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Colin Hinson
In the village of Blunham, Bedfordshire.

THE PLESSEY AR15M

LOW COVER RADAR

PLESSEY RADAR

THE PLESSEY AR15M LOW COVER RADAR

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INTRODUCTION

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INTRODUCTION

GENERAL

1 The AR15M medium-range Air Defence Radar is one of a family of radar systems derived from the well established Plessey AR15 design and incorporates the latest design features introduced as a result of Plessey's experience in the manufacture, installation and operation of more than 150 similar radars. These radars are currently in worldwide operational use and have been demonstrated to meet the most demanding operational and environmental requirements. Thus the AR15M offers a proven capability for reliable operational service.

2 The equipment is capable of a high degree of mobility over A and B class roads (UK classification), can be transported by C-130 aircraft and used in a variety of applications where medium-range, low-angle coverage is a requirement. The siting flexibility of the AR15M resulting from easy transportability makes the radar an ideal choice for the gap-filling role.

3 The design of the radar makes use of the latest solid state technology and includes an advanced digital moving target indicator for the suppression of ground clutter, an essential feature of a system design to detect and track targets at low altitudes.

Figure 1 The Plessey AR-15M Low-Cover Radar

4 The use of a dual transmitter system, besides improving reliability, enables the radar to be operated in a frequency diversity mode with the following advantages:-

- The radar coverage is increased, because target scintillation effects are reduced when a target is illuminated by transmitters of equal power and similar characteristics at different frequencies.

- Continued operation in the event of failure of either transmitter.

- Improved discrimination against external RF interference since two discrete frequencies are used.

5 The system is supplied complete with an IFF capability, specialised anti-jamming receivers to ensure continued operation in a hostile electronic environment, and two operator positions equipped with Plessey 16-A2 Autonomous Displays. Provision is made for the inclusion of air-ground-air and ground-ground communications equipment.

6 A description of the Plessey 16-A2 Autonomous Display is given in Appendix 1.

EQUIPMENT CONFIGURATION

7 The AR15M radar system consists of a transportable antenna pallet and a transportable radar cabin both of which are trailer-mounted. This compact configuration has been achieved by re-packaging the Plessey Type AR15/2C radar into one cabin and using the lightweight antenna system from the Plessey Type AWS-4 radar. Although transported as a separate load, the light weight of this antenna permits it to be mounted quickly on the radar cabin end frame for operation.

The Antenna Pallet

8 The radar antenna, with integral IFF feed, and ancillaries is carried on a pallet which can be mounted on an identical trailer to that used for the radar cabin. A hoist and davit, which fits on to the radar cabin, is provided to assist in mounting the antenna on to the turning gear.

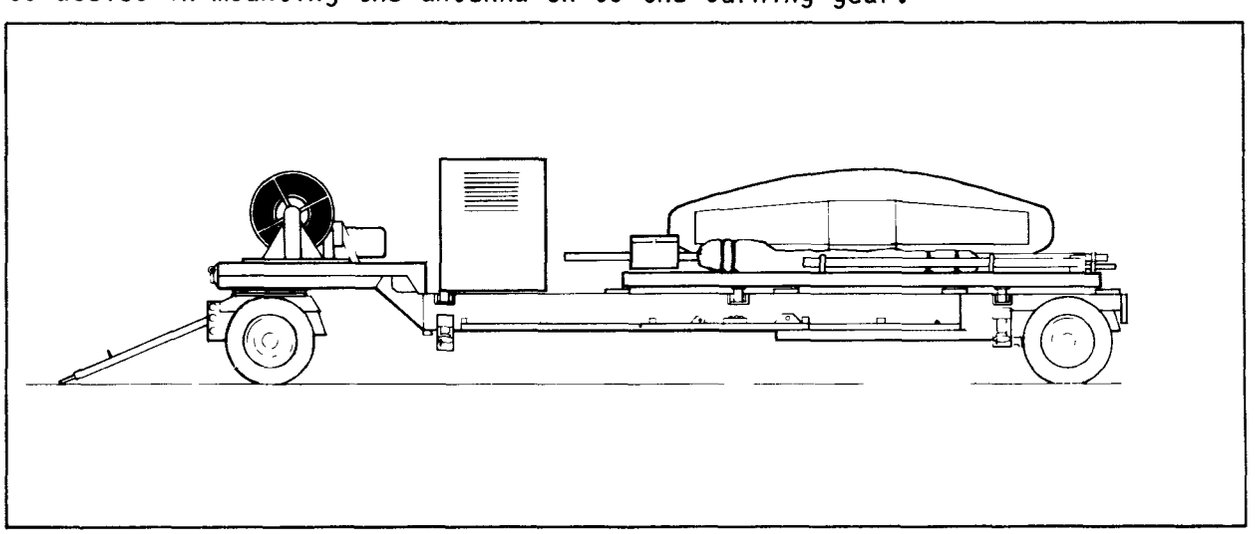


Figure 2 Antenna, Pallet and Trailer with Diesel Generator

The Radar Cabin

9 The air-conditioned cabin is sub-divided into two compartments, the operators compartment and the equipment compartment. Within the equipment compartment stowage is provided for carried spares and for the transportation of external ancillaries. Access to the cabin is via a side entrance door and an emergency escape hatch is provided close to the operator's position. The side entrance door can be fitted with an optional external canvas porch to provide black-out and weather protection.

10 The trailer is equipped with jacking stands to facilitate loading and unloading the cabin. Leveling for operation is carried out using jacks fitted to the trailer. Electrical power for operating the system is provided by air-cooled, diesel-electric generating equipment.

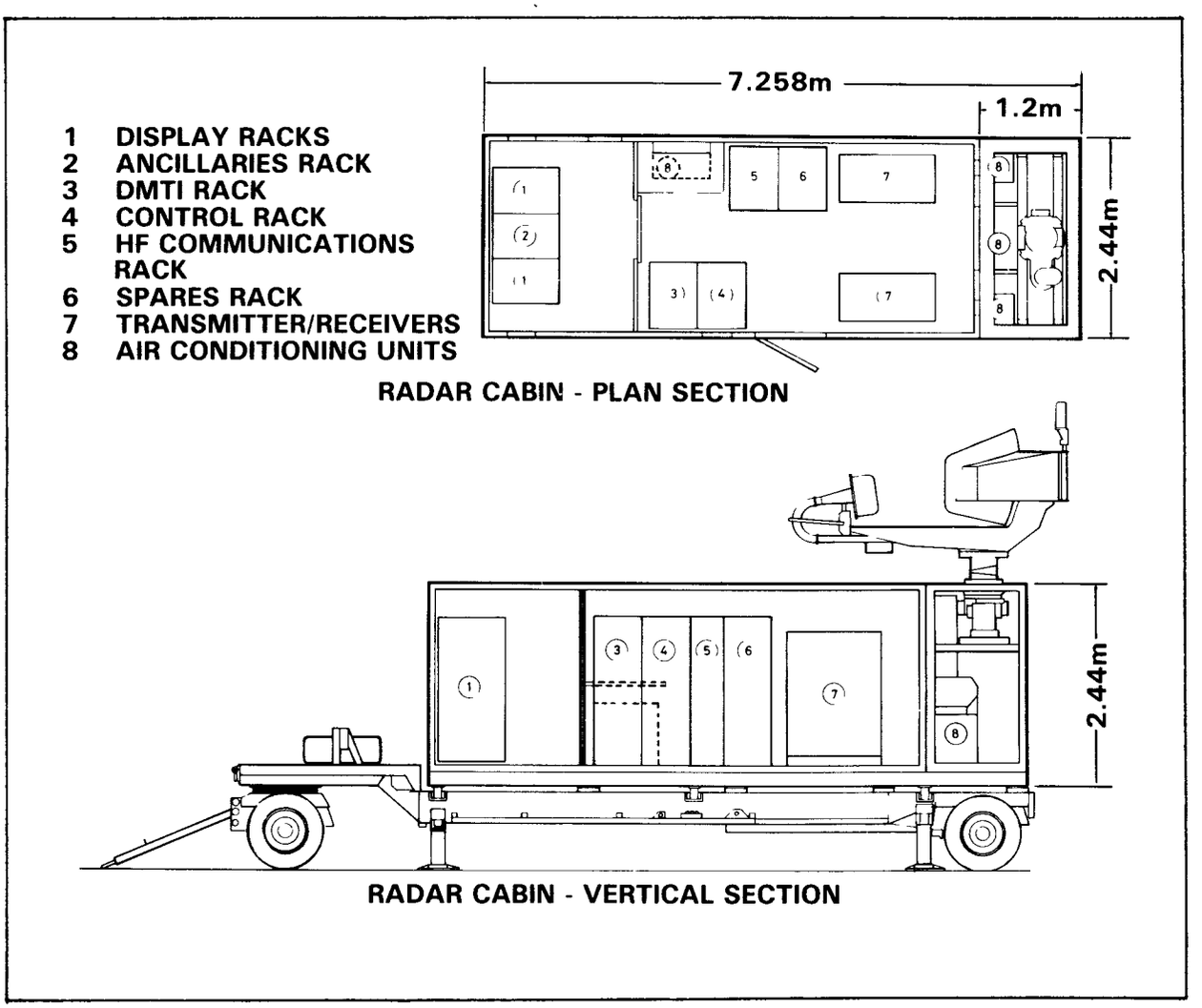


Figure 3 Radar Cabin Configuration

DEPLOYMENT

11 From arrival on-site, in favourable weather conditions the equipment can be brought into operation in less than 90 minutes by a team of 4 men; a deployment plan is shown in Figure 4. Typically, the radar can be operated by 2 men. However the maximum total recommended station team for watch keeping purposes is:

1 NCO
2 Maintenance Technicians
3 Drivers/Diesel Generator Mechanics
4 Operators

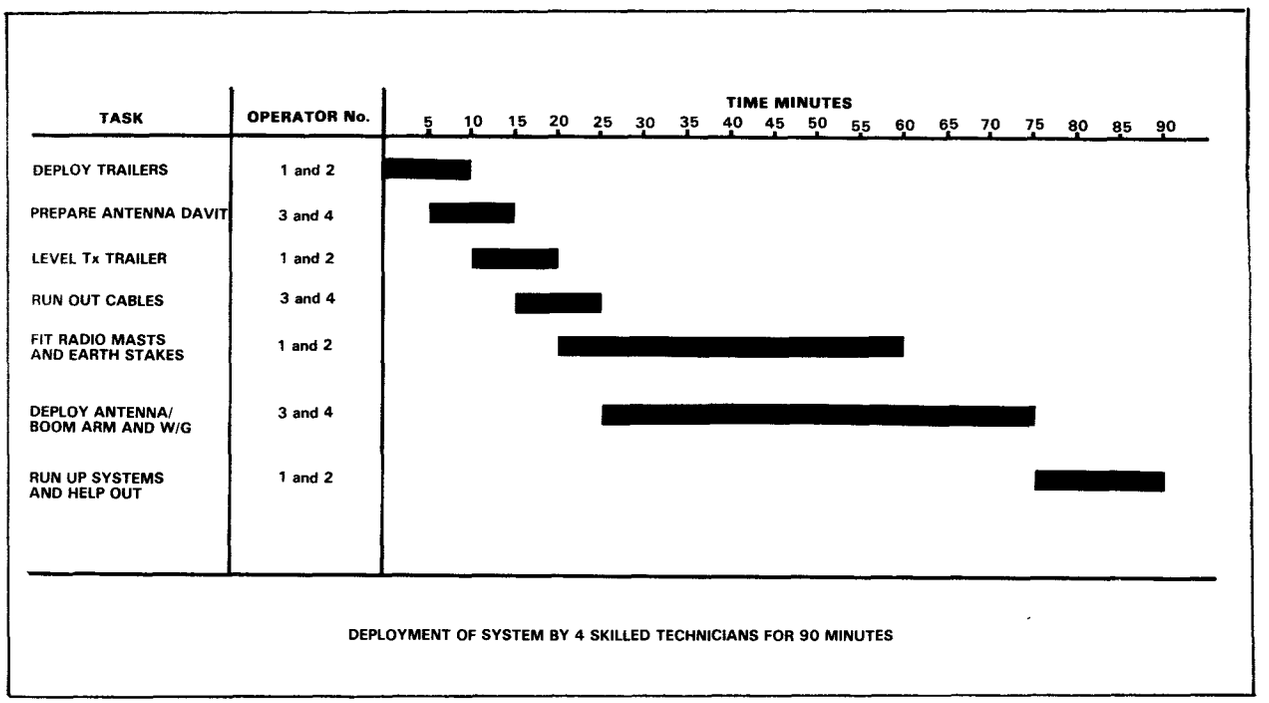


Figure 4 Deployment Plan

SUPPORT

12 Plessey Radar recognises the importance of supporting equipment in the field and to this end, a comprehensive support package is offered as described in Chapter 6. In addition, workshop cabins and standby generators on trailers are available.

CHAPTER 1

OPERATIONAL SUMMARY

GENERAL

1 The AR15M provides all the facilities necessary to operate either as an autonomous air defence unit, as part of an integrated air defence system, or in the air traffic control role.

THE RADAR CABIN

2 The control centre for the system is the radar operators' position, which is equipped with two displays, is screened from the rest of the radar cabin and provided with amber-free variable-intensity lighting. Equipment control facilities are provided at this position to:-

- Control the radar head.
- Display primary and secondary radar data.
- Decode both active and passive IFF signals.
- Communicate by voice with aircraft.
- Communicate with other ground locations for operational purposes.

PERFORMANCE

3 An essential feature of any radar which is to be used in the low-level, gap filling or air traffic control role, is high reliability and hence availability. To achieve this, the AR15M employs dual transmitter/receivers (Tx/Rx). Each Tx/Rx operates on its own discrete frequency and is coupled into the same antenna. Thus, if one Tx/Rx channel should fail, operation may continue using the other channel. In this case the failed channel can be repaired without interrupting the operation of the remaining channel thereby ensuring the continued operational availability of the radar system.

4 The provision of dual Tx/Rx channels also enables the radar to be operated in frequency diversity by using both channels simultaneously. Operation in this mode enhances the overall radar performance, since the radiated power is effectively doubled and the blip-scan ratio is substantially increased. In addition, because each transmitter radiates at a different frequency, the target detection capability is maintained in the event of accidental or deliberate interference on one of the frequencies in use.

5 The coverage obtained in frequency diversity operation, with an antenna rotation rate of 10rev/min against an aircraft of $10m^2$ equivalent echoing area is shown in Figure 1.1.

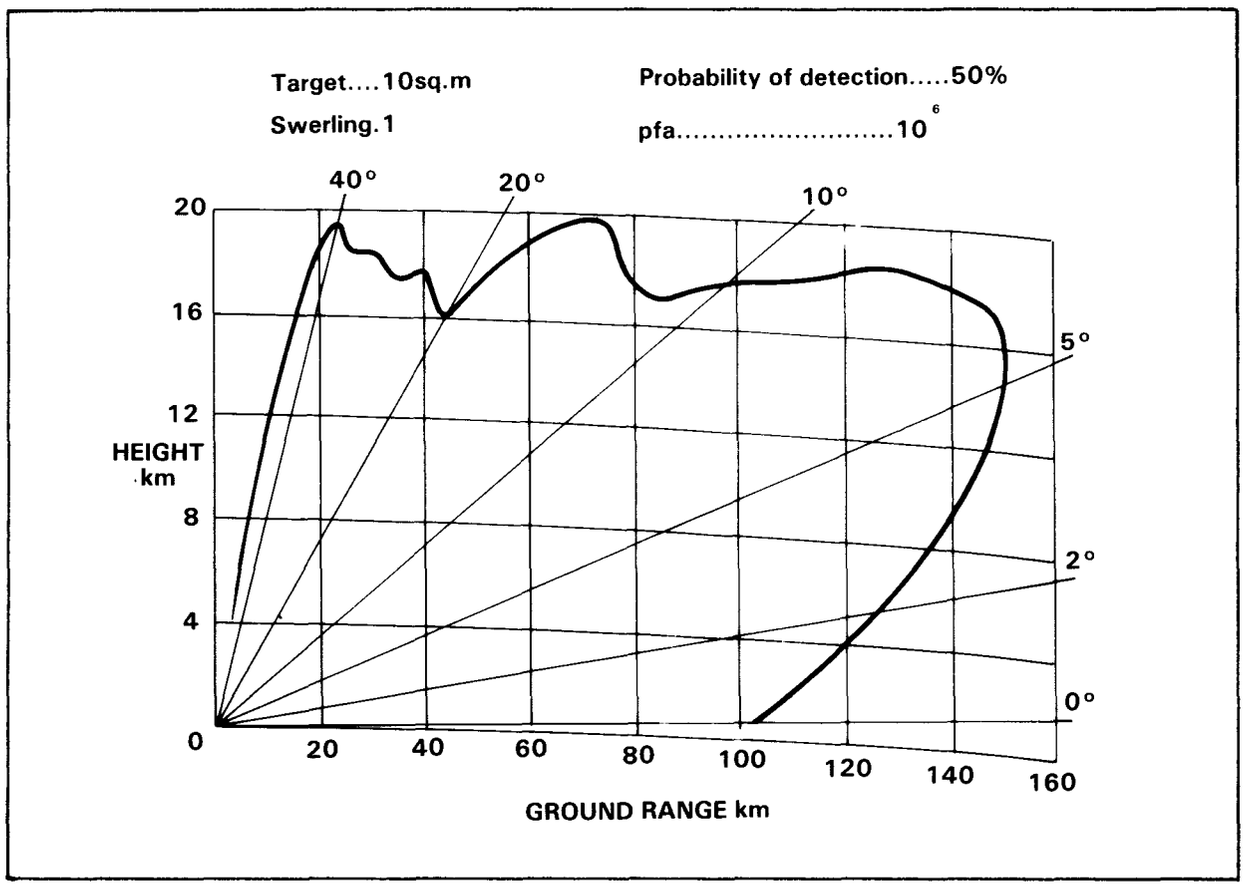


Figure 1.1 Coverage Diagram for Frequency Diversity Operation

RESOLUTION AND ACCURACY

6 Azimuth resolution of targets of similar size is approximately 1.5° and the azimuth accuracy is better than ±1°.

7 The range resolution, which is governed by the transmitted pulse duration and the digital MTI storage circuits, is such that two targets separated by 300m can be resolved as two separate echoes.

MOVING TARGET INDICATION

8 The radar incorporates digital signal processing, including digital moving target indication (DMTI) which employs double cancellation to provide a rack cancellation ratio of 40dB. The sub-clutter visibility is 27dB with the antenna rotating. Seven period PRF stagger is used to eliminate blind speeds. Automatic clutter gating facilities provide special MTI operation in areas where permanent echoes are particularly troublesome. Reversion to normal MTI gating can be made by the operator. Primary radar video is also available at the displays which enables the operator to relate aircraft positions to the known geographical features by superimposing a low-level of permanent echo background in the MTI region.

WEATHER SUPPRESSION

9 Fully variable polarisation and background subtraction are available to aid in detecting targets in precipitation areas. Variable polarisation enables the operator to adjust for optimum performance and the background subtraction circuits remove residual noise and any uncancelled clutter. Video differentiation and a logarithmic receiver channel are also available to assist in suppression of weather clutter.

ELECTRONIC COUNTER COUNTER MEASURES (ECCM)

10 An ECCM receiver is included in each receiver channel to enhance radar operation in an ECM environment. This receiver, which rejects interfering signals whose characteristics differ from the transmitted pulse, is described in Chapter 5.

IDENTIFICATION FRIEND OR FOE (IFF)

11 IFF with SIF facilities is included in the system. A solid-state interrogator/receiver unit, together with the control and decoding units, is located at the display positions. The IFF system performance is completely compatible with the radar coverage and will interrogate military and civil transponders to a range of over 100 nautical miles (185km).

12 The IFF equipment provides the following operational modes

- Interrogation modes 1, 2, 3/A, 4, C.
- Decoding modes 1, 2, 3/A, B, D and C.

RADIO COMMUNICATIONS

13 Provision is made in the cabin for appropriate radio and communications equipment. In a typical installation VHF or UHF transmitter/receivers would be fitted for air-ground-air communications together with an HF transmitter/receiver for ground-to-ground communications.

14 Stowage is provided on the antenna pallet for radio masts and fittings during transit. Whip and dipole antennae, when deployed, are fitted to the cabin so that communications facilities are available shortly after power is connected.

CHAPTER 2

SYSTEM MECHANICAL DESCRIPTION

GENERAL

1 The AR15M system consists of the following units which are suitable for both surface transportation by road and for air transportability by C130 aircraft:-

Radar cabin and trailer.

Antenna pallet, diesel generator and associated trailer.

RADAR CABIN AND TRAILER

2 The radar cabin trailer is fitted with jacking facilities to allow the cabin to be raised off its trailer and skate-loaded into an aircraft. The cabin is attached to the trailer by simple twist-lock retaining bolts.

3 The cabin door and escape hatch open outwards and are of similar construction to the body sides, with locks which allow exit from the cabin even though the doors may be locked from the outside. Detachable steps are provided for access and an optional detachable porch can be fitted to reduce the amount of light and dust entering the cabin when the door is opened.

4 A pressure relief vent is built into the escape hatch to allow pressure equalisation when an aircraft flying at 9100m (30,000ft) suffers accidental decompression, equivalent to an ascent rate of 2450m/min (8000ft/min). The relief vent also caters for reverse conditions.

5 Air conditioning is provided by units fitted to the cabin with hinged covers for protection of the vents during non-operational periods.

6 Electrical connection plug panels, inset in the cabin walls carry all the necessary multi-pin connectors for incoming and outgoing electrical cables. The main cable entry, when connected, is shrouded in a canvas boot with a zip-fastener. A hinged cover is fitted to the outside wall of the cabin for the protection of the connectors and boot during non-operational periods.

Lifting and Anchoring

7 Twist lock lifting points are provided at the top of the cabin, for ship loading, etc. The lifting points can also be used for the attachment of cabin lashing ropes.

Cabin Layouts

8 The cabin, which is illustrated at Figure 2.1, is divided into two rooms, the transmitter room and the display room.

9 The transmitter room contains the following principal units:

- Two transmitter/receivers
- Control rack (including AC distribution units and Waveguide dehydrator unit.
- Digital MTI rack
- ECCM receivers
- HF communications rack
- Air conditioning units

10 The display room contains the following principal units:

- Two radar display units
- Two UHF radios
- Ancillaries rack containing:-
  - Radar control unit
  - IFF interrogator/receiver and decoder units
  - Radio control unit

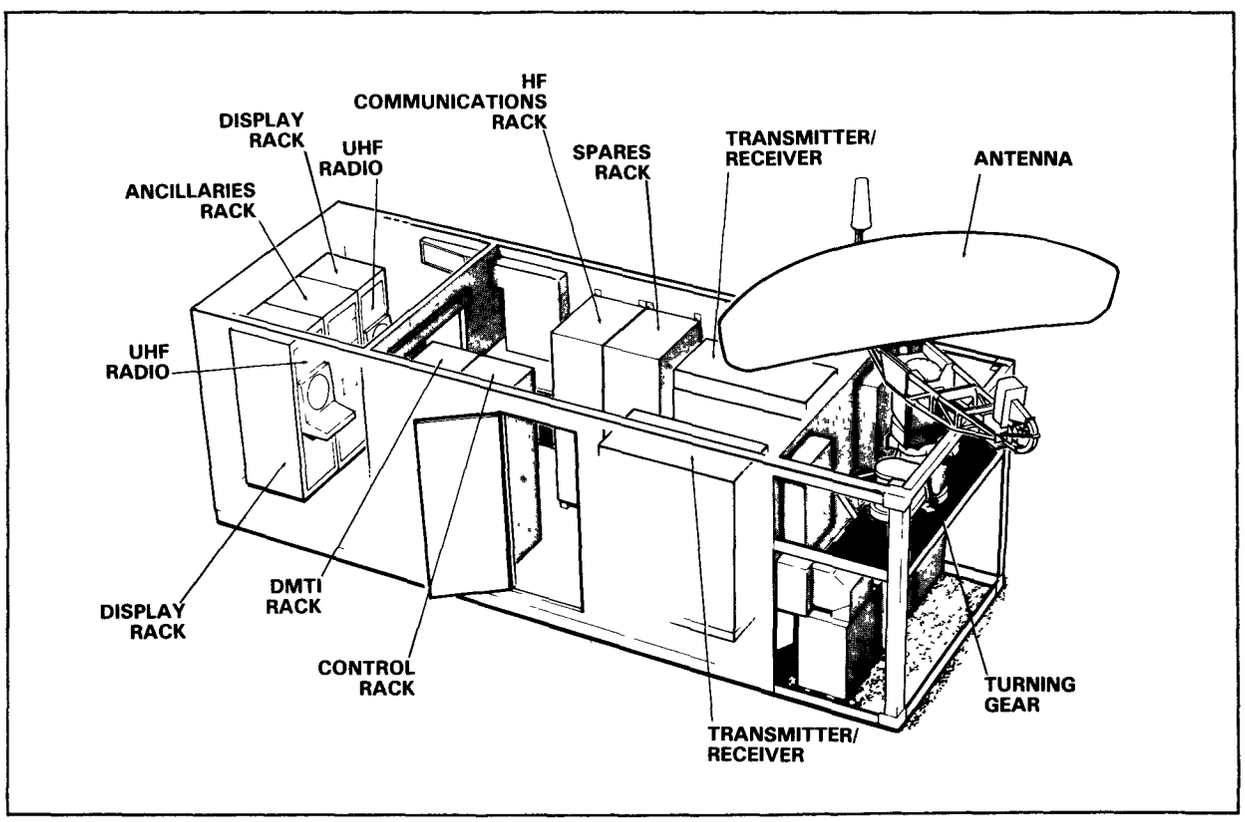


Figure 2.1 Cabin Layout

THE ANTENNA PALLET AND TRAILER

11 The antenna pallet carries the antenna and boom arm, waveguide, cable drums and ancillary equipment during transportation, see Figure 2.2.

12 Lifting eyes are provided on both trailer and pallet, suitable for on/off ship loading, etc. by crane or derrick. Lashing points are available for securing purposes during transportation by air. The lifting eyes on the trailer are capable of lifting the total weight of the trailer when loaded for sea or road transportation.

13 For operation, the antenna is raised off the pallet by means of a davit and winch, and installed on the turning gear which is permanently fitted to the radar cabin end frame.

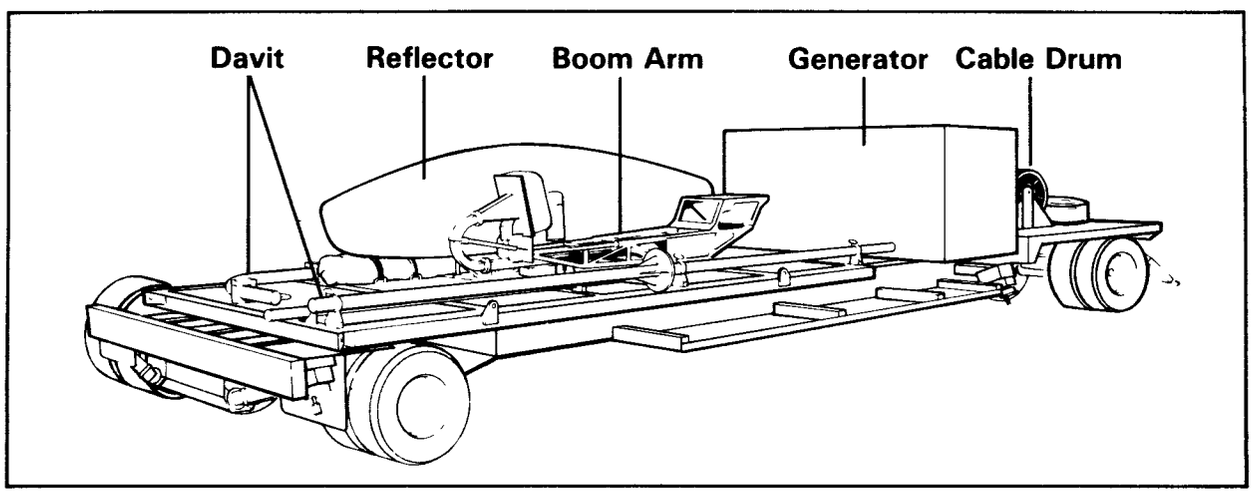


Figure 2.2 Antenna Pallet Mounted on Trailer

THE DIESEL GENERATOR AND PRIME MOVERS

Diesel-Electric Generators

14 The system is powered by an air-cooled diesel-electric generator mounted on the trailer used to convey the antenna to site. A standby generator, mounted on its own trailer, can be provided, if required. Alternatively the equipment may be powered from any mains supply providing 45kVA at 415V 3-phase, 50Hz within the specified voltage and frequency tolerance.

Prime Movers

15 Suitable service trucks which can be recomended by Plessey can be used as prime movers for the AR15M radar equipment. Winches should be fitted but other special equipment should not be required.

CHAPTER 3

TECHNICAL EQUIPMENT DESCRIPTION

INTRODUCTION

1 This chapter describes the main units of the AR15M but only passing reference is made to the moving target indicator equipment which is more fully described under Clutter Suppression in Chapter 4.

ANTENNA

General

2 The antenna is a horn-fed, double-curvature reflector mounted on a turning gear which rotates the antenna at 10 or 20 rev/min as selected by the operator. The horn and variable polariser form an integral part of the RF feed and are supported by the boom arm. The feed contains an integrated radiator for IFF, which obviates the need for an additional IFF antenna.

Reflector

3 The lightweight reflector has a span of 4.7m and an azimuth beamwidth of 1.5°.

Turning Gear

4 The turning gear is driven by a 3-phase motor through a reduction gearbox. Transmission of RF energy is via a low-loss, low-friction, wide-band (2700-3100MHz) rotating joint, located in an accessible position within the main assembly from which it can be removed for servicing. An 8-channel slip-ring unit, provides connections for the circular polariser and the IFF side lobe suppression system.

5 A data take-off unit fitted to the turning gear drives the necessary synchro elements for providing azimuth information to the displays.

6 Power to the turning motor is controlled by a starter fitted in the AC control unit which can be operated either locally or remotely by switches on the operator's control panel.

7 A 'man aloft' switch enables isolation of the antenna circuits to ensure safety of personnel during maintenance of the antenna. The key of this switch is also used to actuate the antenna locking mechanism to hold the antenna stationary.

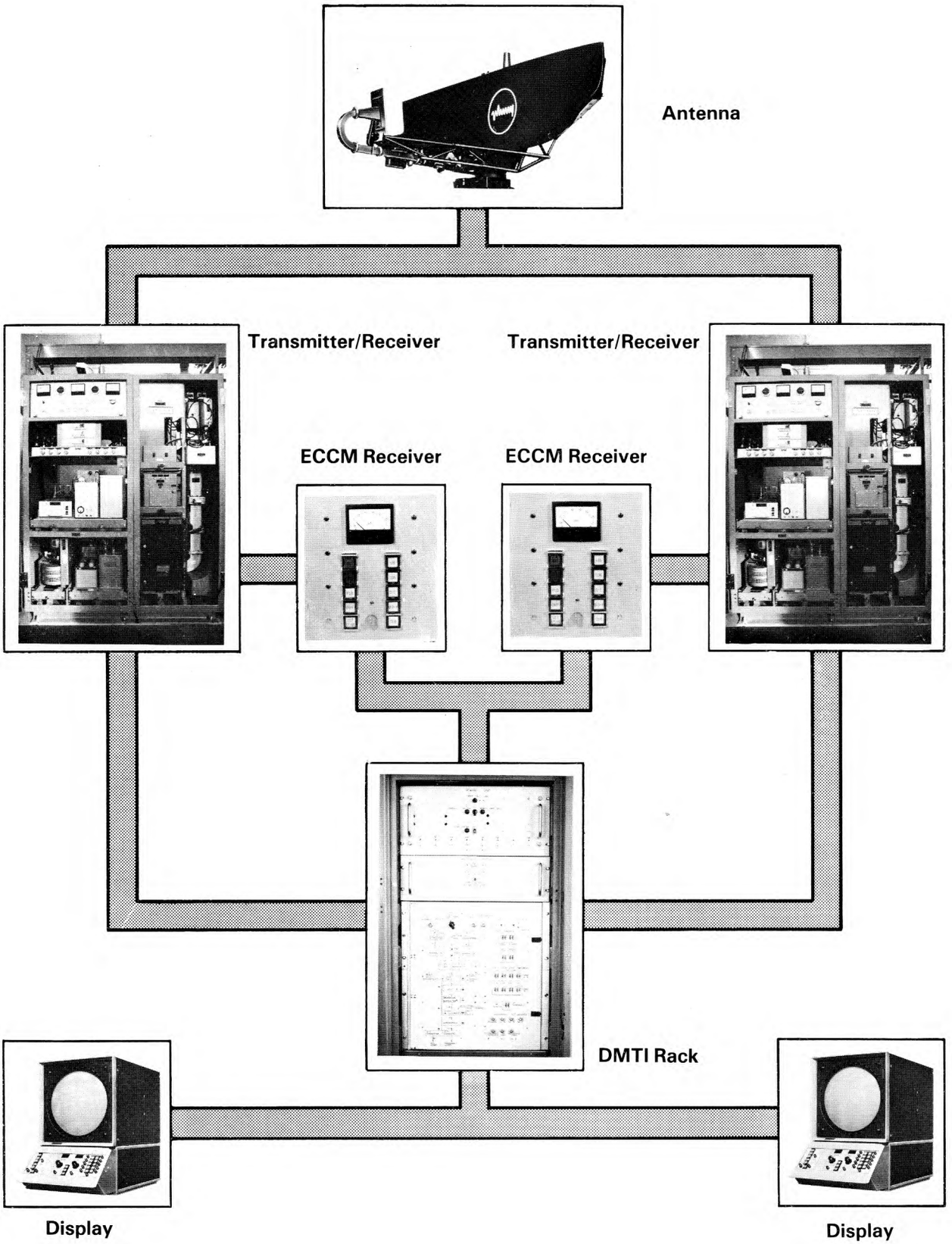


Figure 3.1 AR15M Primary Radar System Configuration

TRANSMITTER/RECEIVER

8 The combined transmitter/receiver provides S-band RF pulses of 1μs duration at a repetition frequency of 700p.p.s. and 625kW peak (nominal) power. The receiver system incorporates a low noise FET RF amplifier for low overall system noise-factor and reliability. To ensure good DMTI performance the local oscillator (Stalo) is a solid-state S-band oscillator, frequency-locked to a crystal-controlled oscillator.

9 Two transmitter/receiver (Tx/Rx) units are fitted, each housed in a cabinet consisting of two compartments (see Figure 3.2). The left hand compartment contains; the meter and control unit, the normal radar receiver, the distribution unit, the trigger and modulator units, and the EHT unit. The right hand compartment contains; the magnetron and pulse transformer, the magnetron tuning drive unit, the duplexer and waveguide components, the FET RF amplifier, the stabilised local oscillator (STALO) and the signal and AFC mixers and pre-amplifiers. Heavy units are mounted on extending runners to provide ready access for maintenance.

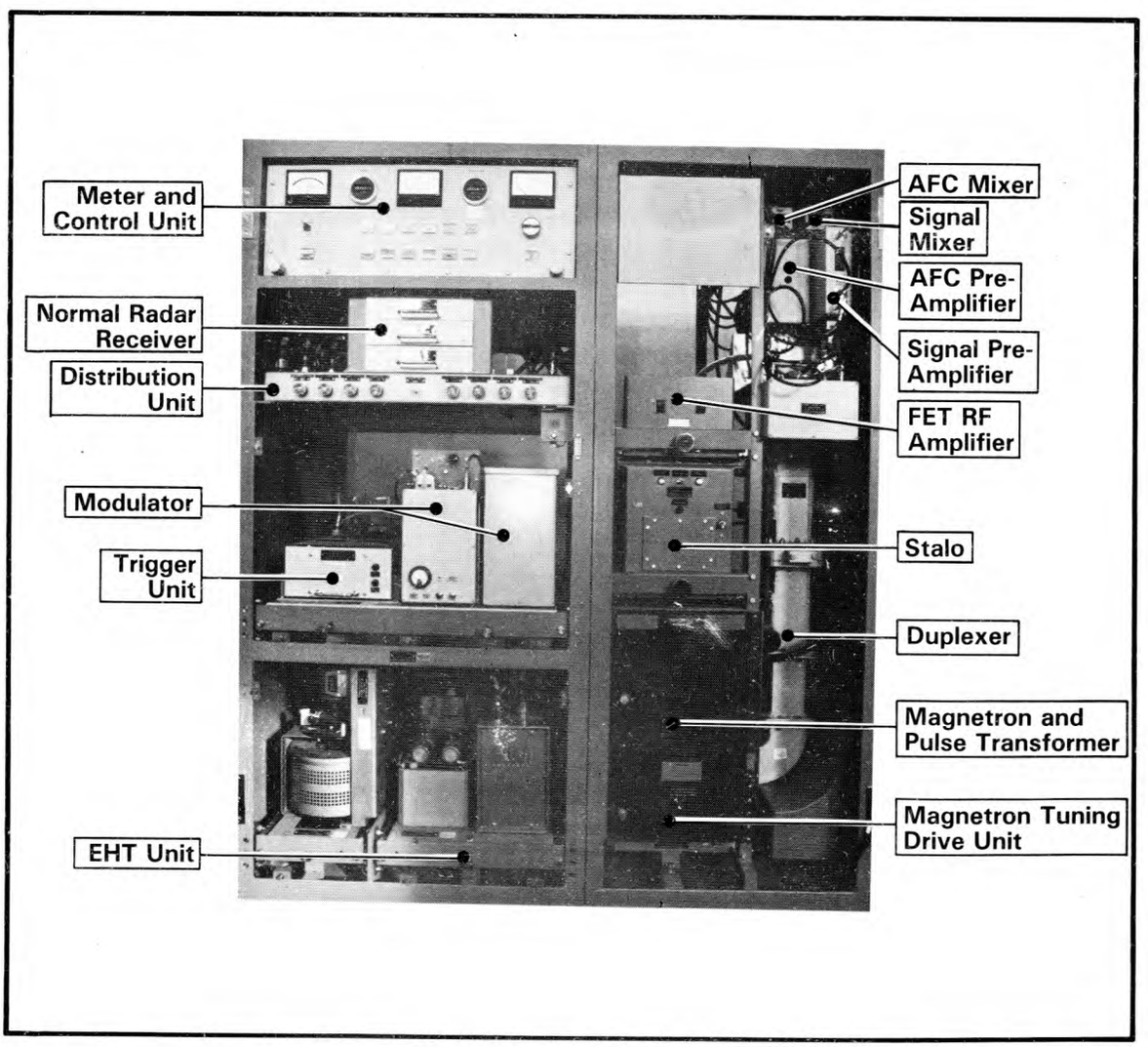


Figure 3.2 AR15M Transmitter/Receiver

10 With the exception of the magnetron and thyratron the whole of the transmitter/receiver uses solid-state techniques. The power supplies for all circuits are stabilised and silicon rectifiers are used for the EHT supply.

11 The configuration incorporates a frequency diversity unit, which permits both transmitter/receivers to operate at the same time into the common antenna system with the two transmitted frequencies separated by a guard band. The frequency diversity units are passive devices requiring no tuning or external power source.

Outline of Operation

12 Figure 3.3 is a block diagram of the transmitter/receiver. The PRF of the system is determined in the DMTI rack and the PRF train is fed to the trigger unit in the modulator section of the transmitter/receiver to trigger the thyratron pulse-modulator. This causes the pulse-forming network, charged between pulses from the EHT unit via a charging choke and regulation unit, to discharge through a pulse transformer for a period determined by the constants of the network. As the network discharges, the pulse developed at the secondary of the pulse transformer is applied to the magnetron. The RF energy generated by the magnetron passes to the duplexer and main waveguide run to the antenna system.

13 A phase changer is fitted in the antenna waveguide run for each transmitter and consists of a low-loss dielectric vane whose insertion into the waveguide is controlled by an uncalibrated multi-turn knob. Its purpose is to enable the phase of the load impedance presented to the magnetron by the antenna feed waveguide assembly to be adjusted to ensure that the magnetron will operate with the necessary frequency stability for good MTI performance.

14 A sample of the transmitted RF pulse beats with the Stalo output in an AFC mixer whose output is fed to the AFC head amplifier to control the magnetron frequency.

15 If required an internal trigger from a unit within the modulator section may be switched into service during maintenance.

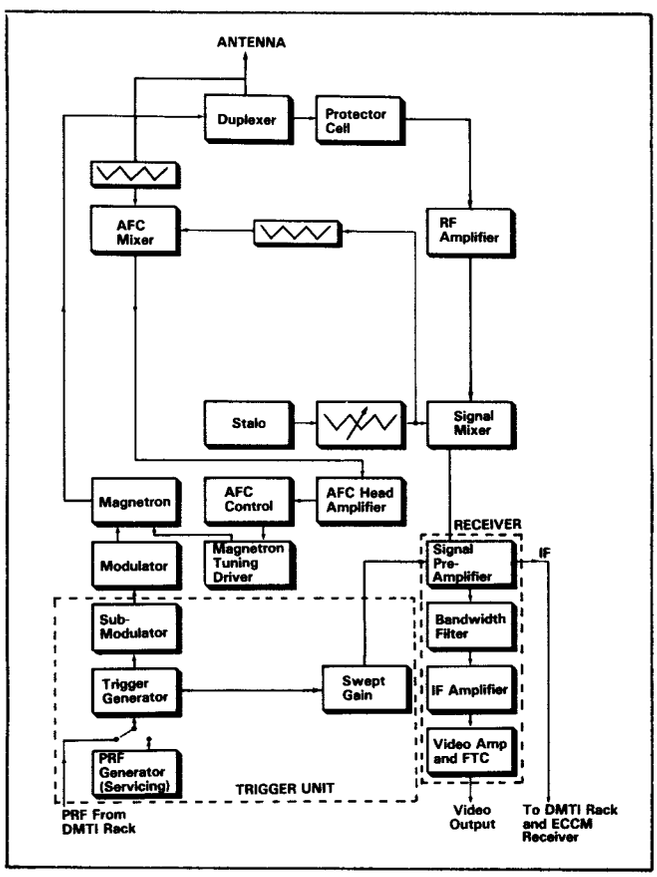


Figure 3.3 Block Diagram of Transmitter/Receiver

16 Received signals pass from the antenna system to the receiver arm of the duplexer, through the protector cell to the RF amplifier. From the RF amplifier the signal is passed to a balanced mixer. The IF output (30MHz) is then fed into the signal pre-amplifier which is mounted directly on the crystal current-monitoring and mixer assembly. The RF receiver noise figure is typically less than 3dB.

17 The receiver sub-system comprises a number of stages:-

- Signal pre-amplifer.
- Bandwidth filter unit.
- Combined linear/logarithmic IF amplifier.
- Video amplifier with differentiation (FTC) facility.

The video output of the receiver is fed to the display system via the control rack (for selection as an alternative to ECCM video) and an IF output from the signal pre-amplifier section of the receiver unit is fed to the DMTI rack for MTI processing and to the ECCM receiver for signal processing as described in Chapter 5.

CONTROL RACK

18 This rack accommodates items of equipment essential to the operation of the system and provides AC distribution and system control. The middle section of the rack houses a number of modules which control the following:

- Trigger switching and timing.
- Standby PRF source.
- PRF main/standby auto-changeover sensing.
- Video combining (diversity operation).
- Relay switching for circular polarisation.
- Trigger delay restoring circuits (diversity operation).
- DMTI video on/off selection circuits.
- Trigger and video remoting circuits.

19 Below the modules are two 50V power units, one main and one standby, which provide a control voltage for operating the relays and indicators associated with remote control of the system.

MTI/RECEIVER RACK

20 The MTI/Receiver rack, located in the transmitter room, contains the digital MTI system, which provides both cancelled and non-cancelled videos, and the ECCM receivers.

ANCILLARIES RACK

21 This rack, located in the display room, contains the following units:

- IFF Interrogator/receiver.
- Interference blanker.
- IFF decoders.
- Air conditioning control panel.
- Radar control unit.
- Communications control unit.

IFF EQUIPMENT

22 The IFF equipment is described in Appendix 2.

RADAR CONTROL UNIT

23 The radar control unit houses the main controls for the radar system, and is placed between the two displays for ease of access by the operators. The control functions have been grouped for easy access. Control is effected by use of push-buttons and switches. Certain controls house associated tellback indicators to show the status of the system. The control unit permits remote control of the system throughout the switching on sequence.

HF COMMUNICATIONS RACK

24 Located in the transmitter room this rack houses the HF transmitter and receiver for ground-to-ground communication. The equipment is described in Appendix 3.

DISPLAY RACKS

25 Two identical display racks are fitted in the display room. Each rack contains a Plessey 16A2 Autonomous Display (see Appendix 1) and UHF or VHF transceivers.

WAVEGUIDE DEHYDRATOR

26 The dehydrator unit, located in the top of the control rack, supplies dried air at above atmospheric pressure to prevent condensation in the waveguide or antenna feeder system. A small air flow is allowed to escape at the antenna to give adequate circulation.

ANTI CONDENSATION EQUIPMENT

27 It is important that condensation shall not occur when the equipment is switched off. For this reason a dehumidifier is automatically switched on when the equipment is not operational (providing that mains power is available).

CHAPTER 4

CLUTTER SUPPRESSION

INTRODUCTION

1 Reference has already been made to the operational value to the user of the moving target indication, which is an integral part of the Plessey AR15M. This chapter deals with the technical aspects of this important technique.

DIGITAL MOVING TARGET INDICATION (DMTI)

2 For a significant improvement in reliability, sub-clutter visibility (typically 27dB for the radar system) and ease of setting-up, the AR15M radar uses a digital moving target indicator system (DMTI) employing medium scale integration (MSI) technology for reliability. Standard features include:-

- MTI double loop cancellation.
- Separate in-phase and quadrature (I and Q) cancellers.
- Built-in highway monitoring system.
- Modular construction.
- High speed clock.
- Constant false alarm rate circuits to reduce the effects of noise-like interference (residual precipitation etc).
- Integration to eliminate the effects of asynchronous pulse interference and to improve target detection.
- Clutter operated gating to ensure that the MTI is only operational when needed i.e. over clutter.

3 Figures 4.1 and 4.2 are simplified block diagrams of the DMTI system.

Timing

4 The system timing is divided into two sub-systems:-

(1) PRF generation.

(2) Clock generation.

5 **PRF generation** is achieved by a stable 1MHz oscillator driving count decoders to generate triggers to 1μs accuracy throughout the PRF interval; the count is reset at the required time to produce the correct PRF. Stagger patterns are also generated in this area with a selection of up to 7 triggers in up to 16 PRF intervals. The triggers thus generated are fed to transmitters, displays and associated equipment.

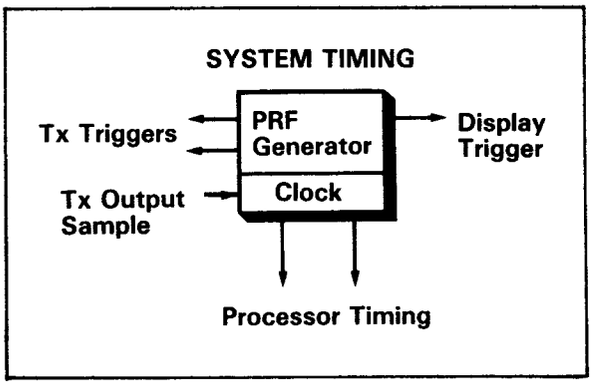


Figure 4.1 System Timing

6 **Clock generation** is achieved by initiating a stable oscillator from a magnetron output pulse sample, and the clocks are enabled at various stages in the system by count decoders. This method of timing virtually removes any jitter which may occur due to the modulator and magnetron system.

IF Receiver

7 A coherent receiver is used which requires IF and lock pulse inputs and delivers, via a dual phase-sensitive detector, in-phase (I) and quadrature (Q) video outputs, to the analogue-to-digital converters (ANDI) in the MTI processor. The normal radar video is also fed to an ANDI and time-aligned data is available for subsequent processing.

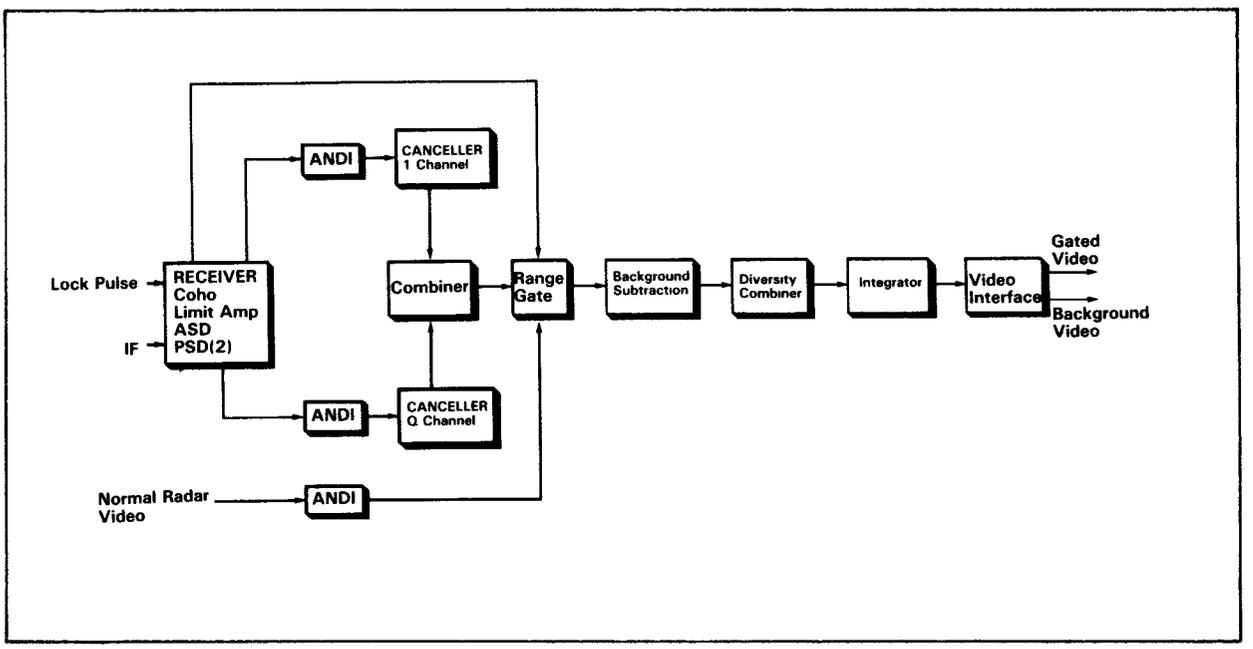


Figure 4.2 MTI System Block Diagram

Digital Processor

8 Cancellation of fixed echoes is achieved by the use of separate I and Q, two-loop, line-by-line type cancellers. The system operates with a resolution of 8 bits and the high clock rate allows three (I) and (Q) samples to be taken per pulse length, thus ensuring that the processor does not limit the system target resolution.

9 The (I) and (Q) videos from the ANDIs are fed to separate cancellers, cancellation being achieved by delaying the coded video and subtracting this from that received from the next transmitted pulse. This process is repeated and the resulting double cancellation enables high clutter rejection to be maintained whilst the antenna is scanning. The (I) and (Q) cancelled outputs are then combined to produce MTI information free of blind phases.

Background Averaging

10 The combined output, still in 8-bit form is now fed to the logarithmic compression and background averaging units. The logarithmic function is performed by a look-up table programmed into a read-only memory. The background averager operates on the principle of averaging the data over a certain range.

Range Gating

11 Range gating takes place between the logarithmic compressor and the background averager enabling averaging to be applied for both MTI and normal radar video over the full display range of the system.

Integration

12 After background averaging, the video is threshold quantised, i.e. video above a certain preset threshold is output as a logic 1 and that below as a 0. This output is fed to a weighted staircase type integrator and helps to keep the false alarm rate low. Finally, the quantised video is reconverted to analogue form.

CLUTTER GATING SYSTEM

13 The DMTI system so far described produces DMTI video, throughout 360°, from the start of each pulse recurrence interval out to a range fixed by the DMTI range gate control; normal radar video (NRV) is produced thereafter, out to the maximum range of the system.

14 Since MTI processing causes tangential fade of target signals, it is undesirable to use DMTI except where it is essential. The clutter gate circuit is therefore designed to select DMTI video, within the limits set by the DMTI range gate, only where clutter is actually present. Where clear areas occur between patches of clutter, NRV is selected, thereby enhancing radar performance in non-clutter areas.

CHAPTER 5

THE PLESSEY ECCM RECEIVER

GENERAL

1 Radar equipments are designed for optimum sensitivity to returns from the radiated pulses and, unless special precautions are taken, they are vulnerable to deliberate jamming or to interference from other radars. An ECCM receiver, fed from the normal radar pre-amplifier, is incorporated in each receiver channel to reject all received signals that do not closely approximate to the transmitted pulse. Using this method the following important features are retained:

- A wide dynamic range to avoid loss of signals due to saturation effects.
- Good constant false alarm rate performance, so that adjustment of the receiver gain by the operator is not necessary to suit varying conditions; hence the output is suitable for feeding automatic data extraction circuits.
- Good transient response, so that the receiver is rendered inoperative for the minimum time after receiving a large transient signal.
- Good long-term stability and reliability to avoid the need for repeated setting-up and tuning operations.

ANTI-JAMMING FACILITIES

2 The following modes of operation are provided by the receiver;

- Linear (LIN)
- Logarithmic (LOG)
- Dicke-fix (DF)
- Quantised Dicke-fix (QDF)
- Combined logic receiver (CLR)

3 Pulse length discrimination (PLD) or differentiation (DIFF) i.e. fast time constant can be selected separately or together as further video processes. PLD is not available with QDF but is automatically selected with CLR.

4 The video output from the ECCM receiver is fed to the control rack for selection as an alternative to normal radar video.

CHAPTER 6

SYSTEM SUPPORT

Plessey Radar offer through life support of AR15M by means of a comprehensive support package and initial training of technical and operational personnel.

GENERAL

1 The full operational potential of the system is most likely to be realised if the equipment is correctly maintained and operated, and is supported technically by the user and manufacturer. Recognising these requirements Plessey Radar's Customer Support Department will be pleased to advise on all aspects of support to achieve satisfactory in-service operation with minimum life cycle cost.

TECHNICAL SUPPORT

2 Proposals for support of the system are tailored to meet particular customer requirements taking into account the technical resources and skill levels available either as currently exist or planned for the future. The services offered by Plessey Radar include spares provisioning, both initial and through life, technical advice, equipment repair at manufacturers works, and if required technical assistance by Plessey Radar Engineers.

TRAINING

3 Sound initial training of technical and operational personnel is an important factor in ensuring correct maintenance and operation of the system. Plessey Radar can offer comprehensive training to meet customer requirements at the Company Training School in the United Kingdom. Both theoretical instruction and practical experience is provided and a high degree of individual tuition achieved by limiting the number of students on any one course to six.

4 Training courses are normally conducted in the English language and assume an understanding of radar principles and techniques: basic instruction in radar principles can however be provided if required. By special arrangement courses may be held at locations suitable to the customer with lectures and practical instruction conducted in a language other than English.

Figure 6.1 Class Under Instruction at The Plessey Radar Training School

CHAPTER 7

AR15M DATA SUMMARY

ANTENNA

Frequency band	2700-3100MHz
Gain	29.5dB relative to isotropic radiator.
Polarisation	Variable from linear through elliptical to circular. (The figures below refer to linear polarisation).
Horizontal beamwidth	1.5° to half-power points (at 2900MHz).
Vertical beamwidth	Cosecant^2 to 40° approximately.
Horizontal sidelobes	-23dB relative to maximum antenna gain at the centre of the main lobe.
Rotation rate	Nominal 10 or 20 rev/min clockwise (at 50Hz supply). Other rates available to special order.
Beam angle	Normally set to approximately +3.5° but adjustable between +0.5° and +8.5°.
IFF	Built into main feed elements using common reflector

TRANSMITTER

Frequency band	2700-3100MHz
Magnetron frequencies	2700-2900MHz and 2900-3100MHz.
Magnetron peak power	600kW peak at a duty cycle of 0.0007 related to mean power not greater than 420W.
Pulse length	1μs ±0.1μs
Pulse repetition frequency	700p/s mean ± 2%
Stagger PRF	Seven-period stagger is provided. Uniform PRF can be selected.
Automatic frequency control	AFC facility is provided by adjustment of magnetron frequency against a crystal-controlled Stalo.

RECEIVER

Intermediate frequency	30MHz.
Overall receiver bandwidth	1.2MHz.
Overall receiver noise factor	Not greater than 4.5dB.
Receiver characteristics	- Linear - Logarithmic - Linear plus differentiation (Selected at radar control unit) - Logarithmic plus differentation
Swept gain	- Available at IF.

DIGITAL MOVING TARGET INDICATOR

Cancellation	Double cancellation.
Rack cancellation ratio	40.0dB.
Range gate	May be set to any range between 0 and 60n.mile (110km).
Integrator maximum range	80n.mile (148km).
Clutter gating	Available within DMTI range gate.

DISPLAYS

Type	16in (405mm) transistorised fixed-coil displays from the Plessey range.
Quantity	Two

RADAR CONTROL UNIT

Location	Rack-mounted unit between the displays.
Controls and indicators	- Radar 'ON/OFF' - EHT 'ON/OFF' and indicator lamps. - EHT reset button and lamp. - Scanner FAST/SLOW and 'ON/OFF' - Receiver Function selector. - MTI 'ON/OFF' - Integrator 'ON/OFF' - MTI range gate control. - MTI clutter gate 'ON/OFF' - Variable polarisation control and indicator.

ELECTRICAL POWER REQUIREMENTS

Supply	Voltage: 415V ± 6%. Frequency: 50Hz ± 2.5%. Phase: 3
Power	45kVA (Nominal)

ENVIRONMENTAL CONDITIONS

Non-Operational Conditions

Ambient temperature	-15°C to +70°C
Maximum altitude	30,000ft (9140m) pressurised 15000ft (4570m) unpressurised.
Humidity	100% relative during 30°C diurnal swing.
Rain	Severe driving rain up to a rate of 4in (100mm)/hr.
Immersion	Shallow fording of trailer to a maximum depth of 30in (0.76m) in fresh or sea water.
Sand/dust	Sand and dust storms with wind speeds up to 50 knots (90km)/hr.

Operational Conditions

Ambient temperature	-15°C to +52°C
Interior temperature	The air-conditioning arrangements will maintain the internal temperature within a range 18°C to 33°C when the ambient lies within a range -15°C to +52°C.
Altitude	Up to 10,000ft (3050m) above sea level.
Humidity	Not greater than 25% relative at 52°C Not greater than 40% relative at 40°C 100% relative at 20°C.
Rain	Driving rain up to a rate of 4in (100mm)/hr.
Sand/dust	Sand and dust storms with wind speeds up to 30 knots (56km)/hr.
Wind	When ground anchors are secured 60 knots (110km)/hr.

APPENDIX 1

PLESSEY 16-A2 AUTONOMOUS DISPLAYS

405mm AUTONOMOUS RADAR DISPLAYS

16-A2 RANGE

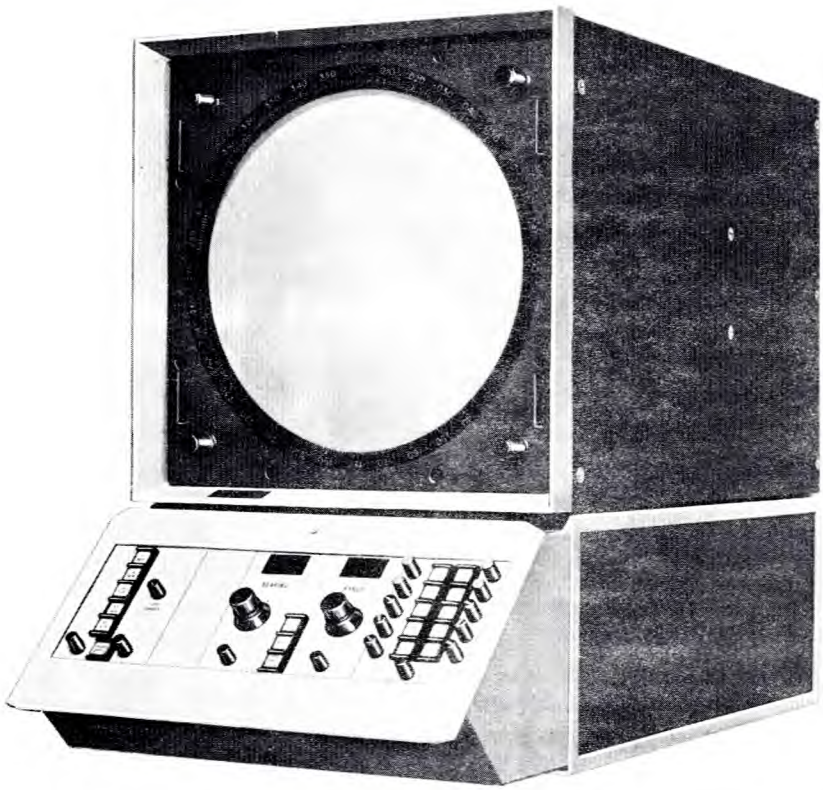
Programmable

Versatile

Civil and military applications

High performance

Synthetic data inputs



Plessey Mk.8 16-A2 Autonomous Display

General description

The Plessey 16-A2 Autonomous Display, in its simplest form, provides a Radar Controller with a conventional p.p.i. presentation on a 405mm (16in) screen. With the addition of 'Customer Options', the basic display may be extended to provide the ability to present:

- Character label data (typically, as derived from an automatically decoded s.s.r. system)
- An electronic range and bearing line with digital readouts
- Direction finder (d.f.) data

Additional space is available within each display, such that other facilities may also be provided. These may include:—

- Radar head selection
- Internally generated characters
- Video compression.

All these facilities may be included in one display, if so desired, at the time of manufacture, or may be added at a future date.

The 16-A2 displays have been designed so that the 'Standard Facilities', in terms of the unit of range calibration, range mark intervals and range scales may all be programmed into the standard display to suit the precise operational parameters required by the customer. Contrary to previous practice, no specific components are required in a display to suit the precise customer requirements. Hence no special (and expensive) design work is necessary when manufacturing a standard 16-A2 autonomous display. The advantages to be gained by the use of autonomous displays, as opposed to a central drive system with slave displays, may be summarised as:—

- Each display is entirely independent of the others, and hence no one failure can affect all displays.
- Installation, cabling and maintenance become simple tasks.
- There are negligible system design problems.
- High quality character presentation with local generation, as opposed to centrally generated and distributed characters.

Probably the only significant disadvantage of the autonomous display concept is that display maintenance may need to be carried out in the operations room. However, with the advent of highly stable circuits using a large percentage of integrated circuits, regular maintenance is only necessary at monthly intervals. In the instance of a failure, the Plessey 16-A2 display can be easily removed from the operations room without disturbance of other displays.

Equipment description

The 16-A2 autonomous display utilises the now well-established Plessey Mk8 405mm (16in) slave viewing unit, together with a number of standard printed-circuit boards from the Plessey Real-Time Display Drive Equipment, Type PRD 100.

The complete display assembly comprises the Mk.8 405mm slave viewing unit and a plinth unit (containing the slave circuits and control panels). This is ideally suited for table or trolley mounting, but may, alternatively, be housed in a console. A separate power supply is provided with each display.

PLESSEY
electronic systems

Data Summary

Customer options

Electronic Range and Bearing Line
Direction Finder Presentation
Synthetic Data Presentation

Standard facilities

Range Calibration: Nautical Miles, Data Miles or Kilometres

Maximum Range: Timebase range may be set to any point between 50 and 300 miles or 90 and 548 kilometres

Range Expansion: Five scales, each of which may be set to any one of 64 ratios between 1:1 and 16:1 with respect to maximum timebase range

Range Markers: Markers are generated at intervals of 1, 2, 5, 10, 20, 50 and 100 units of range (n.m., d.m. or km). Any three markers may be brought out for normal operator usage

Deflection System: Single fixed coil. When calculating overall system timing, allowance for recovery time should be made on the basis of 30μs for centred picture on 1:1 expansion and 45μs for off-centred picture on maximum expansion

Video System: Five input channels, four analogue and one digital, each with individual on/off switch and gain control.

Input requirements

Trigger: +1 to +15V amplitude, 200ns to 50μs duration. Timing between 5μs and 75μs before t_0 75 ohms termination

Videos: +1 to +15V amplitude with 75 ohms termination

Azimuth: D.C. sine/cosine; balanced line or single-ended differential amplitude:—

For balanced line 2 to 80 volts

For single-ended 2 to 59 volts, alternatively synchro resolver rotating at a ratio of 1:1 with aerial. Resolver drive at 400Hz is generated in the display

Direction Finder: As for d.c. sine/cosine azimuth data, plus 'clean' closed contacts to indicate valid d.f. transmission.

Synthetic data

Main Deflection (X and Y): balanced line at 3.2V differential amplitude for maximum display range

Differential input impedance: 24k ohms typical

Auxiliary Deflection (x and y): as for main deflection, but 3.2V represents maximum screen diameter, adjustable to zero

Small signal bandwidth: 3MHz typical at 3dB points

Video: in balanced digital current drive form from Plessey Driver, Type SP721 or equivalent

Interrupt: as for Video

Power supply

Voltage: Single phase, 100 to 125V or 200 to 250V ±10%

Frequency: 45 to 60Hz

Consumption: 600VA maximum

Dimensions (overall)

	Display	Power Unit
Width	448mm	438mm
Depth	1033mm	194mm
Height	730mm	203mm
Weight	92kg	24kg

Environmental conditions

Operating temperature: 0°C to +55°C. Full accuracies of the specification will be maintained in the temperature range +15°C to +35°C

Storage temperature: —40°C to +70°C

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PLESSEY electronic systems

PLESSEY RADAR

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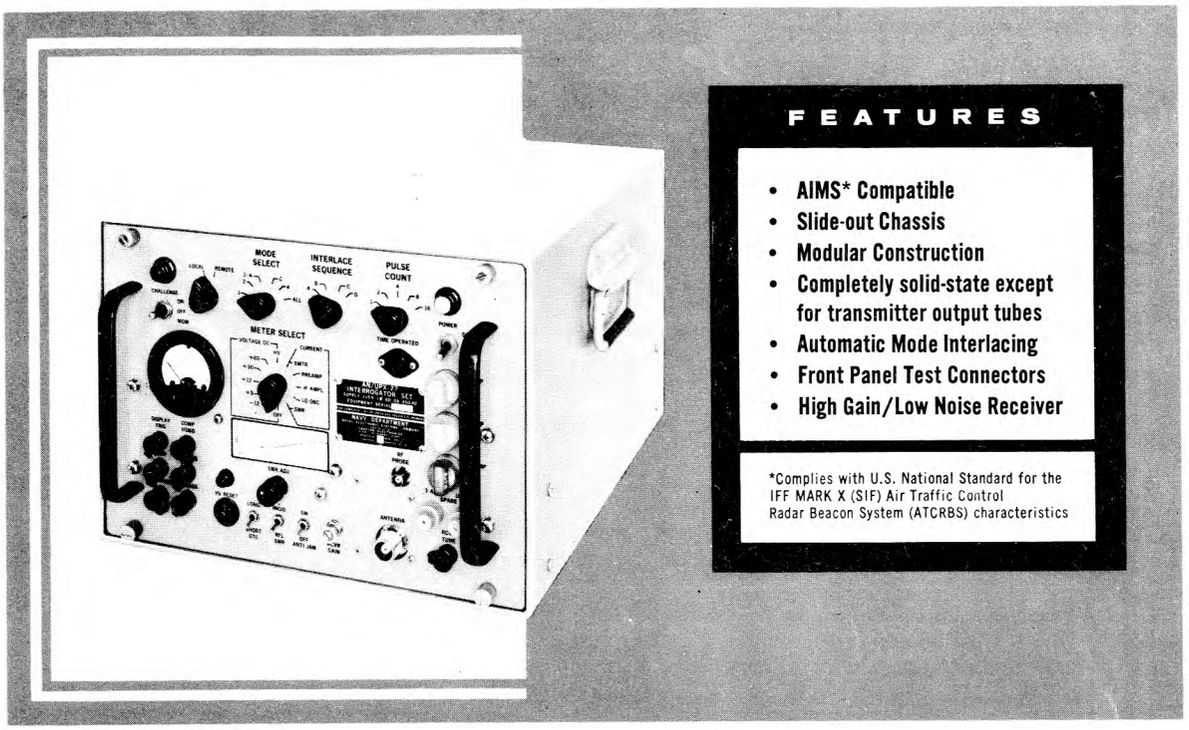
APPENDIX 2

IFF EQUIPMENT

Cardion

UPX-27 INTERROGATOR SET



FEATURES

- AIMS* Compatible
- Slide-out Chassis
- Modular Construction
- Completely solid-state except for transmitter output tubes
- Automatic Mode Interlacing
- Front Panel Test Connectors
- High Gain/Low Noise Receiver

*Complies with U.S. National Standard for the IFF MARK X (SIF) Air Traffic Control Radar Beacon System (ATCRBS) characteristics

Cardion's Interrogator Set is a lightweight, transportable Radar Recognition Set, which is intended primarily for use with one or more Decoder Groups, Radar Indicators, and Radar Sets.

The Interrogator Set is capable of interrogating MARK XII IFF/SIF type Radar Identification Sets (transponders), receiving the r-f replies from them and processing the replies into proper video signals to be applied to the Decoders and Indicators. The interrogations are transmitted on a crystal-controlled frequency of 1030 MHz; the replies are received at 1090 MHz. The Interrogator Set generates interrogation pulse pairs for Modes 1, 2, 3/A, and C whenever one of these modes is challenged. Optional expansion to include modes B and D is available. The Interrogator Set is capable of transmitting auxiliary Mode 4 interrogations. Operation from an external coder is also available.

In normal operation, the Interrogator Set is remotely controlled by a Decoder Group and Interrogator Control C8430 (furnished on special request). However, the Interrogator Set can be controlled locally by means of front panel controls. Connector receptacles for all the interconnecting cables are mounted on the rear panel (with the exception of the antenna connector, which is located on the front panel). A meter on the front panel is provided for checking voltage levels, currents and the standing wave ratio (SWR) of the antenna circuits.

Slide out chassis, printed circuit boards, spare card slots, and modular power supplies (which can be removed physically without interrupting operation) enable convenient servicing.

Cardion

UPX-27 INTERROGATOR SET

OPERATIONAL CHARACTERISTICS

Mode Interrogation	Modes 1, 2, 3/A, 4, C Modes B and D optional
Mode Interlace	Sequence A: 1, 2, 3/A, C, 1, 2, 3/A, C . . . etc. Sequence B: 1, 4, 2, 4, 3/A, 4, C, 4 . . . etc. Sequence C: Mode 4 continuous Sequence D: Program Card (not provided)
Coding	Internal: P1, P2 and P3 pulses External: optional
Transmitter	Frequency of 1030 (±0.2) MHz Min Peak RF Power — 2000 watts at duty cycles up to 1.0%
Receiver	Center Frequency of 1090 (±0.5) MHz 3 dB bandwidth of 8.0 MHz Receiver Gain of 112 dB Switch selectable long and short gain time control gate CW and MCW Anti-jamming circuits
Video Outputs	Two separated video outputs per mode Two composite video outputs
Mode 4 Capability	Video amplification and mode gating to provide display video outputs. Provisions for external processing Three pulse decoding
ISLS Trigger	Interrogation side lobe suppression pulse of 20 to 70 volts amplitude or optional ISLS switch driver
Dimensions	10.7 H x 16.1 W x 18.0 D
Weight	57 lbs
Operating Temperature	Range of −28°C to +65°C
Power	85-125 watts (depending on transmitted duty cycle, excluding 63 watts available for remote power, total 200 watts for full duty cycle and remote control)
Voltage	115 (±10%) volts at 60 to 400 Hz 115/220 volts at 50 to 400 Hz optional

PRINTED IN U.S.A.

BULLETIN NO. 26a

Cardion ELECTRONICS

Cardion

CIB-3
INTERFERENCE BLANKER

FEATURES

- ATCRBS Compatible
- Digital Storage Defruiting
- Low Power Consumption
- Front Panel Test Points
- Modular Construction
- Slide-out Chassis
- Metal-oxide-silicon storage registers
- High reliability

*Complies with U.S. National Standard for the Air Traffic Control, Radar Beacon System (ATCRBS) characteristics

Where air traffic is heavy and a large number of ground interrogators are necessary, there are a considerable number of transponder replies. These replies are triggered by all interrogators that are within transmission range. The responses are received at a recurrence frequency, which in all probability, is different from that of the desired replies. These undesired replies are referred to as "fruit."

Defruiting techniques employ delay lines, storage tubes, or digital storage to remove the non-synchronous replies on a pulse-to-pulse basis. Digital storage is employed by Cardion's blanker.

Cardion's blanker is capable of operating without modification of special triggering devices, with any associated SSR indicators and radar, including those that feature MTI, Video Integrators, Pre-Jittering, and various other techniques requiring close control of the PRF. The Blanker employs metal-oxide-silicon (MOS), integrated-circuit, static-shift registers as the memory elements and accepts any mode sequence of Modes 1, 2, and 3/A. The Blanker is designed for future expansion to provide the capability of Modes B, C, and D by the addition of circuit cards and/or components. Video signals on Modes 1, 2, and 3/A (as well as expansion Modes B, C, and D), are stored and compared with signals received in the next range period of each mode respectively. The range of the equipment is adjustable from 20-300 NM in 20-mile increments.

Automatic-noise thresholding and pulse-width discrimination are provided to improve the system signal to noise ratio. A standby mode enables extensive testing of the unit while bypassing the video to avoid interrupting the PPI Display presentation.

Slide-out chasis, plug-in circuit cards, and a modular power supply enable convenient servicing. Front panel connectors are provided for injecting test signals and also for monitoring of input and output signals.

Cardion

CIB-3
INTERFERENCE BLANKER

PERFORMANCE

1. Selectable defruiting range in increments of 20 NM from 20 NM to 300 (±5%) NM.
2. Uniform "ACCEPT GATE" width independent of range over entire defruiting range.
3. Has "RECIRCULATE" feature for compatibility with aircraft aerial switching.
4. Processing of signals to within 20 mV of noise.
5. Automatic noise threshold is capable of handling GTC or non-GTC video outputs from interrogator.
6. Input pulse width discriminator and restorer of 250 (+25, −0) nanosec. Prevents memory from overloading in presence of a noisy environment.
7. Output pulse width discriminator and restorer of 300 (+30, −0) nanosec. Provides optimum acceptance gate efficiency and prevents output noise pulses from overloading subsequent processing equipment.
8. Maximum standby-defruit video delay of 700 nanosec.
9. Operating temperature range of 0° to 50°C.

SPECIFICATIONS

INPUT REQUIREMENTS

Power: 60 watts max
Voltage: 110 ±10% VAC or 220 ±10% VAC; 45 to 400 Hz.
Triggers: SIF Trigger
Parameters: Amplitude – 2-20 volts
Polarity – Positive
Risetime – less than 0.2 μsec
Falltime – less than 0.2 μsec
Input Impedance – 75 ohms
Signal: Tagged video
Parameters: Amplitude – up to 6 volts
Polarity – Positive
Signal-to-Noise Ratio – Minimum of 2
Risetime – 0.05 to 0.10 μsec
Falltime – 0.05 to 0.20 μsec
Input Impedance – 75 ohms

OUTPUTS

Signal: Tagged video
Parameters: Amplitude – Adjustable between 0.0 and 5.0 volts (±5%) into 75 ohms
Duration – Input ±30 ns
Risetime – 0.05 to 0.1 μsec
Falltime – 0.05 to 0.2 μsec
Droop or overshoot – less than 1 dB
Video Delay – 0.7 μsec max
Temperature: 0° to 50°C
Weight: 17 lbs
Dimensions: 18 inches deep
19 inches wide
5 inches high
Shipping Weight: 43 lbs
Shipping Dimensions: 22 inches deep
22.75 inches wide
11 inches high

BULLETIN NO. 63

Cardion ELECTRONICS
A UNIT OF GENERAL SIGNAL
PRINTED IN U.S.A.

Cardion

IFF DECODER
GROUP OX-5001/UPX

MODELS
CVD-6, CDI-4,
AND CLG-2

Cardion Electronics has designed and developed the latest generation Decoder Group for use with Mark X and Mark XII (SIF) Interrogator Systems. This decoder builds upon the best features of its predecessors by providing the most processing power yet available in a manual, all digital decoder, while keeping volume and power dissipation to a minimum. The OX-5001/UPX Decoder Group consists of the KY-5035/UPX Video Decoder, the ID-5087/UPX Intratarget Data Indicator and the MX-5182/UPX Radar Target Light Gun.

The Video Decoder provides selective identification by passive decoding of all codes on Modes 1, 2, 3/A, B and D with any interlace pattern on each of four separate channels. A unique symbol is settable for each of the four decode channels. Communication failure (7600 emergency), civil emergency (7700 emergency), military emergency (4X emergency) and a user definable emergency (such as 7500 HI-JACK) are automatically decoded and displayed on the PPI with special designations. An audible and visual alarm is also provided. In addition an optional remote alarm monitor may be used.

A Selected Altitude Layer (SAL) feature is provided to decode and filter aircraft replies in specific altitude layers (whose upper and lower limits are settable in 100 foot increments).

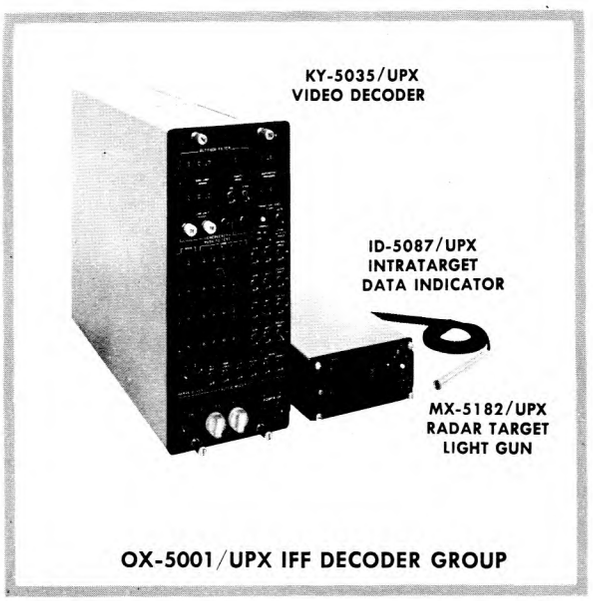
The Decoder also provides for PPI display of I/P decode, X pulse decode, all bracket display, raw video display and Mode C bracket display. Display size is automatically controlled by either the front panel Range Scale switch or the PPI range switch eliminating the need to reset internal adjustments when the PPI range is changed.

The Intratarget Data Indicator allows for active readout of a target selected by the Radar Target Light Gun on any two modes. Mode C replies are converted from hybrid-gray code. All Mode C replies below a settable transition altitude, are corrected for local barometric pressure which is operator programmable in inches of mercury. The corrected altitude is displayed on the digital readout and is also used in SAL determination.

Automatic Altitude Tracking is provided. A Mode C reply which correlates with a selected passive decode on channel 1, within ± 300 ns is presented for display on the Data Indicator and is updated for every antenna rotation.

The Video Decoder contains a built-in, self-test generator. Sufficient inputs are provided to enable operation with virtually any beacon interrogator system which complies with the provisions of ICAO, Annex 10.

The Video Decoder contains spare card slots, spare connectors and provides the necessary output signals to allow for future expansion. Additional decoding channels can be added through an expansion feature.



OX-5001/UPX IFF DECODER GROUP

Cardion ELECTRONICS

Cardion

IFF DECODER
GROUP OX-5001/UPX

MODELS CVD-6, CDI-4, AND CLG-2

DECODER FEATURE COMPARISON CHART

	AN/UPA-59	AN/UPA-59A	OX-5001/UPX
Digital Delay Line	NO	YES	YES
4 Channels Passive Decode	NO	NO	YES
Active Readout	YES	YES	YES
Passive Decode Channel Symbols	NO	NO	YES
Modes B and D Capability	NO	NO	YES
Emergency Decoding	YES	YES	YES
User Definable Emergency Decoding	NO	NO	YES
Transformer Isolated Power Supply	NO	YES	YES
Display Output Range Compensation	NO	NO	YES
Internal Emergency Alarm	NO	NO	YES
100 Foot SAL Increments	NO	NO	YES
Automatic Tracking	NO	NO	YES
Pressure/Altitude Correction	NO	NO	YES
Active Mode Indication	NO	NO	YES
Garble Sensing	YES	YES	YES
Garble Indicator	NO	NO	YES
I/P Decoding	YES	YES	YES

KY-5035/UPX DECODER

INPUT POWER	115, 220V — single phase 50, 60, 400HZ 120 watts
SIGNAL INPUTS	
Tagged Video	Amplitude 2-5 volts Impedance 75 ohms
RADAR TRIGGER	Amplitude 2-20 volts Impedance 75 ohms
ACTIVE GATE TRIGGER	Amplitude 2-5 volts
SIGNAL OUTPUTS	
Display Video (2)	2-6 volts, adjustable into 75 ohms
Parallel Code Video	Framing pulses: F1, F2 Code: A, B, C, D, I/P Decode Bracket Decode Mode Gates 4 volts, TTL compatible
PHYSICAL CHARACTERISTICS	
Size	6.5"W x 15"H x 19"D
Weight	38 lbs.
ENVIRONMENT	
Operating Temp.	−25°C to +55°C
Storage Temp.	−55°C to +125°C
MTBF	4,300 hrs.

ID-5087/UPX DATA INDICATOR

INPUT POWER	Supplied by decoder, approx. 10 watts
SIGNAL INPUTS	TTL compatible
Data Bits	
Control Signals	
SIGNAL OUTPUTS	
Light Pulse	+4 volts, TTL compatible
PHYSICAL CHARACTERISTICS	
Size	6.0"W x 3.0"H x 11.45"D
Weight	3 lbs.
MTBF	35,400 hrs.
MOUNTING PROVISION	4 #6-32 holes on bottom of unit

MX-5182/UPX LIGHT GUN

INPUT POWER	+12V, −12V @ 100mA supplied by ID-5087
WEIGHT	3 oz.
MTBF	100,000 hrs.

BULLETIN NO. 50

Cardion ELECTRONICS

APPENDIX 3

HF COMMUNICATIONS EQUIPMENT

HF Receiver with built-in preselector

R500

One of the Series 2000 range of equipments

1.6 to 30 MHz – liquid crystal readout

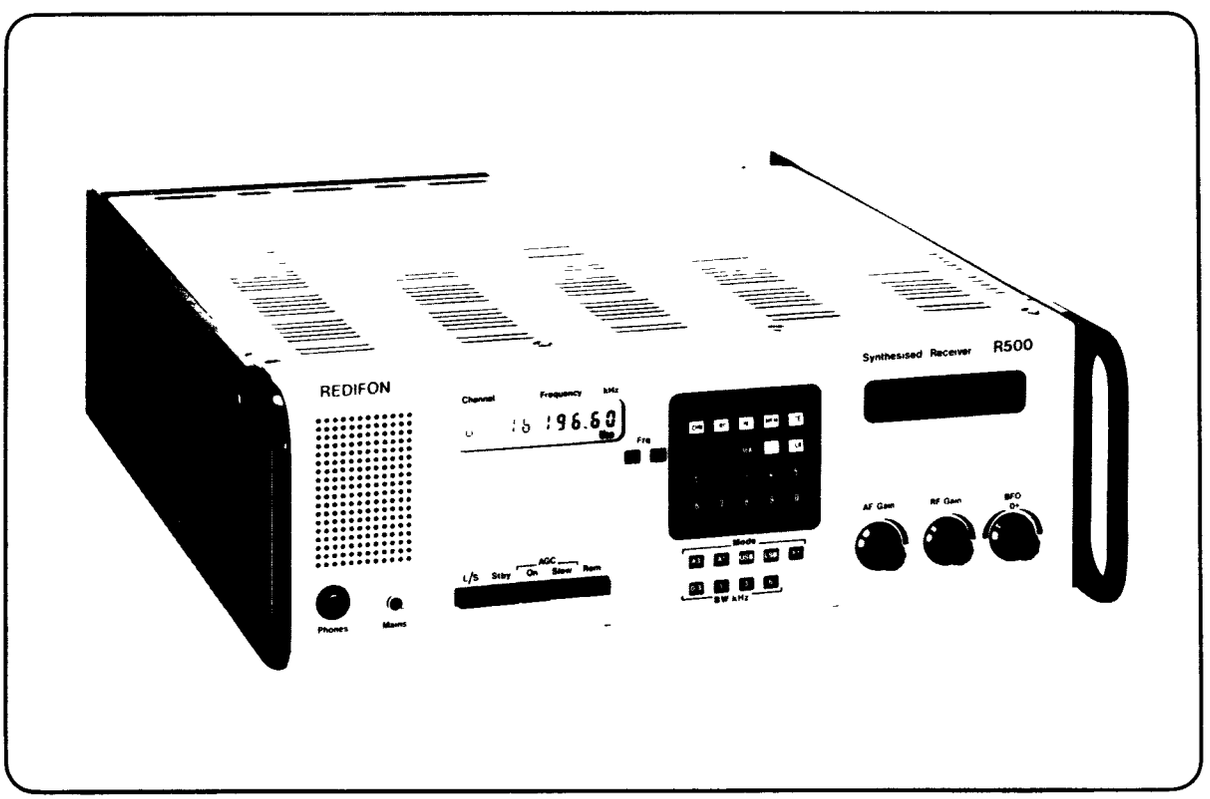
High performance at low cost

Outstanding cosite performance with built-in preselector

Modules compatible with other Series 2000 equipments

Frequency and service selection by keypad with 63 channel memory

Microprocessor control of keypad functions



REDIFFUSION
Radio Systems

HF Receiver with built-in preselector R500

THE SERIES 2000 FAMILY

Series 2000 is a new range of equipments from Rediffusion Radio Systems which represent a real breakthrough in HF communications. Series 2000 is a new approach to simplified system design which takes full advantage of microprocessor technology. It is designed around a 'family' concept with the objectives of reduced cost of ownership, higher system compatibility and better performance in electrically hostile environments.

The 'family' concept involves a high degree of commonality of modules employed in different equipments in the range. In the case of the R500 receiver and the DU500 drive unit, some 80% of modules are common. Modules form discrete functions, are readily accessible, easily serviced, and can be fitted without the need for realignment.

The R500 receiver employs single frequency conversion combined with microprocessor-controlled automatic front-end tuning. This tuning provides excellent preselectivity, so essential in cosited applications, without costly add-on preselector units or sub-octave filters.

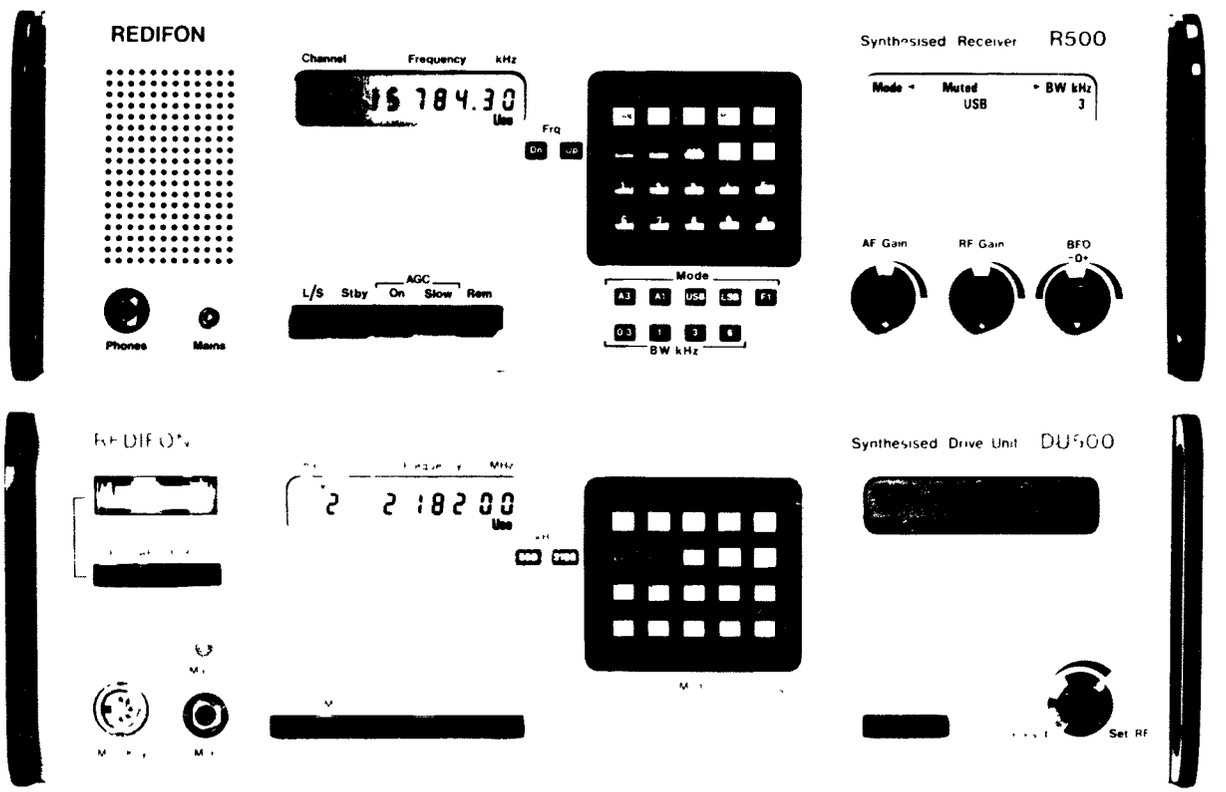
The design concept involves the use of a frequency synthesiser with only one phase-locked loop, which also reduces spurious signals to an absolute minimum.

Description

The R500 is a low cost, high performance, synthesised programmable receiver covering a frequency range of 1.6 to 30 MHz, with provision for full storage of information on 63 channels anywhere in the range. It is suitable for reception on CW, MCW, AM, LSB and USB, with an optional F1B facility. The bandwidth is selectable from 300H, 1K00, 3K00 and 6K00 on AM and CW services, with fixed 3K00 on SSB and 300H on F1B.

A built-in microprocessor enables simple keypad selection of Channel (CHN), Frequency (FRQ), Mode and Bandwidth (SER), with visual presentation on two custom-designed liquid crystal displays. These parameters may then be fed into the memory store by pressing the Memory (MEM) key. The USE key puts the receiver into the operational state.

Any channel may be interrogated by pressing the INT key whilst the receiver is operating, without interfering with the receiver operation. Two other keys are provided: Clear (CLR) allows a wrong entry to be cancelled and corrected, and Test (TST) is provided to enable



HF Receiver with built-in preselector

R500

a comprehensive fault finding check to take place. Visual indication is provided for all keypad operations. Fine tuning is provided by two buttons allowing frequency to be increased or decreased in 10Hz steps.

Having set up the receiver in this manner on the channels required, the operator has only to select the channel number and press the USE key to be in instant operation. If required the memory store can be partially (10 channels) or fully protected, by internal plug-in links, against inadvertent operator re-programming.

AGC

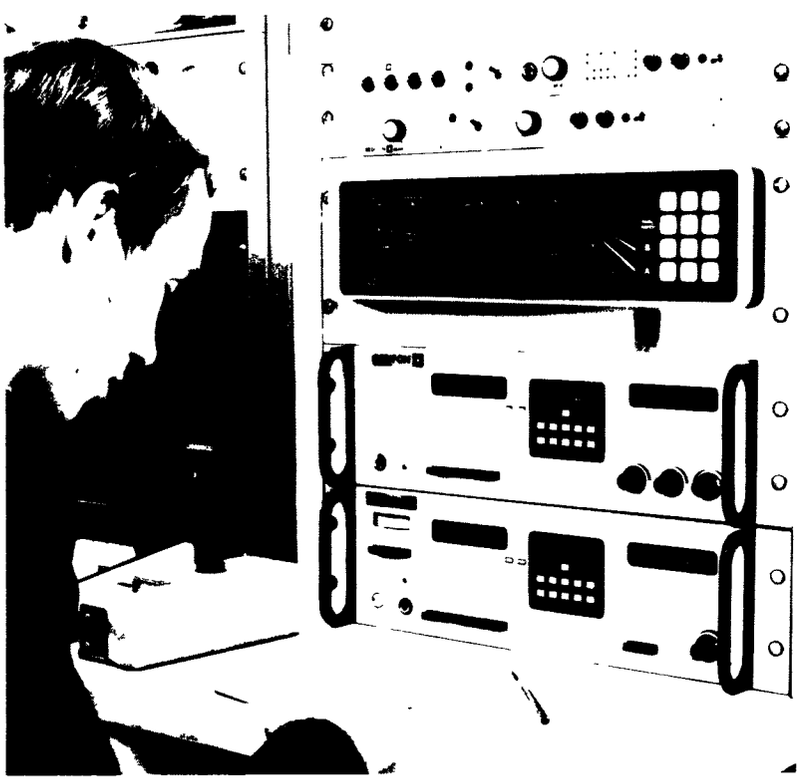
A comprehensive AGC system is incorporated in conjunction with a variable RF gain control which gives a very large dynamic range of reception with excellent linearity and minimum intermodulation products. The AGC is switchable and can be set for normal reception, for conditions of rapid fading, or switched off as required.

Protection

The receiver input stage will withstand, without damage, antenna signals up to 50 volts e.m.f. At 20 volts e.m.f., a protection circuit operates a muting relay, cutting off the incoming signal to the preselector; muting then only occurs for the duration of the excessive signal. The same relay operates while the preselector is tuning and can also be operated by a transmit/receive contact in an associated transmitter. Visual indication is given on the display when the muted condition is operative. Further protection is provided by an RF fuse and spark gap which deals with short duration voltage surges.

Extended/Remote Control Facilities

Since this is not a general requirement, in the interest of cost this facility is not provided as standard. However, a front panel switch and the necessary interconnections are included, so that should the facility be required only optional additional components on the microprocessor PCB are needed. These can be supplied already fitted or incorporated on site. Control is by serial ASCII data on one pair of wires, with another pair providing revertive data.



This 100W HF naval station uses the R500 and DU500 specially designed for the cosited role

REDIFFUSION
Radio Systems

HF Receiver with built-in preselector

R500

Technical Summary

Frequency Range
1.6 to 30 MHz in 10 Hz steps.

RF Tuning
Front end tuning is covered in five bands, each band being continuously tuned by variable capacitors. Bands are 1 – 2 MHz, 2 – 4 MHz, 4 – 8 MHz, 8 – 16 MHz and 16 – 30 MHz. The tuning is automatically set by a combined microprocessor and motor drive system. Rejection is at least 30 dB at ±5% off tune above 2MHz.

Frequency Stability
5×10^{-8} at ambient temperature −10°C to +55°C.

Reception Modes (Services)
A1A, A2A, A3E, R2A, J2A, H2A, R3E, H3E, J3E, (LSB and USB)
F1B option with 6 – 0 – 6V output; 1700 Hz ±85Hz, 100 bauds max.

Bandwidths
300H, 1K00, 3K00, 6K00. SSB passband 300 – 3000Hz.

Antenna Impedance
The receiver is designed with a nominal input impedance of 50Ω.

Sensitivity
1μV e.m.f. for a signal/noise ratio of 10 dB, SSB or 3K00 bandwidth.
2μV e.m.f. gives full audio output and is the threshold of AGC operation.

Selectivity

USB	+300Hz to +3kHz at −6 dB −500Hz to +3.8kHz at −60 dB
LSB	−300Hz to −3kHz at −6 dB +500Hz to −3.8kHz at −60 dB
AM	6K00 bandwidth at −3 dB 20K0 bandwidth at −60 dB 3K00 bandwidth at −6 dB 4K30 bandwidth at −60 dB
CW	1K00 bandwidth at −3 dB 3K50 bandwidth at −60 dB
CW and F1B	300H bandwidth at −6 dB 2K40 bandwidth at −60 dB

Blocking
A wanted signal up to 1mV e.m.f. will not have its output reduced by more than 3 dB in the presence of an unwanted signal 20kHz removed at a level of 500mV e.m.f.

Cross Modulation
A 30% modulated unwanted A2A signal separated at least 20 kHz from a wanted signal of 1mV e.m.f. can have a level up to 300mV e.m.f. before 3% cross modulation occurs.

Intermodulation Products
a) Out of Band:
For two separate 86 dBμV e.m.f. signals removed from the wanted signal by not less than 20kHz, the intermodulation products are at least 86 dB below either of the interfering signals.
b) In Band:
On SSB, and measured at the line output, two in-band signals of levels up to 50mV e.m.f. each, will produce intermodulation products at least 40 dB below each signal.

Automatic Gain Control
An increase of 100 dB from AGC threshold produces a change of output of typically less than 6 dB.
AGC time constants

	SSB	CW	AM
Attack	<20ms	<20ms	<100ms
Fast Decay	200 – 600ms	200 – 600ms	<60ms
Slow Decay	1 – 4s	1 – 4s	<120ms

An increase of 20 dB in level on an input signal giving 20 dB signal-to-noise ratio gives an improvement of at least 15 dB to the signal-to-noise ratio.

Spurious Signal Rejection
At frequencies more than ±20 kHz from the tuned frequency, the spurious signal rejection is at least 80 dB.

Intermediate and Image Frequency Rejection
The intermediate frequency at 1.4 MHz and image frequency (signal frequency + 2.8MHz) are rejected by at least:

Tune Frequency	IF Rejection	Image Rejection
20 – 30MHz	100 dB	60 dB
2 – 20MHz	100 dB	80 dB

Antenna Radiation
The level of any discrete frequency component measured into 50Ω at the antenna is typically <10μV r.m.s. from 0 – 100MHz.

IF/RF Gain Control
A range of at least 100 dB is provided.

AF Outputs and Sidetone
Internal loudspeaker
External loudspeaker: 8Ω
Headphone jack on front panel: 600Ω, 3mW
Monitor facility: 600Ω, 1mW
Line Output: 600Ω balanced, +8 dBm
There is a sidetone input for use with an associated transmitter. The signal is amplified and applied to all audio outputs with preset level adjustment.

BFO
For A1A reception the BFO gives ±3kHz variation.
For F1B (radio – telex service) the carrier insertion oscillator is used to provide an AF output centred on 1700Hz.

Maximum Signal Input
No damage is caused by input signals of up to 50V e.m.f. from a 50Ω source at any frequency between 1MHz and 30MHz.

Mute and Desense
These are provided for use with an associated transmitter. Muting contacts require external switching and typically 126 dB desensitising is provided on the application of +12V d.c.

Power Supplies
100 – 125V in 5V steps and 200 – 250V in 10V steps, 47 – 63Hz. Variations of ±10% will not degrade performance. No damage will result from surges of 100% and up to 1ms duration.
Power consumption: 60W

Environmental
Vibration and humidity to the relative clauses of Def Stan 07 – 55.
Temperature: Operating −10 to +55°C
Storage −40 to +70°C

Dimensions and Weight

Height	Width	Depth	Weight
133mm	483mm	445mm	17.2kg

Suitable for 19 in rack mounting.
Telescopic runners available.

The right is reserved to modify the design of this equipment without notice.

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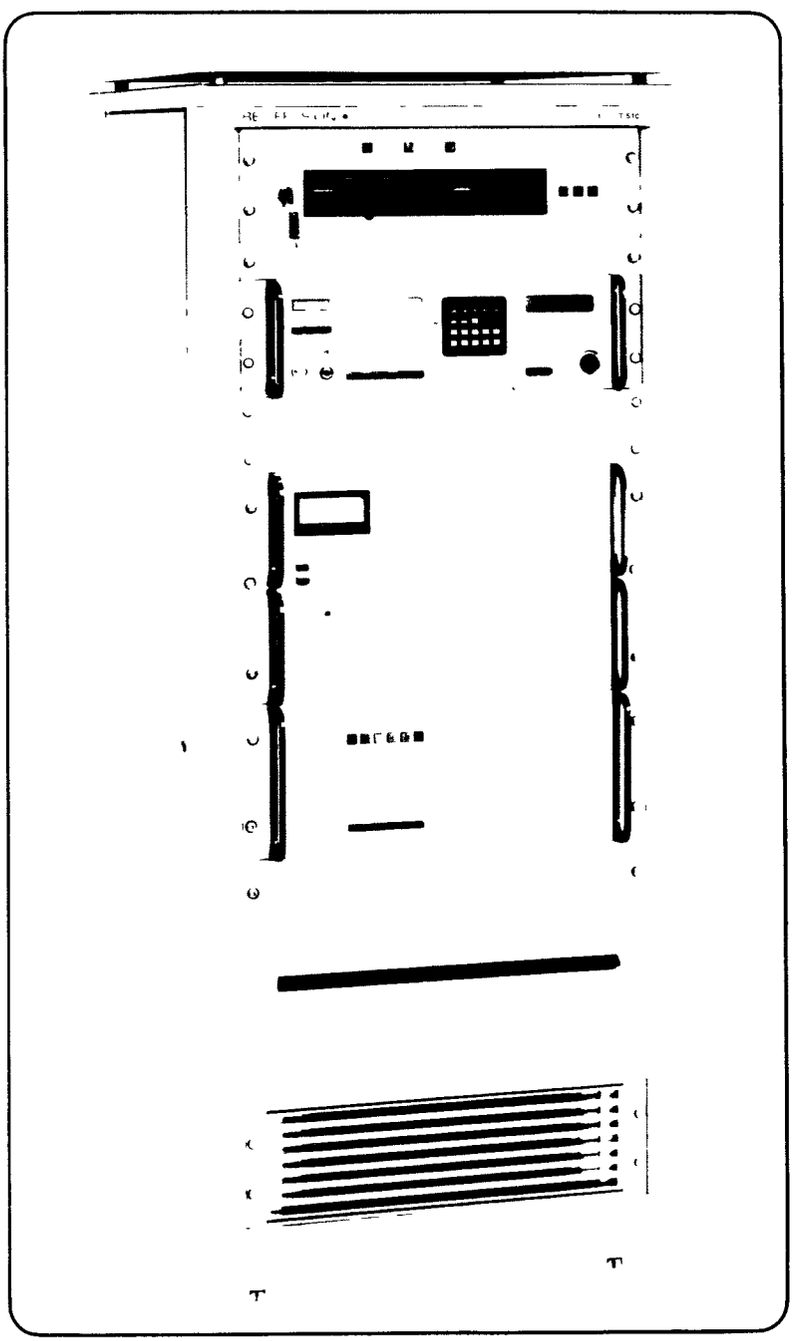
REDIFFUSION
Radio Systems

2823LANS

Registered on DCL to DEF. STAN. 05-21

500W HF Transmitter

T510



One of the Series 2000 range

Covers 1.6-30MHz with 500W p.e.p. output

Provides seven modes of transmission with micro-processor control

Outstanding electrical performance with intermodulation products at least −25 dB below 2-tone level and built in postselector for improved cosite operation

Shares many common functional modules with other equipments

Fast-tuning line matching unit tunes out any antenna mismatch up to 3:1 VSWR

Local, extended or remote control operation

REDIFFUSION
Radio Systems

500W HF Transmitter

T510

THE SERIES 2000 FAMILY

Series 2000 is a new range of equipments from Rediffusion Radio Systems which represents a real breakthrough in HF Communications. Series 2000 is a new approach to simplified system design which takes full advantage of microprocessor technology. It is designed around a "family" concept with the objectives of reduced cost of ownership, higher system compatibility and better performance in electrically hostile environments.

The five transmitters in the Series 2000 range all use the same control unit and line matching filter unit. In addition they all employ multiples of a common 250W RF power amplifier, giving a choice of power output from 250W to 1kW.

The drive units, DU500 and DU505 have an in-built postselector, providing a high degree of drive signal selectivity without costly add-on units. The DU505 offers the option of independent sideband operation and high speed VFT data.

Two of the high performance transmitters, the 1kW T1015 and the 500W T515 use the DU505 drive unit. These two and the 1kW T1014 (with DU500) provide outstanding electrical performance with intermodulation products at least 35dB below 2-tone level and have ventilation arrangements which are capable of being ducted.

The 1kW T1010 and the 500W T510 are built into a smaller cabinet for areas where space is more restricted. They have a mean power output of 500W and 250W respectively, with overdrive on modulated services giving intermodulation products typically 25dB below 2-tone level.

The "family" concept of Series 2000 allows the customer to select, say, one high performance transmitter from the top of the range to work in conjunction with several of the lower cost transmitters whilst retaining the advantages of reduced stocking of spares, simplified training and outstanding cosite performance.

The exceptional degree of commonality of functional modules is extended to receivers and transceivers in the range.

Description

The T510 is the most economical of the new range of transmitters. It can provide an output of up to 500W on peak envelope power on modulated services. The mean, unmodulated power output for keyed service operation is 250W.

The T510 is particularly suitable for cosited applications on account of its outstanding noise performance (typically – 120dB at 5% offtune). A postselector built in to the drive unit ensures a 'clean' stable signal for the wideband amplifier.

The Drive Unit DU500 is used in the T510 and covers the range 1.6 – 29.99999MHz in 10Hz steps. It develops seven modes of transmission including data and up to 62 channels can be programmed.

Drive Unit

The DU500 is a self-contained highly flexible synthesised programmable drive unit for use with almost any HF transmitter or linear amplifier requiring an input of 100 milliwatts. There is provision for storage of full information on 62 channels anywhere in the range of 1.6 to 30MHz in 10Hz steps. Two of these channels are pre-determined as emergency channels and are selectable by pressing a single button. The drive unit is suitable for transmission on CW, compatible MCW, compatible AM, LSB, USB and F1.

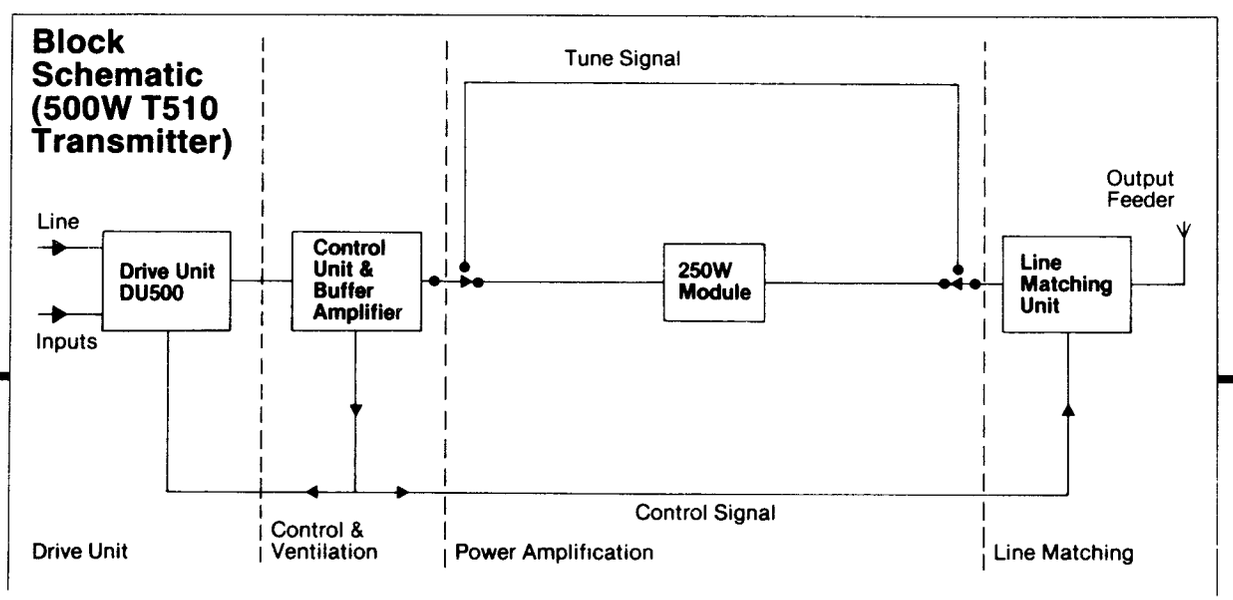
A built-in microprocessor enables simple keypad selection of Channel (CHN), Frequency (FRQ), and Mode (SER) with visual presentation on two liquid crystal displays. These parameters may then be fed into the memory store by pressing the Memory (MEM) key. The USE key puts the drive unit into its' operational state.

Any channel may be interrogated by pressing the INT key whilst transmission is taking place without interfering with operation. Two other keys are provided: Clear (CLR) allows a wrong entry to be cancelled and corrected, and a Test (TST) key is provided to enable a comprehensive fault finding check to take place. Visual indication is provided for all keypad operations.

Having set up the drive unit in this manner on the channels required, the operator has only to select the channel number and press the USE key to be instantly operational. If required the memory store can be protected, by an internal plug-in link, against inadvertent operator reprogramming.

Input Facilities

Comprehensive input facilities are provided. A jack for key or microphone is located on the front panel. Rear connections are available for line and auxiliary inputs, each having its own level



control. A 6-0-6V teleprinter input can be accommodated, and an optional internal F1 modem converts this into voice frequency telegraphy. All these functions are selectable from the front panel.

Microprocessor Control
The most up-to-date technology has been used throughout the design of the transmitter. The maximum advantage has been taken of the flexibility and versatility of the microprocessor for implementing complex control functions required by both the drive unit and the line matching unit with the minimum hardware complexity and therefore minimum cost.

Modular Construction
All the transmitter units employ modular construction and costs have been minimised by employing modules common to other products in the range. The power amplifier is a single 250W RF output unit which contains the mains power supply, driver amplifier/splitter, two PA sub-modules and their output matching/combining module. Each one of these sub-modules is easily and quickly replaceable without the need of a soldering iron after a simple diagnosis of the faulty area by lamp indication.

There is sufficient space to include a further 250W unit and, as the power amplifier contains its own power supply, it is possible to change the power rating of a transmitter from 500W p.e.p. to 1kW p.e.p. by a simple change in the combiner module and the inclusion of an additional power amplifier unit.

Line Matching and Antenna Unit
Previous experience with wideband solid state transmitters has indicated that antenna loads presented to the output terminals of any transmitter is far from ideal. A fast tuning, line matching unit has therefore been included in the transmitter cabinet to tune out any mismatch up to 3:1 VSWR as well as attenuate PA harmonics to the CCIR recommended levels. This line matching unit also contains interfacing circuitry for an external ATU which can be added to the system at any time if a high 'Q' antenna such as a whip antenna becomes an operational necessity. The control of the line matching unit is passed automatically to the ATU via the interfacing circuitry when the ATU is connected to the transmitter, and reverts automatically to the line matching unit on completion of ATU tuning.

The tuning accuracy of these two units has been enhanced by accurate monitoring coupled with microprocessor control of the tuning elements via precision stepper motors. This is a similar technique to that employed in the drive unit (DU500) for 'postselection' of the wanted signal. A common processor board is used in the two units but different software is utilised in each unit for executing the different control requirements.

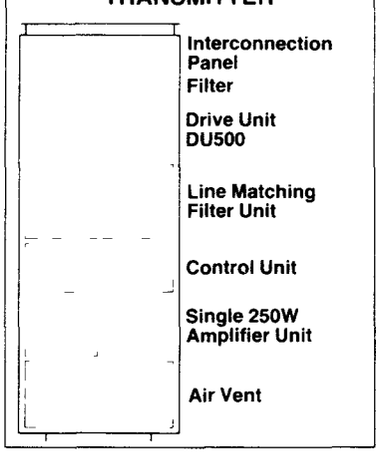
Ventilation
The entire cabinet is forced-air cooled. The cooling air, primarily intended for the power amplifier, is drawn into the top of the cabinet through a dust filter and down across all the units in the cabinet to the blowers mounted in the control unit. These force air down across the PA units to the exhaust vent in the plenum chamber at the bottom of the transmitter.

Diagnostics
Comprehensive metering and functional checks are provided, allowing continuous performance monitoring and aiding in fault diagnosis. Each of the major units in the T510 is monitored separately. The following is a unit-by-unit summary of the monitoring facilities provided.

1) **Drive Unit (DU500)**
   a) Selected input line level
   b) Processed AF input level to modulator
   c) RF drive level
   d) Test switch to provide audio drive and press-to-talk in selected mode
   e) Test key provides display check and full memory integrity check
   f) Power on
2) **Control Unit**
   a) Power on
   b) VSWR above predetermined threshold
   c) Tuning is in progress
   d) Test key to provide program memory integrity check
   e) PA unit fault indicator
   f) Unable to tune indication
3) **PA Unit**
   Each PA unit will display an indication of the following:
   a) Over temperature on each PA sub-module
   b) Supply 'on' indication
   c) A signal input/output comparison fault
4) **Line Matching Filter Unit**
   a) Forward power meter
   b) Reverse power meter

In addition to these test indications and controls, each module has a full range of test points for monitoring major functions.

SCHEMATIC LAYOUT OF TRANSMITTER



500W HF Transmitter

T510

Technical Summary

Frequency Range
1.6-29.99999MHz

Power Output
Minimum power output is 500W p.e.p. and 250W mean into matched 50Ω coaxial feeder. Full output power of not less than 500W p.e.p. is provided over the entire frequency range (1.6-30MHz). This power will also be provided over the full supply variation. The matching unit in the transmitter will match loads of up to 3:1 VSWR.

Modes of Emission
SSB: H3E, R3E (– 20 dB carrier USB or LSB), J3E (– 40 dB carrier on USB or LSB).
MCW: H2A (USB only).
CW: A1A, J2A (USB or LSB) keyed on/off tone with fully suppressed carrier (– 40 dB)
Data: FIB (±85Hz using 1700Hz centre frequency modem, external or internal)

Frequency Stability
a) EXTERNAL STANDARD
The DU500 Drive Unit accepts a minimum of 0 dBm via 50Ω (220mV) at 1MHz
b) INTERNAL STANDARD
After 30 days, the frequency will not swing by more than 1 part in 10^7 in any 30 day period. After 30 minutes warm up, the frequency stability over a 24 hour period at fixed temperature is 1 part in 10^8. Variation with ambient 1 part in 10^9 per °C.
c) If either internal or external frequency standard fails, the output is inhibited and the muted legend displayed.

Phase Stability
With the frequency in use, set in 100Hz increments, the peak deviation of the output signal set at 29.99990MHz is 5° in any 10ms period.

Intermodulation
The two tone intermodulation products are typically 25 dB below either of the two equal tones (– 31 dB wrt p.e.p.) as recommended in CCIR (recommendation 328) for SSB operation.

Spurious Emission
All harmonics of the wanted signal will be at least – 44 dB with respect to p.e.p. i.e. less than 16mW. Any non-harmonic spurious outputs are typically – 53 dB.

Wideband Noise
The wideband noise plateau of the power amplifier in the T510 is – 130 dB wrt full p.e.p. The drive unit takes full advantage of this low figure by using a postselector in its output to reduce the drive unit noise to a nominal – 120 dB at 5% off tune. This gives more than adequate performance for duplex working with receivers cosited with transmitters.

Audio Input
Audio input range over which full p.e.p. output can be obtained is – 30 dBm to + 10 dBm. The input impedance is 600 ohms over the adjustment range of the preset control (better than 20 dB return loss).

Automatic Level Control
When the ALC is selected, the RF output remains constant for an audio input variation of ±10 dB about a range which can be preset from – 20 dBm to 0 dBm. The attack time for this control is 5ms during which time a clipper, set at + 1 dB above the required output level, prevents any over drive. The decay time for the automatic control is one second.

Carrier Suppression
Carrier power will be set to – 6dB on H2A and H3E, – 20 dB on R3E and suppressed to at least – 40 dB on J2A and J3E.

Unwanted Sideband
Unwanted sideband will be suppressed to better than – 50 dB with respect to full p.e.p. on the other sideband.

Audio Response
Band-pass ripple between the maximum and minimum 3 dB band edge points (300Hz-3000Hz) does not exceed 3 dB. Ignoring band edge roll off, this figure is better than 1 dB. The – 60 dB response is 3600Hz to – 400Hz.

Press to talk
External connections provide for press-to-talk.

In-band Noise
When the press-to-talk switch is inactive, the noise measured in any 3kHz bandwidth will exceed – 130 dB relative to full p.e.p.

MTBF and MTTR
The estimated MTTR at second line service for the T510 is 30 minutes. The MTBF of the system failing to half rated power is over 3000 hours, at 100% utilization.

REMOTE CONTROL
Control Features
In addition to operation under local control, the transmitter is capable of being operated under remote or extended control via a serial data stream.

Control Indication
The following indications will be available at the remote control unit:
Transmitter No in control
Channel No
Frequency
Mode of emission
Ready/Tuning
On/Standby
Vox on/off
Press-to-talk active
Nominal carrier is indicated for suppressed carrier services. In addition to this dedicated control unit an intelligent VDU control unit is available which can provide for a variety of display formats under software control giving the user the opportunity to define the displayed information without being constrained by the necessity for changing hardware.

Connection to British Telecom Lines
British Telecom lines carrying both audio and remote control information can be connected to the transmitter via an external remote control interface unit and line modem where necessary. Where multiple transmitters are used on one site, this unit will also route the control information to the addressed transmitter. It also contains British Telecom-approved barrier protection units for the connection of both traffic and control lines.

POWER REQUIREMENTS
Power Supplies
The T510 accepts 200 to 250V a.c. supply or 100-125V selectable in 5 volt steps. The frequency of the supply should be between 47 and 63Hz. At any of the selected tapping voltages the T510 will operate within specification over variations of ±6%. The programmed channel, its frequency and service information, are stored in a non-volatile memory which will retain the information indefinitely in the event of a power supply failure.

Power Consumption
The total power consumption for 500W p.e.p. output is under 1.2 kVA. With the press-to-talk switch inactive the total power consumption will be less than 400VA.

Dimensions and Weight

Height	Width	Depth	Weight
1473 mm	584 mm	737 mm	153 kg

Linear dimensions are exclusive of shock mounts.

General Technical Requirements
The T510 has been designed to meet the following clauses and tests of DEF STAN 07 – 55/1
A1(3) Vibration
A1(4c) Vehicle transportation
A8(b) Bounce (Packaged)
A4 50mm Drop
A10 40g Packaged drop test
Additionally the following clauses of DEF STAN 07-55/2 are met.
B1 to + 55°C operational
B1 to + 70°C storage
B4 to – 10°C operational
B4 to – 40°C storage
B7 to + 40°C @ 95% RU operational
B11 Altitude to 3000m

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