



**FSG 60
FSG 60M**

**VHF
COMMUNICATIONS
TRANSCEIVER**

019.HB.00E

**MANUAL
Installation and Operation**

**1st English Edition
March 1981**

Walter Dittel GmbH Luftfahrtgerätebau

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Anerkannter Luftfahrtgerät-Herstellungsbetrieb I-C 16 und Entwicklungsbetrieb I-EC 13

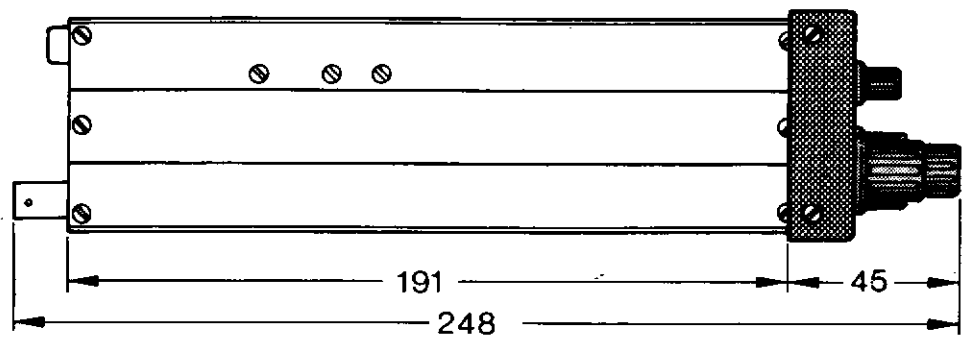
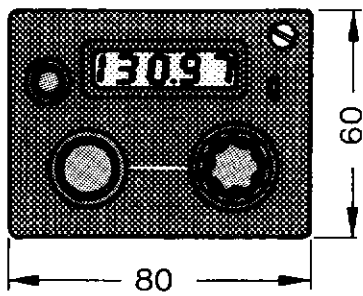


Dittell GmbH
FSG 60/60M

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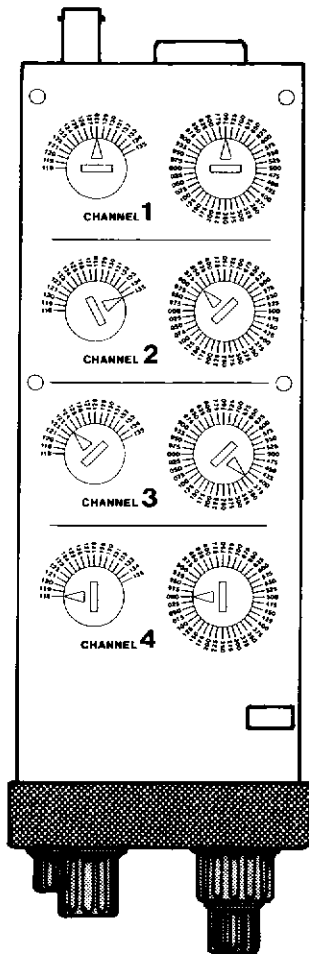
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All dimensions in millimeters

Weight 0.9 kg (2 lbs.)



View of FSG 60M

Fig.1-1 FSG 60/60M
Unit Dimensions

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Attachment:

Complete FSG 60/FSG 60M Circuit Diagram



SECTION II GENERAL INFORMATION

2.1 Introduction

The handbook, 019.HB.00 E, contains instructions and descriptions for installation, operation and testing, as well as the complete circuit diagram of the FSG 60 and FSG 60M 720-channel VHF aircraft transceivers of WALTER DITTEL GmbH.

Handbook 019.HB.10 E contains additionally, detailed circuit description, repair instructions, alignment procedure, testing instructions, and a illustrated parts list.

2.2 Application

The FSG 60/FSG 60M is a fully transistorized VHF voice radio of monoblock construction, which can transmit and receive on all 720 channels of the aviation band from 118.000 to 135.975 MHz. Channel spacing is 25 kHz.

These units were designed for use in motorized gliders, gliders, balloons, sports and touring aircrafts, and feature very low power consumption.

The FSG 60/FSG 60M has an intercom mode (IC) which requires no additional equipment.

The FSG 60/FSG 60M provides ≥ 6 Watts of transmitting power and 5 Watts of audio output into 4 Ohms.



2.3 Brief Description

The FSG 60/FSG 60M unit is a monoblock unit and is designed to be installed into the instrument panel or control console of an aircraft.

All transceiver components are included within the one housing.

All controls necessary for operation are located on the front panel of the unit. On the rear of the FSG 60/FSG 60M are the 14-pin plug and BNC antenna plug, through which the unit is automatically connected with the on-board wiring when the unit is inserted into its mount.

The unit's electronics are divided into 3 subassemblies (4 for the FSG 60M), which are easily removed for servicing.

The receiver of the FSG 60/FSG 60M is designed as a single heterodyne which can be set to a total of 720 channels within the range of 118 to 135.975 MHz.

The transmitter of the FSG 60/FSG 60M is wide-band tuned for the range of 118 to 136 MHz. The transmit frequency is set with the receive frequency. The transmitter delivers ≥ 6 Watts.

Whatever operating frequency is set is indicated by a 5-digit liquid crystal display (LCD), with the channel frequencies ending in "25" or "75" displayed as "20" and "70" respectively, in compliance with ICAO standards. Lighting is available at extra cost.

LCD is heated when temperature falls below -10°C in order to prevent the typical display lag when cold.

Therefore the FSG 60/60M unit can be used in a temperature range from -40°C to $+55^{\circ}\text{C}$, short-term up to $+71^{\circ}\text{C}$.

A storage temperature from -55°C to $+85^{\circ}\text{C}$ is permitted.

The frequency processing employed simultaneously for transmitter and receiver uses digital frequency synthesis.



Dittel GmbH FSG 60/60M

A low-frequency filter is already included for operating the unit in those areas of central Europe in which the CLIMAX system has been introduced.

The threshold of the receiver's automatic squelch adapts automatically to the interference level, or can also be switched off (defeated).

The microphone input can be switched on in the reception mode, enabling intercom operation within the aircraft through the headset.

An additional input of the AF amplifier allows audio signals from navigation-aid receivers (ADF, VOR, DME, MKR) or electronic variometers to be heard on the on-board headset or loudspeaker.

The operating voltage is electronically monitored. If it sinks below 11.0 volts, the frequency display blinks.

An automatic power-saving circuit prevents unnecessary power consumption in some operating modes, thereby extending the operating time available from one battery charge. Particularly the no-signal current drain in the squelch (SQ) mode is reduced to the very low level of approx. 55 mA.

In the FSG 60M, up to 4 channel frequencies can be stored, ready for recall in a mechanical frequency memory, independent of the frequency selector.

The frequency memory is accessible after the transceiver is pulled out of its mount. A coin can be used to set the frequencies. They are recalled with the channel selector.

In the FSG 60, the channel selector is blocked, and the frequency memory is not installed.



2.4 FSG 60/FSG 60M Technical Data

2.4.1. General Data

Model:	FSG 60/FSG 60M
Operating voltage:	13.8 VDC +10%/-20%
Emergency operation:	9 to 11 VDC
Power consumption:	Stand by, 55 mA (typical) Receive (voice), 140 mA (typical) Transmit (voice), 1.6 A
Operation below -10°C:	Additional 110 mA (typical)
Fuse (FSG 60/FSG 60M):	3.15 A fast-acting
Temperature range:	-40°C to +55°C, short-term +71°C
Storage Temperature:	-55°C to +85°C
Altitude capability:	15,000 m/50,000 ft. MSL
Vibration stability:	1.5 g @ 55 to 500 Hz; 1 g to 2,000 Hz
Front panel dimensions:	80 x 60 mm
Installation depth: (measured from rear of panel)	191 mm + approx. 45 mm for plug and wire
Weight:	0.9 kg (2 lbs.)
Overall dimensions	60 x 80 x 248 mm
Equipment category according to	
RTCA DO-156:	Class C
RTCA DO-157:	Class 4
Performance category according to	
DO-160:	B3D1/A/MNO/XXXXXXXXBABA
FTZ listing for FSG 60:	LB-364/81
LBA listing for FSG 60:	10.911/72
FTZ listing for FSG 60M:	LB-364/81
LBA listing for FSG 60M:	10.911/72



2.4.2 Receiver Electrical Data

Receiver type:	Single superheterodyne
Frequency range:	118.000 to 135.975 MHz
Number of channels (FSG 60):	720
Number of channels (FSG 60M):	720, of which, 4 frequencies may be fixed-programmed
Channel spacing:	25 KHz
Sensitivity:	$\leq 1.0 \mu\text{V}$ for 6 dB (S + N)/N mod. 1000 Hz/m = 0.3
Bandwidth:	$\geq \pm 8$ kHz at 6 dB
Selectivity:	≥ 70 dB at ± 25 kHz; ≥ 40 dB at ± 17 kHz
Squelch:	Automatic, defeatable, threshold internally adjustable
Gain control from	
5 μV to 200 mV:	≤ 5 dB
2 μV to 1 V:	≤ 8 dB
Spurious response:	≥ 80 dB
Spurious radiation:	$< 4 \times 10^{-10}$ W
Distortion, m = 85%:	$\leq 10\%$
Frequency response:	≤ 6 dB, 350 to 2,500 Hz ≥ 18 dB @ 5,000 Hz
Intermediate frequency	10.0 MHz
Rated output:	Headphone, 150 mW into 500 Ohms Loudspeaker, 5 W into 4 Ohms 3 W into 8 Ohms



2.4.3 Transmitter Electrical Data

Frequency range:	118.000 to 135.975 MHz
Number of channels (FSG 60):	720
Number of channels (FSG 60M):	720, of which, 4 frequencies may be fixed-programmed
Transmitter output:	Min. 6 W into 50 Ohms at nom. voltage
Type of modulation:	Amplitude modulation (6A3)
Operation:	Simplex (SCS)
Depth of modulation:	Max. 0.95
Modulation limiting:	Adjustable control
Frequency deviation:	$< 15 \times 10^{-6}$
Harmonic and spurious radiation:	$< 2 \times 10^{-5}$ W
Harmonics in the range of 108 to 118 MHz:	$< 2 \times 10^{-7}$ W
1015 to 1045 MHz:	$< 2 \times 10^{-8}$ W
Frequency response:	≤ 6 dB, 350 to 2,500 Hz
Distortion, m = 85%:	$< 10\%$
Modulation S/N ratio:	> 40 dB
Adjacent channel rejection:	≥ 70 dB @ 1,250 Hz, m = 0.6 + 10 dB
Microphone input, selectable:	Dynamic, 2 to 30 mV Amplified, 100 to 1500 mV
Max. transmit duration:	5 min., 50% max. transmit operation

2.4.4 Accessory Equipment

Lighting (optional):	+14 V / 28 V, internally selectable
External audio input:	Min. 1.5 V into 470 Ohms for rated performance
Intercom:	Through mic. input, activated by grounding



2.5 Scope of Delivery

Order Number

FSG 60; incl. two Distance Plates and Manual "Installation and Operation"	021.FG
FSG 60M; incl. two Distance Plates, Memory Label and Manual "Installation and Operation"	022.FG

Optional Accessories

=====

"FSG 60/FSG 60M Installation and Operation" manual	019.HB.00E
"FSG 60/FSG 60M Installation and Operation, Repair and Testing" manual	019.HB.10E

Various mounts

Modification of FSG 60 into FSG 60M is possible.

Lighting can also be retrofitted at extra cost.

For additional accessories, please request our equip-
ment recommendations and price lists for the FSG 60/FSG 60M.

2.6 Equipment Required for Operation but not Included
with Accessories in Scope of Delivery

- a) VHF aviation communications antenna and cable
- b) Headphone (approx. 300 Ohms) or loudspeaker
(4 to 16 Ohms)
- c) Dynamic microphone (200 Ohms) or amplifier
microphone with/without push-to-talk button.
(Selectable microphone input included in unit).
- d) Battery power-pack when there is no on-board
supply system
- e) Push-to-talk button for installation on control
stick (alternative to c) above).
- f) To operate the FSG 60/FSG 60M with 28-V on-board
supply, a suitable voltage regulator is to be
used.

In addition, we have an extensive list of accessories.



SECTION III INSTALLATION

3.1 General

This section contains recommendations and instructions for installing the FSG 60/FSG 60M in an aircraft.

3.2 Pre-installation Check

Carefully remove the transceiver packing and save in case a claim has to be placed with the shipper.

Check the unit carefully for external damage. Before installing, check the main functions:

1. Connect the unit to a test bench, using the test cable set (shown in Fig. 3-1). Ensure 13.8 VDC operating voltage, and switch on the unit (toggle switch, mid-position "ON").
2. Set the channel selector so it points toward the frequency selector (only necessary with FSG 60M).

Turn volume control about half-way open (clockwise). Slight receiver noise should be audible on all channels in the range from 118 to 135.975 MHz. Receiver sensitivity should equal the technical data on all channels (sample at 118.000, 125.950 and 135.200 MHz).
3. Push toggle switch upward (SQ), vary VHF generator output voltage and observe the squelch threshold; it must be between 0.5 and 3 μ V (depending on setting).
4. Connect RF test setup with RF load resistor at the antenna output.

Transmit and measure the output power (≥ 6 W).



5. Connect 1,000-Hz audio generator through a voltage divider or directly (dynamic/amplifier microphone) to the microphone input.
 - a) Amplifier-microphone input
With an AF input voltage of approx. $100 \text{ mV}_{\text{eff}}$ the transmitter should be >40% modulated.
Raise the AF input voltage to 1.0 V. Observe the envelope; a continuous over-modulation must not occur. The depth of modulation must not exceed 80%.
 - b) Dynamic microphone input
At an AF input voltage of approx. $2 \text{ mV}_{\text{eff}}$ the transmitter should be >40% modulated.
Raise the AF input voltage to 20 mV. Observe the envelope; the depth of modulation must not exceed 80%.

Note

With voice modulation, greater depths of modulation occur because of the dynamics typical of speech (quick level changes). Setting the modulation control to approx. 75 % (for sine modulation) results in a favorable compromise between carrier utilization and over-modulation.

6. Talking with the unit's microphone held near the lips, a good carrier utilization should be achieved at an average loudness. The externally adjustable sidetone control must be set so that the tone is understandable, but not too loud.

* FOR TRANSMITTER CHECK
 ** FOR RECEIVER CHECK

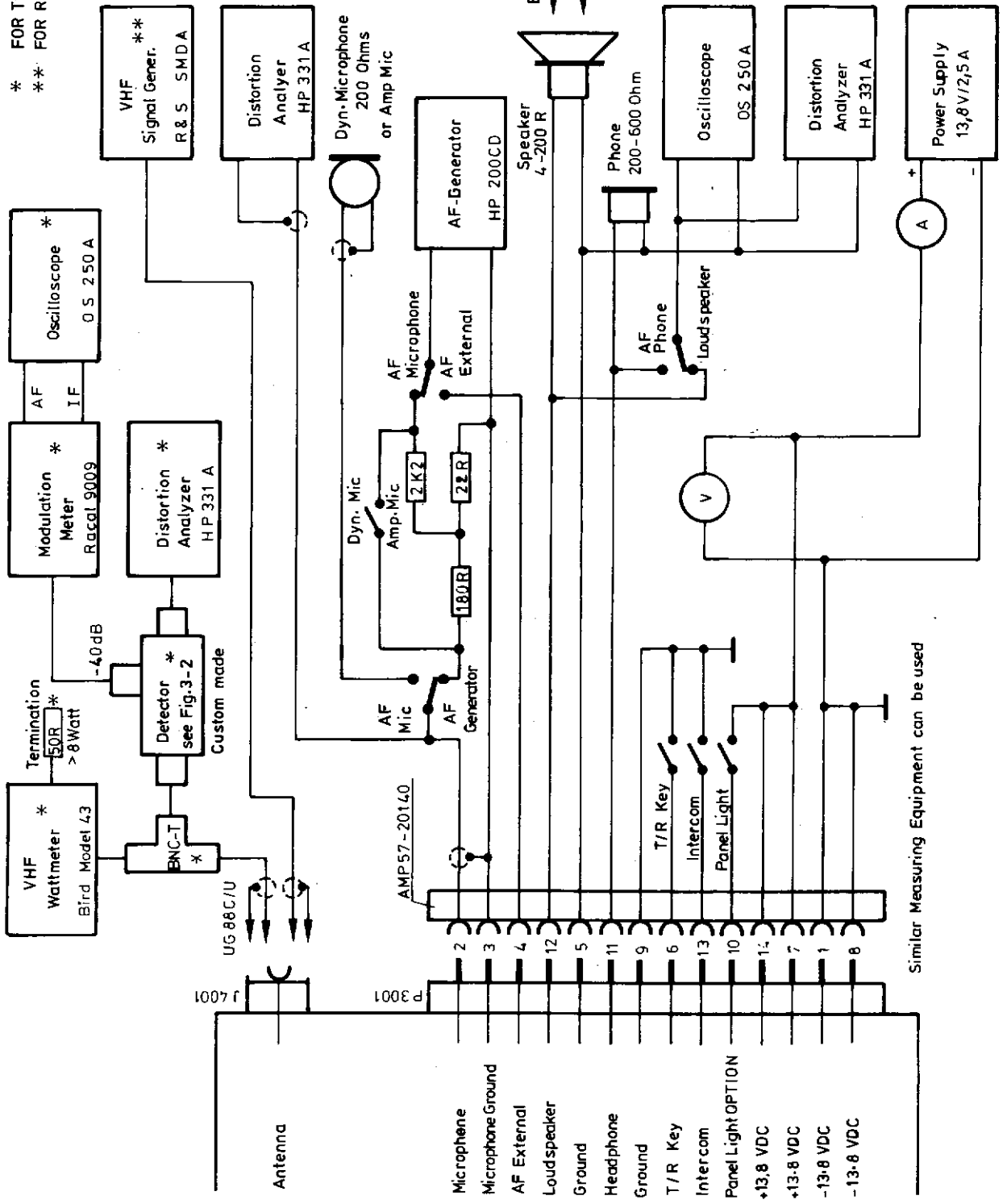
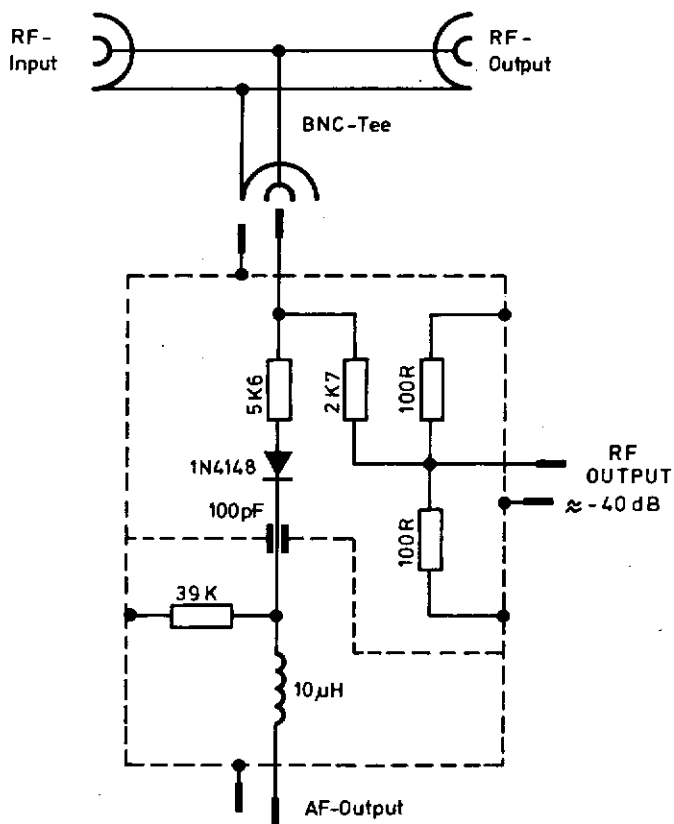
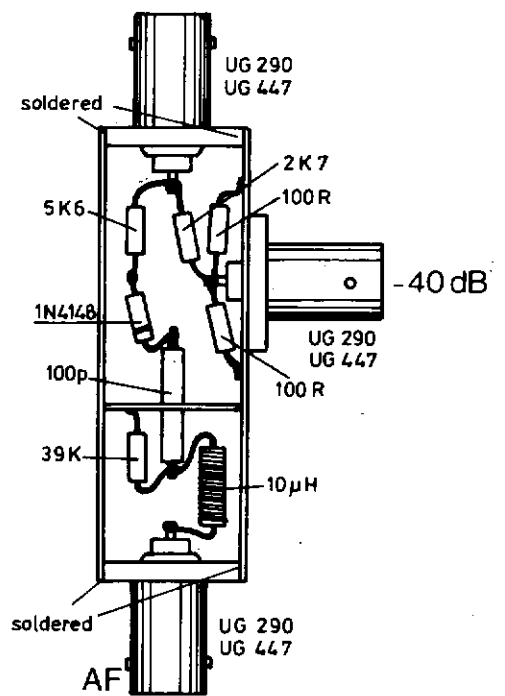


Fig. 3-1 FSG 60/60M Test Setup



a) schematic



Brass Sheet Housing
 All Resistors 1/4 Watt
 Open Cover
 Scale ca- 1:1

b) construction

Fig. 3-2 FSG 60/60M
 Detector



3.2.1 Lighting (optional)

Illumination of the frequency display is set at the factory for an aircraft supply of 14 V. It can be set for a 28-V supply by changing the slide switch SW 1004. It is accessible after removing the unit's lower cover.

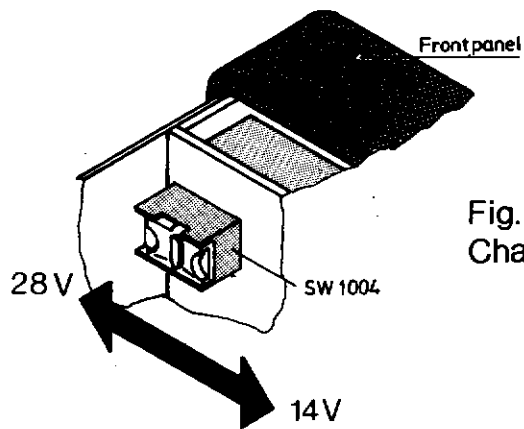


Fig. 3-3
Changing the Lighting Voltage



3.3 Mechanical Installation

3.3.1 Installation of Slide-in Mount

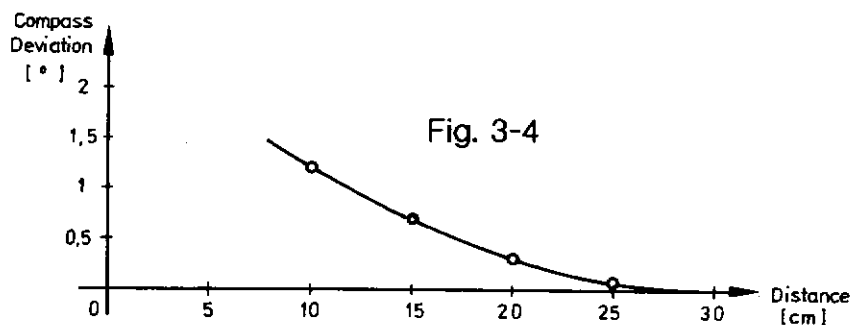
The FSG 60/FSG 60M is designed for installation in the instrument panel or control console of the aircraft.

To install the mount in the instrument panel, select a location which is as far as possible from heat sources, but which can be seen easily and reached by the pilot and co-pilot. Ensure that there is sufficient room behind the slide mount for the wiring.

If there is no cutout in the instrument panel, one can be made following the instructions in Fig. 3-5 and 3-6 (depending on the type of mount).

The rear support required for mechanical stability should be attached to the aircraft chassis or the instrument panel.

3.3.2 Influence on Compass



Compass deviation occurs when the compass is at a close distance from transceiver.



3.3.3 Converting Mount Es 15 of the FSG 15/16 to fit FSG 60/60M

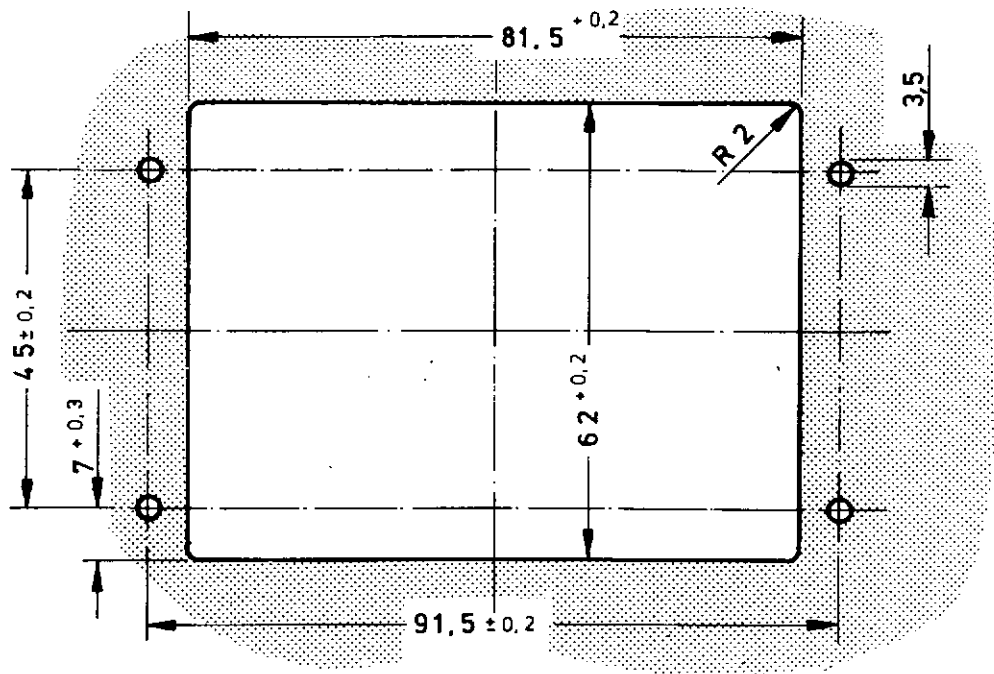
To install the FSG 60/FSG 60M in the ES 15 FSG 15/16 mount, a suitable rear panel (part No. ZT 013) can be supplied which is pre-cut for the plugs.

The mount is to be modified as follows:

1. Disconnect battery.
Loosen securing screw and pull out old unit.
2. Remove the frame from the front panel after loosening the four front screws and any rear support. If a rear support for the frame has not yet been installed, it is recommended that it be provided.
3. Loosen the wire restraint.
4. Remove the bolts securing the main plug of the unit. Feed the main plug out through the rear opening. Keep the bolts and lock washers!
5. Unscrew the antenna plug carrier plate (only the two large bolts need to be unscrewed; do not unscrew the two small ones for the plug's housing!).
Remove the complete plug assembly.
6. Remove the lateral bolts securing the rear panel (secure the chassis nuts with a 5-mm wrench from within), and remove it.
7. Determine the thickness of the instrument panel (a). Push the FSG 60/FSG 60M far enough into the frame that the distance between the unit's front panel and the mounting bracket on the frame is the same as the panel thickness (refer to Fig. 3-7).
Mount the unit with the securing screw.
8. Pick up the new rear panel. Feed the main plug through the correct opening (refer to Fig. 3-7) and secure with suitable bolts.
(Hold the chassis nuts with the wrench, or they will turn).



9. Contrary to the FSG 15/16 mount, the antenna plug is screwed on from within, rather than from the outside. Therefore, feed in the antenna plug assembly and secure from within the two large bolts. The chassis nuts are already correctly mounted.
10. Secure the wire harness to the wire restraint.
11. Emplace the rear panel into the frame so the plugs engage to the limit. Determine which mounting holes (for the rear panel) fit. Mark these holes. Remove the rear panel again. Pull out the unit. Now place the rear panel in the frame and position the marked holes so they correspond.
12. In any case, the securing bolts must be placed in the four corresponding holes; (if inserted into the wrong holes, the rear panel will slant which means the connections will no longer correspond exactly). Mount the lock washers and nuts from within; use 5-mm wrench to secure chassis nuts, and tighten the bolts.
13. Re-install the mount into the instrument panel (see also Item 2 above; rear support is recommended).
14. Fix the two distance plates onto the FSG 60/60 M with the two flat head screws (supplied with each transceiver).
15. The FSG 60/FSG 60M can now be inserted into its mount. Push it in to the limit, and tighten the mounting bolts. Reconnect the battery. The FSG 60/FSG 60M is now ready for operation in the ES 15/16 mount of the FSG 15/16.



Cut out for ZT-No. 001, 020, 022, 023, 024, and 078

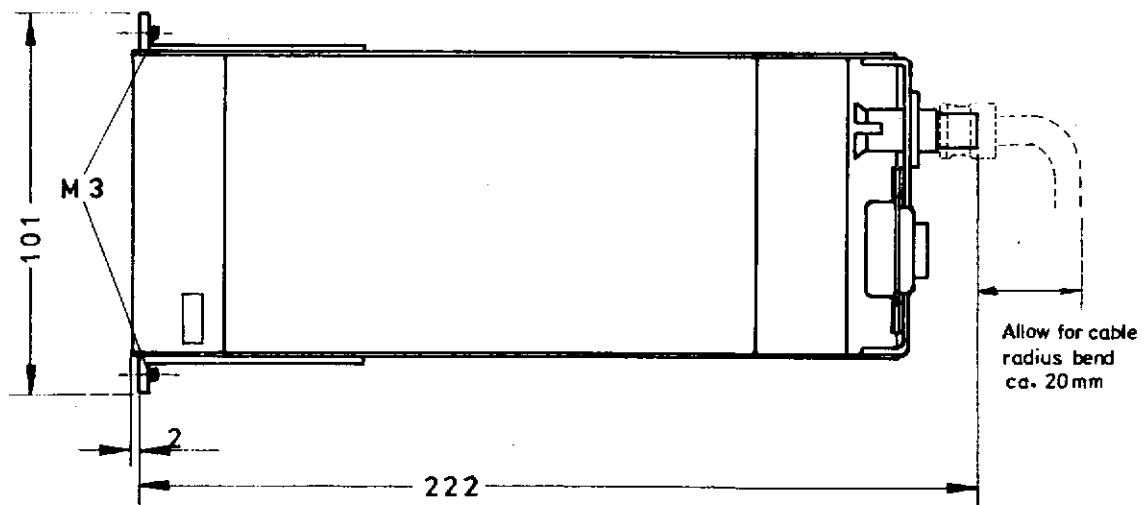
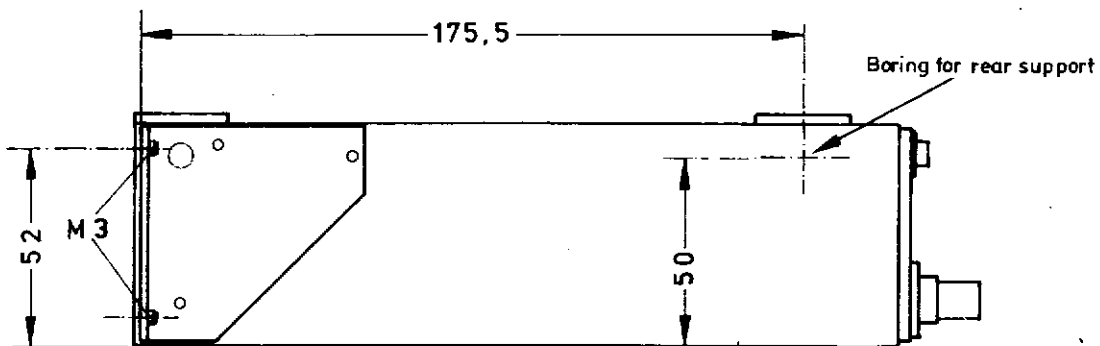
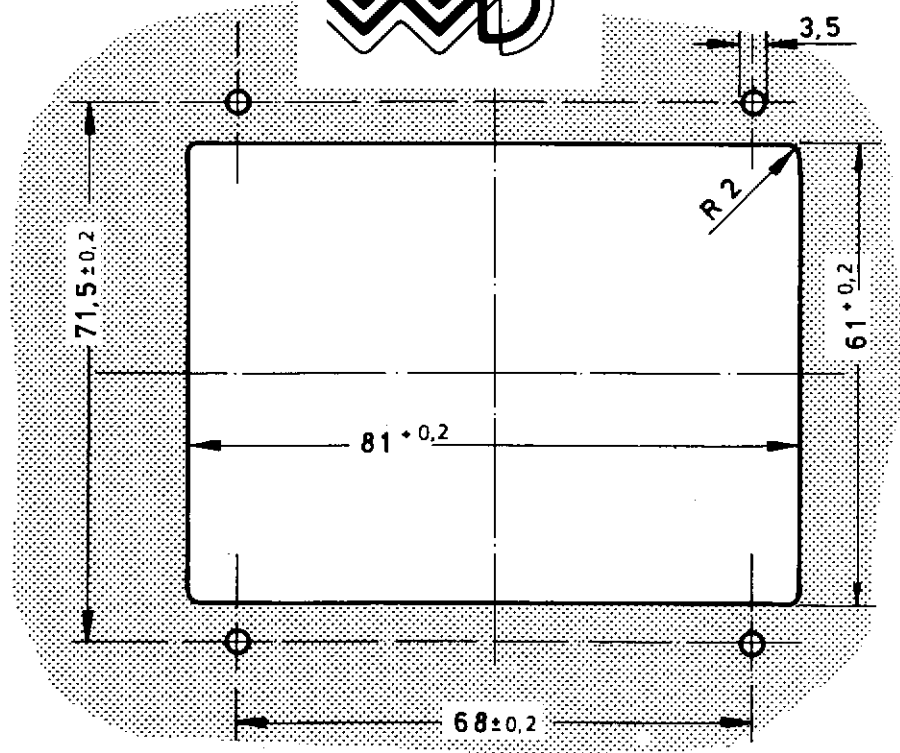


Fig.3-5 Dimension drawing for mount
Lateral attachment



Cut out for ZT-No. 019 and 021

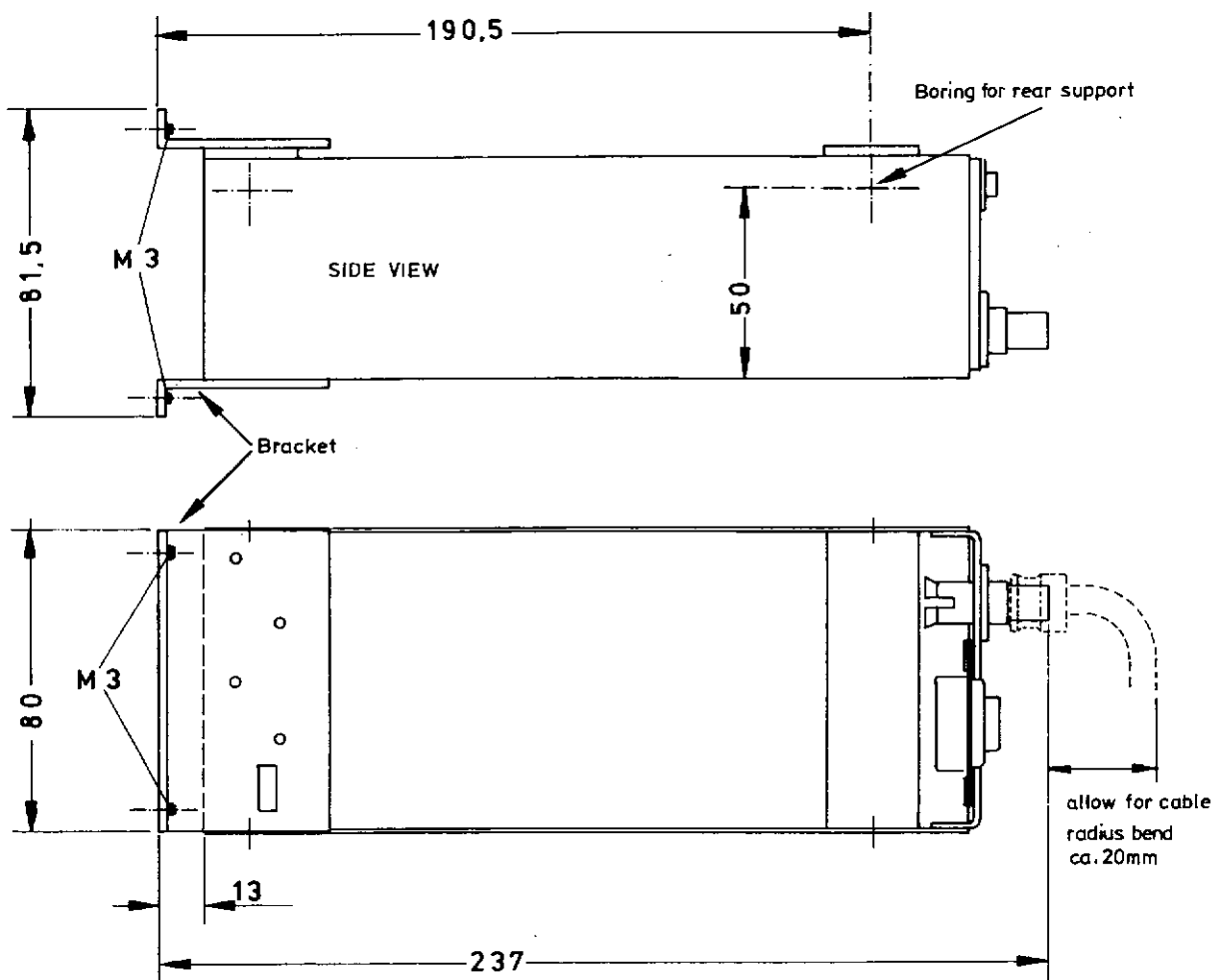
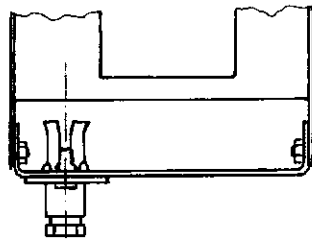
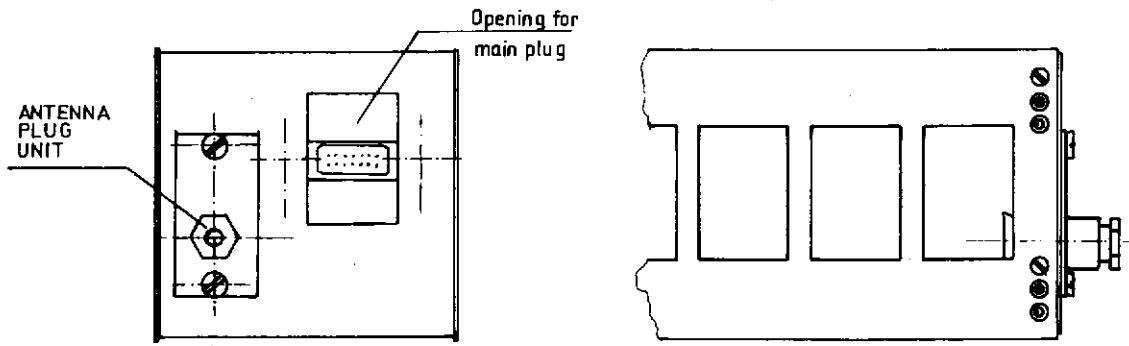
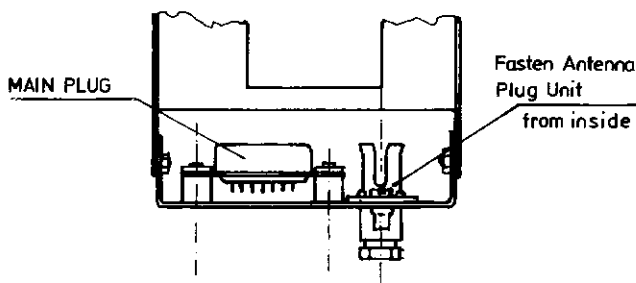
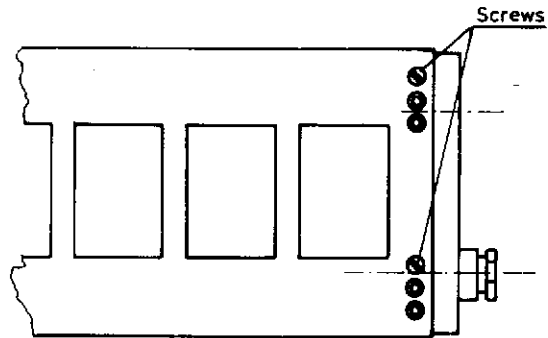
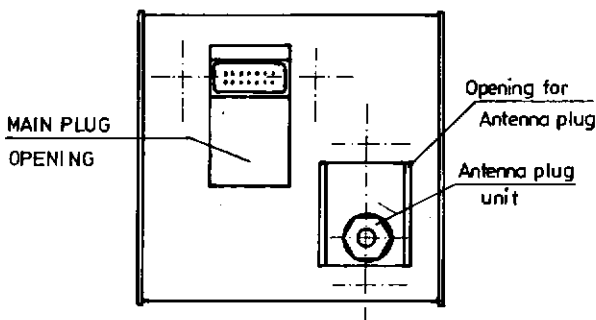
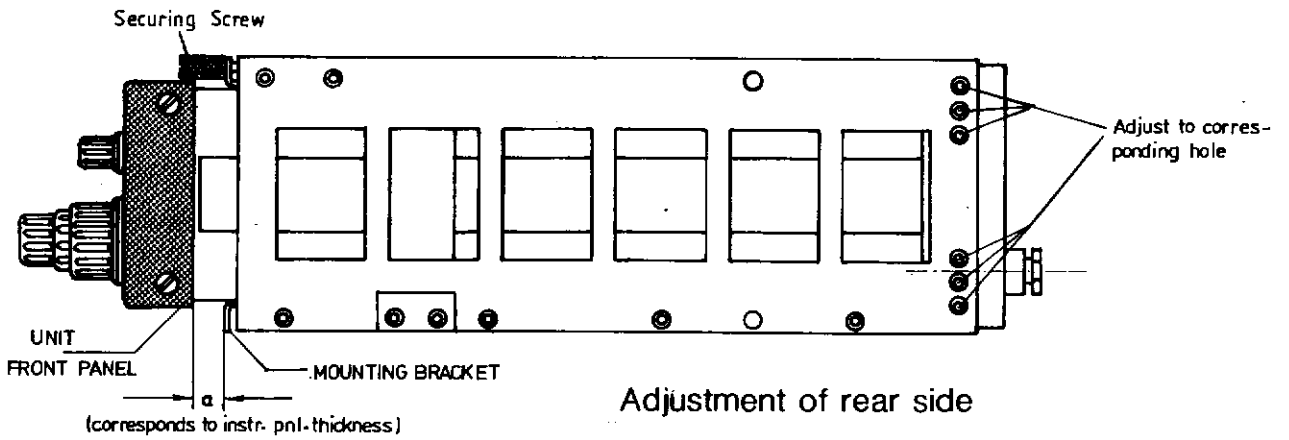


Fig.3-6 Dimension drawing for mount, protruding brackets below and above



Rear side of FSG 15/16 mount



Rear side ES 15 conversion

Fig. 3-7 Converting mount ES 15 to fit FSG 60/60M



3.3.4 Antenna Installation

A vertically polarized 50-Ohm antenna is required to operate the FSG 60/60M transceiver. The antenna must be able to radiate equally distributed RF energy without interference .

For installation in an aircraft with a metal fuselage, we recommend our AV-529 antenna (part No. ZT 037), for wooden and plastic aircraft, our swivelling aviation communications antenna with four aluminum counterpoises, and for aircrafts with vertical tail rudder of non-conductive material , our folded top antenna (to be installed in vertical rudder during rudder manufacturing. Installation drawing obtainable on request.)

The location for the antenna must be carefully selected, and the installation instructions must be followed exactly if optimal results are to be expected.

- The antenna is to be mounted vertically on or under the fuselage in such a manner that it is as far as possible from all parts that may shield RX and TX such as propellor/s, landing gear or rudders.
- The distance to other antennas, e.g., COM, NAV, etc. should be at least 1.5 meters. If two units of FSG 50, FSG 60/60 M are used, a distance of one meter is sufficient.
- The area of installation should be flat as far as possible around the antenna.
- The metal-to-metal contact between the aircraft's surface and the antenna must be very good. For aircraft with non-metallic surfaces, metal foil (80 x 80 cm, min.) is to be glued to the interior of the fuselage or four crossed strips of sheet metal are to be installed (see above: aviation communications antenna with aluminum counterpoises). The counterpoises must be bolted directly at the foot of the antenna (conductive connection).



- With thin sheeting, the mounting hole must be suitably reinforced. All breaches of the exterior skin are to be carefully closed with sealant.
- When routing the antenna cable, sharp bends and unnecessary length are to be avoided.
- Installation of a folded-top antenna in the vertical tail rudder is to be made by the aircraft's manufacturer.

3.4 On-board Wiring

Figures 3-8 to 3-10 show possible ways of connecting the FSG 60/FSG 60M.

3.4.1 General Instructions for On-board Wiring

- Ensure good electrical contacts and interference suppression of all parts of the electrical system, e.g., alternator, ignition system, etc.
- Connecting wires are to be placed as far as possible from other wires carrying large currents, antenna lines, etc., as well as control wires, control cables, etc. Keep power lines at least 15 cm from the compass.
- Use self-extinguishing wires designed for at least 600 V (complying with MIL-W-5086C or MIL-W-16878D). Use only stranded wire, to avoid broken wires caused by vibration.

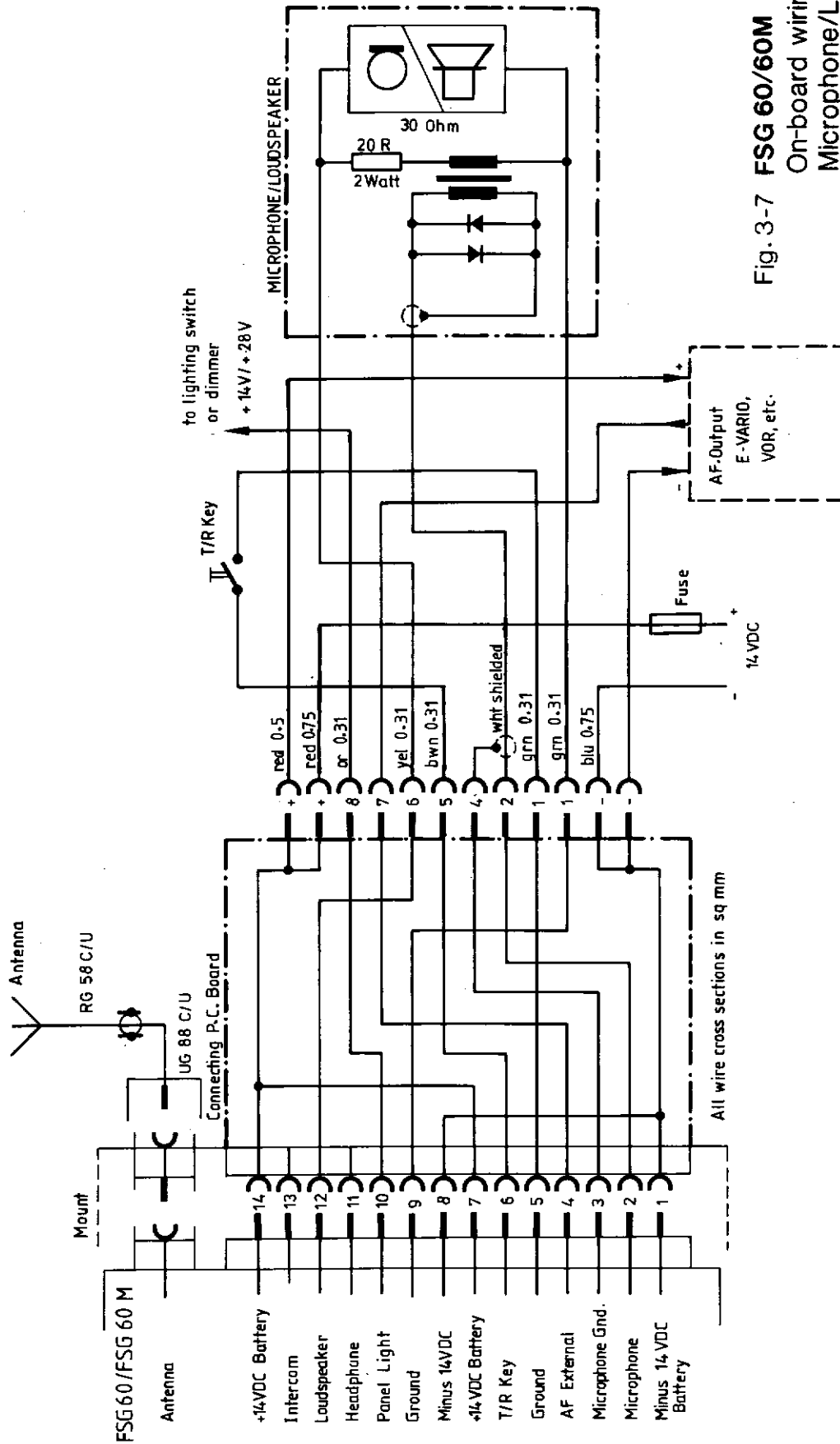
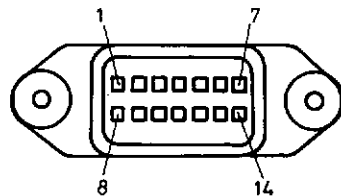
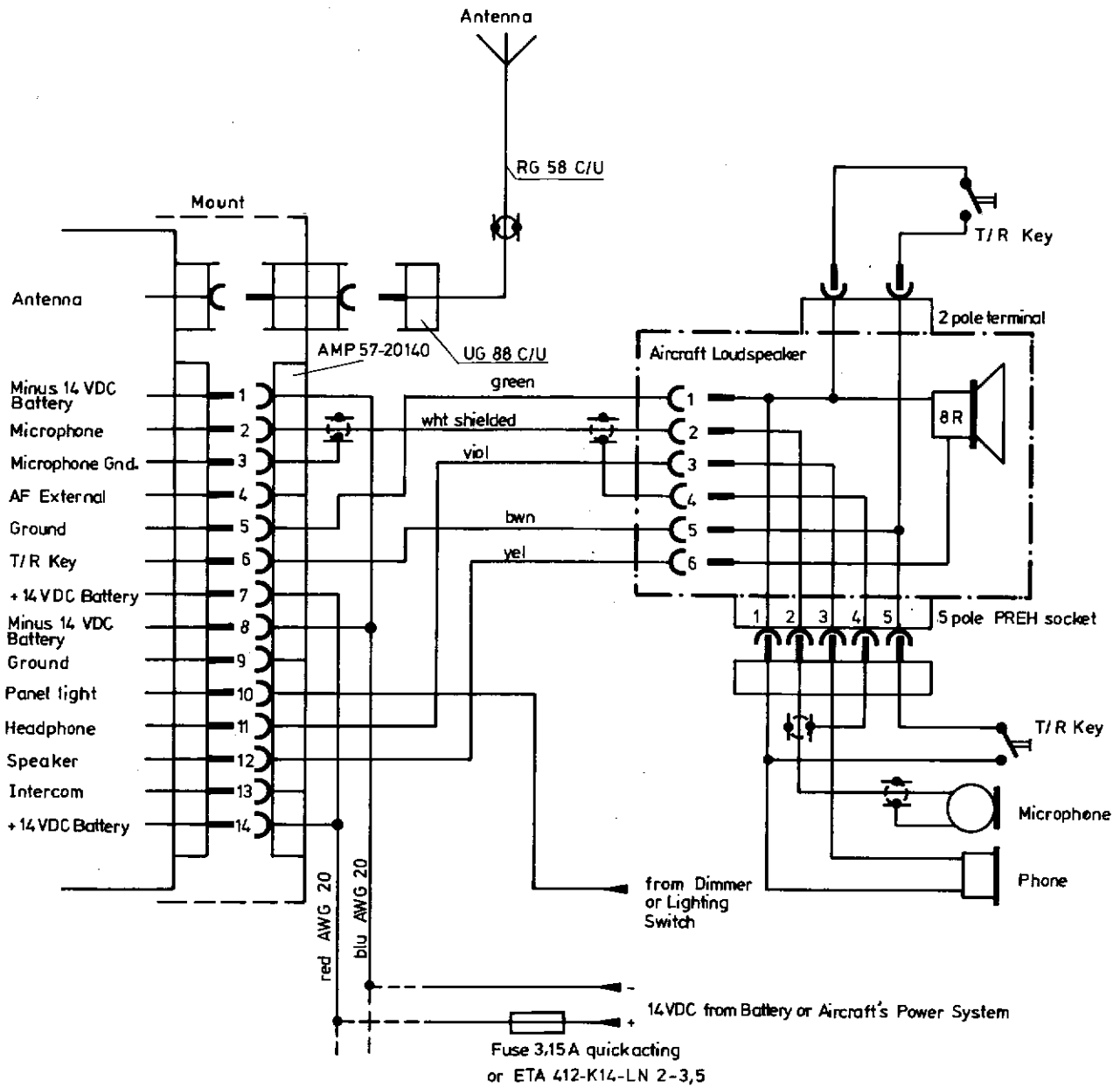


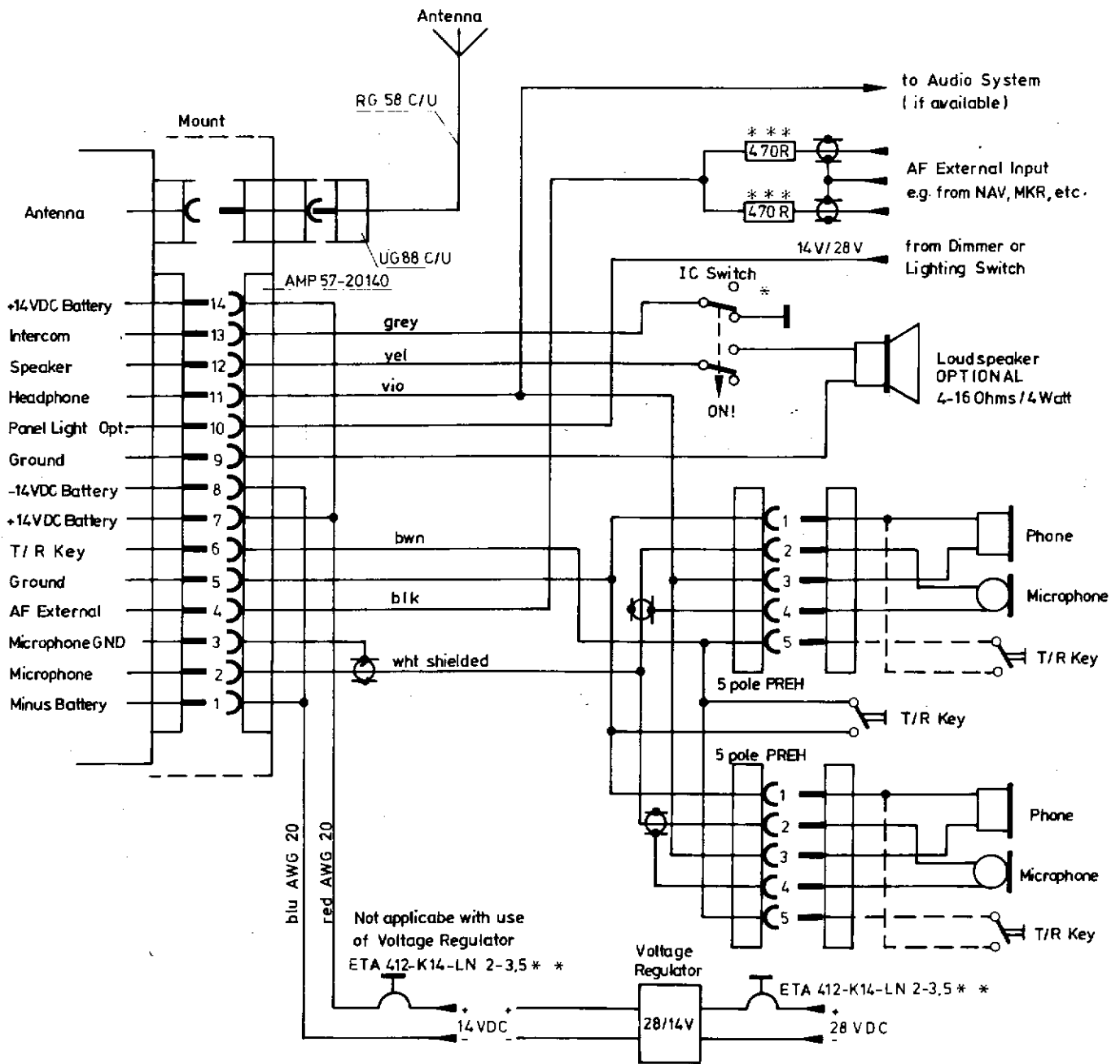
Fig. 3-7 FSG 60/60M
On-board wiring with
Microphone/Loudspeaker
(1 Station only)



AMP 57-20140
Connection Side

NOT INDICATED WIRING CROSS SECTION = AWG 22

Fig.3-9 FSG 60/60M
On-board Wiring
One Station



Not indicated wiring cross section = AWG 22 = 0.31 sqmm

- * Wiring without IC Mode: Loudspeaker direct to Pin 9 and 12
- ** or Fuse 3.15 Amps quick acting
- *** Isolation resistors when more than one AF source

Fig. 3-10 FSG 60/60M
On-board wiring
Two Stations



3.4.2 Wiring of Mount

Connections to the main equipment plug are made by soldering. The soldered connections are to be insulated with heat-shrink tubing.

Wiring is shown in Fig. 3-8 to 3-10.

- When operating the FSG 60/FSG 60M on 28 V, a suitable voltage regulator must be used.
- If the intercom mode is desired, Pin 12 (loudspeaker) must be switched off and Pin 13 is to be grounded; this is effected with a two-pole changeover switch (intercom switch).
- If the "Lighting" option is installed:
The lighting supply voltage is usually supplied externally.
This voltage may be adjustable (from a dimmer), or fixed.
- The "AF Ext." input (pin 4 of the equipment plug) is provided so the headphone output of other communications equipment can be connected and heard through the FSG 60/FSG 60M's audio amplifier.

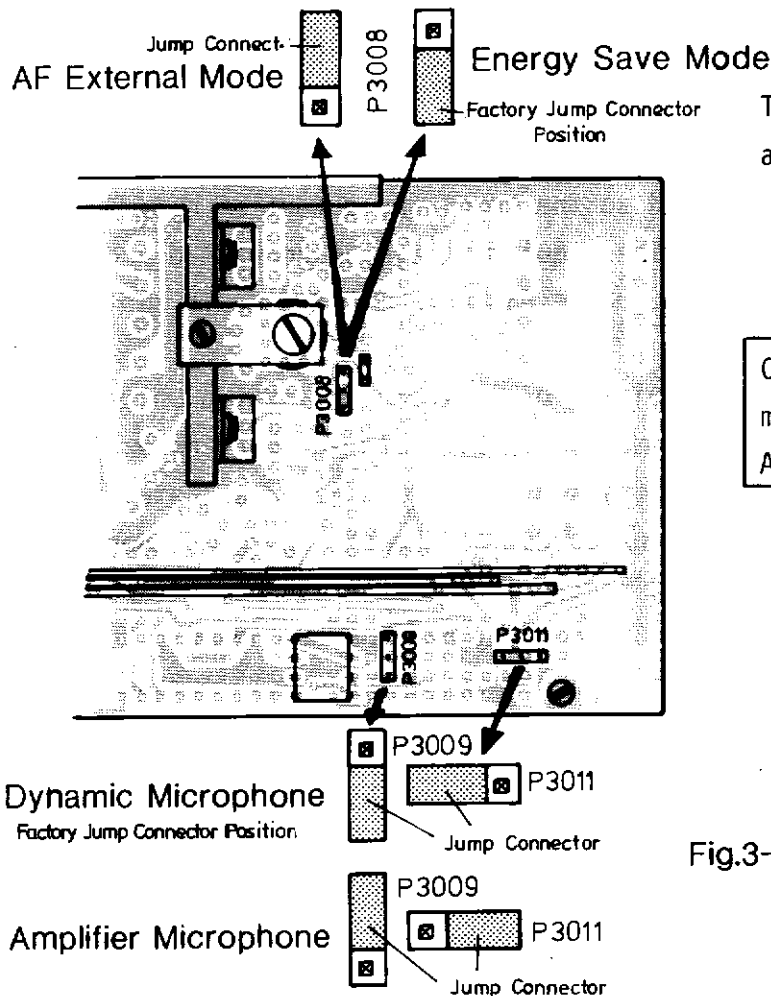
This possibility of interconnecting two units will be used primarily in aircraft in which only a voice communications and a NAV receiver are installed. The headphone output of the NAV unit can then be connected directly to the external audio input of the FSG 60/FSG 60M, and then be heard simultaneously from one common headphone or loudspeaker.

- If external audio operation is desired, the shorting plug at P 3008 is to be reversed as shown in Fig. 3-11. This deactivates the automatic power-saving circuit.



To drive the FSG 60/FSG 60M amplifier to its rated output, an audio input of at least 1.5 V is required (gain is adjustable at R 3034, input impedance is approx. 22 KOhms).

- The FSG 60/FSG 60M can be set for an amplified microphone or a dynamic one. To select, the shorting plugs at P 3009 and P 3011 are reversed as shown in Fig. 3-11. Up to two microphones (pilot and copilot) can be connected to the microphone inputs of the unit.
- After installing the wiring in the aircraft and before installing the unit, ensure that the supply voltage appears only at the correct contacts.



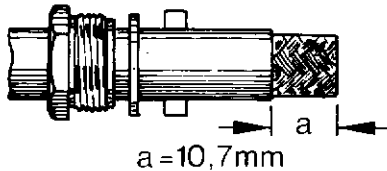
This circuit board is accessible after opening the upper cover

Changing the Jump Connectors may only be Performed by Authorized Personell.

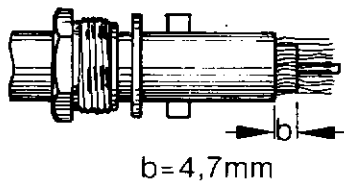
Fig.3-11 Microphone Changeover and Susceptibility to External AF Sources



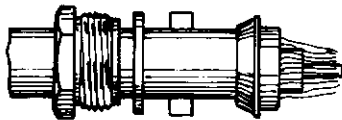
3.4.3 Connecting Antenna Cable to BNC plug



Cut cable sharp; slide on nut, washer and silicon gasket; remove jacket to length indicated.

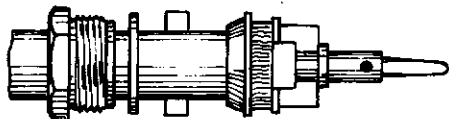


Comb out shield braiding. Strip inner insulation cleanly and at right angles to length indicated. (Warning: do not damage center conductor! Potential breaking point!)

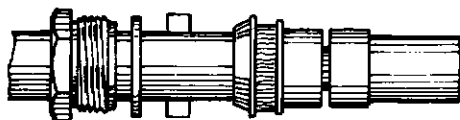


Bend combed shield slightly to the center and slide on clamp.

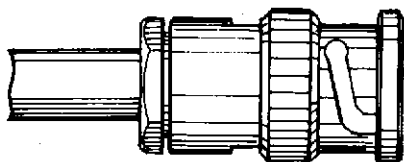
Shorten the shielding so the wires can be bent over the clamp as shown. Tin the center conductor, being careful not to damage the dielectric.



Slide on the bushing and rear insulation. Slide the contact pin onto the center conductor and solder. Thoroughly remove all flux and excess solder.



Allow joints to cool and slide on the front insulator (check for correct direction!).



Insert cable thus prepared into the plug body. Ensure that the individual parts are seated perfectly in the body of the plug. Hold the plug securely and screw in the nut.

Fig.3-12

Important

Overheating may damage plastic parts!

Take care to assemble the parts correctly.

Connect completed cable end to jack on frame.



3.5 Installing into Mount

- a) Push back locking cam on the upper side at the front right into its slot if it is exposed.
- b) Slide the unit into the mount so the front panel is even with the frame. The plugs of the FSG 60/ FSG 60M automatically seat in their counterparts.
- c) Tighten the cylindric screw hand-tight (clockwise; a coin can be used). The cam falls into its slot in the mount and the unit is secured.
- d) Check that the unit is correctly seated.

3.6 Removal from the Mount

- a) Loosen the cylindric screw at the upper right of the FSG 60/FSG 60M front panel a few turns counterclockwise (a coin suffices); this rotates the cam out of the way.
- b) Pull the unit out of the mount; ensure that the securing screw doesn't rotate clockwise again, or the locking cam will engage and prevent removal.

3.7 Testing after Installation

3.7.1 Testing on the Ground with the Engine Off

After installing the unit, all aircraft functions are to be checked out in order to find any malfunctions which the installation may have caused, and to eliminate them.



Then measure the antenna voltage between the RF jack of the mount and the antenna cable. A VHF standing wave meter is required for this measurement, or a directional wattmeter.

The standing wave ratio should lie within 3 : 1 throughout the entire frequency range of the unit (reflected power $\leq 25\%$ of the input power). If this value is exceeded, a mismatch exists which, for example, may be caused by an incorrect or insufficient counterpoise, poor contacts or incorrect radiator length. For higher range we recommend a standing wave ratio of max. 2 : 1 .

NOTE

With COM antennas installed on the underside of the fuselage, this measurement must be performed during flight in order to prevent incorrect measurements.

3.7.2 Testing on the Ground with Engine Running

With the engine running, it must be ensured that the aircraft's electrical system voltage lies within the tolerances permitted at 14 or 28 V, as applicable; this measurement is to be made with the engine operating at cruising RPM.

When carrying out a subsequent voice check, the ground station must be at a distance of approx. one to five km. At engine cruising RPM, aircraft cabin noise should be avoided to be picked up by holding the microphone near the lips in order to provide a much more desired signal than cabin noise.



If noise occurs with the engine running and its frequency varies with the engine speed, it may be caused by an inadequately suppressed ignition system or alternator/voltage regulator equipment, or by a poorly stabilized on-board supply voltage ($V_{\text{interf.}} \leq 1.5 V_{\text{pp}}$).

It is easier to distinguish between RF and AF interferences (carried by the lines) by removing the antenna plug at the transceiver mount; RF interference, which usually comes from the ignition or generating system, disappears. Supply ripple can be found with an oscilloscope. Its source is usually the generating equipment in conjunction with a poor battery or poor wiring (bad contacts, defective switches, inadequate wire cross sections).



SECTION IV OPERATION

4.1 Operating Instructions

1. Turn on FSG 60/FSG 60M transceiver with the toggle switch (middle position: ON).
2. FSG 60
Set desired frequency with the frequency selector (kHz and MHz knobs). The channel selector is blocked for this model.
FSG 60M
Use the channel selector (CHAN) to set the desired channel, or set the desired frequency with the frequency selector (kHz or MHz knob).
The frequency selector is only activated if the mark on the channel selector points to the right toward the frequency selector.
3. When the receiver is operational, noise can be heard which can be suppressed by pushing the toggle switch at the top to the squelch position (SQ). The automatic squelch is now operating.
4. The unit itself does not need to warm up. However, at -40°C , the liquid crystal display (LCD) requires approx. 30 sec. to warm up until it is fully visible.
5. The microphone must be held close to the lips in order for the voice to be picked up better than cabin noise, such as that from the engine, etc. Enunciate clearly at a constant loudness.
6. While listening to the answering station, set the volume control (VOL) so the reception is heard well.
7. Frequent transmission and loud receiver volume reduce available operating time when operating from a battery.
8. The transmitter should not be keyed longer than 5 minutes. Maximum transmit duty cycle: 50 %.

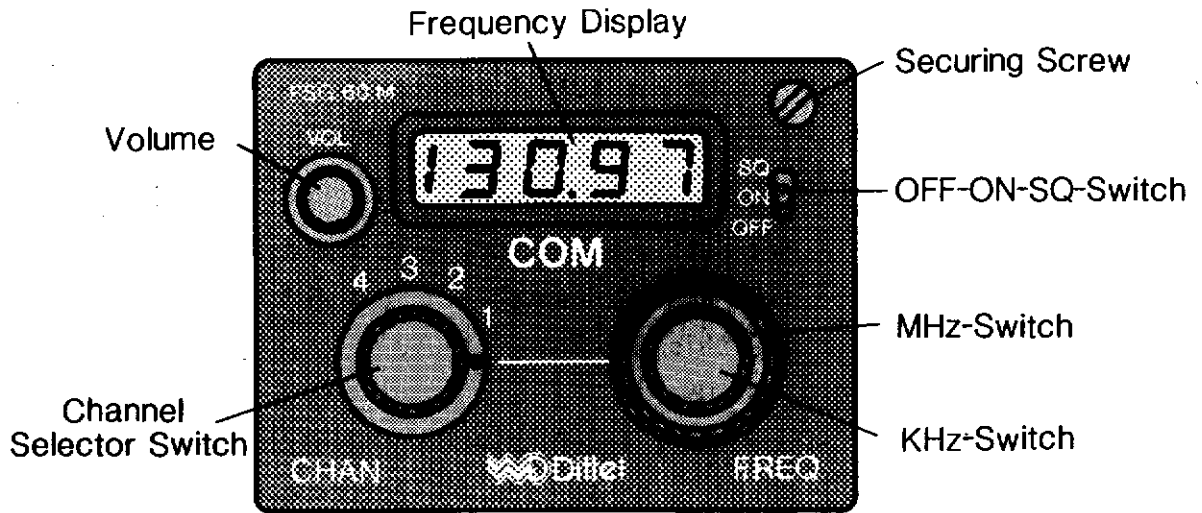


Fig.4-1

Controls Display	Description	Function
VOL	potentiometer	RX Volume
OFF / ON / SQ	toggle switch	OFF: power off ON: unit supplied with power; noise from loudspeaker/headphone SQ: squelch enabled, normal operation
Frequency indicator	liquid crystal display (Illumination possible)	Shows the frequency set from 118.00 to 135.97 MHz; last digit does not appear. Blinks if power supply drops below 11 volts.
kHz selector FREQ	rotary knob with 40 detents	sets frequency in 25-kHz steps
MHz selector FREQ	rotary knob with 18 detents	sets frequency in 1-MHz steps
Channel selector CHAN	<u>FSG 60:</u> blocked <u>FSG 60M:</u> rotary switch with 5 detents	<u>FSG 60:</u> no function <u>FSG 60M:</u> selects channels 1 to 4 and enables kHz and MHz selectors when fully clockwise.



4.2 Battery Check

The FSG 60/60M transceiver indicates low battery voltage by causing the frequency display to blink if the power supplied drops below 11 volts.

Depending on battery capacity and the proportion of transmitting operation, the following operating times may remain after blinking starts until the battery is fully exhausted.

When operating from battery

Assuming:	approx. 20°C, 6 Ah battery, feeding <u>only</u> the transceiver.
Operating modes:	10 % transmit, 20 % receive, 70 % stand by
a) blinks while transmitting	approx. 5 hrs. operation left
b) also blinks while receiving	approx. 45 min. operation left Recommendation: Transmit only when absolutely necessary.
c) Short-Time blinking in "Stand by" mode (switch at "SQ", no reception)	Cease transmitting! approx. 45 min. of receive-only operation left.
d) Continuous blinking in "Stand by" mode	Turn off unit and recharge battery as soon as possible! (See also 4.3, Emergency Operation)

NOTE

The transitions for a, b, c and d have fluent character, the battery recovers somewhat after load is reduced.

When operating from aircraft's power system

Blinking frequency display: The aircraft's power system must be investigated immediately!

When operating from 28 V aircraft power system

Blinking frequency display: Check voltage regulator and aircraft's power system.



4.3 Emergency Operation

In an emergency, the unit can also be operated with supply voltages down to 9 volts. The audio output and transmitting output are of course reduced.

Batteries must always be recharged immediately after emergency operation because extensive discharging incurs the risk of deterioration and permanent damage - this risk is increased if a discharged battery is also stored in that state. This applies to all types of batteries!

4.4. Squelch Function (SQ)

With the toggle switch in the "SQ" position (normal operation), the squelch circuit of the unit is active. This disables the audio amplifier when the receiver has no signal or one which is too weak. Signals stronger than the threshold (approx. 1 μ V) enable the audio amplifier and are therefore reproduced in the headphones/loudspeaker; annoying VHF noise is thereby suppressed. Also, considerable power is saved. If, however, very weak signals are to be received (e.g., a glider landing far from base), then the toggle switch is placed in the center position (ON). This permits noise during pauses, but weak signals of marginal strength are no longer suppressed, and the full reception range is available.



4.5 Intercom (IC)

If the aircraft wiring for the FSG 60/FSG 60M is such that intercommunication on board can be carried out with the FSG 60/FSG 60M, operation is as follows:

1. Turning on the "IC" switch enables intercom operation and simultaneous listening to received signals (radio, NAV, etc.) or variometer.
2. Keying the transmit key causes normal transmitting operation without having to turn off the intercom switch.
3. Approx. 2 seconds after releasing the transmit key, intercom operation is re-enabled. Signals received can be heard immediately after transmission ceases.

4.6 External Audio

A second or third radio (navigation receiver) or variometer can be listened to simultaneously with the FSG 60/60M receiver through the Ext. AF (NF-Fremd) input.

When wired for this purpose, the volume of the external receiver/s is/are to be set so the signals can be easily understood, and distinguished one from another. Amplification is adjusted for the combined input signal by setting potentiometer R 3034 (Fig. 4-2) which is externally accessible. The FSG 60/60M volume control (VOL) is not affected by the volume of the second or third unit, and vice versa. The external audio input is disabled during transmission.



4.7 Audio Sidetone

With the FSG 60/FSG 60M transceiver, part of the modulation signal is fed to the headphone output as long as the transmit key is operated. The volume of this audio sidetone signal can be adjusted with potentiometer R 3002 (see Fig. 4-2) which is externally accessible.

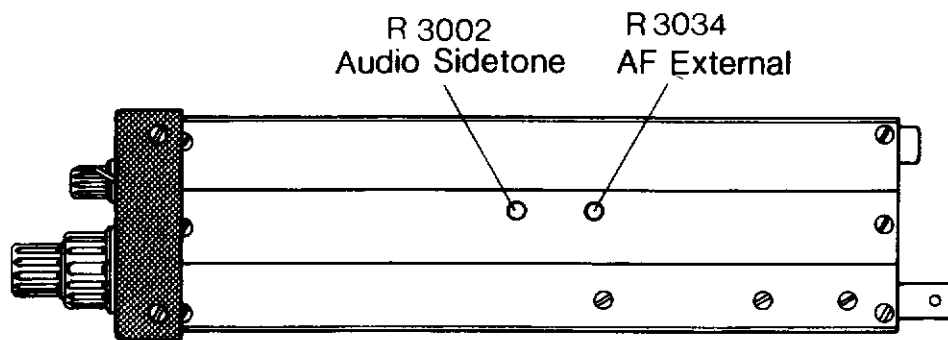


Fig.4-2 Location of Adjustments



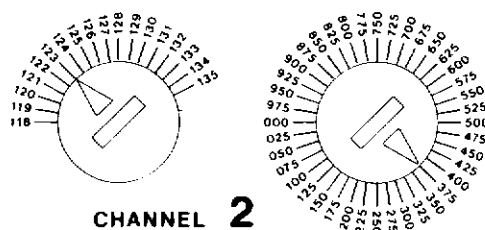
4.8 Programming the Channel Frequency Memory (FSG 60M only)

First, remove the FSG 60M transceiver from its mount (see 3.6). Programming selectors are located in pairs on the upper side of the unit - a MHz selector on the left, a kHz selector on the right for each of the four channels. A coin or screwdriver can be used to set the individual channels to the desired frequency as indicated on the frequency scales printed around the selectors.

After programming, re-install the unit in its mount and turn it on. Rotate the channel selector on the front panel (CHAN) from detent 1 through 4, checking the frequency display at each change to ensure that the frequencies desired have actually been programmed. If the desired frequencies are displayed, secure the unit in its mount by tightening the cylindrical head screw.

Enter the programmed frequencies on the "memory label" supplied with the FSG 60M and apply it at a suitable location on the instrument panel.

Replacement labels may be obtained at stationery shops under the Avery No. 3324 or similar.



Channel 2 programmed
for 123.375 MHz

Fig. 4-3
Programming Example



SECTION V ELECTRICAL OPERATION

5.1 Foreword

Referring to the block diagram, the electrical operation of the FSG 60/FSG 60M transceiver will be explained.

The FSG 60 and FSG 60M is divided into seven and eight electrical functional groups respectively:

Frequency Synthesizer, Receiver, Audio (AF) Amplifier, Transmitter, Voltage Regulator, Frequency Selection, Frequency Display, and for the 60M, Channel Frequency Memory.

5.2 Functional Description (with Block Diagram Fig. 5-1)

5.2.1 Frequency Synthesizer

The transmission and injection frequencies for the channel frequencies from 118.000 to 135.975 MHz are prepared with 25 kHz spacing.

Because the heterodyne frequency in the receiver lies +10.0 MHz above the channel frequency, the synthesizer frequency is 118.00 to 135.975 MHz in transmit mode, and 128.00 to 145.975 MHz in receive mode.

For this purpose a voltage-controlled oscillator (VCO) is used, the tuning of which lies in a control loop. The VCO output frequency is fed to a dual modulus prescaler (dividing ratios, 80 and 81). The output frequency of this prescaler (approx. 1.47 MHz to 1.82 MHz) is fed parallel to the main counter (MHz divider) and the auxiliary counter (kHz divider) which act both as down-counters.

The entire divider/counter chain operates at a cycle frequency (reference frequency) of 12.5 kHz. Therefore, the number (N) of input pulses (at the prescaler input)



counted for each counter cycle, is the same as the desired VCO frequency divided by 12.5 kHz. ($N_{\max.} = 11680$, $N_{\min.} = 9440$). At the start of the cycle, the number of (12.5 kHz) steps which are to be counted in the auxiliary counter, and the number of (MHz) steps which are to be counted in the main counter, are read into the (kHz and MHz) dividers.

For example, with $f_{VCO} = 145.175$ MHz,

145 x 1 -MHz steps in the main counter,

14 x 12.5-kHz steps in the aux. counter

would be the result.

Since the secondary counter is no longer at 0, the divider ratio of the initial-divider is set to 81 and remains so until the aux. counter has received 14 pulses. Then the initial-divider ratio is reset to 80 and remains so until the end of the main cycle. The main cycle is ended when the main counter has also counted down to 0.

The overall divider ratio (N) is composed as follows:

$$\begin{array}{rcl} 14 \text{ times} \div 81 & = & 1134 \\ (145-14) \text{ times} \div 80 & = & \underline{10480} \\ \Sigma & = & 11614 = (145.175 \text{ MHz} / 12.5) \end{array}$$

When the main counter is at 0, the read-in procedure is started, thus beginning a new cycle.

If a channel frequency with integer MHz (zero kHz) is set, the prescaler is firmly locked by the $\div 80/81$ latch switch at $\div 80$.

The frequency of the main cycle is now compared in the phase detector with a crystal-derived signal of 12.5 kHz from the reference oscillator. Due to the large divider ratio of 9440 to 11680, VCO frequency errors lead first to increasing phase errors which changes the phase detector output voltage. The phase detector output voltage is fed through the tuning filter (low pass) to the VCO tuning input, closing the control loop (see block diagram).



5.2.2 Receiver

The FSG 60/60M receiver section consists of a single-heterodyne receiver with four resonant circuits tuned by Varicaps, a RF amplifier with common-base bipolar transistor, dual gate MOSFET mixer, monolithic crystal filter, automatic gain control (AGC) through two PIN diodes, and an automatic squelch circuit.

The gain control of the input circuit is delayed and responds only at signals of more than approx. 20 μV , when an adequate signal-to-noise ratio is insured. A wide-band, fixed-tuned antenna bandpass filter prevents interference by signals outside the 115 to 140-MHz range. The antenna filter is used for the transmitter as harmonic filter.

The squelch circuit operates automatically and adapts the squelch threshold (normally approx. 1 μV) to whatever noise level exists. The squelch switch itself (in the audio amplifier) can be forced to close the signal path by the SQ switch (on the unit's front panel).

The audio-frequency signal from the demodulator is amplified and sent to the volume control and then to the audio amplifier.

The receiver is supplied with a stabilized 10.0 V DC, which is divided by an operational amplifier into 5.5 V for the RF input stage, and 4.5 V for the integrated IF amplifier.

The receiver input is blocked during the transmit mode by the input circuits AGC diodes.



5.2.3 Audio Amplifier

The audio (AF) amplifier includes analog switches and a depth-of-modulation control with a field-effect transistor (FET), a low-noise microphone amplifier, and an active 3rd-order low-pass filter to suppress audio heterodynes resulting from the reception of two or more frequencies in a multi-carrier system (CLIMAX installations), as well as a push-pull power amplifier. Microphone amplification can be selected (jumper) to match dynamic or amplifier microphones.

The circuits operate as follows:

In the receive mode, the external audio input (AF-Ext.) can pass through; the AF receiver input may pass only when 0 to 3.5 V DC appears at the squelch (SQ) line. This mode is reached when the squelch is disabled by the front-panel switch, or when a signal of adequate level appears at the receiver input.

In the transmit mode the microphone input can pass to the AF amplifier, and all other inputs are blocked.

The threshold of the modulation control is continuously variable between approx. $m = 0.3$ and 1.0, and requires approx. 2 mV microphone voltage (dynamic mic.), or approx. 100 mV (amplifier microphone).



5.2.4 Transmitter

The transmitter amplifier is of wide-band design and consists of four stages:

- a) buffer amplifier
- b) preamplifier with base modulation
- c) driver stage with collector modulation
- d) final stage with collector modulation

The stages are coupled with wide-band LC networks and ferrite transformers. The antenna filter (bandpass filter) is also used by the receiver. An antenna relay switches the antenna line between the receiver input and the transmitter output.

The frequency synthesizer requires a certain amount of time to stabilize onto the transmitter frequency after being switched from receive operation (approx. 5 to 20 ms). Since the "false" frequencies occurring during the stabilization period must not be radiated, a certain circuitry (phase lock detector) ensures that the transmit amplifier remains blocked during the frequency synthesizer transient period and that it is only opened when the transmit frequency is fully stabilized and accurate. Only then power is fed to the buffer amplifier.

5.2.5 Power Supply, Voltage Regulator

The FSG 60/60M uses an operating voltage of +14 V DC. When operating on +27.5 V DC aircraft systems, an external voltage regulator must be connected between the aircraft system and the FSG 60/60M to ensure +14 V operating voltage.



A reverse polarity diode protects the unit against incorrect polarization at the DC-Supply input. Incorrect polarization blows the 3.15-A line fuse.

The supply voltage is fed from the ON/OFF switch to the line filter which suppresses noise coming from the aircraft's electrical system (cutoff frequency approx: 100 Hz). The filtered supply voltage is then fed directly to the driver and output stage of the audio amplifier, the antenna relay, the transmitter output stages through the modulation transformer, the LCD heater, and the voltage regulator which produces 10.0 V to operate all low-power stages of the FSG 60/60M.

5.2.6 Frequency Selection

The frequency is set by MHz and kHz through two coding selectors. The selectors are operated by dual concentric knobs on the front panel.

5.2.7 Frequency Display

The operating frequency is indicated by a five-digit liquid crystal display (LCD) complying with ICAO standards. This means that the 1-kHz position is not displayed, since it would only differentiate between 0 and 5. Channel frequencies ending in 25 or 75 kHz are therefore displayed as 20 and 70 kHz. For example, instead of 123.525 MHz, 123.52 is displayed, or instead of 123.075 —► 123.07 MHz. The LCD panel can be illuminated. In order to prevent the slow response characteristic of LCDs at low temperatures, a thermostatically controlled heater is built in which operates at equipment temperatures below -10° C.



5.2.8 Channel Frequency Memory (only with FSG 60M)

In addition to the frequency selector, the FSG 60M is equipped with a channel selector with which the information carrier which determines the operating frequency is selected. This information carrier can also be one of the four channels of the channel memory in addition to the frequency selector. The channel memory is accessible through four pairs of coders when the FSG 60 M has been removed from its mount; the programming selectors are located on the upper side of the unit, and frequency scales are printed on the cover as an aid. A coin can be used to set the frequencies. The frequency can then be checked with the frequency display on the front panel.

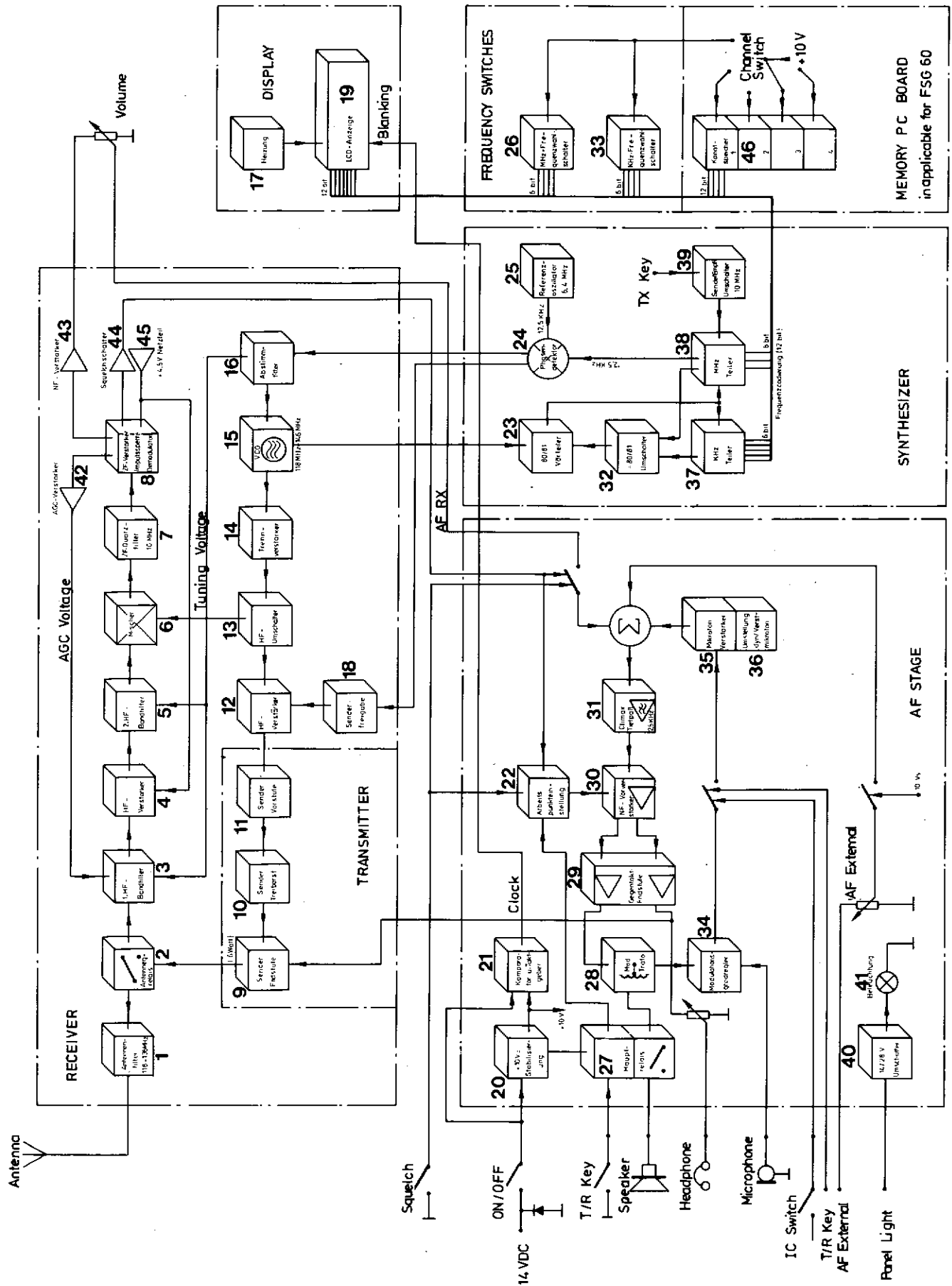


Fig.5-1 FSG 60/FSG 60 M Block Diagram



Block diagram FSG 60/60 M

- 1 Antenna Filter 118 - 136 MHz
- 2 Antenna Relay
- 3 1st RF Bandfilter
- 4 RF Amplifier
- 5 2nd RF Bandfilter
- 6 Mixer
- 7 IF Xtal Filter 10 MHz
- 8 IF Amp, Noise Processor, Demodulator
- 9 Transmitter Final Stage
- 10 TX Driver Stage
- 11 TX Pre Amp
- 12 RF Amplifier
- 13 RF change over switch
- 14 Buffer Amplifier
- 15 Voltage Controlled Oscillator
- 16 Loop Filter
- 17 Heater
- 18 TX enable
- 19 LCD
- 20 +10 VDC Regulator
- 21 Comparator and Clockgenerator
- 22 Bias point adjustment
- 23 80/81 Prescaler
- 24 Phase detector
- 25 Reference Oscillator 6.4 MHz
- 26 MHz-Switch
- 27 Main Relay
- 28 Modulation Transformer
- 29 Push-pull Amp
- 30 AF Pre Amp
- 31 CLIMAX Lowpass 2.5 KHz
- 32 ÷ 80/81 latch
- 33 KHz switch
- 34 Modulation control
- 35 Microphone amp
- 36 Change over Dyn./Amp. Microphone
- 37 KHz-Divider
- 38 MHz-Divider
- 39 TX/RX change over switch 10 MHz
- 40 14/28 VDC change over switch
- 41 Panel Light
- 42 AGC-Amp
- 43 AF-Amp
- 44 SQ
- 45 +4,5 V supply
- 46 Channel Memory



FSG TEST RECORD

VHF AVIATION TRANSMITTER/RECEIVER

FACTORY TEST ANNUAL TEST

Type: FSG 50 / FSG 60 / FSG 60M Ser. No.: Modification:

Only for factory test: Dimensions: (check)

Operating voltage for all measurements is 13.8 +0.2V

Stabilized voltage:V (10 ±0.06 V)

Stand by current:mA (55 ±5 mA)

Undervoltage indication;
frequency display blinks at:V (11 ±0.2 V)

1. Transmitter Measurements

Transmitter output and frequency deviation

P ≥5 watts for FSG 50, P ≥6 watts for FSG 60/60M, |Δf| ≤0.5 kHz

f(MHz)	P(watts)	Δf(kHz)	f(kHz)	P(watts)	Δf(kHz)	f(kHz)	P(watts)	Δf(kHz)
118.000			.025			.525		
119.000			.050			.550		
120.000			.075			.575		
121.000			.100			.600		
122.000			.125			.625		
123.000			.150			.650		
124.000			.175			.675		
125.000			.200			.700		
126.000			.225			.725		
127.000			.250			.750		
128.000			.275			.775		
129.000			.300			.800		
130.000			.325			.825		
131.000			.350			.850		
132.000			.375			.875		
133.000			.400			.900		
134.000			.425			.925		
135.000			.450			.950		
			.475			.975		
			.500					



Modulation control: m = (m = 0.72 to 0.78;
 10mV with dyn. mic.; 118.00MHz,
 500mV with ampl. mic.; 1kHz)

Depth of modulation: m = (≥ 0.35 ; 1mV with dyn. mic.; 118.000MHz
 50mV with ampl. mic.; 1kHz)

Distortion:% (m = 0.85, 1kHz; $\leq 10\%$)

Audio sidetoneV (m = 0.75, 1kHz; $3 \pm 0.5V$)

Power consumption:A /A (1kHz, m = 0; $\leq 1.8A$ / m = 0.75; $\leq 2.3A$)

2. Receiver Measurements

Squelch threshold and sensitivity

(RF levels into 50 Ohms)

f (MHz)	118.050	121.500	125.050	128.775	131.000	135.975	135.975 MHz
SQ ON Fac: $\leq 5\mu V$ Ann: 0.7 to $2\mu V$							SQ OFF..... μV ON:OFF = 3 to 6dB
$\frac{S + N}{N}$ (dB) ($\geq 10dB$ at $1\mu V$)							

Gain :..... μV ($\leq 5\mu V$ at 1kHz, m = 0.3,
 5W into 4 Ohms $\hat{=} 4.47V_{eff}$)

Bandwidth:kHz / kHz ($\geq 9.5kHz$; 6dB at 123.100MHz;
 m = 0.3; 1kHz)

Selectivity:dB / dB ($\geq 70dB$; $\pm 25kHz$ at 123.100MHz,
 m = 0.3; 1kHz)

AGC: dB ($\leq 5dB$; $5\mu V$ to 200mV; m = 0.3; 1kHz)

Audio frequency response dB ($\leq 6dB$ with m = 0.3 from 350 to 2500Hz;
 100 μV RF)
 dB ($\geq 18dB$ with m = 0.3 at 5000Hz; 100 μV RF)

Distortion: % ($\leq 10\%$ with m = 0.85, at 1kHz, 20 μV RF,
 5W into 4 Ohms)

Noise processor (functional test)

3. Additional Functions

Intercom:V / mV (factory test: 0.7 to 1.5V / $\leq 10mV$)

Aux. audio: V (factory test: 0.7 to 1.5V)

Lighting: (functional test, if installed)

Only for FSG 60M:
 Channel selector: (functional test)