battery and ground signals to tone and no-tone signals between the radio site and CROWN CONTROL. SF signaling is normal (tone on) toward the control office and inhibited (tone off) toward the radio site when a circuit is in the idle condition.

4.16 When a signal is received at the radio site (far end), the squelch relay (COR) operates and applies battery through RC1 to the M lead connected to the far end SF unit. This removes the 2600-Hz signaling tone to the near end. The SF unit at the near end detects tone dropout and grounds the E lead to signal CROWN CONTROL (Fig. 3).

4.17 An airborne customer is signaled by the ground customer in the reverse fashion; battery is removed from the M lead at the near end to cause tone-on at the near end SF unit. The SF unit at the far end detects the tone and removes ground from the E lead connected to relay SW14 (Fig. 3) at the far end. Relay SW14 releases and applies battery to the base transmitter keying relay K502 through TC1.

B. Data Auxiliary Set 806A3

4.18 The resistance bridge in the transmit pair provides an input to the data auxiliary set 806A3. Application and removal of 2400-Hz RF loopback tone on the line (3.10) will be detected by the set to close an operate path for the

oscillator-converter high-voltage relay (Fig. 4). A second application and removal of the 2400-Hz tone reverts the set to normal.

C. Land Line Facilities

4.19 As mentioned in 2.01, land line facilities for Echo-Fox service have been dedicated from the Bell System network.

5. CONTROL AND MAINTENANCE RESPONSIBILITIES

NETWORK CONTROL

5.01 Network Control, Washington 1, is responsible for the overall performance of the Echo-Fox system. Designated circuit control offices (Table A) are responsible for normal maintenance of their circuits. These offices ***must*** inform Network Control of any major problems or conditions which may affect the operation of the system.

MAINTENANCE

5.02 The Plant Network Manager is responsible for close liaison with Network Control to maintain and preserve system integrity. Land line circuits and ground stations are maintained in full readiness at all times as calls may be placed without advance flight information. Advance flight information may be provided to the control offices by CROWN CONTROL.

TROUBLE REPORTING

5.03 Customer trouble reports are normally made to Network Control, Washington 1. Reports received by other offices are immediately relayed to Network Control or to the circuit control office if Network Control cannot be contacted.

TESTING

5.04 Normal private line testing criteria are used for the land line facilities in this system. Tests related to ground-based radio equipment are covered in Sections 406-116-501, -505, -510, and -514. Section 406-116-500 contains overall system tests.

MAINTENANCE SPARES

5.05 Section 406-116-800 describes procedures for the repair and procurement of radio equipment.

6. RELEASES

6.01 A release must be obtained from the customer through the circuit control office before any test, rearrangement, or change of the land line or air-ground circuits or equipment is made.

7. REFERENCES

SECTION	SUBJECT
406-001-011	Equipment Test List
406-116-101	Base Station Description
406-116-102	Transmitter Description
406-116-103	Receiver Description
406-116-500	Overall System Tests
406-116-501	Transmitter Tests
406-116-502	Transmitter Alignment
406-116-505	Receiver Tests
406-116-506	Receiver Alignment
406-116-510	Station Power Supply Tests
406-116-514	Auxiliary Equipment Tests
406-116-800	Replacement and Repair Procedures

*DRAWINGS	TITLE
FA40843ED	SD&T Radio Systems 400-MHz FM Base Station

*Order from: American Telephone and Telegraph Co.
Long Lines Drafting Department
2000 L Street, NW
Washington, DC 20036

TABLE A

INSTALLATION LOCATIONS

STATION	OWNER	CIRCUIT NUMBER	CONTROL OFFICE
Waldorf, Maryland	Long Lines	GR59708	Washington No. 1
New York City, N. Y.	Long Lines	GR59709	Arlington No. 2
Navarre, Ohio	Long Lines	GR59710	Arlington No. 2
Williamstown, Kentucky	Long Lines	GR59711	Arlington No. 2
Memphis Jct, Arkansas	Long Lines	GR59713	Arlington No. 2
Alexandria, Louisiana	South Central Bell	GR59714	Washington No. 1
Ennis, Texas	Long Lines	GR59715	Arlington No. 2
Seguin, Texas	Long Lines	GR59716	Washington No. 1
Norway, Illinois	Long Lines	GR59717	Washington No. 1
Red Oak, Iowa	Long Lines	GR59718	Arlington No. 2
Hays, Kansas	Southwestern Bell	GR59719	Washington No. 1
Prospect Valley, Colorado	Long Lines	GR59720	Arlington No. 2
Rock Springs, Wyoming	Mountain Bell	GR59721†	Washington No. 1
Levan, Utah	Long Lines	GR59722†	Arlington No. 2
Winnemucca, Nevada	Bell Tel of Nev	GR59723	Washington No. 1
Turquoise Jct, California	Pacific Tel & Tel	GR59724	Washington No. 1
Stockton, California	Pacific Tel & Tel	GR59725	Arlington No. 2
Adairsville, Georgia	Long Lines	GR59727†	Washington No. 1
Hillsboro, Missouri	Long Lines	GR59728	Arlington No. 2
Mounds, Oklahoma	Long Lines	GR59729	Washington No. 1
Minneapolis, Minnesota	Long Lines	GR59730	Washington No. 1
Chamberlain, South Dakota	Northwestern Bell	GR59731†	Arlington No. 2

† Station equipped with data auxiliary set 806A2.

TABLE A (Cont)

INSTALLATION LOCATIONS

STATION	OWNER	CIRCUIT NUMBER	CONTROL OFFICE
Portland, Maine	New England Tel & Tel	GR59732	Washington No. 1
Brewton, Alabama	Long Lines	GR59733	Arlington No. 2
Perrine, Florida	Southern Bell Tel & Tel	GR59735	Washington No. 1
Amarillo Jct, Texas	Long Lines	GR59736	Washington No. 1
Midland, Texas	Southwestern Bell	GR59737	Arlington No. 2
Mt. Wilson, California	Pacific Tel & Tel	GR59738	Arlington No. 2
Mt. Baldy, Oregon	Pacific Northwest Bell	GR59739†	Washington No. 1
Seattle 5, Washington	Pacific Northwest Bell	GR59740†	Arlington No. 2
Spokane, Washington	Pacific Northwest Bell	GR59741	Washington No. 1
Boise Jct, Idaho	Long Lines	GR59742†	Arlington No. 2
Holbrook, Arizona	Mountain Bell	GR59743†	Washington No. 1
Clines Corner, New Mexico	Long Lines	GR59744†	Arlington No. 2
Seligman, Arizona	Long Lines	GR59745	Arlington No. 2
Helena Jct, Montana	Long Lines	GR59746	Arlington No. 2
Miles City, Montana	Mountain Bell	GR59747†	Washington No. 1
Cresent Jct, Utah	Long Lines	GR59750†	Washington No. 1
Charleston, S. Carolina	Southern Bell Tel & Tel	GR59751	Washington No. 1
Daytona Beach, Florida	Southern Bell Tel & Tel	GR59752	Arlington No. 2
Westover, North Carolina	Long Lines	GR59753	Arlington No. 2

† Station equipped with data auxiliary set 806A2.

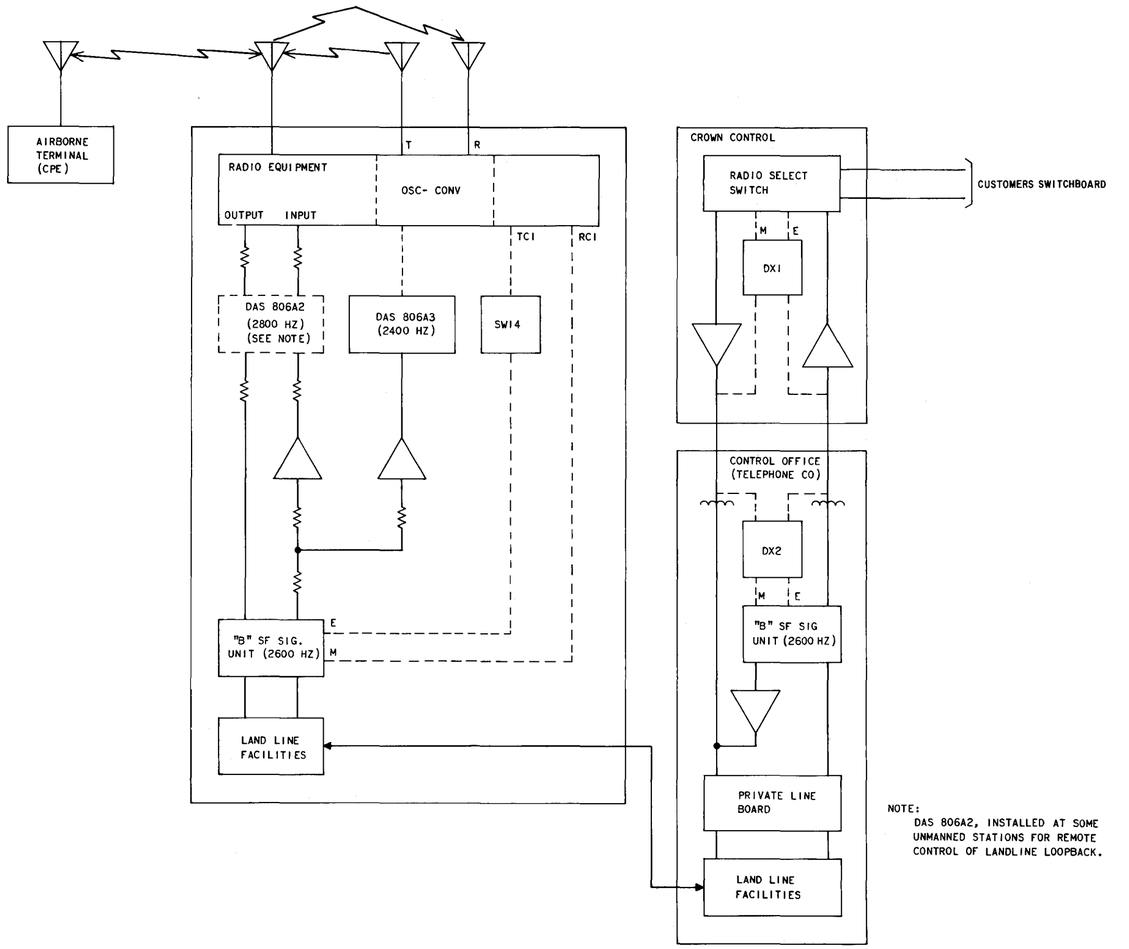
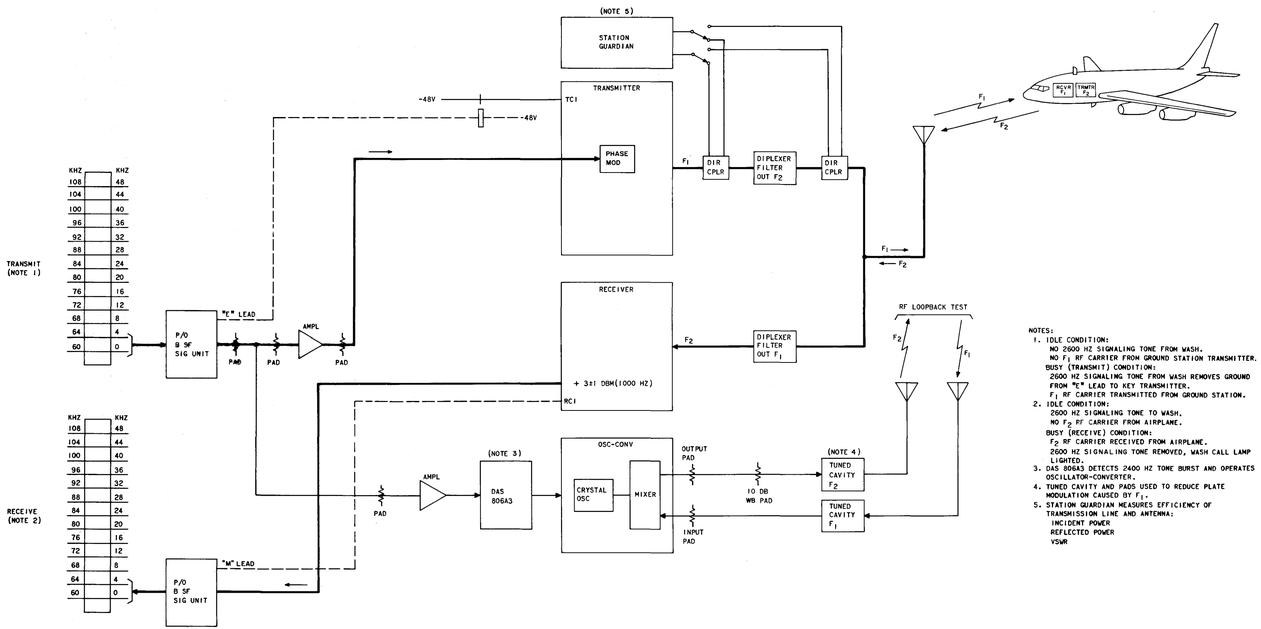


Fig. 1—Simplified Transmission Circuit—Echo-Fox System



NOTES:
1. IDLE CONDITION:
   NO 2600 HZ SIGNALING TONE FROM WASH.
   NO F_1 RF CARRIER FROM GROUND STATION TRANSMITTER.
   BUSY (TRANSMIT) CONDITION:
   2600 HZ SIGNALING TONE FROM WASH REMOVES GROUND FROM "E" LEAD TO KEY TRANSMITTER.
   F_1 RF CARRIER TRANSMITTED FROM GROUND STATION.
2. IDLE CONDITION:
   2600 HZ SIGNALING TONE TO WASH.
   NO F_2 RF CARRIER FROM AIRPLANE.
   BUSY (RECEIVE) CONDITION:
   F_2 RF CARRIER RECEIVED FROM AIRPLANE.
   2600 HZ SIGNALING TONE REMOVED, WASH CALL LAMP LIGHTED.
3. DAS 80643 DETECTS 2400 HZ TONE BURST AND OPERATES OSCILLATOR-CONVERTER.
4. TUNED CAVITY AND PADS USED TO REDUCE PLATE MODULATION CAUSED BY F_1.
5. STATION GUARDIAN MEASURES EFFICIENCY OF TRANSMISSION LINE AND ANTENNA:
   INCIDENT POWER
   REFLECTED POWER
   VSWR

Fig. 2—Ground Radio Station—Simplified Functional Schematic Diagram—Echo-Fox System

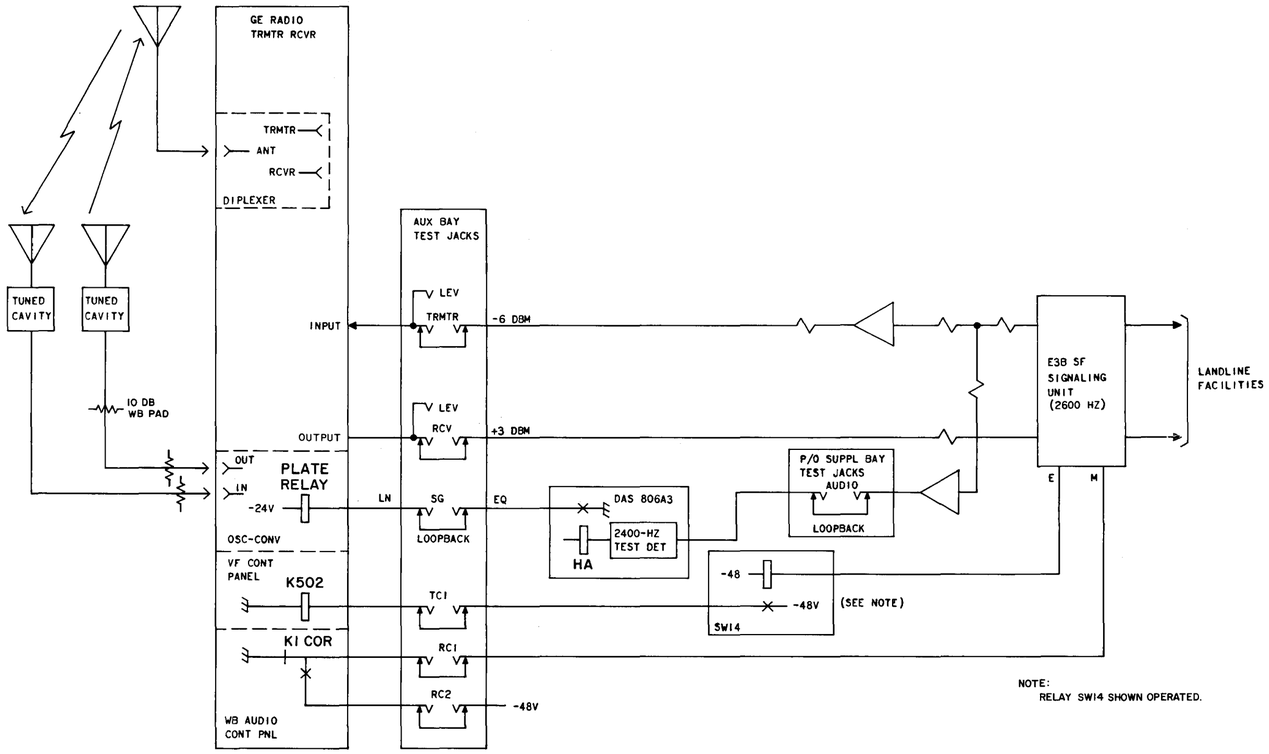


Fig. 3—Simplified Functional Schematic—Echo-Fox System (Sheet 1 of 2)

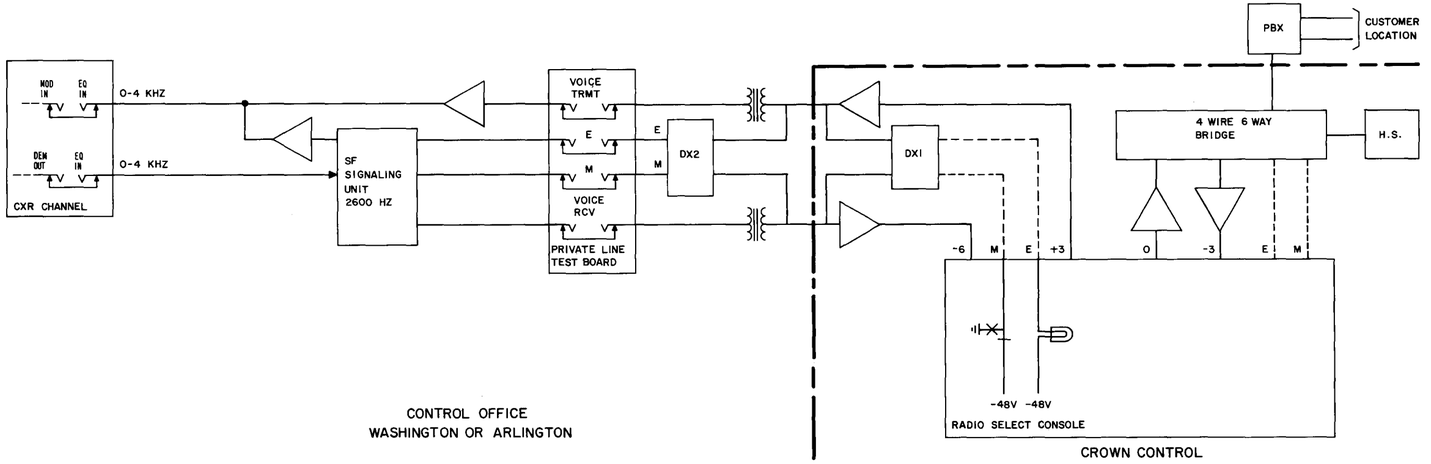


Fig. 3—Simplified Schematic Diagram—Echo-Fox System (Sheet 2 of 2)

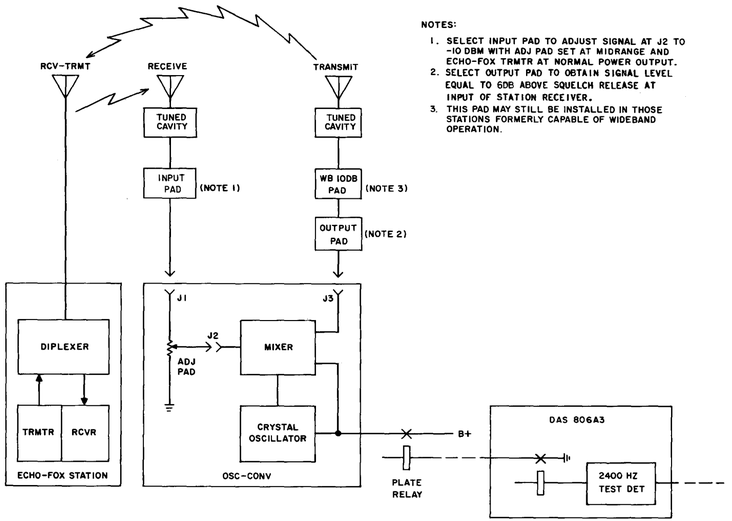


Fig. 4—Oscillator-Converter—Block Diagram—Echo-Fox System

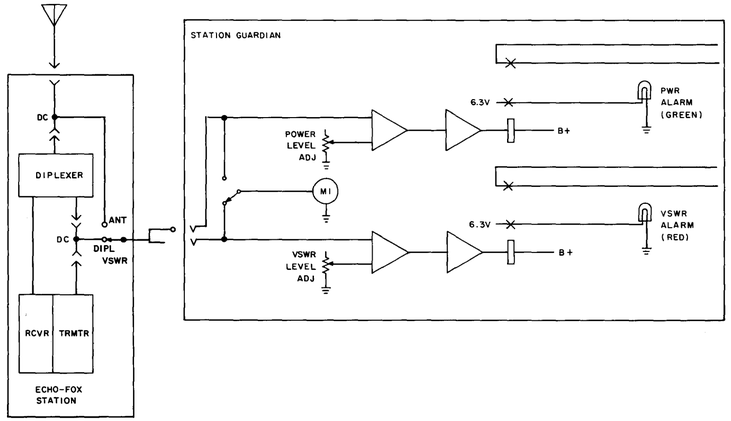


Fig. 5—Station Guardian—Simplified Block Diagram—Echo-Fox System