

Swordfish

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Summary The Marconi Swordfish transceiver is a multi-mode frequency-agile v.h.f./u.h.f transceiver designed for military or civil use on land or at sea.

It covers the range 30MHz to 400MHz, with a.m, f.m, s.s.b and c.w capability. Voice or data can be handled, and both speech-encryption and fast-frequency hopping are optional. Additionally the transceiver may be configured for Satcom or Link 11 use.

Swordfish is modular in construction and features an automatic built-in test system which enables fault location to an individual module.

As a consequence of these features, Swordfish is versatile, cost-effective and is easy both to use and to maintain.

Introduction

Swordfish is a new concept in the field of v.h.f and u.h.f transceivers. It is capable of fulfilling a very wide range of operational roles in naval, military, civil and civil aviation fields and offers a greater choice of operating modes than equipments currently in service.

This degree of flexibility is achieved by modular design (figure 1). Each module performs a specific function and can easily be replaced or upgraded. Thus it is possible for the user to configure the transceiver to suit current requirements and budgets, and upgrade it at a later date.

By paying particular attention to the design of the front panel, Swordfish has been made as simple to operate as possible (figure 2). The key pad has large, easy-to-read keys, each incorporating tactile feed back. Key sequences have been kept to a minimum with the software prompting the operator via the dot matrix display when necessary. User friendliness and reliability is further enhanced by the addition of a self-test facility which enables rapid fault location to module level. These features, together with the comprehensive status monitoring available via the display, make Swordfish easy to use and maintain. The principal functional blocks are shown in figure 3.

Operational characteristics

Frequency ranges

Swordfish operates in the ranges

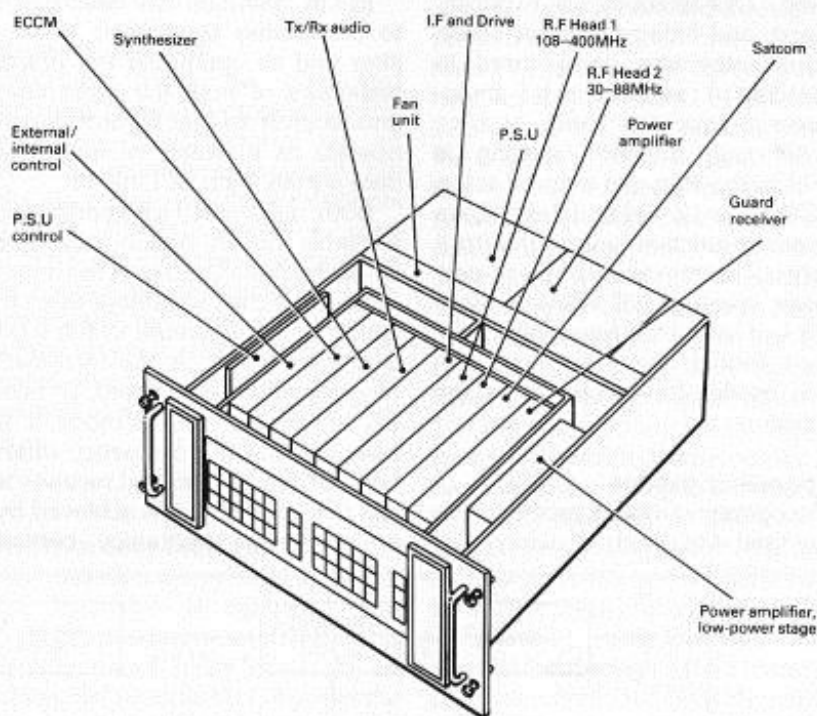


Fig. 1. Diagram showing modular design of Swordfish

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Kevin Kearns graduated from Manchester University in 1977, after obtaining an Honours Degree in Physics. He then joined Racal Tacticom as an r.f design engineer working on the Jaguar range of military manpacks. Kevin joined Radio Systems Division of Marconi Communication Systems in 1984 as a Section Leader, and later became Project Leader with responsibility for the development of the Swordfish v.h.f./u.h.f transceiver. He was promoted to his present position of Group Leader in 1985 and has responsibility for the development activities of the Tactical Department of Radio Systems Division.





Fig. 2. The land version of Swordfish

108MHz to 174MHz and 225MHz to 400MHz as standard. With the optional addition of one extra module, the coverage can be extended to the 30MHz to 88MHz band. This removes the expense, space, and fitting problems which would otherwise be incurred in installing a separate v.h.f transceiver to cover this band.

Although channel spacing is 25kHz, the step size may be set to 6.25kHz or 12.5kHz, if desired, via a special-function key on the front panel. The provision of these narrower spacings will allow a more efficient use of the frequency spectrum should alternative transmission modes be employed in the future.

Operating modes

The operating modes provided are a.m and f.m, both of which will

support clear voice, digital voice using 16kbit non-return-to-zero data, Teletype and hand-keyed morse. In the a.m mode, a 16kbit diphas capability is also provided.

In f.m, attention has been given to minimizing synthesizer phase-jitter and to optimizing the phase responses of both the transmitter and receiver so that Swordfish can operate as a bearer of multitone data signals such as Link 11.

Both u.s.b and l.s.b modes are available as an option over the whole frequency range of the transceiver. The chief advantage of s.s.b, which is a new feature in the v.h.f and u.h.f bands, is the increased range that can be obtained. To take full advantage of this mode it is essential that the frequency offset between transmitter and receiver is less than 30Hz. This is achieved by an automatic frequency control

(a.f.c) loop to remove frequency errors due to temperature effects and Doppler shifts.

Swordfish also provides an optional u.h.f satellite communication (Satcom) capability to enable communications well beyond the normal radio horizon encountered in line-of-sight links. An optional, multi-rate, phase shift keying/differential phase shift keying (p.s.k/d.p.s.k) modem allows split-frequency data transmission.

Transmitter

The transmitter, which is force air-cooled, using a.c fans for reliability, has a 100W p.e.p output in s.s.b and c.w modes. A 25W carrier output is available for a.m use. These power levels are available for use at any frequency within the 30MHz to 400MHz range of the transmitter.

The output power may be switched to one of ten preset levels via a front-panel key. Each level represents a 3dB change in output, thus power may range from 200mW to 100W.

Emergency signals

For reception of emergency signals an optional guard frequency module may be accommodated in the Swordfish chassis. Its function is to monitor the civil and military emergency channels 121.5MHz and 243MHz in parallel with, and independently of, the main

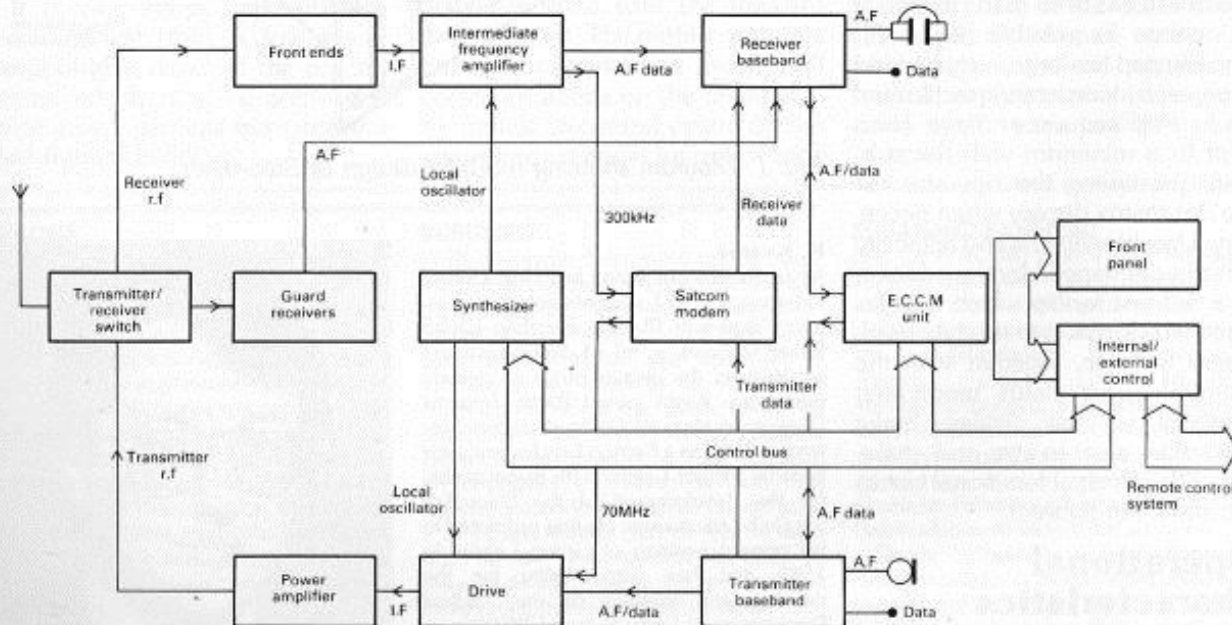


Fig. 3. Swordfish block diagram

receiver. If the main receiver is operating in the 108MHz to 174MHz band it will select the 121.5MHz channel, and if in the 225MHz to 400MHz band the 243MHz channel will be monitored. When an emergency signal is received, the operator will hear the message irrespective of the mode or frequency of the main receiver, and can quickly reply to the transmission simply by pressing one button on the transceiver front panel.

ECCM and ECM capability

The transceiver has a fast frequency-hopping, electronic-counter-counter-measures (ECCM) capability. This has been achieved by developing a fast-locking synthesizer in conjunction with fast-tuning receiver front ends and wideband, high-power, transmitter stages.

As the ECCM and synthesizer modules are replaceable, various hop-rates and ECCM systems can be accommodated. A Havequick module is available to obtain compatibility with NATO forces, and a Scimitar ECCM module for the optional 30MHz to 88MHz coverage can also be housed in the chassis.

A further ECCM mode provides burst-data operation. Using a Marconi Mardate terminal it is possible to transmit and receive burst-data messages, which are difficult to intercept or detect because of their short duration. A message, which may be in plain text or ciphered, is entered using the Mardate keyboard, checked on the display and then transmitted. A reply is received and automatically decoded and may be read from the Mardate display when required.

Optional voice encryption is available in all modes and on all frequencies, using either an optional internal module or an external equipment operating at up to 16kbit/s.

The Swordfish receiver can be used in an electronic counter-measures (ECM) role by using the built-in scanning facility in conjunction with a panoramic adaptor connected to an output port at the first intermediate frequency. Various sweep band-widths and rates may be programmed using a special-function key on the front panel. The

sweep may be continuous for rapid checking of band occupancy or be arranged to stop when a signal exceeding a preset threshold is detected.

To process the ECCM and frequency data efficiently a fill management system is available. It consists of two equipments, a fill-gun and a fill management unit. This latter is used to store all the frequency, channel, mode and ECCM data for each net, thus acting as the master source of the overall frequency plan. This data is then downloaded into the hand-held fill-gun and disseminated to each transceiver as required. Both items have a 'zeroize' function whereby data may rapidly be erased in an emergency.

Remote control

Swordfish may be controlled remotely via a wide range of control interfaces. Serial control via an RS232C interface is standard, but the user may specify an optional 1553B MIL-STD bus or a naval ICS3/Seafox interface. It is possible to control all the functions of the transceiver remotely. In situations where space is restricted, the front panel may be detached and re-located in a more convenient position.

Built-in test facilities

To maximize operational availability, Swordfish is equipped with built-in test equipment (BITE). This rapidly traces faults down to an individual module and obviates the need for trained-operator intervention.

Two levels of BITE are provided. The first is automatic and checks the general status of the transceiver. If a fault condition is detected the operator is alerted both audibly and visually on the display. The second level of BITE can then be entered, initiating a sequential search of each module. If a fault is detected, the status display will read 'Test Fail' followed by an indication of which module is faulty - for example, 'Mod 6, Audio'. The faulty module may then be removed and the replacement will automatically be tested when power is applied to the equipment.

Electrical characteristics

Figure 3 shows the block diagram of the transceiver.

Antenna selection

The transceiver is fitted with four antenna connectors to allow selection of the antenna appropriate to the operating mode and frequency. In multi-equipment fits, such as on board naval vessels, the transceiver is normally operated, via a multi-coupler system, into common transmit and receive antennas. The selected antenna is routed to either the receiver or transmit power amplifiers via a high-speed pin diode switch.

Receive system

Received signals are fed through a protection circuit to one of two tuned r.f heads, one covering the two bands 108MHz to 174MHz and 225MHz to 400MHz, and the other the 30MHz to 88MHz band. From the selected r.f head the signal is passed to a high-intercept point, double-balanced mixer which produces an i.f output of 70MHz. This signal may be fed either to an external modem port for Satcom or fast ECCM systems, or to a second mixer. Here it is converted down to 10.7MHz and is then fed through a crystal filter which determines the i.f bandwidth according to the operating mode selected. A 50kHz-wide filter is provided for 16kbit NRZ and diphas data use and a 16kHz filter is fitted for voice and teletype traffic.

Following amplification, the signal is fed through a third mixer to produce a final i.f of 300kHz, which is passed to the a.m, f.m and s.s.b demodulators. The audio or data signals are routed via the appropriate post-demodulation filter to the remote lines, the ECCM module or, for local use, the loudspeaker/headphone. An a.g.c system maintains a constant output with attack, hold and decay time constants selected in accordance with the operating mode. Also fitted is an adjustable multi-mode squelch system.

Transmit system

In the transmit mode, audio signals are routed through a voice-operated gain-adjusting device (VOGAD) to maintain a constant

audio modulation level. Data signals are passed through the appropriate pre-modulation filter. The selected input is then fed to the corresponding modulator (a.m, f.m or s.s.b). A keyed 1kHz tone oscillator provides c.w in s.s.b and m.c.w in a.m or f.m.

For a.m and f.m, the audio or data signals are converted within the synthesizer module to an i.f of 70MHz. For s.s.b, signals are routed to an optional modulator and drive board, producing an output of 70MHz. An optional modem for Satcom provides a drive at 70MHz, and a separate drive can be produced for an external ECCM modem if required. The selected 70MHz drive is then combined with a local oscillator signal from the synthesizer in a high-level mixer which provides a signal at the final r.f to drive the power amplifier.

The 100W power amplifier comprises four stages of amplification designed to give linear operation over the whole 30MHz to 400MHz band. The final output is routed through a current-and-voltage monitor and a reflectometer to generate a.i.c and v.s.w.r signals and then by way of the transmit/receive switching circuit to the selected antenna. A filtered and buffered output at approximately 200mW is available to drive an external high-power amplifier.

Synthesizer

The local oscillator signals for both transmit and receive circuits are

generated in the synthesizer module which is referenced either to an internal crystal oscillator or an external high-stability 1MHz standard.

To provide both low-noise for use near other equipment and short lock-times for fast frequency-hopping uses, a twin-loop synthesizer has been designed. It is made up of two single loops which operate in an alternate 'one locked, one locking' sequence. By this means, lock times of the order of a few hundred microseconds are achieved.

Controls

The front panel has a waterproof membrane keypad with 'feel' provided by snap-domes. The keys are arranged in specific functional blocks such as mode-select, test and measurement, etc. (figure 2).

The microprocessor-controlled, internal/external control module transmits and receives data from the other modules and also controls the synthesizer via a data bus. It thus completely controls the operation of the transceiver. This module also contains a replaceable remote control interface board which provides compatibility with 1553B, RS232 or ICS3 remote-control systems. Other interfaces may be specified by the user.

Character and address lines from the internal control module enable the required frequency, mode or operator prompts to appear on the 7x5 dot matrix display. The ability

to handle full alphanumeric contributes greatly to the user-friendliness of the equipment.

Power supply

Operation may be taken from 115/240V, 50/60Hz mains. There is full protection from r.f interference, overvoltages and short-circuits.

Mechanical characteristics

Continuous operation in harsh military environments, combined with ease of operation and maintenance are features catered for in the mechanical design which is built to DEF-STAN 07-55. The modular construction is based on a rugged chassis, with 19in rack mounting.

Modules are interconnected via a motherboard at the bottom of the chassis. For servicing, the transceiver can be drawn forward from its cabinet and access to the modules is from the top.

Conclusions

The adoption of a modular design in both hardware and software has made it possible to produce a multi-mode, frequency-agile v.h.f./u.h.f transceiver, which is compatible with present-day requirements but has the capability of being upgraded to meet future needs. It combines reliability with low cost and has both military and civil applications.

Résumé

L'émetteur-récepteur Swordfish de Marconi est un poste à ondes métriques/ondes décimétriques multimode à fréquence agile, spécialement conçu à des fins militaires ou civiles, sur terre ou sur mer.

Couvrant la portée de 30MHz à 400MHz, il se caractérise par ses possibilités m.a, m.f, b.l.u et de graphie, pouvant en outre prendre en charge des fonctions de téléphonie et de transmission de données, le chiffrement vocal et le saut de fréquence rapide représentant des options. Il peut aussi être agencé en tant que terminal Satcom ou Link 11.

De construction modulaire, le Swordfish est équipé d'un système de test incorporé automatique qui permet toute détection d'avarie par module individuel.

Compte tenu de tous ces atouts, le Swordfish est un équipement polyvalent, d'un rapport coût-efficacité remarquable, d'une manipulation et d'un entretien des plus aisés.

Resumen

El Swordfish de Marconi es un transceptor V.H.F./U.H.F multimodal, ágil en frecuencia, diseñado para aplicaciones militares o civiles, en tierra o en el mar.

Comprende la banda de 30 a 400MHz y tiene capacidad A.M, F.M, S.S.B (banda lateral única) y C.W (onda continua). Permite cursar señales vocales o datos, junto con las opciones de encriptación vocal y saltos rápidos de frecuencia. Adicionalmente, el transceptor puede configurarse como terminal Satcom o Link 11.

El Swordfish es de construcción modular y lleva incorporado un sistema automático de pruebas que permite localizar las fallas en los módulos individuales.

Como resultado de estas características, el transceptor Swordfish es muy versátil, económico y eficaz, con fácil manejo y mantenimiento.

Zusammenfassung

Der Marconi Sender/Empfänger Swordfish ist ein für Wahlbetrieb ausgelegtes V.H.F./U.H.F.-Gerät, welches für militärische oder zivile Anwendungen an Land und auf See bestimmt ist.

Das Gerät deckt den Bereich von 30MHz bis 400MHz mit A.M., F.M., ESB- und engedämpfte Welle-Betrieb. Sowohl Sprach- und Datenbetrieb ist möglich mit wahlweiser Sprachverschlüsselung und Frequenzhüpferschaltung. Zusätzlich eignet sich das Gerät zur Ausbildung als SATCOM- bzw. LINK 11-Terminal.

Swordfish ist in Bauteinkonstruktion ausgeführt mit einem eingebauten automatischen Testsystem, mit dem eine Störung auf einen einzelnen Baustein zurückgeführt werden kann.

Dank dieser Einrichtungen erweist sich Swordfish als anpassungsfähig, kostengünstig sowie bedienungs- und wartungsfreundlich.