TÍTULO

SERVICE TELECOMUNICATIONS (TMTC) SUBSYSTEM SPECIFICATION

CÓDIGO O.T.

AC6-E-100

PREPARADO POR

ASS.	JANIO KONO	8/6/86
ASS.	PAULO M. MARSHALL	8/6/86
ASS.	JOSÉ A. RODRIGUES	8/6/86
ASS.	ANTONIO M.P. DE LUCENA	8/6/86
ASS.	MAX H.M. COSTA	/ /

APROVAÇÕES

ASS.	CARLOS E. SANTANA	9/6/86
ASS.		/ /
ASS.		/ /
ASS.		/ /
ASS.		/ /

LISTA DE DIVULGAÇÃO

NOME	ORGÃO	Nº CÓPIAS
- Oscar Pereira Dias Jr.	Ger.Planej.C.Progr.Inst.	1
- Getúlio Camargo	Dir.Progr.Institucionais	1
- Janio Kono	" " "	1
- Carlos Eduardo Santana	Ger.Seg.Esp.Col. de Dados	1
- Paulo Mello Marshall	Depart. de Telecom.	1
- Plínio Tissi	" " "	1
- Cesar Celeste Ghizoni	Dir. de Eng. e Tec.Esp.	1
- Paulo Tromboni S. do Nascimento	Ass. de Dif. Tecnolog.	1
- Mário Mammoli	LIT	1

PÁGINA	VERSÃO	DATA	REFERÊNCIA DA MODIFICAÇÃO	OBSERVAÇÃO
i	1	09/06/86		
ii	3	21/09/87	conforme pedido nº PMS-35	
iii	5	28/09/87	conforme pedido nº PMS-45	
iv	1	09/06/86		
v	1	09/06/86		
vi	1	09/06/86		
vii	1	09/06/76		
1	2	03/12/86		
2	1	09/06/86		
3	2	03/12/86		
4	2	03/12/86		
5	3	21/09/87	conforme pedido nº PMS-35	
6	2	28/09/87	conforme pedido nº PMS-45	
7	1	09/06/86		
8	3	28/09/87	conforme pedido nº PMS-45	
9	1	09/06/86		
10	2	03/12/86		
11	3	28/09/87	conforme pedido nº PMS-45	
12	1	09/06/86		
13	3	28/09/87	conforme pedido nº PMS-45	
14	1	09/06/86		
15	2	28/09/87	conforme pedido nº PMS-45	
16	1	09/06/86		
17	2	03/08/87	conforme pedido nº PMS-19	
18	3	28/09/87	conforme pedido nº PMS-45	
19	2	03/12/86		
20	2	03/12/86		
21	2	28/09/87	conforme pedido nº PMS-45	
22	2	21/09/87	conforme peiddo nº PMS-35	
23	2	28/09/87	conforme pedido nº PMS-45	
24	1	09/06/86		
25	1	09/06/86		
26	1	09/06/86		
27	1	09/06/86		
28	1	09/06/86		

SUMARY

Page

Page

LIST OF FIGURES

TMTC SUBSYSTEM SPECIFICATIONS

1. PURPOSE

This specification establishes the requirements for the performance, design, construction and test of the TMTC Subsystem to be used in the MECB/S1 satellite.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1 - APPLICABLE DOCUMENTS

a) Spacecraft specification A-ETC-0002,

b) Spacecraft to ground interface specification A-EIF-0002.

c) Design and construction specification A-ERC-0001.

d) Environmental specification A-EAB-0001.

e) EMC specification A-ECE-0001.

f) Spacecraft product assurance plan A-GQL-0006.

g) Listas preferenciais de componentes A-GQL-0008.

h) Listas preferenciais de materiais e processos A-GQL-0009.

i) PSS-45 ESA PCM Telecommand Standard (April 78).

j) TTC-A-04 ESA Ranging Standard (July 80).

k) Pss-46 ESA PCM Telemetry Standard (April 78).

l) TTC-A-05 ESA Radio Frequency & Modulation Standard (May 81).

m) PSS-48 S + S/X Bands Coherent Transponder Specification (March 79).

2.2 - REFERENCE DOCUMENTS

a) Plano de desenvolvimento e teste do satélite de coleta de dados A-GRC-0010.

3. REQUIREMENTS

3.1 - SUBSYSTEM DEFINITION

3.1.1 - FUNCTIONS

The TMTC subsystem shall provide a two way transfer of information between the satellite and the ground segment. It shall perform the following functions:

a) Receive the S-band telecommand (TC) messages transmitted by the ground segment.

b) Execute direct (high-level) commands.

c) Supply the messages addressed to the Data Handling subsystem.

d) Retransmit the ranging tones (R) transmitted by the ground segment, in a downlink carrier.

e) Transmit to the ground station the telemetry (TM) message generated by the Data Handling subsystem.

3.1.2 - OPERATING MODES

The TMTC subsystem is required to operate in the following modes:

Mode	Uplink	Downlink
1	idle	TM
2	R	R+TM
3	TC	TM
4	R+TC	R+TM

In modes 2, 3 and 4 the subsystem shall be capable of operating coherently with a turnaround frequency ratio of 240/221.

The control of the operating modes shall be made by direct commands.

3.1.3 - SUBSYSTEM DESCRIPTION

The TMTC subsystem shall comprise a radiating system, two transponders, a dual TC decoder and rf interconnecting cables, as depicted in Figure 1.

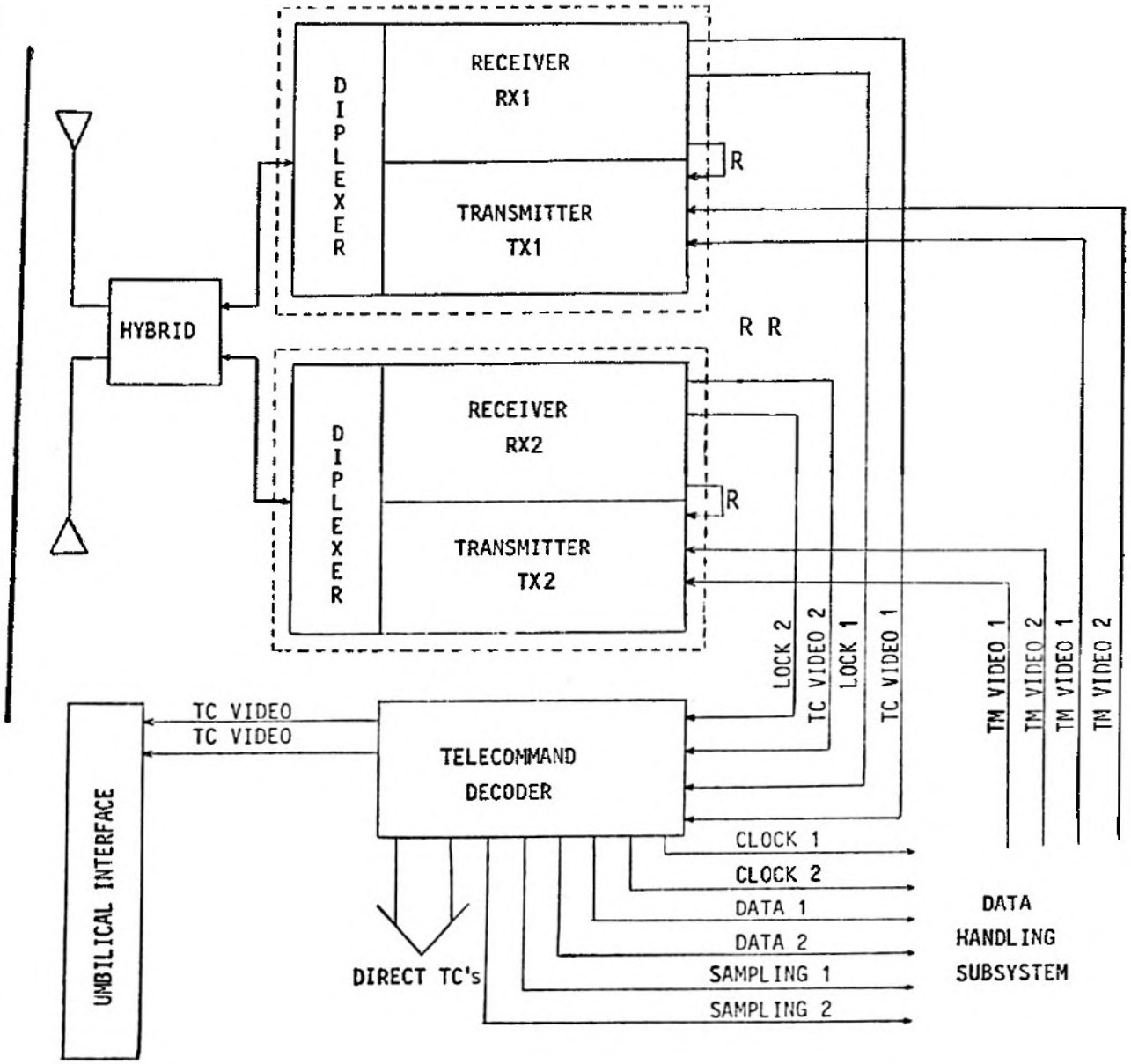

Fig. 1 - TMTC subsystem block diagram.

The radiating system is formed by 2 S-band antennas mounted on opposite faces of the satellite and are connected to the transponders via a 3 dB hybrid.

The S-band transponders consist of a receiver and a transmitter. The receivers are in hot redundancy and feed coherent L.O. signals to each of the transmitters as chosen by telecommand. The transmitters in cold redundancy transmit the satellite telemetry data of the telemetry plus ranging data depending on the operating mode. The demodulated range tones are directly connected to their respective transmitters.

The decoder has full back-up and performs demodulation of the TC video signal, decoding verification and execution of the TC message.

The rf cables interconnect the antennas to the transponders.

The S-band receivers and the dual TC decoder are permanently connected to the satellite power bus. During launch, the separation switch will be open and the S-band transmitter 1 will be off. On separation, the separation switch will close and transmitter 1 will turn-on automatically. As back-up to this operation a direct command is required.

The separation switch and non-rf interconnecting cables are not part of the subsystem.

3.1.4 - SUBSYSTEM INTERFACES

The TMTC subsystem interfaces with the ground segment and with other subsystems as described below.

3.1.4.1 - INTERFACE WITH THE GROUND SEGMENT

a) RF uplink:

The uplink is a unified S band signal conveying a TC subcarrier and ranging tones in accordance with AD-2.1.i and AD-2.1.j.

The nominal frequency is 2033.2 MHz.

The uplink frequency will vary by up to ±60 kHz due to Doppler, at a rate not exceeding 0.75 kHz/s. The uplink carrier frequency will be swept by ±45 kHz about the nominal frequency compensated for Doppler assuming carrier acquisition with a sweep rate of 20 kHz/s.

The procedure for acquisition of the uplink carrier shall be in accordance with AD-2.1.b.

The uplink signal polarization shall be right-hand circular.

The uplink video spectrum is composed of the NRZ-L/PSK TC subcarrier and the non-modulated, sinusoidal major and minor ranging tones, as depicted in Figure 2.

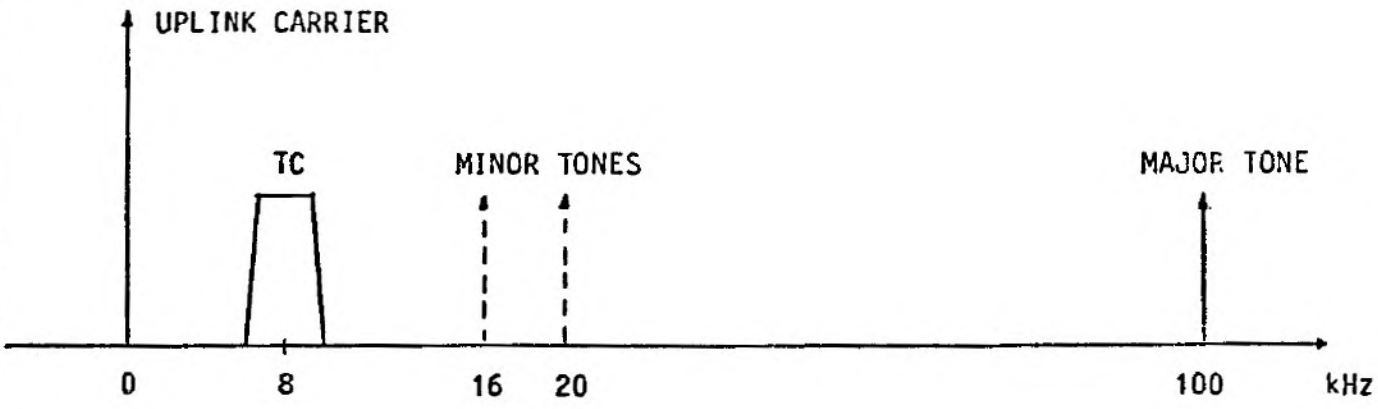

Fig. 2 - Uplink spectrum.

The telecommand and ranging signals phase modulate the uplink carrier with peak modulation indices of θ_{TC} = 0.98 rad ±5%, θ_r = 0.45 rad ±5% and θ_R = 0.87 rad ±5%, where the TC, r and R subscripts denote telecommand, minor and major ranging tones, respectively.

The subsystem G/T shall be as defined in 3.2.1.3.

b) RF downlink:

The downlink rf signal is phase modulated by the telemetry subcarrier, the ranging tones, the remanescent TC subcarrier and the uplink noise, in accordance with AD-2.1.i and AD-2.1.k.

The nominal frequency is 2208 MHz.

The downlink signal polarization shall be right-hand circular.

The downlink video spectrum is composed of the remanescent TC subcarrier, the minor and major ranging tones and the TM subcarrier, as shown in Figure 3.

The downlink carrier is modulated with nominal peak modulations indices of 1.15 rad for telemetry and a root sum square (rss) index of 0.8 rad for the remaining modulating signals with the ranging channel on. A variation of 10% is allowed in the downlink modulation indices.

The downlink EIRP shall be as defined in 3.2.2.2.

The spectrum of the modulated transmitter shall be as defined 3.2.2.5.

The transmitter spurious outputs shall be as defined in 3.2.2.4.

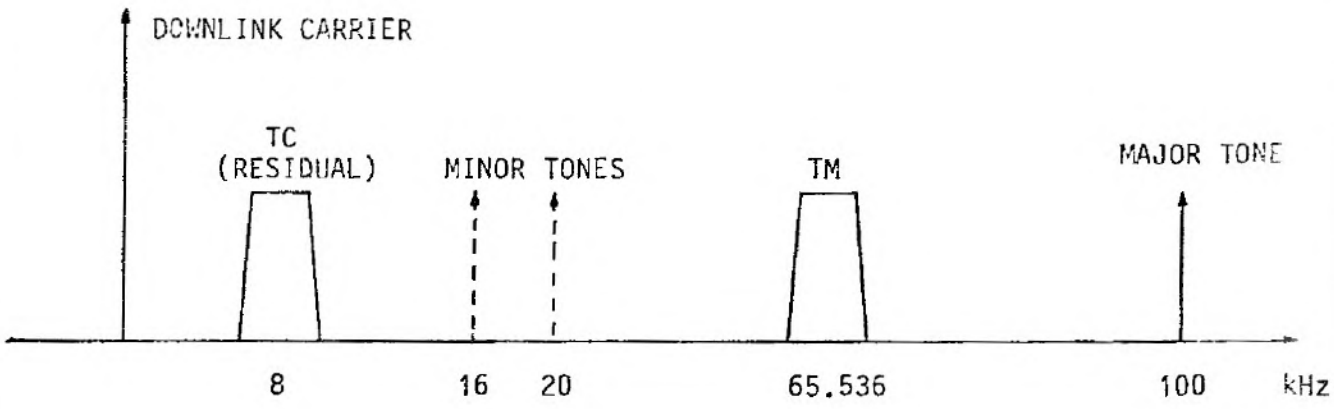

Fig. 3 - Downlink spectrum.

c) Telecommand:

The TC subcarrier is a 8 kHz sinusoid PSK-modulated (0 and π rad) by a NRZ-L bit stream at a rate of 2000 bps, in accordance with AD-2.1.i. The PCM message format is described in the Appendix 1. For the MECB/S1 satellite the address and synchronization words (ASW) and mode words are in accordance with 3.2.3.6 and 3.2.3.7.

d) Ranging:

The ranging tones consist of minor and major sinusoidal tones.

The minor tones sequentially take on the frequencies of 20000 Hz, 16000 Hz, 16800 Hz, 16160 Hz, 16032 Hz and 16008 Hz, and are used to remove ambiguities in the range measurement procedure.

The major ranging tone is a 100 kHz tone.

e) Telemetry:

The TM interface with the ground segment shall have the characteristics described in 3.1.4.2.

3.1.4.2 - INTERFACE WITH THE DATA HANDLING SUBSYSTEM

a) 24-bit serial data:

The TMTC subsystem shall provide 24-bit serial data, clock and sampling signals to the Data Handling subsystem in accordance with AD-2.1.c.

b) Telemetry subcarrier:

The TM subcarrier is a 65536 Hz square wave PSK-modulated by a Bi-ϕ-L sequence of rate 2048 bps.

Each S-band transponder shall provide two telemetry video inputs. The input impedance shall be greater than 100 KΩ and the nominal input level shall be 3 Vpp ±5%.

3.1.4.3 - DIRECT COMMAND INTERFACE

The TMTC subsystem shall provide high-level pulse command to other subsystems in accordance with AD-2.1.c.

The number of high level commands shall be as defined in 3.2.3.4.

3.1.4.4 - INTERFACE WITH POWER SUPPLY SUBSYSTEM

The TMTC subsystem shall receive voltage of 26.5V ± 5% with maximum power consumption of 19W.

3.1.4.5 - UMBILICAL INTERFACES

The TMTC subsystem shall provide two interfaces for telecommand access to the satellite via the umbilical for use during AIT and launch preparations. Each interface shall have the following characteristics:

a) Subcarrier and modulation as defined in 3.1.4.1.c.

b) Load impedance: 50Ω differential type.

c) Signal level: (6 ± 0.5) Vrms.

3.1.4.6 - TELEMETRY INTERFACES

The telemetry signals are classified as analog, digital serial, digital bi-level and thermistors and are listed in 3.2.5. The TM electrical interfaces shall be in accordance with AD-2.1.c.

3.1.4.7 - MECHANICAL INTERFACES

The subsystem mechanical interfaces shall be in accordance with AD-2.1.c. and specific requirements of the IDS.

3.1.4.8 - THERMAL INTERFACES

The subsystem thermal interfaces shall be in accordance with 3.3.7 and specific requirements of the IDS.

3.2 - PERFORMANCE REQUIREMENTS

The TMTC subsystem shall meet the following performance requirements over the specified environmental range and mission lifetime specified herein, except where specifically excluded.

3.2.1 - RECEPTION REQUIREMENTS

The TMTC subsystem shall phase-demodulate the uplink signal to extract the TC subcarrier and the ranging tones. The ranging tones are delivered to the transmitter, while the TC subcarrier is further processed by a command decoder. The following reception requirements shall be met:

3.2.1.1 - COVERAGE

The reception requirement shall be met over the bounds $0^o \leq \theta \leq 85^o$, $95^o \leq \theta \leq 180^o$ and $0^o \leq \phi \leq 360^o$, where θ and ϕ are defined in Figure 4.

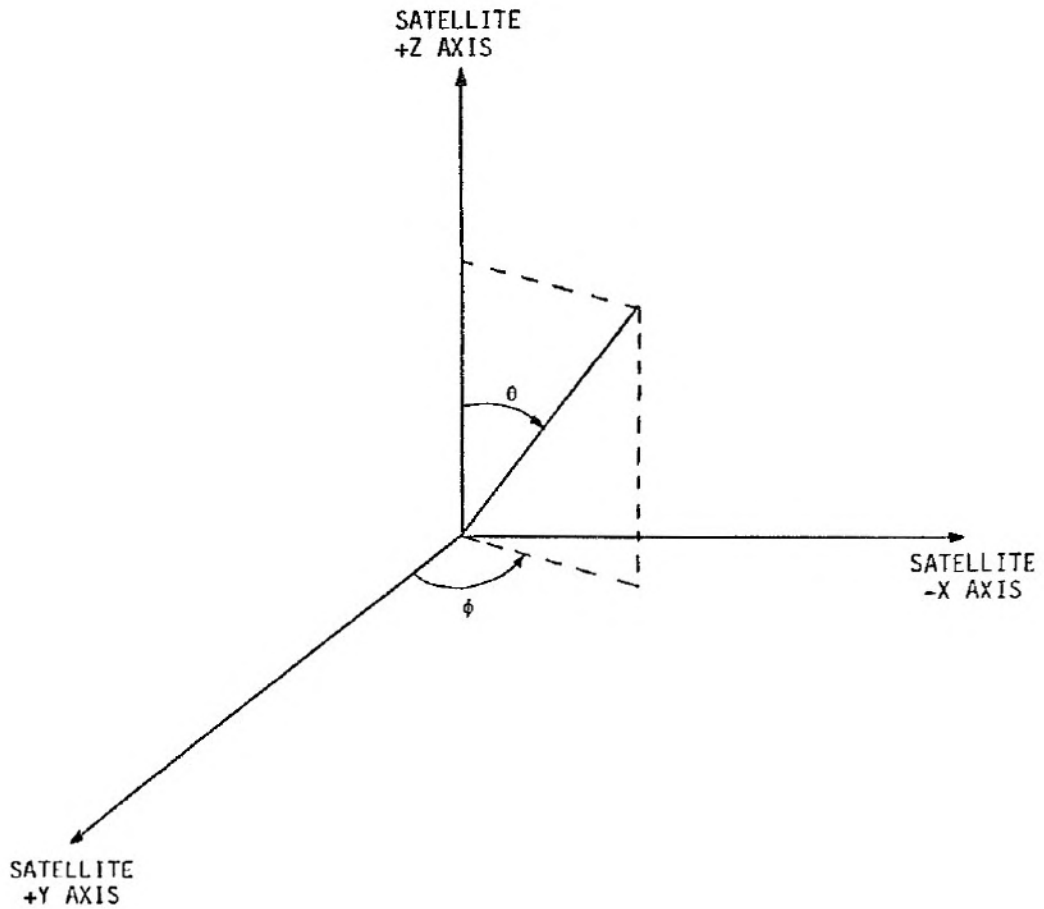

Fig. 4 - Antenna pattern coordinates.

3.2.1.2 - POWER FLUX DENSITY

The TMTC subsystem shall meet the requirements for input power flux density between -105 to -52 dBW/m² over the coverage defined in 3.2.1.1.

3.2.1.3 - G/T AND AXIAL RATIO

The subsystem G/T shall be between -44 and -32 dB/K and the axial ratio shall be less than 6 dB over the bounds defined in 3.2.1.1.

3.2.1.4 - INPUT SIGNAL

The TMTC subsystem shall accept input signals with the characteristics described in 3.1.4.1.a. No permanent damage shall occur for transponder input powers up to 0 dBm.

3.2.1.5 - RECEIVER TYPE

The receiver shall be a superheterodyne type with a second order phase-locked loop tracking the carrier, in accordance with AD-2.1.m.

3.2.1.6 - PHASE-LOCKED LOOP BANDWIDTH

The phase-locked loop bandwidth 2BLO shall be 800 Hz.

3.2.1.7 - REST FREQUENCY

The receiver rest frequency shall not vary by more than ±35 kHz from the nominal frequency specified in 3.1.4.1.a, including initial setting inaccuracies and ageing, over the specified temperature and power supply variations.

3.2.1.8 - ACQUISITION THRESHOLD

The carrier acquisition threshold, defined as the transponder RF input power at which the SNR in 2BLO is 10 dB with an input noise level equivalent to 300K, shall not be greater than -128 dBm.

3.2.1.9 - CARRIER ACQUISITION

The receiver shall acquire the uplink carrier swept through the rest frequency at a rate lower or equal to 32 KHz/s with a probability greater than 99%. This requirement shall be met for power levels to the transponder between -122 dBm and -50 dBm.

3.2.1.10 - CARRIER TRACKING

The receiver shall maintain lock while the uplink carrier is swept ±60 kHz about the nominal receive frequency specified in 3.1.4.1.a at a rate of 32 kHz/s. Lock shall also be maintained over a sweep range of ±80 kHz about the nominal frequency and ±115 kHz about the rest frequency at a rate of 3 kHz/s.

3.2.1.11 - SELECTIVITY

The selectivity curve shall be within the limits set by Figure 5.

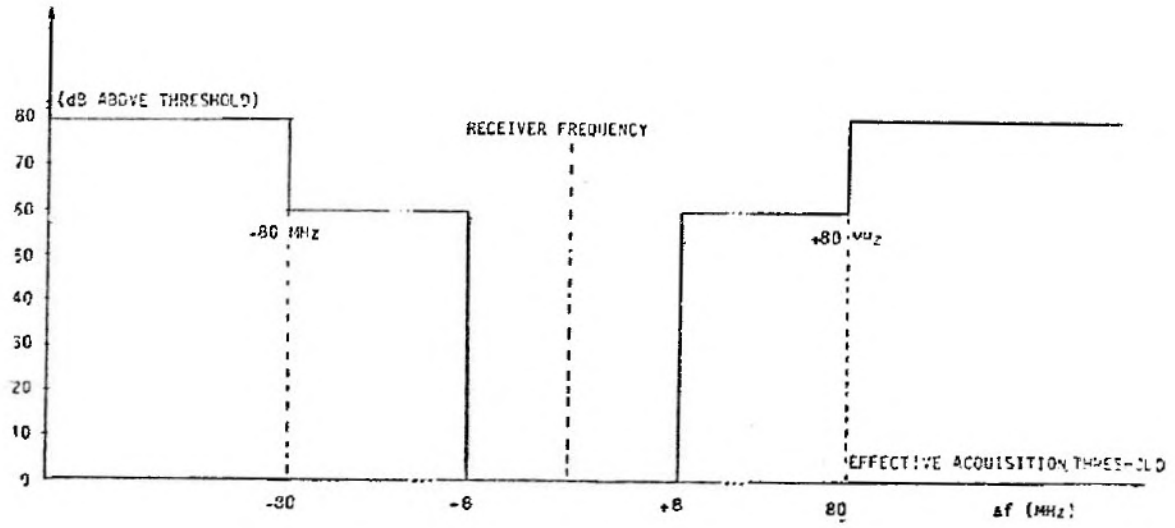

Fig. 5 - Receiver selectivity.

3.2.1.12 - AGC

The TMTC subsystem AGC response time shall be such as to ensure compliance with the specifications even in the presence of additional amplitude and phase ripple due to the spacecraft spin. For the purpose of this specification the worst-case additional modulation due to the spin shall be taken as simultaneous sine waves of frequency 36 Hz, with peak amplitude ±6 dB about the nominal and phase ±50 degrees about the nominal, where the amplitude and phase modulation are $\pi/2$ radians out of phase.

3.2.1.13 - DEMODULATION

With an uplink modulation index of 1.2 rad ±5% the performance shall be within 1.5 dB of the theoretical for input levels to the transponder of between -109 and -85 dBm and the S/N density ratio shall not fall below the level for -85 dBm for powers between -85 and -50 dBm. The demodulated signals shall meet the following requirements:

- *TC Signal:* The demodulated TC signal is a PCM/PSK subcarrier, as described in 3.1.4.1. The performance of the transponder shall be compared with the theoretically expected taking account of the noise figure and the PM modulation loss $2J_1^2(\theta_{TC})$.

- *Ranging tones:* The demodulated ranging tones have characteristics described in 3.1.4.1. The rms voltage delivered by this channel for all temperature, supply voltage, input power and Doppler conditions shall not vary by more than ±0.5 dB.

3.2.1.14 - RECEIVER OUTPUTS

The TMTC subsystem shall provide the following reception outputs:

- TC subcarrier,
- ranging tones,
- VCXO output suitable for use as a coherent drive source with the turnaround frequency ratio of 240/221,
- lock status signal.

3.2.2 - TRANSMISSION REQUIREMENTS

The TMTC subsystem shall phase-modulate and transmit the downlink S band signal to the ground segment. This signal is modulated by the TM subcarrier and by the ranging baseband. The following transmission requirements shall be met within 10 seconds of prime power application unless specified otherwise.

3.2.2.1 - COVERAGE

The transmission requirements shall be met over the bounds defined in 3.2.1.1.

3.2.2.2 - EIRP AND AXIAL RATIO

The EIRP shall be between 11 and 23 dBm and the axial ratio shall be less than 6 dB over the bounds defined in 3.2.1.1.

3.2.2.3 - OUTPUT SIGNAL

The TMTC subsystem shall transmit the downlink S band signal with the characteristics described in 3.1.4.1.b. This signal is derived either coherently from the receiver with a turnaround frequency ratio of 240/221, or non-coherently from an independent oscillator as chosen by telecommand.

3.2.2.4 - SPURIOUS EMISSIONS

The TMTC subsystem shall show no spurious outputs higher than -50 dB with respect to the unmodulated carrier, in both coherent and non-coherent operating modes.

3.2.2.5 - MODULATED SPECTRUM

The spectrum of the modulated output shall be within the mask of Figure 6. The spectrum shall be symetrical to 1 dB.

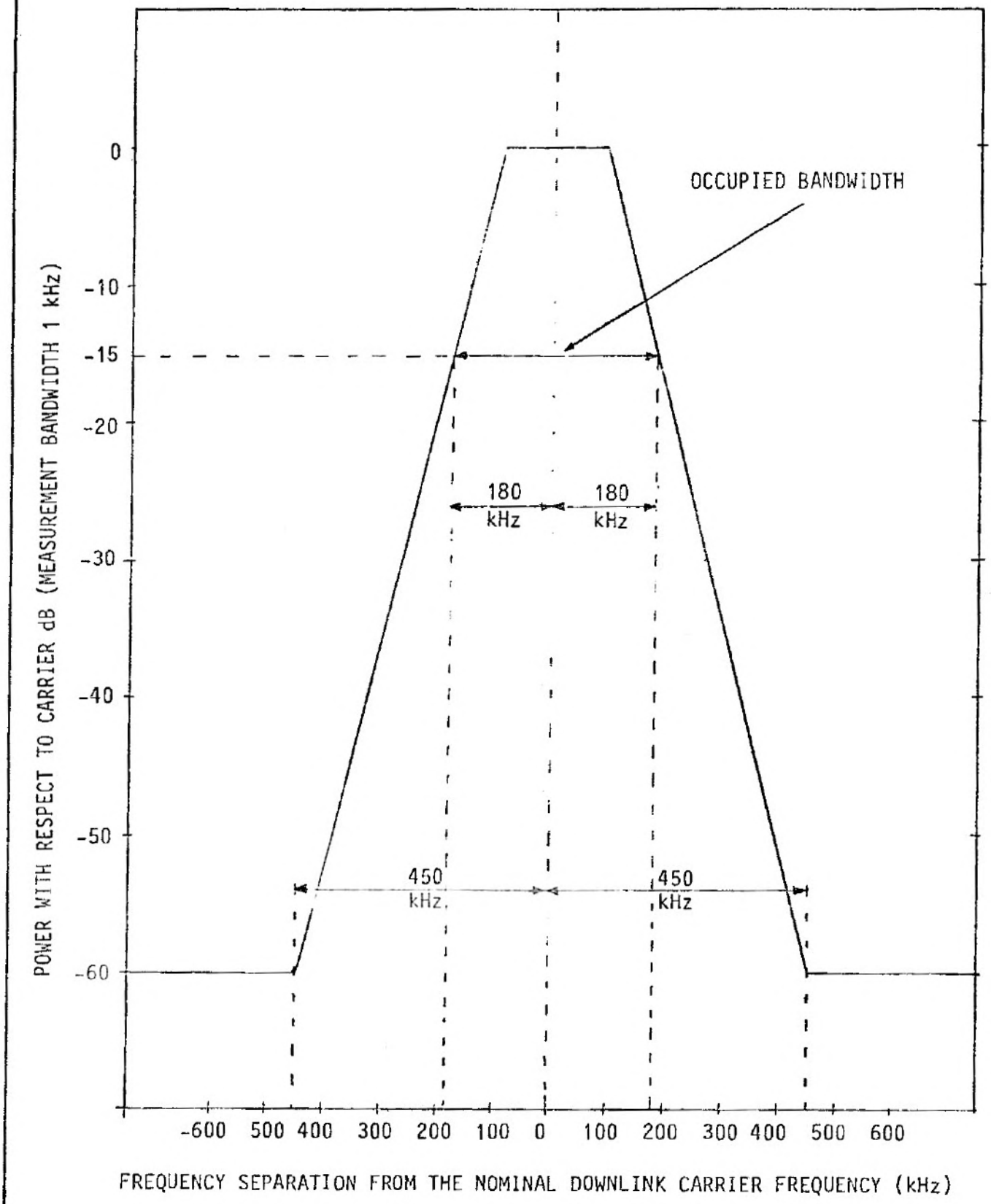

Fig. 6 - Downlink spectral mask.

3.2.2.6 - FREQUENCY STABILITY REQUIREMENTS

In the non-coherent mode the downlink carrier frequency shall meet the following requirements:

- Initial frequency setting shall be within ±5 ppm of the nominal frequency specified in 3.1.4.1.b.

- Frequency variation shall be less than ±15 ppm of the nominal including initial setting inaccuracies and ageing, over the specified temperature and power supply variations.

3.2.2.7 - PHASE NOISE

The phase noise of the downlink carrier shall not exceed 5^{o} rms when measured in a test receiver with 2 BL = 20 Hz, i.e. the phase noise is integrated between BL (10 Hz) and an upper limit of 100 kHz. For this measurement the signal level into the test receiver shall be greater than 50 dB above the threshold of the test receiver and the uplink signal power to the transponder in the coherent mode shall be 20 dB above its acquisition threshold.

3.2.2.8 - MODULATION INPUTS

The transmitter shall accept three modulation inputs and provide a phase modulated downlink carrier. The inputs are one ranging and two TM channels.

- *Telemetry video:* The telemetry message is delivered by the Data Handling subsystem with the characteristics described in 3.1.4.2. The voltage of telemetry input required to maintain a modulation index of 1.5 radian or less shall not vary by more than 1 dB in the frequency range 3.6 KHz to 300 KHz, and over the specified temperature and power supply variations. The choice of the transmitted TM channel is made by command.

- *Ranging baseband:* The ranging tones are delivered by the receiver with the characteristics described in 3.2.4. The voltage required to maintain a modulation index of 1.0 radian or less shall not vary by more than ±0.5 dB in the frequency range 3.6 kHz to 300 KHz and over the specified temperature and power supply variations.

The modulation linearity shall be better than 3% up to 1.5 rad in the telemetry channel and up to 1.0 rad in the ranging channel.

3.2.2.9 - RESIDUAL AM

The residual AM of the modulated downlink carrier shall be less than 2%.

3.2.3 - TC DECODING REQUIREMENTS

The TMTC subsystem shall perform the following tasks:

- Receive and demodulate the PCM/PSK TC subcarrier and perform the bit synchronization.
- Decode the demodulated data stream.
- Distribute the decoded commands to the Data Handling subsystem in the form of serial data.
- Distribute the high level commands to the users in the form of voltage pulses.

The following requirements shall be met:

3.2.3.1 - INPUT SIGNAL

The TC decoder shall accept inputs signals with modulation, subcarrier and bit rate as described in 3.1.4.1.c. The nominal symbol energy/noise density (E/N_0) shall be greater than 16 dB. The frame format is described in Appendix 1.

3.2.3.2 - TIME ACQUISITION

The acquisition of data must be performed during the reception of the initialisation word described in Appendix 1.

3.2.3.3 - BIT ERROR RATE

The bit error rate shall be less than 10^{-5} when E/N_0 = 16 dB.

3.2.3.4 - NUMBER OF HIGH LEVEL COMMANDS

The number of high level commands shall be 64.

3.2.3.5 - FALSE COMMAND PROBABILITY

Under any signal to noise ratio conditions, the false command probability shall be less than 10^{-5}.

3.2.3.6 - MODE WORD

A minimum of two mode words shall be used, one for high level command and the other for serial data command.

3.2.3.7 - ADDRESS AND SYNCHRONIZATION WORD (ASW)

Two ASW shall be used, 05D9 and 05E2, each one addressing one of the two decoders. Provision shall be made to make the ASW's selectable externally to the decoder (e.g. by plugable connector fitted with wire links).

3.2.3.8 - CRITERIA FOR FRAME ACCEPTANCE

The following requirements must be met for a frame to be decoded:

1) A frame is accepted when:

   - an assigned address and synchronization word (ASW) is recognized at the begining of the frame and immediately after the frame;
   - the mode word is accepted;
   - at least one of the two words of each of the three commands in a frame is accepted.

2) The ASW is recognized if at least 15 of the 16 bits are correct. The word may be received in complemented from.

3) The criterion of acceptance of the mode words shall be the following:

   - one and only one of the two words is acceptable;
   - if both words are acceptable they must be identical.

4) The criterion for an acceptable data word is that no error is detected by the Hamming code in the received command word.

3.2.3.9 - OUTPUT SIGNALS

The TC decoder shall provide serial data output to the Data Handling Subsystem and high level pulse commands to users, in accordance with the characteristics described in 3.1.4.2 and 3.1.4.3 respectively.

3.2.4 - RANGING REQUIREMENTS

The TMTC subsystem shall retransmit the ranging tones transmitted by the ground station. These consist of minor tones and a major tone with the characteristics described in 3.1.4.1. The following requirements shall be met for input power to the transponder between -105 dBm and -50 dBm with simultaneous telecommand and between -109 dBm and -50 dBm with ranging alone. In addition all requirements shall be met for frequency offset of ±115 kHz about the rest frequency or ±80 kHz about the nominal frequency.

3.2.4.1 - MODULATION INDICES

The uplink and downlink modulation indices shall be as given in 3.1.4.1. The downlink modulation index of any one tone shall always be greater than 0.2 radian peak for input power to the transponder in the range from -109 to -50 dBm.

3.2.4.2 - FREQUENCY CAPABILITY

The frequency capability of the ranging channel shall range from 3.6 kHz to 300 KHz.

3.2.4.3 - MAJOR TONE DELAY STABILITY

The major tone delay through the TMTC subsystem shall be constant to within ±70 ns over the full range of Doppler, input level, temperature, voltage and mission lifetime. It shall be possible to know the on board delay to ±5 ns at any time, using telemetered data of voltage and temperature and predicted Doppler.

3.2.4.4 - AMBIGUITY RESOLUTION

There shall be a linear relationship between the ranging tone delay, expressed in terms of phase, and the tone frequency. Departures from this relationship should be less than $\pm 5^{o}$ of phase.

3.2.4.5 - POLARITY

A positive phase shift on the uplink shall give rise to a positive phase shift on the downlink.

3.2.4.6 - AGC RANGING

The transponder shall contain AGC in the ranging channel to mantain the rms sum of the major tone, minor tone, residual TC subcarrier and any noise, constant.

3.2.5 - TELEMETRY AND TELECOMMAND REQUIREMENTS

The TMTC subsystem shall accept and perform at least the telecommand actuations listed below, in accordance with the requirements specified in 3.1.4.3:

- Ranging on/off,
- Telemetry channel 1/channel 2,
- Coherent/non-coherent.

The following telemetry monitoring, classified as digital bi-level, digital serial or analog, shall be available and compatible with the specifications in 3.1.4.6:

Digital bi-level telemetries

- Ranging on/off.
- Coherent/non-coherent status,
- Telemetry channel 1/channel 2,
- Receiver lock status,
- TC subcarrier presence.

Digital serial telemetries (TC Decoder)

- ASW status, Frame valid, mode word, data word A (16 bits),
- Data word B, data word C (16 bits).

Analog telemetries

- TX output power monitor,
- Transponder temperature,
- Receiver AGC,
- Receiver static phase error (SPE),
- TC decoder temperature.

3.3 - DESIGN AND CONSTRUCTION REQUIREMENTS

The subsystem equipments shall meet the following design and construction requirements, except where specifically excluded.

3.3.1 - GENERAL REQUIREMENTS

3.3.1.1 - LIFETIME

The subsystem shall be designed to meet all specifications for a life expectancy of up to 1 year of integration and tests, 2 years storage and 6 months mission over all environmental conditions specified in 3.3.5.

3.3.1.2 - RELIABILITY

The TMTC subsystem shall met the requirements of this specifications for the mission lifetime defined in 3.3.1.1 with the minimum probability of 0.99.

3.3.1.3 - REDUNDANCY

The receivers shall be connected in hot redundancy while the transmitters in cold redundancy. Full redundancy shall also be provided internally to the TC Decoder.

3.3.1.4 - INTERCHANGEABILITY

The interchangeability requirements shall be in accordance with item 3.5 of AD-2.1.c.

3.3.1.5 - MAINTAINABILITY

The subsystem equipments shall be designed such that replacement and maintainability can be readilly carried out at the manufacture premises, in accordance with item 3.8 of AD-2.1.c.

3.3.1.6 - TEST POINTS

Test points shall comply with the specifications of item 3.9 of AD-2.1.c.

3.3.1.7 - SAFETY

The subsystem equipments shall meet the safety requirements specified in item 3.10 of AD-2.1.c.

3.3.1.8 - WORKMANSHIP

The subsystem equipments shall be built to standards normally associated with satellite hardware and shall be in accordance with item 3.11 of AD-2.1.c.

3.3.1.9 - IDENTIFICATION OF PRODUCT

The subsystem equipments shall be identified in accordance with item 3.12 of AD-2.1.c.

3.3.1.10 - PRODUCT ASSURANCE

The equipments shall be designed and constructed according the requirements of AD-2.1.f.

3.3.1.11 - MATERIAL, COMPONENTS AND PROCESS

Components, materials and processes used must comply with items 3.3 and 5 of AD-2.1.c.

3.3.1.12 - PREPARATION FOR DELIVERY

Each subsystem equipment and part shall be shipped in accordance with item 3.14 of AD-2.1.c.

3.3.2 - ELECTRICAL REQUIREMENTS

The subsystem shall be able to operate with (26.5 ± 0.8)V supply voltage and power consumption less than:

. 13.5W in stand-by.

. 19W with TX on and decoder in stand-by,

. 23W during TC output.

The requirements on item 6.5 of AD-2.1.c. shall apply to the sybsystem.

3.3.3 - GROUNDING REQUIREMENTS

Primary power returns shall be isolated from DC/DC converters secondary returns.

3.3.4 - EMC REQUIREMENTS

The subsystem and associated equipments shall be designed in accordance with the requirements of AD-2.1.e, except where specifically excluded.

3.3.5 - ENVIRONMENTAL REQUIREMENTS

The subsystem shall be designed to withstand all mechanical, thermal, climatic and other in-orbit (pressure and radiation) environmental conditions defined in AD-2.1.d.

3.3.6 - MECHANICAL REQUIREMENTS

The requirements of AD-2.1.c for dimensions, mass properties, structural design, fixations and alignments shall apply.

The total mass of the subsystem shall be less than 14 kg.

The equipments dimensions and associated tolerances and the mass properties are indicated in the Interface Data Sheet (IDS).

The antennas requires positioning accuracy on the structures, but without use of optical reference reflectors.

3.3.7 - THERMAL REQUIREMENTS

This item shall be according to item 5 of AD-2.1.c, except where specifically excluded.

4. VERIFICATION AND TESTS

The compliance of the subsystem with all portions of this specifications shall be demonstrated by analysis or test. The tests shall be done in the equipment level.

The subcontractor shall submit a test plan and test procedure to the prime contractor.

All test conditions and equipments shall be according to spacecraft product assurante plan AD-2.1.f.

APPENDIX 1

COMMAND FORMAT

1. MESSAGE

As shown in Figure 7, the PCM telecommand message is composed of the following three component sequences, forming a uninterrupted message sequence:

- Initialization word: It consists of a fixed number of acquisition bits and is used to initialize the message. The standard sequence is 128 bits long and formed by alternated ones and zeros, starting with a one.

- Message sequence proper: It consists of an uninterrupted sequence of one or more 96-bit telecommand frames.

- End-of-message word: It consists of a 16-bit word and is used to terminate the telecommand message.

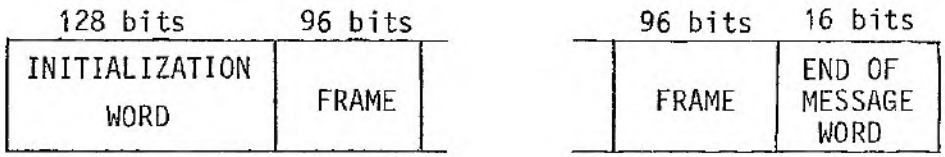

Fig. 7 - Telecommand message.

2. FRAME STRUCTURE

The telecommand frame is shown in Figure 8. The 16-bit address and synchronization word (ASW) is used to identify the spacecraft, to synchronize the frame and to resolve the ambiguity inherent to the demodulated data. Following the ASW is the "mode" indication which identifies the mode of distribution of command data.

The frame has three 12-bit data words that contain the command information to be transmitted. Each data word is repeated, in order to lower the probability of command rejection.

16 bits	4 bits	4 bits	12 bits	12 bits	12 bits	12 bits	12 bits	12 bits
ASW	MODE WORD	MODE WORD	A DATA WORD	A DATA WORD REPEATED	B DATA WORD	B DATA WORD REPEATED	C DATA WORD	C DATA WORD REPEATED

Fig. 8 - Telecommand frame structure.

3. ADDRESS AND SYNCHRONIZATION WORD (ASW)

The list of permitted address and synchronization words is given in Table 1. The minimum mutual Hamming distance between these codewords is 3. The first 7 bits of each ASW form one of the permitted NASA-GSFC addresses. For each word the most significant bit is the first one to be transmitted.

TABLE 1

ADDRESS AND SYNCHRONIZATION CODEWORDS

7 bits (NASA)	9 bits (ESA)	7 bits (NASA)	9 bits (ESA)
0111011	000100101	1101110	000010100
	001010000		000110010
	010011000		100001100
	100001001		101000011
	100010110		101100000
	111000101		110000101
1110000	010100110	1000011	001011110
	011001010		011010101
	100010110		011101010
	100110101		101110101
	101001101		110100010
	110011010		111010110
1011010	000011100	0010110	000111011
	000101110		010101111
	001000111		011101010
	011100000		011110100
	100010011		101110000
	101110001		111011100
	111000001		
0100000	101110011		
	110010101		
	110111001		
	111001101		
	111001010		

4. MODE WORD

A 4-bit mode word is included in every frame, after the ASW. The mode word is repeated once and contains information relating to the distribution of the 24-bit command data on board the spacecraft. The code used for the mode word is the 2-out-of-4 code permitting 6 different modes. The 6 mode words are given in Table 2.

TABLE 2

MODE CODEWORDS

MODE Nº	CODE
1	1100
2	0011
3	0110
4	1001
5	0101
6	1010

5. DATA WORD

Each data word is a 12-bit sequence conveying 8 bits of information. The code used is a (12,8) systematic code derived by truncation from the (15,11) Hamming code. Each data word is sent twice in every frame in order to lower the probability of frame rejection. The 12-bit data word structure is shown in Figure 9, together with the generation law of the 4 check bits. The first bit to be transmitted is B_0 and the last is P_3.

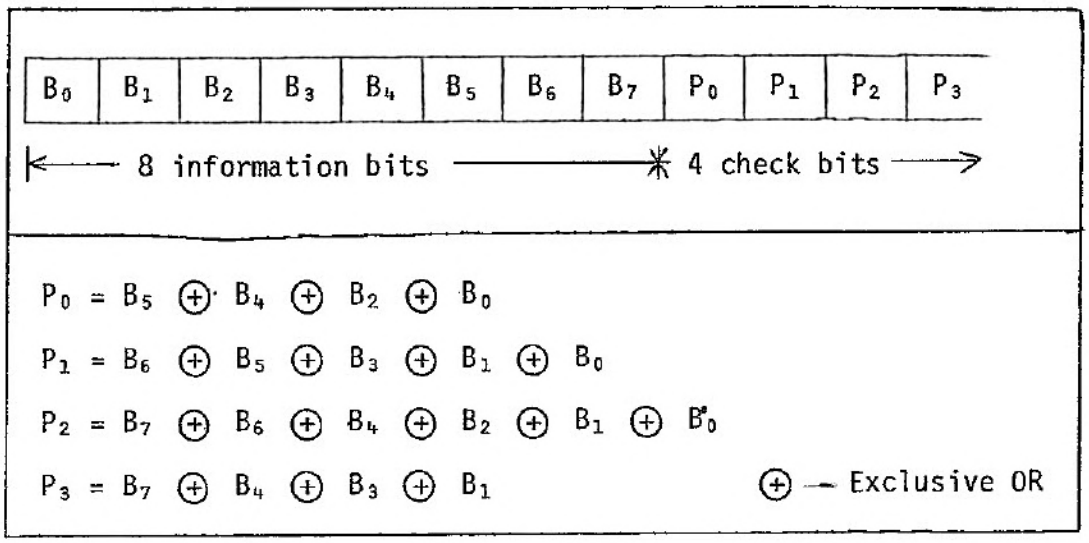

Fig. 9 - Data word structure and coding.

6. END-OF-MESSAGE WORD

The end-of-message word is a 16-bit word identical to the ASW.