Transportable satellite earth terminals

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Summary This article describes the new Marconi Type P7020 Transportable Satellite Earth Station. Performance, and characteristics of the various elements of the earth terminals are given, with special attention being paid to the elliptical antenna which is of unique design. Uses to which the terminals may be put are discussed and mention is made of other terminals in the Marconi range of transportable systems.

Introduction

In recent years there has been a rapid expansion in the use of transportable satellite earth terminals. This phenomenon has arisen for a number of reasons, viz:

a) the requirement of news organizations to broadcast sound and vision directly from the event,

b) the need to have cheaper electronic equipment capable of meeting the same performance criteria,

c) delivery timescales which are much less than those for fixed earth stations, which required buildings, power supply, etc.

The major growth area, until recently, has been the USA. The first transportable terminals came into use in the mid 1970s. They operated at C-band (6/4GHz) and used 6m dish antennas mounted on 12·8m (42ft) trailers. Over the past decade the antennas, and hence trailers, have reduced in size. Also another frequency band, Ku band (14/11GHz), has become available.

There are, of course, as many solutions as there are operational requirements regarding transportable satellite earth terminals. However, most scenarios in the field can be met by just three major types of terminal:

a) the trailer-mounted or flat-bed vehicle supporting a 5·6m diameter antenna with high-power amplifiers (h.p.a) of typically 600W output power,

b) an antenna of approximately 2·4m diameter mounted on a land cruiser type of vehicle using either one 300W h.p.a or two in parallel to produce 600W output power,

c) the 'flyaway' type of package using a lightweight, easily stowed antenna of approximately 1·8m diameter in conjunction with either a 300W or 600W h.p.a.

In simplistic terms, a) is used for pre-planned and/or full broadcast events, whereas the other two types are applied more for emergency events. Marconi Communication Systems manufactures all three types and this article will deal in depth with a). Types b) and c) will form the subjects of future articles.

General description

The P7020 terminal has a trailer-mounted, offset-fed, Gregorian antenna. The elliptical shape of this antenna leads to a very compact design with low wind loading, resulting in good physical stability. The electronic equipment is housed in a container which can be mounted either directly on the trailer or on the towing vehicle. The equipment configuration can give single or redundant communication chains as shown in figure 1.

The system is readily transportable by road, sea or air and there are two standard implementations to suit different operational needs:

a) a steered trailer with electronics equipment housed in pannier-style cabinets. This alternative gives a compact and very economical package that is particularly suited for rapid deployment by road, rail, sea or air.

b) a low-loader/semi-trailer with electronics equipment housed in a small ISO-style container. This alternative is also transportable by road, rail or sea. It offers greater security and a better operating environment for those who need it.

Antenna design considerations

The following conditions were considered in the design of the antenna:

a) the mandatory requirements of Eutelsat, Intelsat, FCC, etc, for off-axis radiation. This pattern is defined as:

$20-25 \log \theta$ (dBi)

where θ is the off-axis angle,

b) the physical size must be such that wind loading is at a minimum

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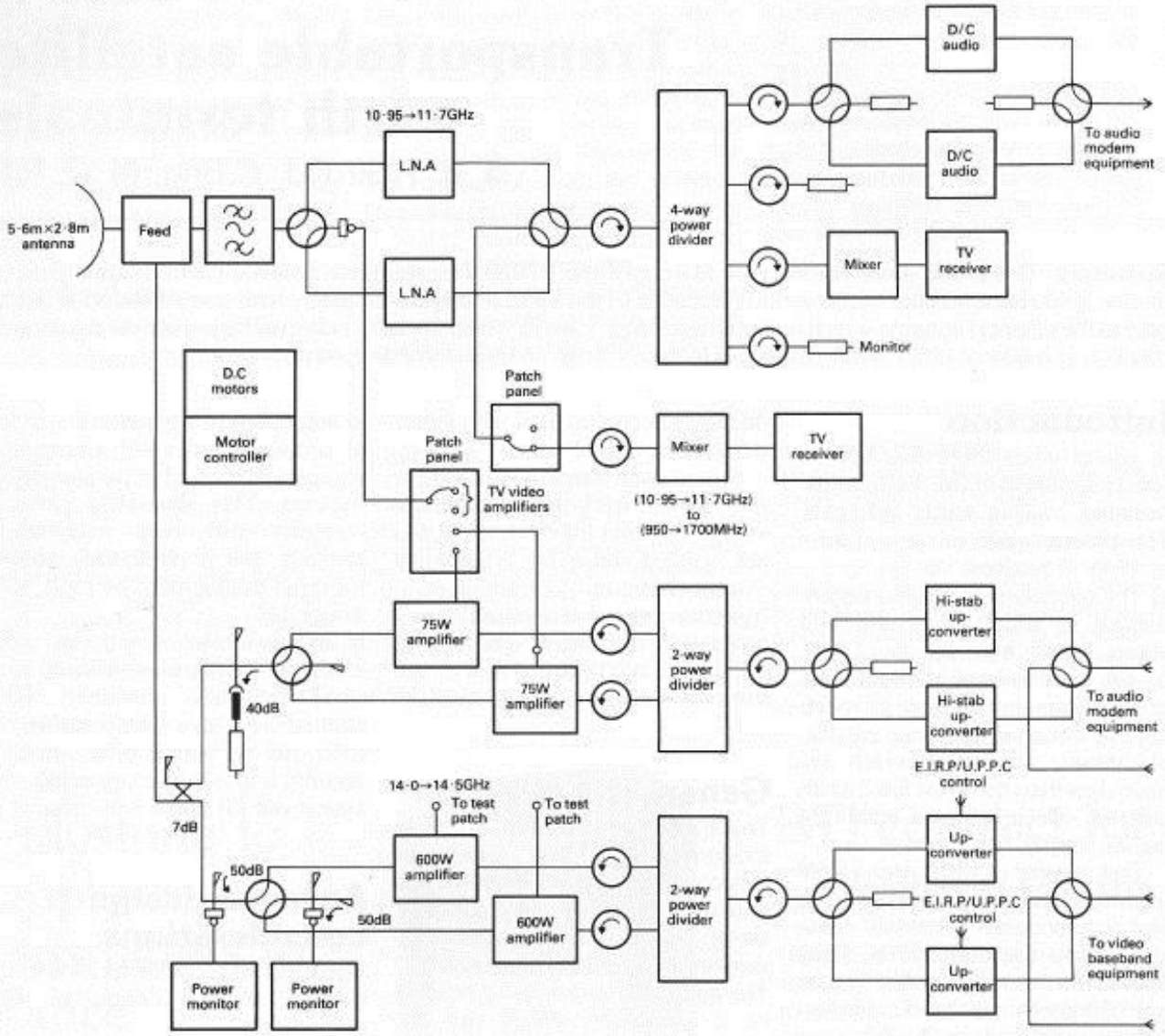

Fig. 1. Typical communication system

and presents no problem for trailer-mounting. In addition it must be transportable in a commercial aeroplane such as the Boeing 747 Combi or its equivalent,

c) the gain must be such that any electronic communication system associated with the antenna can utilize standard high-power amplifiers.

These conditions have been met by an offset, Gregorian antenna with an elliptical main reflector having axes of 5·6m and 2·8m. This design was carried out within the GEC group, at the Marconi Research Centre, using advanced computer software called Diffraction Profile Synthesis (DPS). This sophisticated program allows very accurate optimization of antenna performance without the use of a

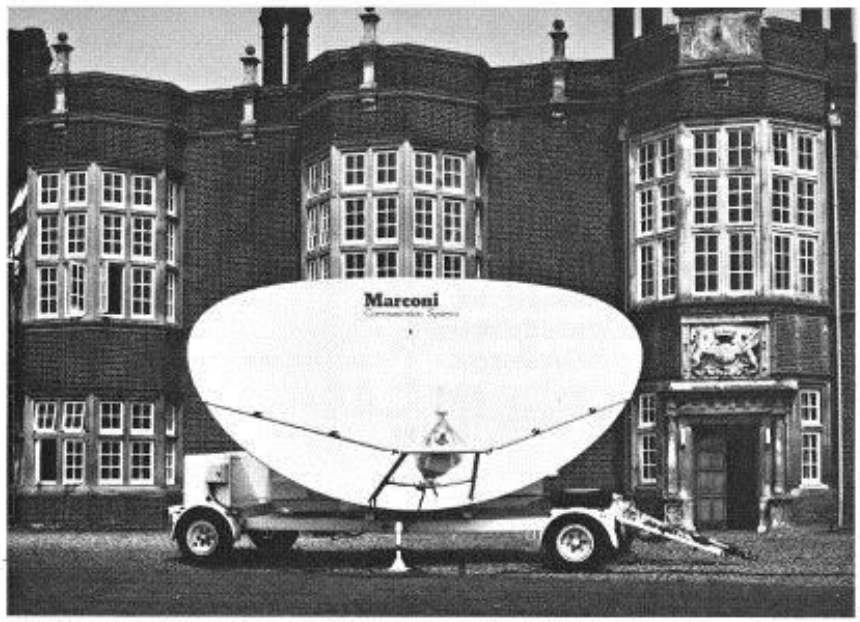

Fig. 2. Overall transportable system

Table 1: Electrical performance summary

Frequency (GHz)	10·95 to 14·5 with standard 2-port linear feed
Gain (dBi)*	G_{TX} 53·1+20 log. (f/14·0) G_{RX} 52·4+20 log. (f/12·5) G_{RX} 51·3+20 log. (f/10·95) (where f=frequency in GHz)

Beamwidth (°)

Freq (GHz)	1dB Azimuth	1dB Elev.	3dB Azimuth	3dB Elev.
10·95	0·21	0·39	0·36	0·67
12·75	0·19	0·34	0·32	0·59
14·0	0·17	0·32	0·29	0·55

V.S.W.R. (max)	Transmit port 1·2 Receive port 1·3
Pattern envelope	The antenna conforms to the CCIR design objective, Recommendation 580 of the XV Plenary and FCC Regulation 25–209.
Polarization isolation	35dB peak

Antenna noise temperature (10·95GHz)

Elevation	Temperature
10°	55K
20°	40K
30°	30K
60°	20K

Feed port isolation (2-port feed)	Better than 50dB at all frequencies in the band 10·95 to 14·5GHz.
Power handling	1kW CW

* referred to input/output flanges of 2-port feed

Table 2: Mechanical performance summary

Weight	1·6 tonne
Elevation speed	
High	25 min/s
Low	1·25 min/s
Azimuth speed	
High	20 min/s
Low	1 min/s
Elevation angle	Beam elevation from 7° to 68°
Dimensions – major axis	5·6m
minor axis	2·8m

Table 3: Environmental specification

Vibration/shock characteristics transmitted into the antenna should be limited to:

Up to 15Hz	±1·5g max (vertically)
Above 15Hz	±1g max (vertically)
Ambient temperature	−30°C to +70°C
Relative humidity	10% to 95%
Wind speeds	
60km/h	full performance
120km/h	degraded performance
200km/h	survival (stowed)
Solar radiation	1100W/m² max.

test range. The final design produced an antenna (figure 2) with the characteristics shown in Tables 1 to 3.

The single piece, elliptical reflector is of glass fibre, sandwich construction, with an aluminium alloy backing structure. The low profile of the reflector reduces wind loading, allowing operation in wind speeds of up to 100km/h and survival in winds up to 200km/h.

The antenna has an elevation-over-azimuth mount, the azimuth bearing being mounted directly on to the bed of the road trailer.

The reflector can be rotated through 100° of elevation, operation being either motor-driven or hand-cranked. Adjustment between 10° and 78° is by screwjack, again either by motor or manual drive.

The sub-reflector and the feed horn assembly are mounted on an 'A' frame assembly. This is hinged to the lower end of the main reflector and is supported by two struts from the sub-reflector mount to the widest point of the main reflector backing structure. To adjust polarization, a single clamp mechanism is released and the entire feed assembly can be rotated, a calibrated scale providing an angle reference.

The antenna can be mounted on a trailer less than 2·25m wide, allowing unrestricted movement by road throughout the world. For fixed applications, a tripod mount is available which supports the slewing ring of the antenna assembly.

The method of housing the electronic equipment varies according to customer requirements. In the current system it is housed in enclosures which are mounted directly on to the antenna trailer.

Communication equipment

A typical system configuration is shown in figure 1 and each subsystem will now be considered in greater detail.

High-power amplifier system

This comprises h.p.as, high-pass filters, output switching and combining (if required). A typical system is shown in figure 3.

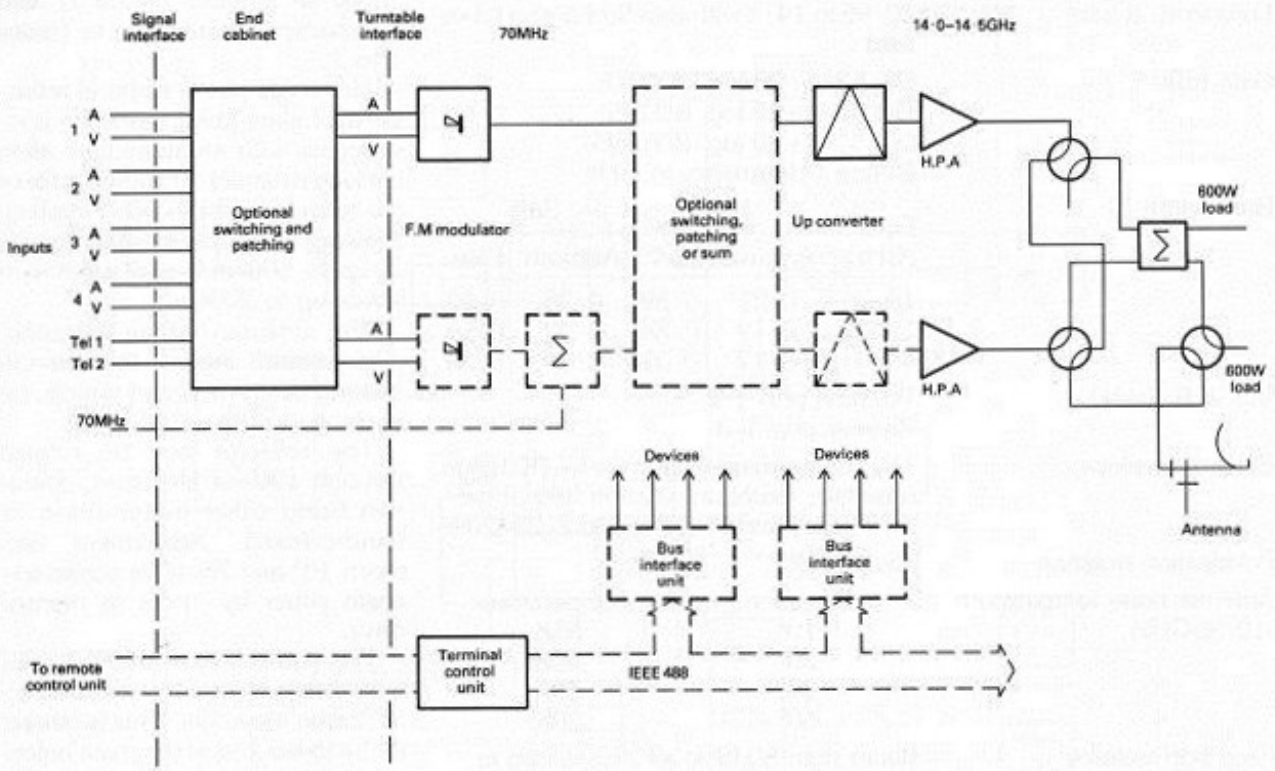

Fig. 3. A high-power amplifier configuration

The following configurations are possible:

a) a single amplifier,

b) two amplifiers providing a 1 for 1 redundancy capability, with separate amplifier outputs fed to each polarization,

c) a single, combined output operating to either polarization.

In c), the coupling combiner will give a 3dB loss to the system.

The switching system includes tellbacks for applying mute control during h.p.a changeover, the muting being done in the upconverter module via an interface unit.

The output ports of the h.p.as are fitted with pressure windows which seal between the transmit waveguide and the amplifiers. The waveguide runs are fitted with dessicator units rather than a pressurization system.

The h.p.as operate between 14·0GHz and 14·56GHz with output powers up to 750W. The travelling-wave tube (t.w.t) gives full output over the whole 500MHz communication band without tuning. The amplifier is usually packaged in a two-shelf assembly comprising a power-supply drawer and an r.f drawer which contains the t.w.t, solid-state intermediate power amplifier (i.p.a), isolators, level attenuators, filtering and monitoring.

H.P.A driver

The h.p.as are driven by the Marconi P4521 Upconverter (figure 4). The P4521 range of ground communication equipment (g.c.e) is designed to meet Eutelsat requirements and can, in fact, cater for all international standards. Each shelf is self-contained, with its own power supply, and has to perform the following functions:

Baseband processing. Pre-emphasis, out-of-band-noise stop filter, deviation, sound sub-carrier modulator, energy dispersal, etc.

Modulator. Modulates baseband signal on to 70MHz carrier. Includes a.f.c, a.l.c and deviation alarms.

I.F module. Spectrum shaping to 17·5MHz or 30MHz, as required. Includes satellite group delay and system equalization.

14GHz upconverter. Converts 70MHz up to 14GHz using a double upconverter, contains carrier fail mute and summary alarms.

Receive system

When accommodating television only, the receive system will be of a relatively simple form, consisting of a transmit reject filter, low-noise converter (l.n.c), splitter and television receiver.

Typically, the l.n.c will have the parameters shown in Table 4.

This converter is mounted directly on to the receiver feed horn assembly and is powered by a Type P3401 System Shelf. This shelf contains not only a power supply for the l.n.c but also a splitter which takes the output from the l.n.c and splits it before feeding it back to Type P3400 Satellite Television Receivers.

The P3400 accepts a signal in the frequency range 900MHz to 1700MHz, downconverts and demodulates it to recover both video and audio transmissions, the receiver determining the receive baseband performance in terms of video and audio. The receiver is housed in a 19in shelf which is only $1\frac{3}{8}$in (47·6mm) high. It can be either free-standing or rack-mounted.

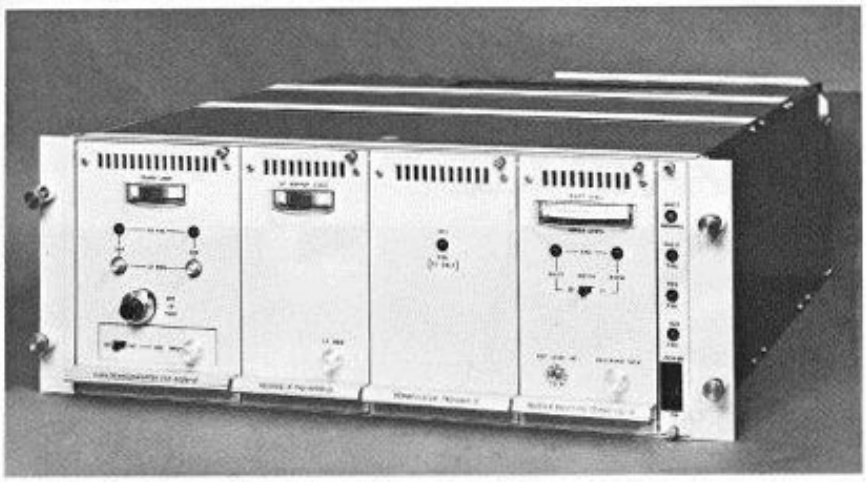

Fig. 4. Upconverter shelf

Table 4: Low-noise amplifier performance

Frequency range	10·95GHz to 11·7GHz
Noise temperature	180K at 23°C 200K at 50°C
Gain	60dB
Gain ripple across band	±0·5dB max.
Gain slope	±0·1dB/10MHz max.
Gain stability	±0·2dB/month
Group delay (per 40MHz segment)	
linear	±0·01ns/MHz max.
parabolic	0·001ns/MHz/MHz max.
ripple	0·1ns p-p max.
A.M/P.M conversion	0·03°/dB max at –10dBm output 0·05°/dB max at 0dBm output
Power output at 1dB compression	+10dBm
Third order intercept point	+20dBm
Inband overdrive	0dBm at input, no permanent degradation of performance.
Operating temperature range	0 to 50°C
Normal prime power	230V ±10% 47–63Hz
R.F input	WR–75 waveguide
Output connector	SMA female

Note: Since the amplifier is part of a redundant plate assembly, a further allowance of 3K is made for the input waveguide switch and connecting waveguide.

Control and supervisory system

It is usually the case that the control and supervision of an earth terminal are designed to customer requirements. For transportable systems it is obviously essential that individual units should give an indication of status and fault location for the h.p.as and upconverters. In addition, local alarm status panels and h.p.a mute controls can be fitted and a remote control system is possible which brings individual alarms together and transmits them to a location remote from the terminal, the distance being dependent on modem availability.

Apart from the above, a variety of test equipment is available, such as spectrum analysers, monitors, etc, to monitor signals, to assist in setting up the system and in fault finding.

A test translator is also available which allows the system to be tested without the use of a satellite signal. The translator takes a sample of the transmit signal, mixes it down to a receive-band frequency, and the resulting signal is fed into the receive system where it is demodulated and can be analysed.

Conclusions

The system described provides a solution to the needs of the operator of a transportable terminal and is flexible in terms of both equipment and system housing. The antenna is unique in form and performance and is most effective where professional-quality transmission and reception is essential, with tight specifications which require state-of-the-art design.

RÉSUMÉ

Cet article décrit la nouvelle station terrestre transportable pour satellite Marconi Type P7020. La performance et les caractéristiques des divers éléments des terminaux terrestres sont fournis ici, en particulier en ce qui concerne l'antenne elliptique qui est de conception inédite. L'article décrit aussi les utilisations possibles des terminaux et mentionne d'autres terminaux dans la gamme Marconi des systèmes transportables.

RESUMEN

Este artículo describe la nueva estación Marconi terrena transportable de telecomunicaciones por satélites, tipo P7020. Se expone el comportamiento funcional y las características de los diferentes elementos de los terminales de puesta a tierra, dándose atención especial a la antena elíptica que es de diseño único. Se discuten los usos que pueden darse a los terminales, y se hace mención de otros terminales dentro de la variedad Marconi de sistemas transportables.

ZUSAMMENFASSUNG

Dieser Aufsatz beschreibt die neue transportable Marconi Erdsatellitenstation P7020. Leistungsdaten und Eigenschaften der verschiedenen Elemente dieser Erd-Endstation werden angegeben, mit besonderer Betonung der elliptischen Antenne einzigartiger Konstruktion. Es werden Anwendungsmöglichkeiten der Station erörtert und andere Endstationen in der Reihe der transportablen Einrichtungen von Marconi werden erwähnt.