

GMS-5 Telemetry and Command SubSystem¹

Telemetry

The telemetry subsystem consists of redundant Central Telemetry Units (CTU 1 & 2) and Remote Telemetry Units (RTU A & B). This subsystem multiplexes telemetry data from sources throughout the spacecraft and converts analog signals to digital. The data is then formatted and synchronized in to the PCM serial data stream. In addition, satellite attitude data from Sun and Earth sensors, nutation data from accelerometers, command execute verification and thrusters and Apogee Kick Motor (AKM) firing signals are sensed and sub-carriers are modulated for simultaneous real time transmission. The signals, the PCM data stream and the sum of the real time sub-carriers are transferred to the communications subsystem for transmission to the ground by either the redundant S-band telemetry or Unified S-band (USB) transmitters.

Channel capacity	256 x 2 (combination of analog and digital)
Digital Format	Biphase level (Biφ-L) PCM
Bit rate	250 bits per second
Minor frame length	64 words of 8 bits per word
Major Frame	64 Minor frames
Subcommutation	Housekeeping spacecraft data 1 x 64, 1 x 32 & 1 x 16 word
Analog accuracy	±0.6% (8 bits)
Real time	Sun pulses, earth pulses, index pulses, accelerometer, thruster valve actuation and AKM verification, command execute with priority gating of IRIG channel 12 and B SCOs and gating of a 64 kHz and 48.25 kHz tone.
S-band telemetry (CDAS)	1694.0 MHz +40 ±1.5 dBm EIRP PCM/PSK/PM, FM/PM, FSK/PM
USB telemetry (TT&C)	2280.721 MHz +27 ±1.5 dBm EIRP PCM/PSK/PM, FM/PM, FSK/PM

¹ Information extracted from

1. Geostationary Meteorological Satellite GMS Mission Plan, Hughes D6009, January 1977.
2. Geostationary Meteorological Satellite Data Book, Hughes D1388, January 1977.
3. GMS-2, NASDA, February 1979.
4. GMS Simulator Equipment, Japan Meteorological Agency, Meteorological Satellite Centre Technical Note 6, pp.69-76, March 1982.
5. GMS-3, NASDA, August 1983.
6. Telemetry Sub-system, MSC TN Special Edition (1989), V.1, Chap.7, pp.63-77, 1989.
7. Command Sub-system, MSC TN Special Edition (1989), V.1, Chap 7, pp.71-77, 1989.
8. Improvement of Telemetry Watching Function, MSC TN 20, pp.85-97, March 1990.
9. GMS-4, NASDA, March 1991.
10. GMS-5, NASDA, June 1992.

GMS Telemetry Format

MFW	0	1	2	3	4	5	6	7	8	9	-----	30	31	32	33	34	-----	61	62	63
0	Frame sync	1	2	3	4	5	6	7	8	9	-----	30	31	32	33	34	-----	61	62	63
1																				
2																				
3																				
.																				
.																				
.																				
.																				
61																				
62																				
63																				

Word 0 & 1 - Minor Frame Synchronization - 16 bits, 1110 1011 1001 0000, ED90 hex, most significant bit first

Word 2 - Minor Frame Identification - upper 6 bits, 000000XX to 111111XX, Minor Frame ID 0 to 63

Word 2 - Telemetry mode - lower 2 bits, 00 Normal, 01 Dwell, 10 sub-com, 11 sub-com & Dwell

Word 3 - PCM Mode - Primary or operate mode 00001111 hex, 15 dec

Word 4 - always 00000000, 00 hex

Word 5 & 6 - Command Verification from Command Decoder A,

Word 5 upper 5 bits - Decoder Address 00101 A, 00111 B,

Word 5 lower 3 bits 001 50ms pulse mode, 011 continuous mode, 010 multiple mode

Word 6 command

Word 7 & 8 - Command Verification from Command Decoder B

Command

Redundant command demodulator-decoders demodulate and decode PCM (NRZ)/FSK-AM baseband signals received from the S-band or USB receivers. The two command channels are actively redundant (both in simultaneously in operation). Satellite received command messages are verified by telemetry prior to command execution. Command outputs to the various spacecraft subsystems consist of discrete pulse and serial magnitude commands. The command driver unit amplifies pulse commands for driving relays, pyrotechnic devices, valves, thrusters and thermal control heaters.

Number of commands over 200

Format PCM (NRZ)/FSK-AM/PM

Bit rate 128 bits per second

Command tones Logic 1: 8600 Hz

Logic 0: 7400 Hz

Execute: 5790 Hz

Hold: 7400 Hz

Guard modulation 128 Hz, 50% AM over Preamble, Sync word and Command Frame

Drivers Total 66

Heater,

solenoid,

valve,

relay,

squib AKM ignition,

AKM separation

Passive Nutation damper

VISSR Cooler cover,

S-band command 2034.2 MHz

(CDAS uplink) PCM/FSK-AM/PM

USB command 2100.164MHz

(TT&C uplink) PCM/FSK-AM/PM

GMS Command Format

128 Hz 50 % AM								
Introduction		Command Frame						
Preamble	Sync word	Decoder address	Command Type	Command	Hold Tone	Execute Tone	Hold Tone	Clear
27 bit	2 bit	5 bit	3 bit	8 bit	7400 Hz variable length - cmd verify via tlm	5790 Hz cmd execute tone on RT tlm (IRIG B)	7400 Hz variable time	325±125 mS of no tone. cmd verf in tlm goes to 0
SMS 0 GMS 0 GMS-2 1 GMS-3 1 GMS-4 GMS-5	1 0 1 0 0 1 0 1	00101 - Decoder A 00111 - Decoder B	001 - 50 mS pulse 011 - continuous 010 - multiple pulse					

GMS Command examples

- 82 High power Mode - S-band
- 83 Low Power Mode - S-band, used for Ranging

- 78 MFR - VISSR mode
- 91 MFR - SV mode
- 105 MFR - Transponder mode for WEFAX

Spacecraft Parameter		GMS	GMS-2	GMS-3	GMS-4	GMS-5
S-band	Antenna	Parabola reflector with cavity-backed dipole feed				
	Gain	~18 dB				
	Polarization	Vertical (Parallel to spin axis)				
	Coverage	Earth				
	G/T	-19 dB/°K	-14.7 dB/°K	-22 dB/°K		
	EIRP	+56 dBm	+40 ±1.5 dBm			
	Telemetry	1694.0 MHz				
	Command	2034.2 MHz				
TT&C	Antenna	8, $\lambda/2$ monopoles	Bi-cone			
	Gain	-10 dBi				
	Polarization	RHCP	Vertical			
	Coverage	Omni	±50°			
	G/T	-44 dB/°K	-42.7 dB/°K	-40.0 dB/°K		
	EIRP	+25 dBm	+28.34 dBm	+27.5 ±1.5 dBm		
	Telemetry	136.89 MHz	2286.5 MHz	2280.721 MHz		
	Command	149.10 MHz	2110.8 MHz	2100.164 MHz		
Telemetry	Capacity	254	384	2 x 256		
	Coding	Bi- ϕ PCM				
	Modulation	PCM/PSK/PM				
	PCM PM Mod Index	≈ 0.4 rad				
	Minor Frame	64, 8 bit words				
	Major Frame	64 Minor frames				
	Sub com	HK 2 x 64 word SEM 2 x 8 word	HK 1 x 64 HK 1 x 32 HK 1 x 16 SEM 2 x 8 word			HK 1 x 64 HK 1 x 32 HK 1 x 16 SEM none
PCM	Total channels	254		2 x 256		2 x 256
	Analog	105				
	Digital Status	121				
	Serial digital	2				
	Spare	26				

Real Time channels	Modulation	FSK/PM, FM/PM				
	Mod index	≈ 1.7 rad				
	IRIG B Sub Carrier Oscillator 27.1 kHz Centre Freq	ψ_1, ψ_2 Sun Angle Sensor (34.0 kHz FSK) two 2ms pulses per rev North, South Earth Sensor (26.6 \approx 27.1 kHz FM) two 25 ms pulses per rev Antenna DBA Index (28.1 kHz FSK) Command execute (30.3 kHz FSK) 50ms pulse, can be synchronized with Sun/Earth pulses				
	IRIG 12 Sub Carrier Oscillator 11.0 kHz Centre Freq	AKM ignition verify ANC thruster actuation				
	64 kHz Sub Carrier Oscillator	Precision Sun Sensor (one 1.5 ms pulse per revolution)				
Command	Number	254 pulse 3, 16 bit serial	254 pulse 1 serial	254 pulse 1 serial		254 pulse 3 serial
	Modulation	PCM/NRZ/FSK-AM				
	Bit rate	128 bps				
	Logic 1	8600 Hz + AM				
	Logic 0	7400 Hz +AM				
	Execute	5790 Hz				
	AM	128 Hz sine wave 50%				
	Preamble	27 1s or 0s + AM				
	Hold	7400 Hz				
	Command address	8 bits				
	Command word	8 bits				
Commands						
Driver Unit	Total	68	68	68		66
	Heater	2 x 4 pairs	6	6		
	Squib	2 x 4 pairs	6	6		
	Solenoid	6	6	6		
	Relay	44	44	44		
	Latch valve	2	4	4		