Towards a satellite-based data network for Europe

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Summary This article describes a prototype high speed data distribution network using the European Space Agency's Orbital Test Satellite. The link provides a 1 Mbit/s data channel between a number of regional computing centres with a b.e.r of 10^{-9} for 99·3% of the time. Users access the satellite through small earth terminals and three-metre antennas located on their own premises.

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Since 1976 he has worked firstly for the Contracts Division and currently for the Space & Microwave Operations Unit on system engineering and evaluation of a new generation of 11/14GHz earth stations, particularly for the European domestic system.

Introduction

The demand for data transmission services between computer users can be broadly divided into two categories; a slow/medium speed service (<10kbit/s) for remote computer access among several thousand widely distributed users and a high-speed service for bulk transfer of data between a limited number of regional computing centres.

While the terrestial telephony network can provide leased line facilities of up to 9·6kbit/s, it cannot satisfy the rapidly growing demand for a high-speed service in the near future.

A satellite-based data network between small earth terminals has some considerable advantages, namely:
– data rates in the Mbit/s region are possible since the transponder bandwidth is not limited in the same way as local exchange lines.
– a full duplex service is possible and since the satellite signal is broadcast to all users, switching centres are unnecessary.
– link costs are related to the distance between users.
– the service can be made available within a time-scale which does not have to take account of modernization of the terrestial network.

A number of problems must be resolved before an operational service can be introduced, not least of which is the potential loss of revenue to the existing terrestial network at a time of heavy investment in digital equipment.

The market for satellite based data networks is clearly demonstrated in the USA where several major organizations now operate, or plan to operate their service through small terminals sited on the customer's premises. The most well known is Satellite Business Systems, a joint venture by IBM, Comsat and Aetna to provide a general purpose digital network, for voice, facsimile and data. Transmission speeds of up to 6·3Mbit/s are planned, using either five-metre or seven-metre diameter antennas. More recently the Xerox Telecommunications Network has been announced. This system will operate in the 10·55 to 10·68GHz band with a data rate of 256kbit/s.

As a step towards a European system, the European Space Agency is conducting a series of data transmission experiments during the period 1979 to 1981 via the OTS satellite.

It is proposed to evaluate the link at data rates of 1·024Mbit/s and 512kbit/s using three-metre antennas for the earth terminals. Two separate groups of users are being considered. In the first experiment called STELLA, the High Energy Physics Laboratory CERN in Geneva will be linked to computing centres in the Rutherford Laboratory near Oxford, DESY in Hamburg and CNUCE near Pisa.

The second link will become part of the SPINE data network joining host computers in three ESA establishments; ESTEC (Holland), ESOC (Germany) and ESRIN (Italy). A further terminal will also be sited at RAE Farnborough.

The nuclear physics community were selected for the trial, as representatives of a wider class of potential users, for which the lack of high speed data links across Europe is causing considerable delays in data processing. The volume of data produced daily by the particle accelerators at CERN for analysis by the remote computers is large, typically 300 megabytes (eight bits per byte) stored on ten magnetic tapes. With a 1 Mbit/s satellite channel, the data transfer can be completed in under two hours instead of several days whilst the tapes are physically shipped.

The satellite channel will be shared among the users by a simple time division multiple access procedure. The designated master station will provide a timing reference for the data bursts from each active station. Forward error correction will improve the error rate over the satellite link from 10^{-5} to better than 10^{-9}. Since fading in poor weather conditions will degrade the bit error rate performance, the experiments aim to establish the degree of availability of the service over the trial period.

The data link

Data will be transferred between host computers over the link shown in figure 1.

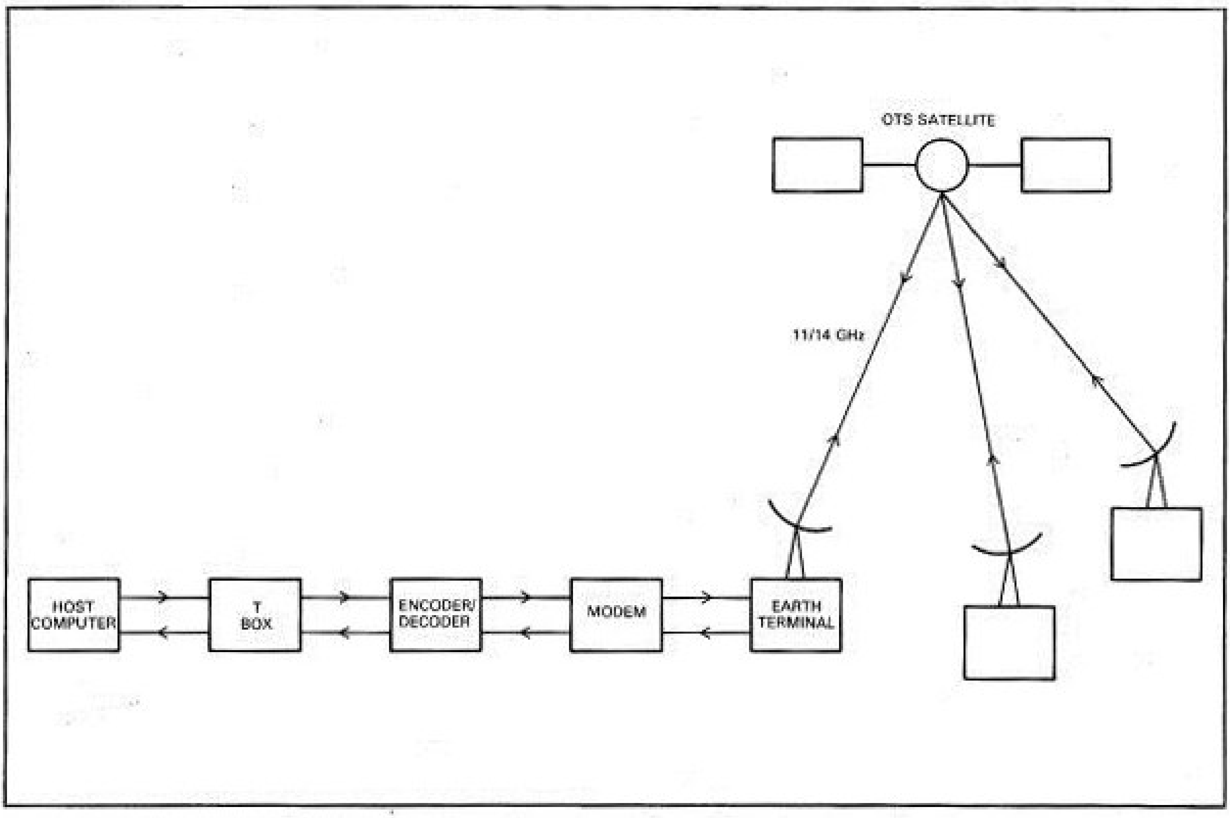


Fig. 1. Satellite link between host computers

The computer is interfaced to the earth terminal via a separate mini-computer called the 'T-box'. The latter performs all the tasks necessary for t.d.m.a working: burst timing, the sending of acknowledgement signals to the originating station, error detection and requests for retransmission. By this means, the 'T-box' exchanges essentially error-free data packages with the host computer.

The outgoing data burst is encoded by a half-rate convolutional encoder and modulated onto a 70MHz carrier using two-phase p.s.k modulation. The transmission rate is therefore twice the data rate. The spectrum of the modulated carrier is shaped using identical baseband filters in the modulator and demodulator, which together give a 100% cosine roll off response. The transmission rate may be readily changed from 2·048Mbit/s to 1·024Mbit/s by replacing the baseband filters in the modem.

The signal is upconverted from 70MHz to the satellite transponder frequency in the band 14·0–14·5GHz, amplified by a 140W travelling wave tube and transmitted via a roof top mounted three-metre antenna to the OTS satellite. The data burst is received at 11GHz by all terminals, downconverted to 70MHz, demodulated and transmission errors corrected by a Viterbi decoder.

Figure 2(a) shows the format proposed for the data burst. During the preamble of 660 bits the 'T-box' ignores the incoming data burst. The demodulator recovers the carrier phase and clock signal within the first 160 bits (of 0101 . . . 01 sequence) from the start of the burst, but a further 500 bits are necessary for the Viterbi decoder to give an error output of less than 10^{-9}. When the 'T-box' receives the 'in-sync' signal from the decoder, it begins to search for the frame flag marking the start of the data package. The flag is an 8-bit sequence (01111110) occurring at the start and finish of a package of 10kbit/s. To ensure the sequence does not occur within the data, a zero is inserted after five consecutive ones. A guard time of 70μs between bursts should ensure bursts do not overlap because of variations in the satellite position.

Ninety-six such bursts make up a frame period of one second as shown in figure 2(b) enabling the satellite channel to be shared by up to 20 users. The first N slots are pre-assigned one to each active earth station effectively providing a 9·6kbit/s channel at all times. The remaining slots will be shared equally among a smaller number of users, up to eight, to provide a high-speed channel of at least 100kbit/s. These slots will be allocated dynamically in each frame by the 'T-boxes' using a common algorithm and requests made by each station in the pre-assigned channels of the previous frame.

The receiving terminal will transmit an acknowledgement, or request to resend signal, through the signalling channel in the next frame according to whether errors are detected in the frame checking sequence at the end of each burst. Since the delay in re-transmission may be up to 1·5s, arising from the two way transit time (0·5s) and a frame period, all bursts up to the last correctly acknowledged one will be re-sent.

The codec, modem and earth terminal are housed within a single six-foot cabinet connected via short waveguide runs to the three-metre antenna. The terminal is designed to operate while unattended and can be sited up to 100 metres from the host computer and 'T-box'. All necessary control and monitoring signals are made available to operate the terminal from the computer room.

Marconi Communication Systems has installed termi-

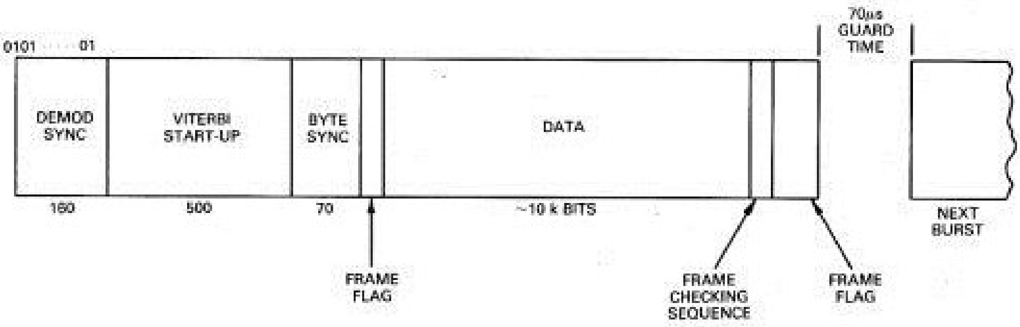


Fig. 2a. Data Burst Format

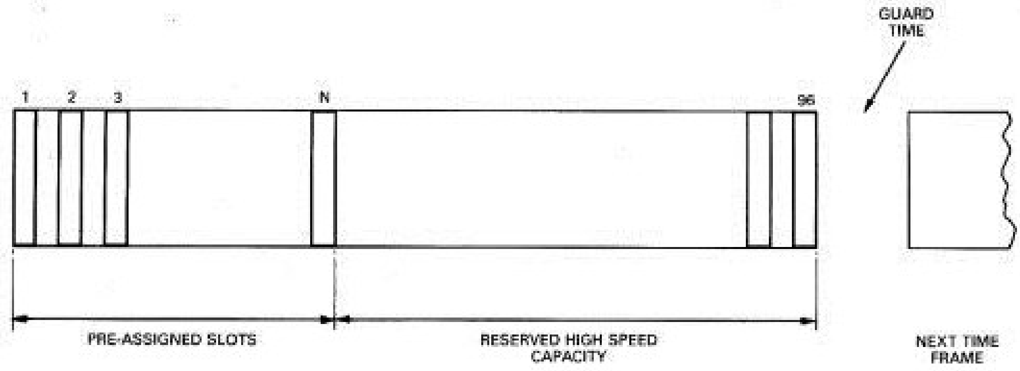


Fig. 2b. Frame format

Fig. 2. Proposed t.d.m.a. frame format

nals of this type at CERN, the Rutherford Laboratory and at RAE, Farnborough. A further terminal is destined for ESOC (Darmstadt, Germany).

The space segment

To predict the bit error rate performance of the satellite link, it is necessary to examine in some detail the achievable carrier to noise (c/n) ratio of the uplink and downlink, by means of a link budget.

To meet the performance objective, thermal noise added by the space segment should give rise to a demodulator bit error rate (b.e.r) not worse than 10^{-5}. At a rate of 2Mbit/s, the error rate after decoding should be 10^{-9} or better. The soft decision Viterbi decoder provides a coding gain in excess of 5dB in the energy per bit/noise density ratio (Eb/No) versus b.e.r curve for coherent p.s.k demodulation with additive white noise.

The coding improvement will not apply if blocks of errors occur. Such events are unlikely but are being monitored during the trial period. The transmission path is shown schematically in figure 3.

For an ideal two phase p.s.k modem, the error probability is given by:

$\text{b.e.r} = 0{\cdot}5\,\text{erfc}\,\sqrt{Eb/No}$

From the above equation, a b.e.r of 10^{-5} will require a value of Eb/No of 9·6dB. An additional implementation margin of 1·5dB must be allowed for a practical modulator and demodulator when connected back to back at 70MHz. Non-linearity of the earth terminal and satellite t.w.t amplifiers will increase the Eb/No required by a further 0·8dB. Hence a value of Eb/No=11·9dB must be achieved over the satellite link, which is equivalent to a carrier/noise ratio of 11·9dB at the demodulator input, in a 2MHz bandwidth.

The uplink and downlink contributions to the c/n ratio expressed in terms of carrier/noise temperature ratio can be found using:

uplink c/t=terminal e.i.r.p – propagation loss+satellite g/t

downlink c/t=satellite e.i.r.p – propagation loss+terminal g/t

where the e.i.r.p=equivalent isotropic radiated power

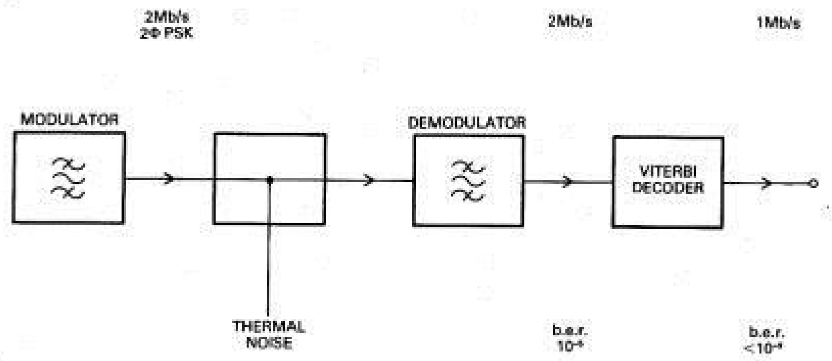


Fig. 3. Schematic block diagram of modem

Uplink		*Module A*	*Module B*	
Transmitter power	(dBW)	20·0	14·0	
Antenna gain	(dB)	49·8	49·8	
Uplink e.i.r.p	(dBW)	67·8	61·8	Note 1
Propagation loss	(dB)	208·1	208·1	Note 2
Satellite g/t	(dB/K)	−4·2	−2·1	Note 3
c/n ratio in 2·0MHz	(dB)	21·1	17·1	
Downlink				
Satellite e.i.r.p	(dBW)	47·3	41·0	
Antenna pointing loss	(dB)	−2·6	−1·8	
Satellite t.w.t.a backoff	(dB)	−7·3	0	
Downlink e.i.r.p	(dBW)	37·4	39·2	
Propagation loss	(dB)	206·0	206·0	Note 2
Effective terminal g/t	(dB/K)	16·0	16·0	
Downlink c/n in 2·0MHz	(dB)	13·0	14·8	
Net c/n	(dB)	12·4	12·8	
Required c/n for b.e.r $=10^{-5}$	(dB)	11·9	11·9	
Margin	(dB)	0·5	0·9	

Note 1 A 2dB loss in uplink e.i.r.p arises from antenna pointing errors and waveguide connection losses.
Note 2 The propagation loss includes spreading losses and clear weather attenuation.
Note 3 The satellite g/t takes into account the satellite antenna gain loss in the direction of the earth terminal.

Fig. 4. Link budgets for OTS satellite

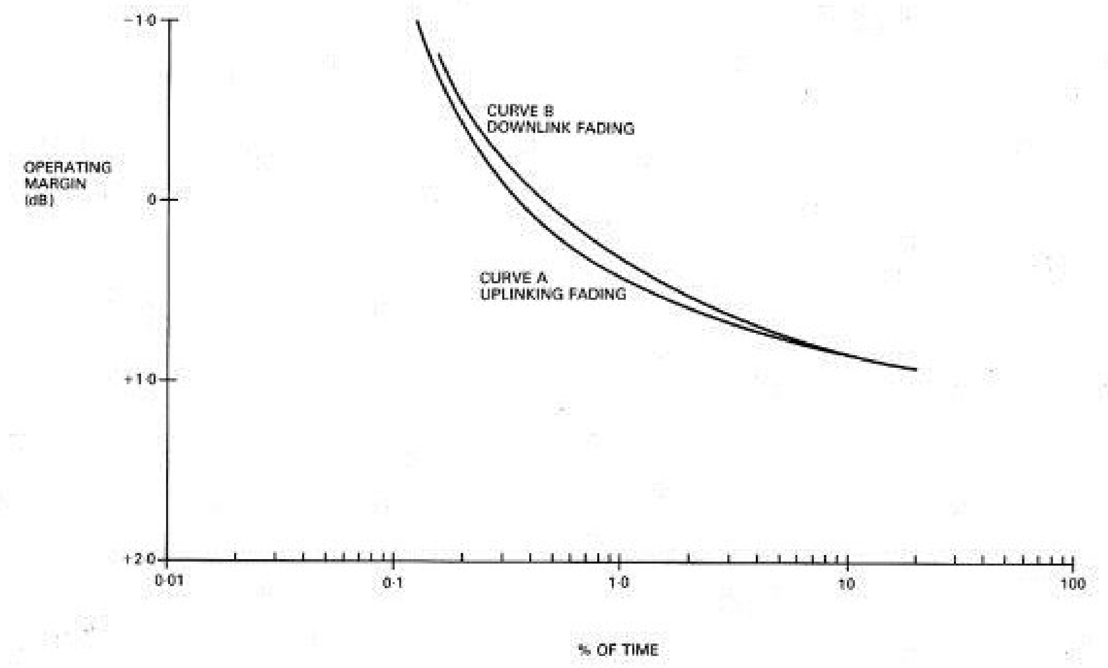


Fig. 5. Availability of service

and g/t = the ratio of antenna receive gain to system noise temperature.

The link budget has been summarized in figure 4 for an earth terminal using a three-metre antenna, 140W transmitter and f.e.t low noise amplifier.

The trial will evaluate two transponders of the OTS satellite. Module A has a high e.i.r.p downlink spot beam, but insufficient gain to saturate the output t.w.t.a with the relatively low e.i.r.p of the three-metre terminal. Module B has sufficient gain to be saturated.

The table shows that a b.e.r of 10^{-5} can be achieved with both transponders in clear weather. To calculate the availability of the service, the effect of uplink and downlink fading on the c/n ratio must be calculated using a statistical model for weather losses. For the new 11/14GHz band, weather losses are more significant than for the established 4/6GHz band currently used by Intelsat and most domestic systems. The OTS satellite has a number of onboard beacons which will be measured over a period of several years at many European sites, to confirm the weather model.

A recent model recommended by ESA for the European region is tabulated below:

% of time loss not exceeded	80	95	99	99·7	99·9	99·97
Uplink loss (dB)	0·6	1·0	1·8	2·9	5·3	11·8
Downlink loss (dB)	0·4	0·6	1·2	1·9	3·5	7·7

Clear weather losses are defined as those not exceeded for 80% of the time. Figure 5 shows how the available margin varies with time for Module B. It is assumed that since the transmitting and receiving terminals are distant, fading occurs over one half of the link, with clear weather occurring over the remaining half.

Curve A of figure 5 shows uplink fading and Curve B downlink. Extrapolating both curves to the point at which the margin is zero, shows outages of 0·3% and 0·4% for uplink and downlink fading respectively. The availability of the service through Module B is therefore 99·3% which compares favourably with the availability of the Rutherford Laboratory computers of 98–99%. These predictions of availability are highly sensitive to the implementation margin achieved with a clear weather satellite loop.

The small clear weather margin predicted with Module A means that a 1Mbit/s data service will have a low availability. On this basis it will be necessary to operate at 512kbit/s for which 3dB less downlink power is required.

Because of the experimental nature of the data links, the earth terminals have been designed to be non-redundant. Some outages may arise from equipment faults, although the cabinet is constructed on a modular basis so that spare modules can be readily fitted to minimize the downtime.

The OTS satellite

Before considering the earth terminal in more detail, it is useful to look at some relevant aspects of the satellite. The latter will be used by Interim Eutelsat for a three year period of field trials, in advance of the operational European Communications Satellite. ECS will supplement the terrestrial network of long haul telephony and television circuits and is scheduled for launch at the end of 1981 and become operational during 1982.

The European system incorporates many new features. Transmission will use the band 14·0–14·5GHz for the uplink and split bands 10·95–11·2GHz and

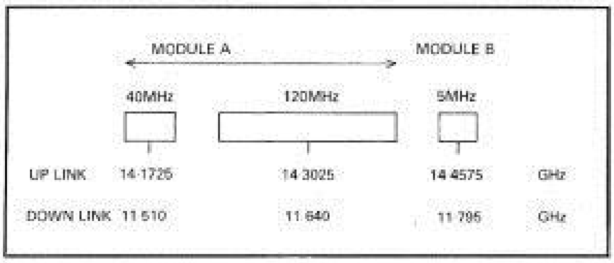


Fig. 6. Orbital test satellite transponders

11·45–11·7GHz for the downlink. Frequency re-use through dual polarization will double the traffic capacity of the satellite. Telephony traffic will be carried using 120Mbit/s t.d.m.a with four-phase p.s.k modulation. Twelve transponders of 80MHz bandwidth will be accommodated within the 500MHz frequency band. The Orbital Test Satellite is equipped with six transponders (including frequency re-use), as shown in figure 6.

The 40MHz and 120MHz transponders of Module A share the same uplink antenna, whose elliptically shaped beam covers Europe, N. Africa, Scandinavia and Iceland. The 120MHz transponder has a downlink spot beam covering Europe, with a circular 3dB beamwidth of 2·5°. Module A antennas are linearly polarized and interconnected such that a signal transmitted on the horizontal (X) polarization by the earth terminal is received back on the vertical (Y) polarization. This enables transmit and receive signals to be separated by an orthomode transducer in the feed of the three-metre antenna.

Module B contains two narrow band (5MHz) transponders with the higher gain and g/t ratio required when small earth terminals are used. Its antenna is circularly polarized so that the three-metre antenna must be capable of readily changing from linear to circular polarization.

The satellite is three-axis stabilized and maintains its longitudinal position to within ±0·1°. Its orbital plane may be inclined by up to 0·1° relative to the equator which causes the satellite position to follow a daily figure of eight, as viewed from the terminal. A significant advantage of using a small three-metre antenna is that a tracking system is unnecessary. With a 3dB receive beamwidth of approximately 0·5°, the signal loss through pointing errors should not exceed 0·7dB. This figure includes errors due to wind deflections of the antenna. The structure is sufficiently rigid to give an error of less than 0·05° r.m.s in winds of 50km/h, gusting to 75km/h.

The Marconi earth terminal

The data transmission experiments form one aspect of an

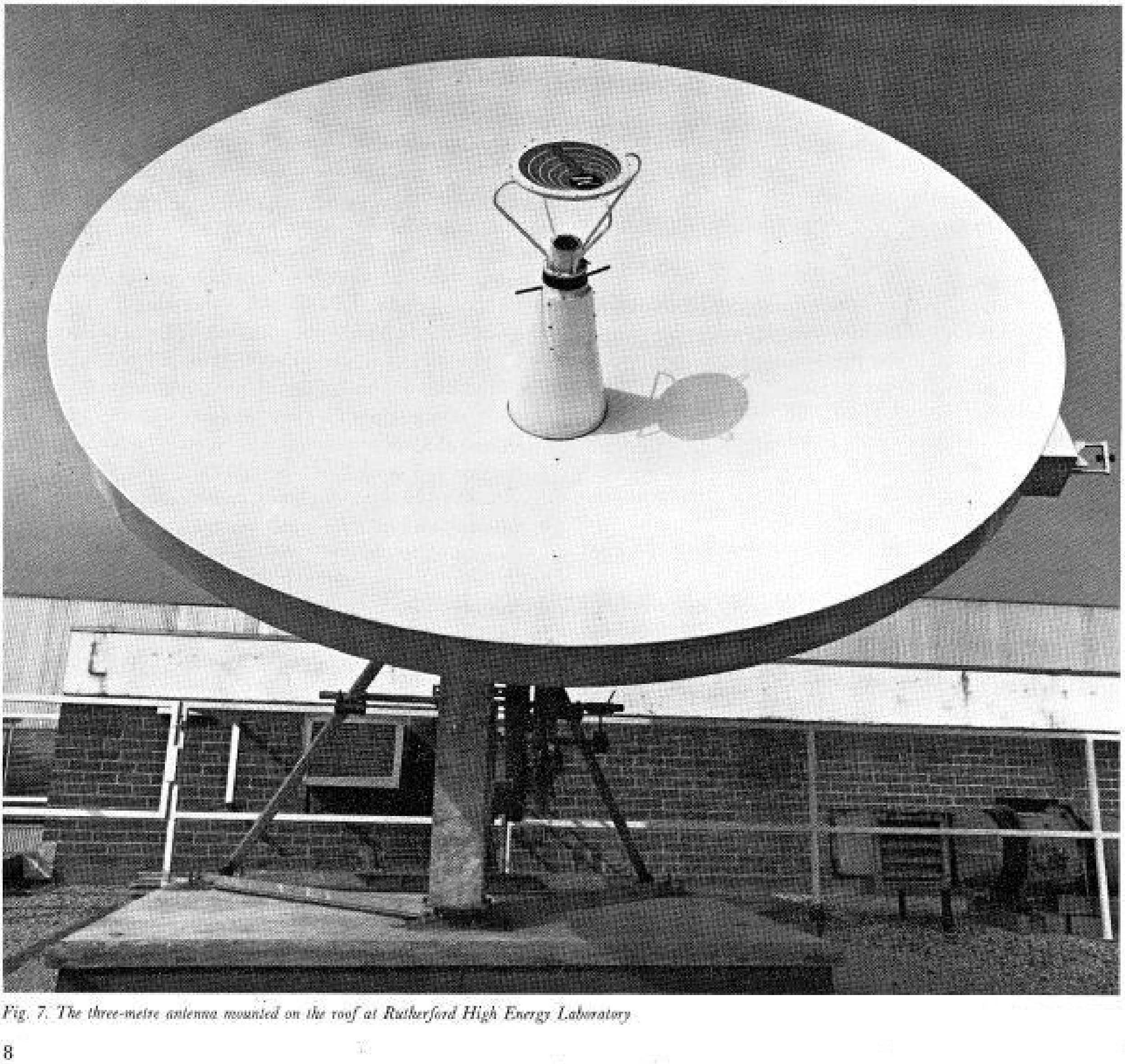


Fig. 7. The three-metre antenna mounted on the roof at Rutherford High Energy Laboratory

extensive programme of satellite tests including a large number of widely distributed earth stations. This article concerns itself with the description of the Marconi design of data terminal.

The three-metre antenna

The antenna is a high efficiency Cassegrain design, covering the 14·0–14·5GHz transmit band and 10·95–11·8GHz receive band. The feed and sub-dish form an integral unit, which can be fitted on site within a few minutes without further alignment.

The feed assembly is made up of a conical corrugated horn to illuminate the subdish, with a polarizer and orthomode transducer to separate the orthogonally polarized signals.

The assembly can be rotated by ±95° about the axis of the dish to line up the orthomode transducer with the plane of polarization of a linearly polarized signal from the satellite.

The polarizer introduces a 90° differential phase advance in one plane of the feed. By rotating this plane of the polarizer to one of the three pre-set positions, at either −45°, 0° or +45° with respect to the orthomode transducer, the antenna radiates left-hand, linear or right-hand circularly polarized signals.

By adding a diplexer to each port of the orthomode transducer, a four port feed can be obtained, suitable for frequency re-use. The cross polar performance of the antenna for circularly polarized signals is better than 30dB.

The feed and interconnecting waveguides to the equipment cabinet are pressurized with dry air at 0·5lb/sq. in. by a dehydrator located within the cabinet.

The main reflector is made from glass fibre formed over a precision mould with a layer of aluminium sprayed over the reflecting surface. Both subdish and main dish profiles are modified from the true Cassegrain design to enhance the antenna efficiency.[1] To eliminate gravity-induced distortion in the profile, a rigid support is provided for the main dish.

The antenna position can be varied in elevation between 0 and 57° and rotated by ±25° in azimuth, either manually using a dual nut and screw arrangement, or with motorized jack screws.

It can be conveniently located on a roof top with an unobstructed view of the satellite (approximately due South), although the roof must be adequately reinforced to withstand the uplift thrust created in the maximum survival windspeed of 200km/h.

The downlink performance is dominated by the antenna g/t ratio. Although the maximum value would be achieved with the f.e.t amplifier mounted directly on the back of the dish, for practical reasons a value of 16dB/K has been specified. This enables the f.e.t to be mounted within the cabinet with up to ten metres of interconnecting waveguide.

Transmitter noise from the broadband t.w.t amplifier degrades the g/t ratio by less than 0·2dB.

A potential drawback to the widespread use of small diameter antennas is the relatively poor discrimination of the sidelobe pattern. The discrimination is defined as the difference in antenna gain at boresight and at an angular offset (θ). The level of interference radiated into neighbouring satellites within the geostationary arc will determine the satellite spacing and hence the number of satellite systems which can be operated. A factor which will no doubt influence the licencing of future small terminals is the compliance of the sidelobe envelope with the CCIR recommendation, *i.e.*:

$1° < \Theta \leq 48°$: Gain $= 32 - 25 \log_{10} \Theta$ dBi

$\Theta > 48°$: Gain $= -10$ dBi

In the case of the ECS1 and ECS2 satellites spaced two degrees apart, the e.i.r.p. radiated will have dropped 26dB. For a major PTT station in the 11/14GHz band

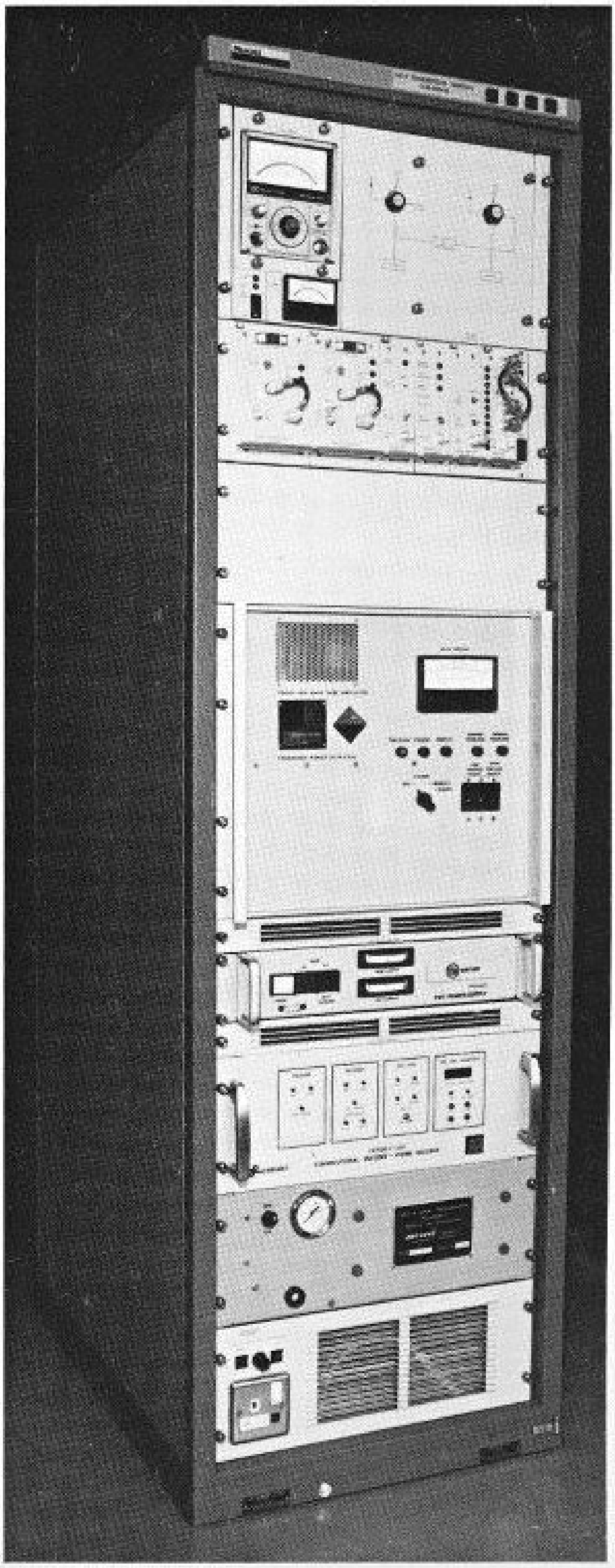


Fig. 10. Equipment cabinet

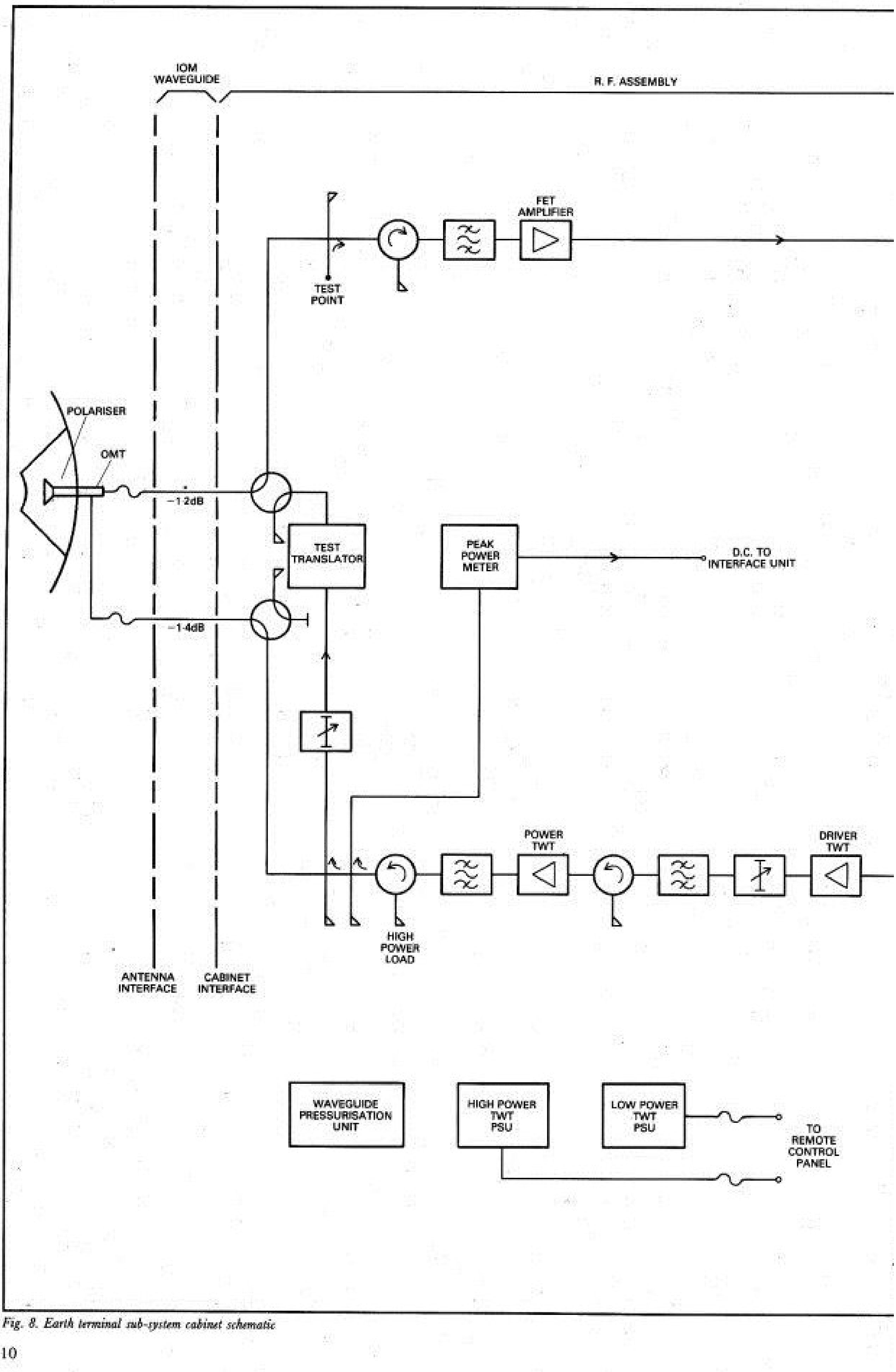
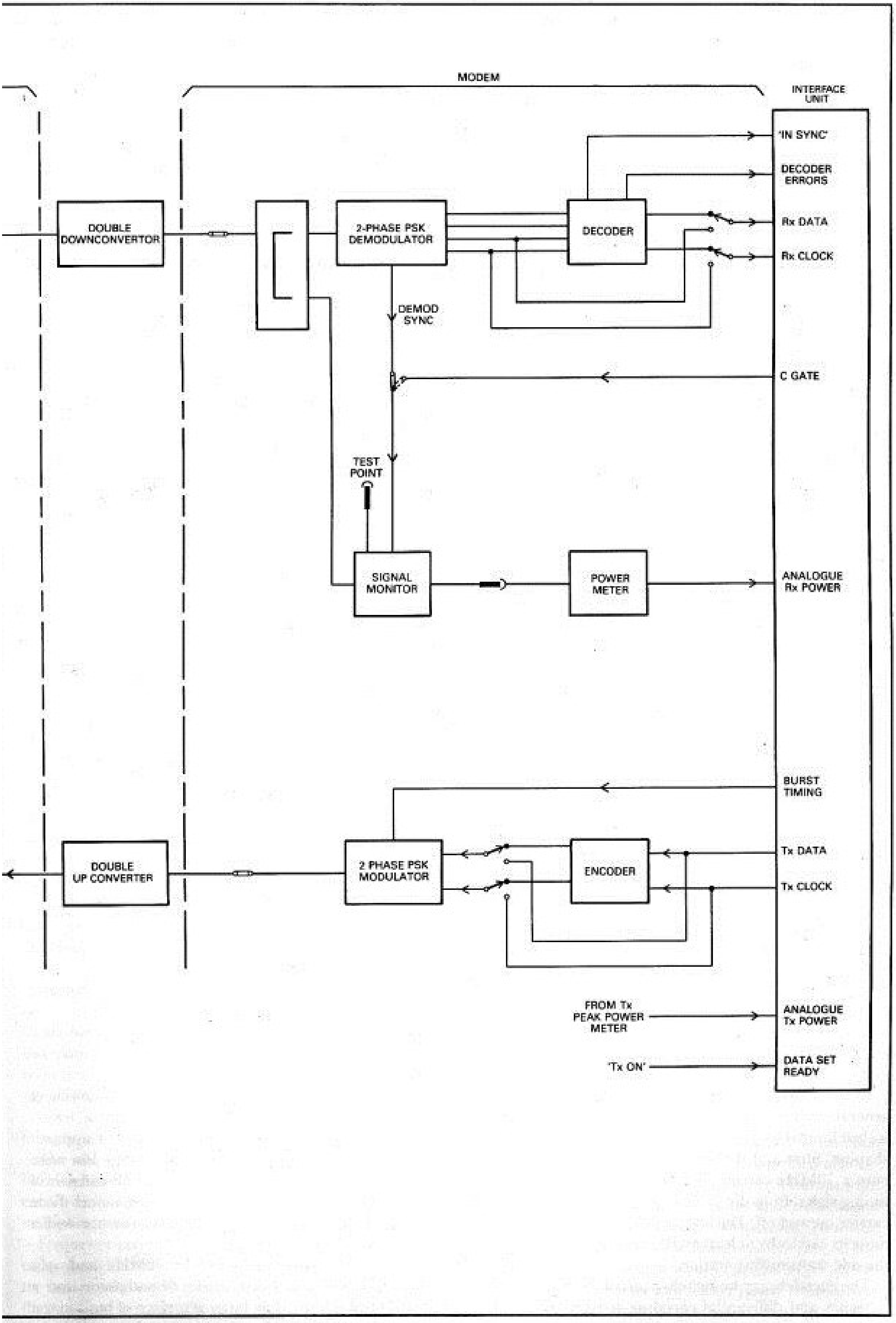


Fig. 8. Earth terminal sub-system cabinet schematic


MODEM
INTERFACE UNIT
'IN SYNC'
DECODER ERRORS
Rx DATA
Rx CLOCK
DOUBLE DOWNCONVERTOR
2-PHASE PSK DEMODULATOR
DECODER
DEMOD SYNC
C GATE
TEST POINT
SIGNAL MONITOR
POWER METER
ANALOGUE Rx POWER
BURST TIMING
DOUBLE UP CONVERTER
2 PHASE PSK MODULATOR
ENCODER
Tx DATA
Tx CLOCK
FROM Tx PEAK POWER METER
ANALOGUE Tx POWER
'Tx ON'
DATA SET READY

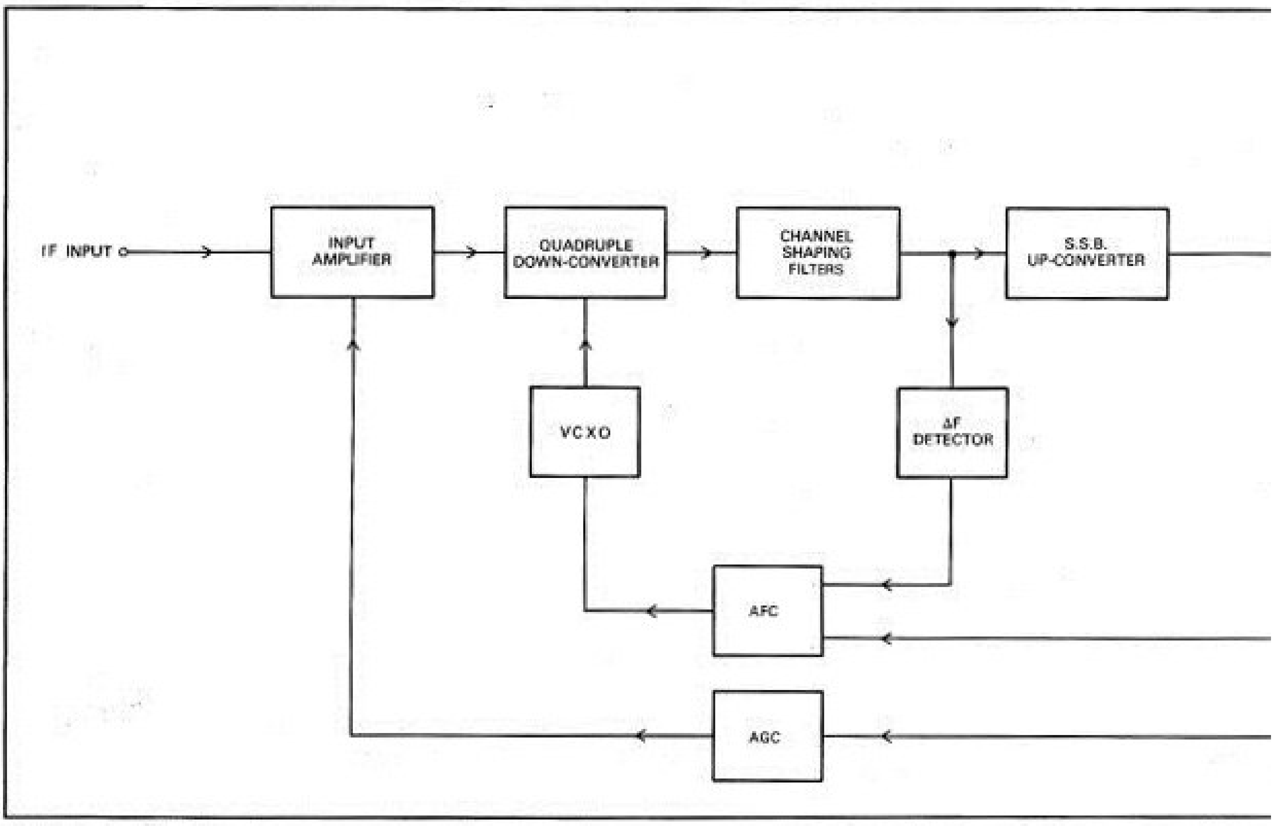


Fig. 9. Burst mode demodulator

with a 19m diameter antenna the corresponding figure will be 42dB. However, interference effects cannot be calculated until the relative e.i.r.p and modulation bandwidth of each transmission are known. The 11GHz frequency band is also shared with terrestrial radio relay links, although it should be possible to site the antenna so that it is screened by local buildings from this source of interference.

The equipment cabinet

The cabinet, shown schematically in figure 8 contains all the equipment necessary to exchange data between T-boxes over the satellite link. The terminal may be sited up to 100m from the computer room, with a twisted pair cable link between the two. An Interface Unit at each end converts t.t.l data and clock signals into balanced differential form for transmission over the cable together with control and status signals.

Transmit data at a rate of 1·024 or 0·512Mbit/s is encoded by a half-rate convolutional encoder. Differential encoding resolves the phase ambiguity at the demodulator.

In the modulator, the t.t.l data stream is sampled to generate narrow bipolar pulses. The spectrum of the latter is then limited by passing through the baseband 'channel shaping' filter and the output signal linearly modulated onto a 70MHz carrier by a balanced mixer. The burst timing signal from the 'T-box' is used to gate the 70MHz carrier on and off. During off periods, each station will mute its carrier by at least 40dB to limit the interference to the one transmitting station.

The encoder may be switched out of the circuit for test purposes and differential encoding selected at the modulator.

The 70 MHz carrier is upconverted to the transponder frequency in the 14·0–14·5GHz band. A two-stage upconversion is made, with an intermediate frequency of 770MHz. To change from Transponder A to Transponder B working, the second local oscillator is retuned and locked to a new crystal oscillator.

The double upconverter output signal is amplified by a 10W t.w.t driving a 140W power t.w.t. Bandpass filters at the final t.w.t input and output define the 14·0–14·5GHz transmit bandwidth. A variable waveguide vane attenuator between the two t.w.t stages sets the e.i.r.p level required for the transponder.

Both t.w.t amplifier power supplies may be switched on and off from the computer room over the cable link. A standby state, in which the h.t is removed from the power amplifier, may be selected if the terminal is to remain in a quiescent state for a long period.

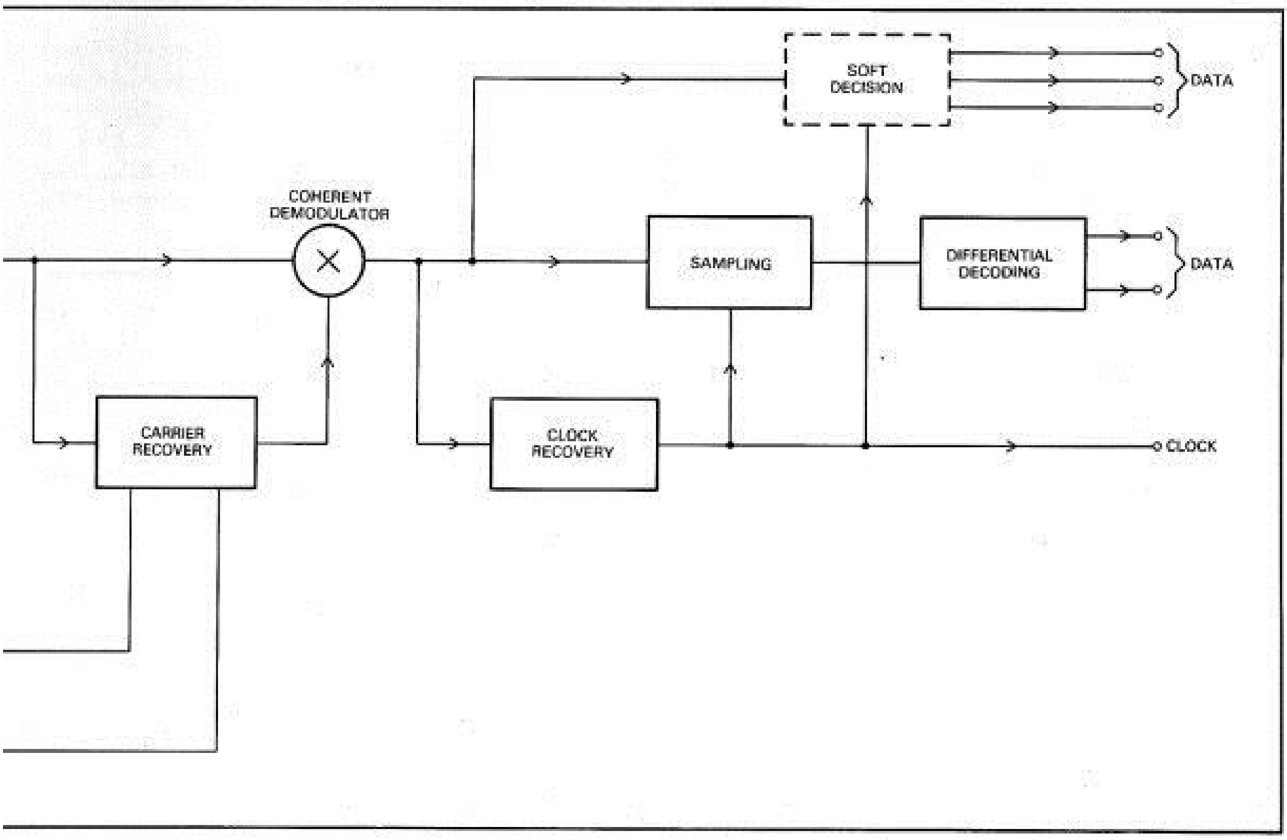
The transmit signal may be switched to the antenna or to the high-power load of the output circulator.

The transmit and receive chains may be looped via a test-translator so that the digital performance may be checked without accessing the satellite.

A peak power detector provides remote monitoring of the transmitted data burst power.

The 11GHz downlink signal, at a level of approximately −90dBm, is amplified by a two-stage low noise f.e.t amplifier, which has a noise figure of 4dB and gain of 27dB. These amplifiers are now replacing tunnel diode amplifiers, offering a better noise performance and a wider dynamic range.

The signal is downconverted to 70MHz and split equally between the burst mode demodulator and a Signal Monitor Unit. The latter is a piece of built-in test equipment which enables the b.e.r performance to be



correlated with the Eb/No ratio over the link. It contains a filter of accurately known noise bandwidth, through which either the signal, or noise, can be measured with a sensitive power meter. The analogue voltage output from the power meter is fed over the cable link to the computer room so that remote measurements can be made. The power meter may be gated in synchronism with the data burst, if required, by using the demodulator 'in lock' signal to switch the Monitor Unit to the power meter.

The demodulator has been designed to perform the complex task of recovering the data and clock signals within a minimum number of bits, from bursts which will inevitably differ in level and frequency as they originate from several stations. With this design, the steady state error rate performance is achieved within 160 bits from the start of the burst. The demodulator is shown schematically in figure 9.

An a.g.c amplifier reduces the burst-to-burst level variations before the two phase p.s.k modulated signal is downconverted, to give two in-quadrature signals at an i.f frequency of zero. Baseband filtering is carried out at this point to complete the 100% cosine roll-off shaping of the signal. This scheme permits the filter response to be easily realized, while the data rate can be readily changed by fitting a new baseband filter.

The in-quadrature signals are upconverted to 6MHz before coherent demodulation by a balanced mixer. The carrier is derived from a carrier recovery loop, using a ×2 multiplier, a narrow band 12MHz filter and ÷2 circuit.

Frequency errors in the incoming 70MHz carrier will cause the signal to be initially offset within the passband of the carrier recovery loop filter. The phase variation across the passband provides the error signal in the a.f.c loop to the voltage-controlled crystal oscillator of the down converter. The oscillator incorporates a 'track and hold' facility to minimize the frequency drift between bursts and hence speed up the acquisition. Burst-to-burst frequency shifts of 4kHz may be accommodated. The demodulated signal is split into three paths. The clock signal is regenerated with a high-pass filter and full wave rectifier. The analogue baseband signal is converted to t.t.l form in a sampling circuit gated by the regenerated clock. This data output is only used for test purposes, when the coding is bypassed.

The third path feeds the Viterbi decoder via a three-bit a/d converter. In the 'soft decision' mode the decoder will improve the b.e.r to better than 10^{-9}, although it takes some 500 bits to synchronize.

An 'in-synch' t.t.l signal from the decoder is used to signal the remote computer that the data is now valid. The decoder also outputs a t.t.l transition for each transmission bit error, which is made available for remote performance monitoring. A second error output, of residual bit errors after forward error correction is available at the decoder but has not been extended.

The equipment cabinet is shown in figure 10.

Future systems

Already before the outcome of these data transmission experiments is known, EUTELSAT has formed a working group to explore an operational system in Europe from 1983/4 onwards. Several proposals are under discussion based on the use of a spare ECS transponder. To utilize the bandwidth efficiently, the transmission rate would increase to 30Mbit/s, which would require larger antennas of five metre diameter and higher power transmitters of up to 2kW. The transponder would be shared using t.d.m.a to provide the users with a medium speed service of 64kbit/s and high-speed service of 2Mbit/s. If this interim ECS solution is successful a dedicated satellite may well be launched, designed to operate with the smaller and cheaper earth terminals.

Through these moves, significant progress has been made to establish an operational satellite based data distribution network within Europe.

Acknowledgements

The author would like to acknowledge the use of information provided by the European Space Agency and other participants in the STELLA and SPINE experiments.

References

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RESUME

Cet article décrit un réseau-prototype de distribution rapide utilisant le satellite d'essai orbital de l'Agence européenne de l'espace. Le dispositif de liaison donne un canal de donnée de 1MB/s entre un certain nombre de centres de calcul régionaux avec une erreur de séquence des bits de 10^{-8} pour 99,3% du temps. Les utilisateurs ont accès au satellite au moyen de petits terminaux terrestres et d'antennes de 3 mètres implantées sur leurs propres locaux.

RESUMEN

Este articulo describe un prototipo de la red de alta velocidad de distribución que usa el satélite orbital de pruebas de la Agencia Europea del Espacio. El enlace provee un canal de datos de 1MB/seq. (Megabitio/seg.) entre un cierto número de centros regionales de cálculo, con un r.e.b (régimen de error de bitios) de 10^{-8} durante el 99,3% del tiempo. Los usuarios pueden establecer contacto con el satélite mediante pequeños terminales y antenas de 3m situados en sus propios centros de trabajo.

ZUSAMMENFASSUNG

Dieser Aufsatz beschreibt die Prototype eines Schnellverteilernetzes, das mit dem Testsatelliten der europäischen Raumfahrtgesellschaft arbeitet. Diese Verbindung stellt einen 1MBit Datenkanal zwischen einer Anzahl von regionalen Computerzentralen her, die über der Betriebszeit mit einer Fehlerhäufigkeit von 10 arbeiten. Zugriff zum Raumsatelliten wird durch kleine Erdstationen mit 3m Gebäudeantennen erreicht.