EASAT-2 AND HADES – TRANSMISSIONS DESCRIPTION

AMSAT EA's EASAT-2 and HADES satellites employ a 50-bit-per-second FSK modulation system for telemetry, as well as 32-word-per-minute Morse for their beacon transmissions. The ability to relay data and voice is also available, as described below.

Summary of transmissions:

There are 9 types of transmissions:

- Fast FSK telemetry (every 60 seconds)
- Slow FSK telemetry (2 times every 14 minutes)
- FSK statistics telemetry (every 14 minutes)
- CW beacon (every 14 minutes)
- FM Vocoder (digitized voice) (every 2 minutes)
- SSTV Robot36 (every 14 minutes, HADES only)
- FSK data spin experiment (every 14 minutes)
- FSK radiometer experiment data (every 14 minutes)
- FSK data lunar basaltic experiment (every 14 minutes, EASAT-2 only)

Apart from these satellite-generated transmissions, two types of retransmissions are available as a service to users of ground stations:

- FM voice broadcasts
- FSK data retransmissions at 50 bits per second

Working frequencies and modes

The working frequencies coordinated with the IARU are the following:

EASAT-2 (SO-114)

- Uplink 145.875 MHz, Modes: FM voice (no subtone) and FSK 50 bps
- 436.666 MHz (436.680 MHz real) downlink CW, FSK 50 bps, FM voice beacon with callsign AM5SAT

HADES (SO-115)

- Uplink 145.925 MHz, Modes: FM voice (no sub tone) and FSK 50 bps
- 436.888 MHz (436.898 MHz real) downlink CW FSK 50 bps, SSTV Robot 36, FM voice beacon with callsign AM6SAT

In case the satellite is in FM voice repeater mode, it is activated by level without the need for sub-tone.

For the case of FSK packets, when the digital transponder is active, the received signals are sampled 100 times per second. If their level is 6dB above noise, they will be digitally restored and sent to the broadcast module.

The repeater capability, both FM voice and FSK, is available if the satellite has been activated for that function from the ground control station. Said activation will occur once the correct operation of the satellites is verified, which are at first configured to operate only when they receive sunlight.

The satellites have limited storage and forwarding capacity (Store & Forward), (byte by byte), implemented in a conceptual way and managed only by remote commands sent from Mission Control at URE Madrid.

Transmission format

The format of each transmission is as follows:

CW beacon

The CW beacon is sent at 32 words per minute, every 14 minutes. An example of a message transmitted is:

EASAT-2: VVV OF AM5SAT AM5SAT EASAT2 HI HI
HADES: VVV DE AM6SAT AM6SAT HADES HI HI

Another 19 different types of message are sent with greetings from space in Spanish and English.

* The CW beacon as well as other transmissions may not be generated in case the satellite is in a low power state.

FSK packets

In EASAT-2 and HADES, FSK packets can be of six types: fast, slow, statistics, spin determination, radiometer data, and basaltic experiment data (EASAT-2 only) telemetry. Each of them is generated at the time of transmission. Bytes are sent in 'LSB first' format (least significant bit first).

Scrambling of data packets

A scrambling process is carried out on all FSK packets. The only fields that are not encoded are the training sequence, the sync bytes (fields 1, 2 and 3 in all packets) as well as the CRC at the end.

The encoding and decoding algorithms are based on a multiplicative scrambler. The implementation of itself is defined by the following polynomial: G (x) = x ^ 17 + x ^ 12 + 1. Figures 1 and 2 show the multiplicative encoder and decoder respectively.

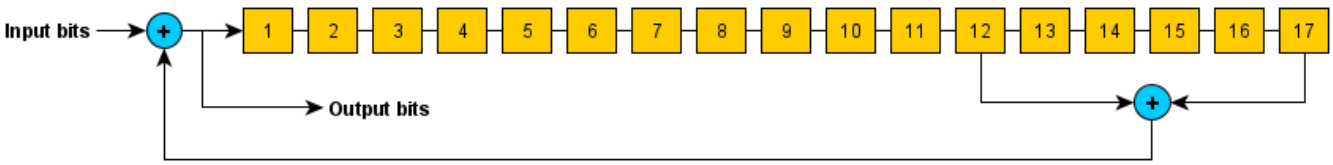


Figure 1. Implementation of the shift register for the multiplicative encoder.

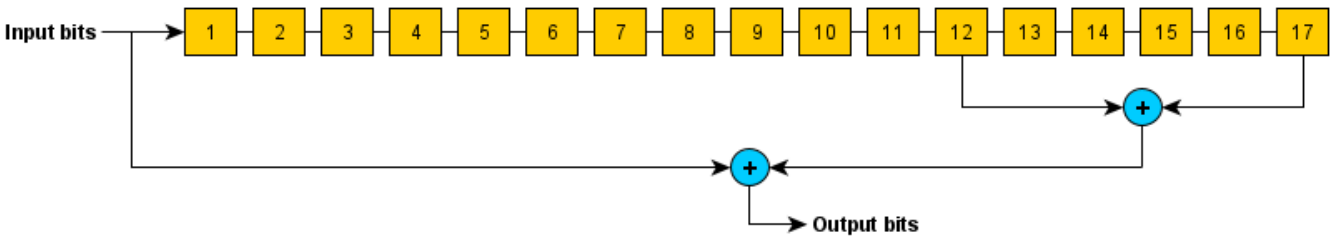


Figure 2. Implementation of the shift register for the multiplicative decoder.

Although it is not very usual and because not all the fields of the packet are encoded, we initialize the shift registers for each received packet. The initial state of the registers (assuming we use a 32-bit variable for the implementation) is 0x2C350000 and we only apply the shift register to the encoded bits.

Example:

Data entry (ASCII): “GENESIS-Genesis”.

Encoded Data (Hex): 0xC7434C274B1713 D76B05AAD189 9747C8.
Decoded data (ASCII): “GENESIS-Genesis”.

CRC calculation

The calculation of the checksum with CRC is done using CRC-CCITT-FALSE. Figure 3 shows the shift register used for the CRC calculation algorithm.

- Polynomial: 0x1021.
- Initial value: 0xFFFF.
- Final value Xor: 0x0.

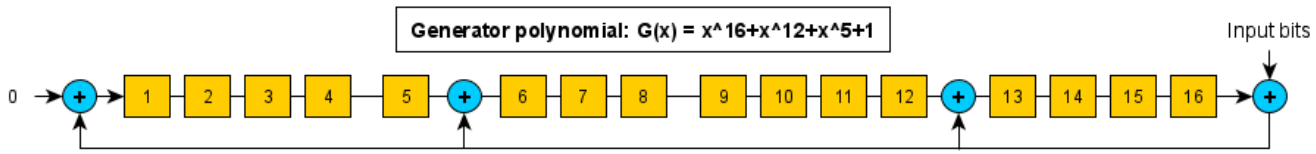


Figure 3. CRC-CCITT-FALSE 16-bit shift register.

Example:

- Input string: “EASAT-2”.
- CRC output: 0x7D58.

Description of packets

The fields are always sent in LSB format first, that is, the least significant bit is the first to be sent.

FSK Packet Type 01: Fast Telemetry

Packet type 01 (sequence 0, type 1) corresponds to the most frequent (fast) telemetry. It is sent every 60 seconds, even in low power states. It provides the most representative data regarding the state of the satellite.

Table 1 Description of the fast telemetry packet in EASAT-2 and HADES

Field ID	Lenght in bits	Field name	Magnitude	Field description and value
1	32	Training	--	Training sync header (0x55555555)
2	32	Training	--	Training sync header (0x55555555)
3	8	Sync	--	Sync sequence (0x33)
4	2	Seq	--	**00**
5	4	Address	--	2 EASAT-2, 3 HADES
6	2	Type	--	**Packet type (0x1)**
7	5	Free	--	Unimplemented
8	10	Ixp	uA	XP panel current
9	10	pwrdet_filtrd	uA	Uplink power detector filtered
10	10	Iyp	uA	YP panel current
11	10	Iyn	uA	YN panel current
12	10	Izp	uA	ZP panel current
13	10	Izn	uA	ZN panel current
14	10	Vbat	mV	Battery voltage
15	10	Vbus	mV	EPS bus voltage
16	10	Vcpu	mV	CPU voltage
17	10	Vmpt		MPPT DAC status (3 bits)

18	10	Pwrdet	dBm	Uplink power detector instant value
19	5	num_syncs	--	Number of packet syncs detected [0-31] cyclic
20	16	Checksum	--	Packet checksum

Table 2 Summary of the fast telemetry packet in EASAT-2 and HADES

Useful data	**152**	**Bits**
Useful data	**19**	**Bytes**
Full packet length	**216**	**Bits**
Transmission time	**4320**	**ms**

FSK Packet Type 02: Slow telemetry

The type 02 packet is related to the sending of less frequent telemetry parameters and shows information such as temperatures, number of resets or the time since the last power on. This type of packet is sent 2 times every 14 minutes.

Table 3 Description of the slow telemetry packet in EASAT-2 and HADES

Field ID	Lenght in bits	Field name	Magnitude	Field description and value
1	32	Training	--	Training sync header (0x55555555)
2	32	Training	--	Training sync header (0x55555555)
3	8	Sync	--	Sync sequence (0x33)
4	2	Seq	--	**00**
5	4	Address	--	2 EASAT-2, 3 HADES
6	2	Type	--	**Packet type (0x2)**
7	2	Free	--	Unimplemented
8	10	Ttx	Celsius	TX module temperature
9	10	Trx	Celsius	RX module temperature
10	10	Tbat	Celsius	Battery temperature
11	10	Txp	Celsius	XP panel temperature
12	10	Txn	Celsius	XN panel temperature
13	10	Typ	Celsius	YP panel temperature
14	10	Tyn	Celsius	YN panel temperature
15	10	Tzp	Celsius	ZP panel temperature
16	10	Tzn	Celsius	ZN panel temperature
17	16	Mptx	Seconds	MPPT X time active
18	16	Mpty	Seconds	MPPT Y time active
19	16	Mptz	Seconds	MPPT Z time active
20	16	Mptxyz	Seconds	MPPT XYZ time active
21	24	Sclock	Seconds	Local time at satellite (3 LSB bytes of 4)
22	16	Nrun	--	CPU runs since deployment
23	8	checksume2p	HEX	EEPROM checksum
24	16	Uptime	Minutes	Uptime
25	12	nSSTVstone	--	On board experiment activations
26	8	Alarms	HEX	Status flags [SOL 6 5 4 3 E2P RAM ROM]
27	16	orb_period	Seconds	Estimated orbital period
28	4	Bate	HEX	Battery status (0-F)
29	4	Mote	HEX	Mode 0 repeater off Mode 1 FM->FM audiofrecuencia Mode 2 AM->FM audiofrecuencia Mode 3 FSK->FSK 100 Hz

				Mode 4 ASK->FSK 100 Hz (reduced bandwidth) Mode 5 ASK->FSK interrupt controlled for signal time measurement Mode 6 FSK+ASK->FSK (packet retransmission with right CRC)
30	4	Busdrop	--	VBUS drop counter
31	4	Lastreset	HEX	Last reset reason WD PD POR BOR (12 is OK, other means anomaly)
32	8	strfwd1	HEX	Store & forward byte 1
33	8	strfwd2	HEX	Store & forward byte 2
34	8	strfwd3	HEX	Store & forward byte 3
35	8	strfwd4	HEX	Store & forward byte 4
36	16	Checksum	--	Packet checksum

Slow telemetry packets may not be sent in low power condition.

Table 4 Summary of slow telemetry packet in EASAT-2 and HADES

Useful data	**336**	**bits**
Useful data	**42**	**bytes**
Full packet length	**400**	**bits**
Transmission time	**8000**	**ms**

FSK Packet Type 03: Statistics telemetry

Type 03 packet contains statistics and data that have been stored throughout the orbit and is in the form of maximum and minimum voltages, currents and temperatures.

Table 5 Description of the statistics telemetry packet in EASAT-2 and HADES

Field ID	Lenght in bits	Field name	Magnitude	Field description and value
1	32	Training	--	Training sync header (0x55555555)
2	32	Training	--	Training sync header (0x55555555)
3	8	Sync	--	Sync sequence (0x33)
4	2	Seq	--	**00**
5	4	Address	--	2 EASAT-2, 3 HADES
6	2	Type	--	**Packet type (0x3)**
7	4	Free	--	Unimplemented
8	8	ttx_pk+	Celsius	Transmitter max temperature
9	8	trx_pk+	Celsius	Receiver max temperature
10	8	tba_pk+	Celsius	Battery max temperature
11	8	txp_pk+	Celsius	XP panel max temperature
12	8	txn_pk+	Celsius	XN panel max temperature
13	8	typ_pk+	Celsius	YP panel max temperature
14	8	tyn_pk+	Celsius	YN panel max temperature
15	8	tzp_pk+	Celsius	ZP panel max temperature
16	8	tzn_pk+	Celsius	ZN panel max temperature
17	8	ttx_pk-	Celsius	Transmitter min temperature
18	8	trx_pk-	Celsius	Receiver min temperature
19	8	tba_pk-	Celsius	Battery min temperature
20	8	txp_pk-	Celsius	XP panel min temperature

21	8	txn_pk-	Celsius	XN panel min temperature
22	8	typ_pk-	Celsius	YP panel min temperature
23	8	tyn_pk-	Celsius	YN panel min temperature
24	8	tzp_pk-	Celsius	ZP panel min temperature
25	8	tzn_pk-	Celsius	ZN panel min temperature
26	16	ixp_pk+	uA	XP panel max current
27	16	ixn_pk+	uA	XN panel max current
28	16	iyp_pk+	uA	YP panel max current
29	16	iyn_pk+	uA	YN panel max current
30	16	izp_pk+	uA	ZP panel max current
31	16	izn_pk+	uA	ZN panel max current
32	20	ixp_acc	uA*t	Accumulated current panel XP
33	20	ixn_acc	uA*t	Accumulated current panel XN
34	20	iyp_acc	uA*t	Accumulated current panel YP
35	20	iyn_acc	uA*t	Accumulated current panel YN
36	20	izp_acc	uA*t	Accumulated current panel ZP
37	20	izn_acc	uA*t	Accumulated current panel ZN
38	10	vbus_pk+	mV	Bus max voltaje
39	10	vbat_pk+	mV	Battery max voltaje
40	10	vcpu_pk+	mV	CPU max voltage
41	10	pk+ vmpt	mV	MPPT DAC max voltage
42	10	vbus_pk-	mV	Bus min voltage
43	10	vbat_pk-	mV	Battery min voltaje
44	10	vcpu_pk-	mV	CPU min voltage
45	10	pk- vmpt	mV	MPPT DAC min voltaje
46	16	ix+	uA	X axis max current
47	16	iy+	uA	Y axis max current
48	16	iz+	uA	Z axis max current
49	16	isolar+	uA	Max solar current
50	16	ibus+	uA	Max bus current
51	16	ibatp+	uA	Max battery out current
52	16	ibatn+	uA	Max battery in current
53	20	ix_acc	uA*t	X axis accumulated current
54	20	iy_acc	uA*t	Y axis accumulated current
55	20	iz_acc	uA*t	Z axis accumulated current
56	20	isolar_acc	uA*t	Accumulated solar current
57	20	ibus_acc	uA*t	Accumulated bus current
58	20	ibatp_acc	uA*t	Accumulated battery out current
59	20	ibatn_acc	uA*t	Accumulated battery in current
60	16	**Checksum**	--	Packet checksum

Statistics on type 03 packets are initialized every 12 hours. This type of packet may not be transmitted in low power state.

Table 6 Summary of the statistics telemetry packet in EASAT-2 and HADES

Useful data	**728**	**bits**
Useful data	**91**	**bytes**
Full packet length	**792**	**bits**
Transmission time	**15840**	**ms**

FSK Packet Type 11: Spin telemetry

Type 11 packet contains information on the currents of the solar panels at different points in time. With this information it would be possible to determine the spin of the satellite.

Table 7 Description of the spin packet in EASAT-2 and HADES

Field ID	Lenght in bits	Field name	Magnitude	Field description and value
1	32	Training	--	Training sync header (0x55555555)
2	32	Training	--	Training sync header (0x55555555)
3	8	Sync	--	Sync sequence (0x33)
4	2	Seq	--	**01**
5	4	Address	--	2 EASAT-2, 3 HADES
6	2	Type	--	**Packet type (0x1)**
7	4	Free	--	Unimplemented
8	32	Sclock	S	Clock in seconds for sample 0
9	10	ixp0	uA	current in panel XP time 0
10	10	ixn0	uA	current in panel XN time 0
11	10	iyp0	uA	current in panel YP time 0
12	10	iyn0	uA	current in panel YN time 0
13	10	izp0	uA	current in panel ZP time 0
14	10	izn0	uA	current in panel ZN time 0
15	10	ixp1	uA	current in panel XP time 1
16	10	ixn1	uA	current in panel XN time 1
17	10	iyp1	uA	current in panel YP time 1
18	10	iyn1	uA	current in panel YN time 1
19	10	izp1	uA	current in panel ZP time 1
20	10	izn1	uA	current in panel ZN time 1
21	10	ixp2	uA	current in panel XP time 2
22	10	ixn2	uA	current in panel XN time 2
23	10	iyp2	uA	current in panel YP time 2
24	10	iyn2	uA	current in panel YN time 2
25	10	izp2	uA	current in panel ZP time 2
26	10	izn2	uA	current in panel ZN time 2
27	10	ixp3	uA	current in panel XP time 3
28	10	ixn3	uA	current in panel XN time 3
29	10	iyp3	uA	current in panel YP time 3
30	10	iyn3	uA	current in panel YN time 3
31	10	izp3	uA	current in panel ZP time 3
32	10	izn3	uA	current in panel ZN time 3
33	10	ixp4	uA	current in panel XP time 4
34	10	ixn4	uA	current in panel XN time 4
35	10	iyp4	uA	current in panel YP time 4
36	10	iyn4	uA	current in panel YN time 4
37	10	izp4	uA	current in panel ZP time 4

38	10	izn4	uA	current in panel ZN time 4
39	10	ixp5	uA	current in panel XP time 5
40	10	ixn5	uA	current in panel XN time 5
41	10	iyp5	uA	current in panel YP time 5
42	10	iyn5	uA	current in panel YN time 5
43	10	izp5	uA	current in panel ZP time 5
44	10	izn5	uA	current in panel ZN time 5
45	10	ixp6	uA	current in panel XP time 6
46	10	ixn6	uA	current in panel XN time 6
47	10	iyp6	uA	current in panel YP time 6
48	10	iyn6	uA	current in panel YN time 6
49	10	izp6	uA	current in panel ZP time 6
50	10	izn6	uA	current in panel ZN time 6
51	10	ixp7	uA	current in panel XP time 7
52	10	ixn7	uA	current in panel XN time 7
53	10	iyp7	uA	current in panel YP time 7
54	10	iyn7	uA	current in panel YN time 7
55	10	izp7	uA	current in panel ZP time 7
56	10	izn7	uA	current in panel ZN time 7
57	10	ixp8	uA	current in panel XP time 8
58	10	ixn8	uA	current in panel XN time 8
59	10	iyp8	uA	current in panel YP time 8
60	10	iyn8	uA	current in panel YN time 8
61	10	izp8	uA	current in panel ZP time 8
62	10	izn8	uA	current in panel ZN time 8
63	10	ixp9	uA	current in panel XP time 9
64	10	ixn9	uA	current in panel XN time 9
65	10	iyp9	uA	current in panel YP time 9
66	10	iyn9	uA	current in panel YN time 9
67	10	izp9	uA	current in panel ZP time 9
68	10	izn9	uA	current in panel ZN time 9
69	10	ixp10	uA	current in panel XP time 10
70	10	ixn10	uA	current in panel XN time 10
71	10	iyp10	uA	current in panel YP time 10
72	10	iyn10	uA	current in panel YN time 10
73	10	izp10	uA	current in panel ZP time 10
74	10	izn10	uA	current in panel ZN time 10
75	10	ixp11	uA	current in panel XP time 11
76	10	ixn11	uA	current in panel XN time 11
77	10	iyp11	uA	current in panel YP time 11
78	10	iyn11	uA	current in panel YN time 11
79	10	izp11	uA	current in panel ZP time 11
80	10	izn11	uA	current in panel ZN time 11
81	10	ixp12	uA	current in panel XP time 12
82	10	ixn12	uA	current in panel XN time 12
83	10	iyp12	uA	current in panel YP time 12
84	10	iyn12	uA	current in panel YN time 12
85	10	izp12	uA	current in panel ZP time 12
86	10	izn12	uA	current in panel ZN time 12
87	10	ixp13	uA	current in panel XP time 13
88	10	ixn13	uA	current in panel XN time 13

89	10	iyp13	uA	current in panel YP time 13
90	10	iyn13	uA	current in panel YN time 13
91	10	izp13	uA	current in panel ZP time 13
92	10	izn13	uA	current in panel ZN time 13
93	10	ixp14	uA	current in panel XP time 14
94	10	ixn14	uA	current in panel XN time 14
95	10	iyp14	uA	current in panel YP time 14
96	10	iyn14	uA	current in panel YN time 14
97	10	izp14	uA	current in panel ZP time 14
98	10	izn14	uA	current in panel ZN time 14
99	16	checksum	--	checksum

Table 8 Spin Telemetry Packet Summary on EASAT-2 and HADES

Useful data	**968**	**bits**
Useful data	**121**	**bytes**
Full packet length	**1032**	**bits**
Transmission time	**20640**	**ms**

FSK Packet Type 12: Radiometer

Type 12 packet contains information from the radiometer experiment (a sample of the signal measured in VHF in taken during the last 90 minutes throughout the orbit).

Table 9 Description of the radiometer packet in EASAT-2 and HADES

Field ID	Lenght in bits	Field name	Magnitude	Field description and value
1	32	Training	--	Training sync header (0x55555555)
2	32	Training	--	Training sync header (0x55555555)
3	8	Sync	--	Sync sequence (0x33)
4	2	Seq	--	**01**
5	4	Address	--	2 EASAT-2, 3 HADES
6	2	Type	--	**Packet type (0x2)**
7	4	Free	--	Unimplemented
8	32	Sclock	S	Clock in seconds for sample 0
9	10	rad0	--	measured signal in minute 0 (oldest)
10	10	rad1	--	measured signal in minute 1
11	10	rad2	--	measured signal in minute 2
12	10	rad3	--	measured signal in minute 3
13	10	rad4	--	measured signal in minute 4
14	10	rad5	--	measured signal in minute 5
15	10	rad6	--	measured signal in minute 6
16	10	rad7	--	measured signal in minute 7
17	10	rad8	--	measured signal in minute 8
18	10	rad9	--	measured signal in minute 9
19	10	rad10	--	measured signal in minute 10
20	10	rad11	--	measured signal in minute 11
21	10	rad12	--	measured signal in minute 12
22	10	rad13	--	measured signal in minute 13
23	10	rad14	--	measured signal in minute 14
24	10	rad15	--	measured signal in minute 15
25	10	rad16	--	measured signal in minute 16

26	10	rad17	--	measured signal in minute 17
27	10	rad18	--	measured signal in minute 18
28	10	rad19	--	measured signal in minute 19
29	10	rad20	--	measured signal in minute 20
30	10	rad21	--	measured signal in minute 21
31	10	rad22	--	measured signal in minute 22
32	10	rad23	--	measured signal in minute 23
33	10	rad24	--	measured signal in minute 24
34	10	rad25	--	measured signal in minute 25
35	10	rad26	--	measured signal in minute 26
36	10	rad27	--	measured signal in minute 27
37	10	rad28	--	measured signal in minute 28
38	10	rad29	--	measured signal in minute 29
39	10	rad30	--	measured signal in minute 30
40	10	rad31	--	measured signal in minute 31
41	10	rad32	--	measured signal in minute 32
42	10	rad33	--	measured signal in minute 33
43	10	rad34	--	measured signal in minute 34
44	10	rad35	--	measured signal in minute 35
45	10	rad36	--	measured signal in minute 36
46	10	rad37	--	measured signal in minute 37
47	10	rad38	--	measured signal in minute 38
48	10	rad39	--	measured signal in minute 39
49	10	rad40	--	measured signal in minute 40
50	10	rad41	--	measured signal in minute 41
51	10	rad42	--	measured signal in minute 42
52	10	rad43	--	measured signal in minute 43
53	10	rad44	--	measured signal in minute 44
54	10	rad45	--	measured signal in minute 45
55	10	rad46	--	measured signal in minute 46
56	10	rad47	--	measured signal in minute 47
57	10	rad48	--	measured signal in minute 48
58	10	rad49	--	measured signal in minute 49
59	10	rad50	--	measured signal in minute 50
60	10	rad51	--	measured signal in minute 51
61	10	rad52	--	measured signal in minute 52
62	10	rad53	--	measured signal in minute 53
63	10	rad54	--	measured signal in minute 54
64	10	rad55	--	measured signal in minute 55
65	10	rad56	--	measured signal in minute 56
66	10	rad57	--	measured signal in minute 57
67	10	rad58	--	measured signal in minute 58
68	10	rad59	--	measured signal in minute 59
69	10	rad60	--	measured signal in minute 60
70	10	rad61	--	measured signal in minute 61
71	10	rad62	--	measured signal in minute 62
72	10	rad63	--	measured signal in minute 63
73	10	rad64	--	measured signal in minute 64
74	10	rad65	--	measured signal in minute 65
75	10	rad66	--	measured signal in minute 66
76	10	rad67	--	measured signal in minute 67

77	10	rad68	--	measured signal in minute 68
78	10	rad69	--	measured signal in minute 69
79	10	rad70	--	measured signal in minute 70
80	10	rad71	--	measured signal in minute 71
81	10	rad72	--	measured signal in minute 72
82	10	rad73	--	measured signal in minute 73
83	10	rad74	--	measured signal in minute 74
84	10	rad75	--	measured signal in minute 75
85	10	rad76	--	measured signal in minute 76
86	10	rad77	--	measured signal in minute 77
87	10	rad78	--	measured signal in minute 78
88	10	rad79	--	measured signal in minute 79
89	10	rad80	--	measured signal in minute 80
90	10	rad81	--	measured signal in minute 81
91	10	rad82	--	measured signal in minute 82
92	10	rad83	--	measured signal in minute 83
93	10	rad84	--	measured signal in minute 84
94	10	rad85	--	measured signal in minute 85
95	10	rad86	--	measured signal in minute 86
96	10	rad87	--	measured signal in minute 87
97	10	rad88	--	measured signal in minute 88
98	10	rad89	--	measured signal in minute 89 (current)
99	16	checksum	--	Checksum

Table 10 Summary of radiometer telemetry packet in EASAT-2 and HADES

Useful data	**968**	**Bits**
Useful data	**121**	**Bytes**
Full packet length	**1032**	**Bits**
Transmission time	**20640**	**Ms**

FSK Type 13 Packet: Basalt Material Experiment Data (EASAT-2 only)

Type 13 packet contains information from the experiment of basalt material that can be used for constructions on the Moon. This packet is only transmitted in the case of EASAT-2.

Table 11 Description of the basalt material experiment packet (EASAT-2)

Field ID	Lenght in bits	Field name	Magnitude	Field description and value
1	32	Training	--	Training sync header (0x55555555)
2	32	Training	--	Training sync header (0x55555555)
3	8	Sync	--	Sync sequence (0x33)
4	2	Seq	--	**01**
5	4	Address	--	2 (EASAT-2)
6	2	Type	--	**Packet type (0x3)**
7	0	Free	--	Unimplemented
8	32	sclock	--	Clock in seconds when measurement was done
9	12	freq0_real	--	sample in freq 0 real part
10	12	freq0_imag	--	sample in freq 0 imaginary part
11	12	freq1_real	--	sample in freq 1 real part
12	12	freq1_imag	--	sample in freq 1 imaginary part
13	12	freq2_real	--	sample in freq 2 real part
14	12	freq2_imag	--	sample in freq 2 imaginary part
15	12	freq3_real	--	sample in freq 3 real part
16	12	freq3_imag	--	sample in freq 3 imaginary part
17	12	freq4_real	--	sample in freq 4 real part
18	12	freq4_imag	--	sample in freq 4 imaginary part
19	12	freq5_real	--	sample in freq 5 real part
20	12	freq5_imag	--	sample in freq 5 imaginary part
21	12	freq6_real	--	sample in freq 6 real part
22	12	freq6_imag	--	sample in freq 6 imaginary part
23	12	freq7_real	--	sample in freq 7 real part
24	12	freq7_imag	--	sample in freq 7 imaginary part
25	12	freq8_real	--	sample in freq 8 real part
26	12	freq8_imag	--	sample in freq 8 imaginary part
27	16	Checksum	--	checksum

Table 12 Telemetry packet summary of the basalt material experiment in EASAT-2

Useful data	**280**	**bits**
Useful data	**35**	**bytes**
Full packet length	**344**	**bits**
Transmission time	**6880**	**ms**

Telemetry, CW, SSTV and transponder timing pattern

The transmissions follow a cyclical pattern of 14 minutes. At the beginning of each minute a fast telemetry packet is always sent under all circumstances. In 30 seconds, if the squelch level that activates the transponder has not been broken before, and the minute is the first, a slow telemetry packet is sent as well. If the minute is the second, a vocoder transmission with the callsign, etc. The comparison of lengths between the different types of transmissions and the time available for the FM voice transponder and FSK data is shown below:

Table 13 Comparison of the duration of the different transmissions

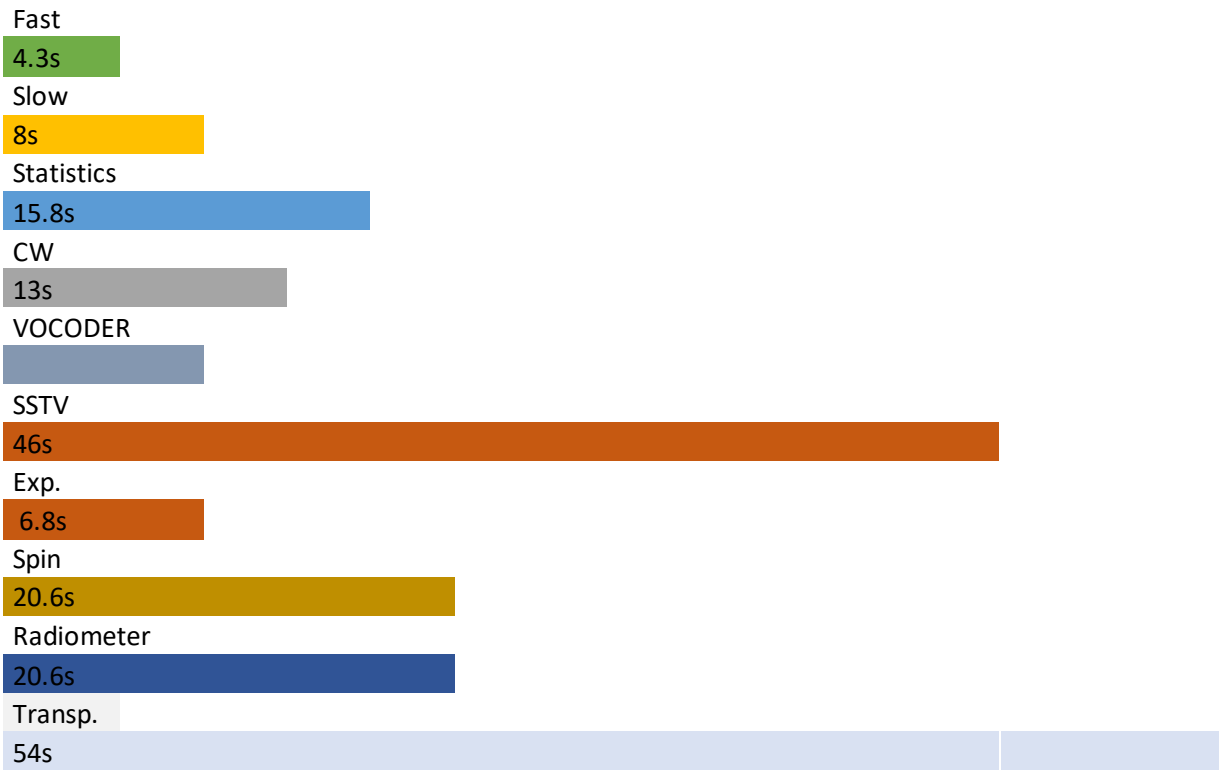
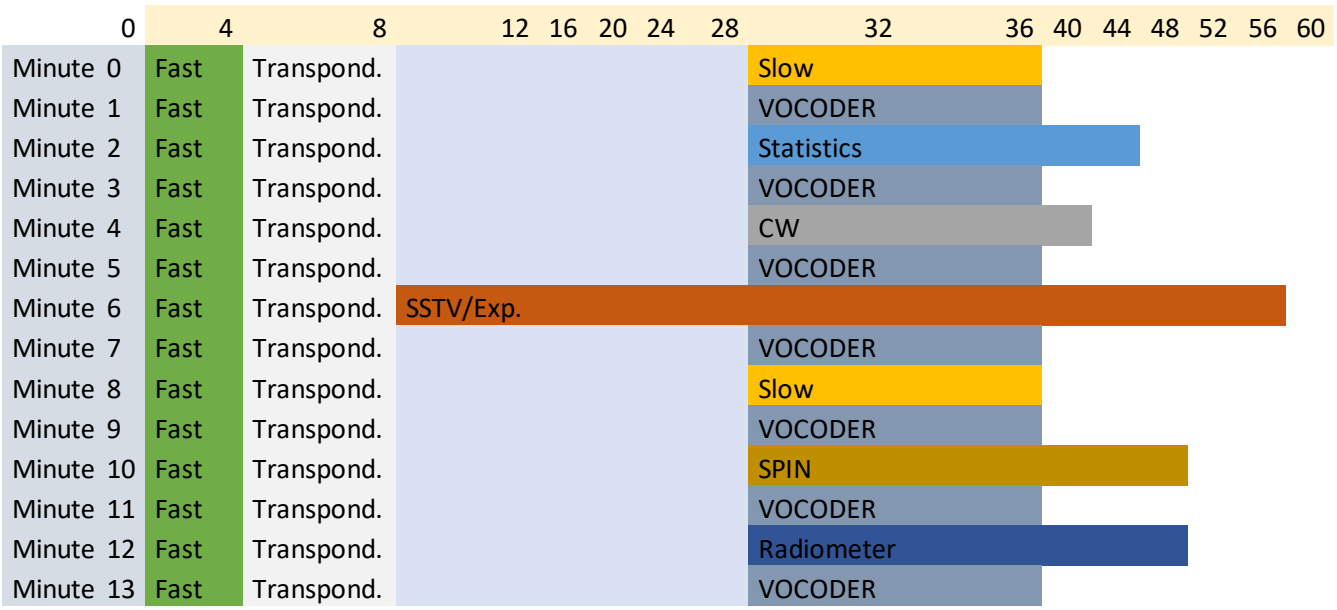


Table 14 Transmission pattern (cyclical)



Transponder operation

The transponder can be used immediately after the Fast telemetry packet. You have 22 seconds to break the squelch level. The level should break for at least about 2 seconds. If not, the corresponding telemetry will be generated in second 30 and it will be necessary to wait for the next minute (to the next Fast telemetry transmission) to try to activate it again. In the event that the squelch level has been broken, the transponder remains active immediately from that moment until the end of the minute, not generating the telemetry / VOCODER at second 30. Therefore, each minute, approximately 54 consecutive seconds are available as maximum for transponder use, which can be renewed as long as the squelch is broken after each Fast telemetry transmission. This applies to both FM voice transponders and FSK data, although only one of the two modes is active at any given time. To know the mode in which it is configured, the latest Slow telemetry packet can be consulted.

The maximum speed of the repeater in FSK mode is 50 bps.

More information

More information, updates and implementation of the ground station can be found on the AMSAT EA website, in the projects section: https://www.amsat-ea.org/proyectos/

QSLs

Telemetry reception will be rewarded with a printed QSL. Please send your reports to: genesis@amsat-ea.org or by post:

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