HADES-L
TRANSMISSIONS DESCRIPTION

This document describes the transmissions of the HADES-L satellite, which will be launched aboard SpaceX's Transporter-18 mission.

HADES-L is a digital satellite featuring a 29 MHz USB-to-436 MHz transponder, along with CODEC2 transmissions. It also transmits the same storytelling messages previously carried by HADES-ICM.

As a secondary mission, HADES-L carries a materials characterization experiment developed by the startup Lofith Composites.

Modulations used:

For transmissions from the satellite, FSK modulation is used, with a tone separation of 1600 Hz at 800 bps and 1125 Hz at 200 bps. The transmission rate can be changed by telecommand. The lower-frequency tone (mark) represents a bit value of 1, while the higher-frequency tone (space) represents a bit value of 0. The occupied bandwidth is only 3.6 kHz.
The satellite is initially configured to transmit at 800 bps.

Types of transmissions:

These are the types of transmissions performed from the satellite:

- Type 01 packet: SAT-TO-EARTH FSK Telemetry Power
- Type 02 packet: SAT-TO-EARTH FSK Telemetry Temp (temperatures)
- Type 03 packet: SAT-TO-EARTH FSK Telemetry Status (satellite status)
- Type 04 packet: SAT-TO-EARTH FSK Telemetry Power ranges
- Type 05 packet: SAT-TO-EARTH FSK Telemetry Temp ranges
- Type 06 packet: Not used
- Type 07 packet: SAT-TO-EARTH FSK Telemetry Lofith Experiment data
- Type 08 packet: SAT-TO-EARTH FSK Telemetry Deploy (antenna deployment data)
- Type 09 packet: SAT-TO-EARTH FSK Telemetry Extended Power stats
- Type 10 packet: Not used
- Type 11 packet: SAT-TO-EARTH CODEC2 (FSK)
- Type 12 packet: SAT-TO-EARTH FSK Telemetry Ephemerides
- Type 13 packet: SAT-TO-EARTH FSK Telemetry PN9 random data (link quality)
- Type 14 packet: SAT-TO-EARTH FSK Telemetry Time series
- Type 15 packet: SAT-TO-EARTH FSK Telemetry ICM Messages

The FSK packets (all initially at 800 bps) are distinguished from each other by the **type** field.

Operating frequencies and modes

The operating frequencies are as follows:

HADES-L
✓ 29.472 MHz, uplink, modes: USB Voice
✓ 436.665 MHz, downlink, modes: FM Voice, FSK 200 bps – 1600 bps

Transmission format
The format of each transmission is as follows:

FSK Packets

The FSK packets generated on the satellite can be of the types indicated above. Each of them is generated at the time of transmission, and their bytes are sent in **MSB-first** format (most significant bit first).

Data packet encoding (scrambling)

A scrambling process is applied to all FSK packets. The only fields that are not scrambled are the training sequence itself, the synchronization field, the packet type (fields 1, 2, and 3 in all packets), and the CRC, which is located at the end.
The encoding and decoding algorithms are based on a **multiplicative scrambler**. Its implementation is defined by the following polynomial:

$G(x) = x^{17} + x^{12} + 1$.

Figures 1 and 2 show the multiplicative encoder and decoder, respectively.

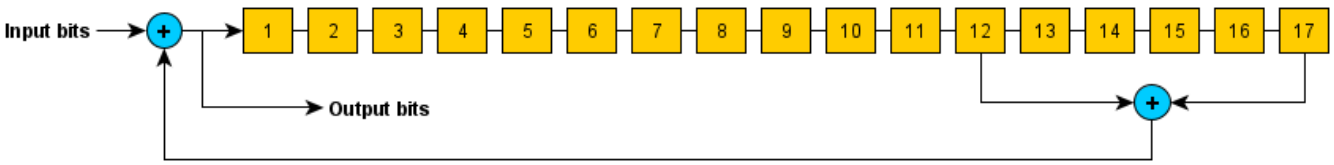

Figure 1. Shift register implementation for the multiplicative encoder

Figura 2. Implementación del registro de desplazamiento para el decodificador multiplicativo.

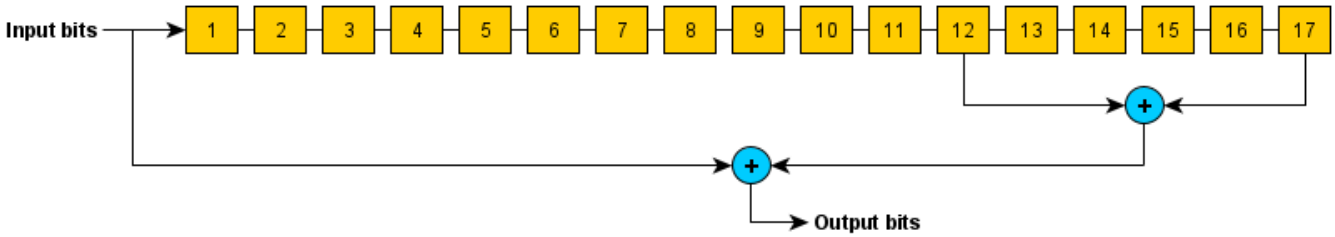

Figure 2. Shift register implementation for the multiplicative decoder.

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

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

CRC Calculation
The checksum is calculated using **CRC-CCITT-FALSE**. Figure 3 shows the shift register used for the CRC calculation algorithm. The CRC is applied starting from the **type** field through to the end of each packet’s data.

- Polynomial: 0x1021
- Initial value: 0xFFFF
- Final XOR value: 0x0

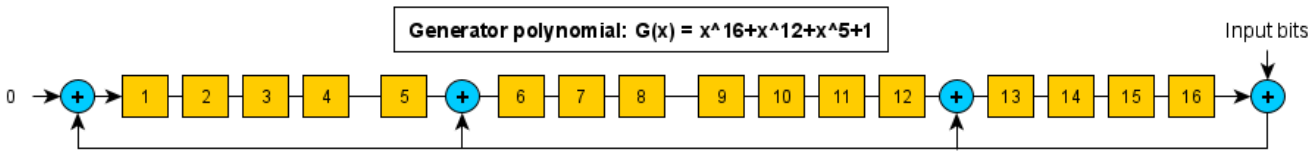

Figure 3. 16-bit CRC-CCITT-FALSE shift register

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

NOTE: The CRC and Scrambler source code is available on the website.”

FSK Packet Description

The structure of each packet is described below. All packets begin with a **128-bit training sequence** that alternates ones and zeros, followed by **two synchronization bytes**, which allow the receiver to detect the start of the packet. The next field is always **size**, which indicates how many bytes follow, followed by **type**, which allows distinguishing one packet from another. The **source address** in this case is 3 (HADES-L).

Fields are always transmitted in **MSB-first** format, meaning the **most significant bit is sent first** (the leftmost bit).

FSK Packet Type 01: Power

Type 01 provides data on the generated power, as well as the satellite’s most representative voltages and currents. It is transmitted even when the satellite has low power.

ID	bits	FIELD NAME	MU	DESCRIPTION
1	128	**Training**	--	0xAAAAAAAA
2	16	**Sync**	--	0xBF35
3	8	**Size**	31,00	Data length (including CRC bytes)
4	4	**Type**	--	Packet Type: 1
5	4	**Address**	--	Source Address: 5 for HADES-L
6	32	**Sclock**	s	System clock at time of tx
7	8	Spa	mW	SPA (Panel A Power) I2C Max 3 last minutes power
8	8	Spb	mW	SPB (Panel B Power) I2C Max 3 last minutes power
9	8	Spc	mW	SPC (Panel C Power) I2C Max 3 last minutes power
10	8	Spd	mW	SPD (panel D Power) I2C Max 3 last minutes power
11	16	Spi	mW	SPI Total instant power (SPA+SPB+SPC+SPD)
12	12	vbus1	mV	VBUS1 CPU.ADC MPPT Out
13	12	vbat1	mV	VBAT1 EPS.ADC BAT
14	12	Vcpu	mV	VCPU CPU.ADC
15	16	vbus2	mV	VBUS2 EPS.I2C (VBUS in EPS board)
16	12	vbus3	mV	VBUS3 CPU.I2C (VBUS in CPU board) I2C
17	12	vbat2	mV	VBAT2 EPS.I2C EPS.I2C
18	12	Ibat	mA	IBAT I2C
19	12	Icpu	mA	ICPU I2C
20	12	Ipl	mA	IPL (Payload current. Last different from 0) I2C, EPS board

21	8	Peaksignal	dBm	1 LSB=0.5dB
22	8	modasignal	dBm	Noise level 1 LSB=0.5dB
23	8	lastcmdsignal	dB	1 LSB=0.5dB
24	8	lastcmdnoise	dB	1 LSB=0.5dB
25	16	**checksum**	--	Checksum
Useful	**248**	**bits**		
	31,00	**bytes**		
Total	**400**	**bits**		Scrambled fields begin after type/address. NOTA: Se scramblea desde después de address hasta último campo sin incluir checksum
Total	**50**	**bytes**		Checksum includes type/address
Time	**500**	**ms**		

FSK Packet Type 02: Temperatures

Type 02 contains the different temperatures measured in the system. This packet is transmitted even in low-power states.

ID	bits	VARIABLE	MU	DESCRIPTION
1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	17,00	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 2
5	4	**address**	--	Source Address: 5 for HADES-L
6	32	**sclock**	S	System clock at time of tx
7	8	tpa	oC	TPA (Temperature Panel A) I2C
8	8	tpb	oC	TPB (Temperature Panel B) I2C
9	8	tpc	oC	TPC (Temperature Panel C) I2C
10	8	tpd	oC	TPD (Temperature Panel D) I2C
11	8	tpe	oC	TPE (Temperature Panel E) I2C - Not used
12	8	teps	oC	TEPS (Temperature EPS) I2C
13	8	ttx	oC	TTX (Temperature TX) I2C
14	8	ttx2	oC	TTX2 (Temperature TX) NTC
15	8	trx	oC	TRX (Temperature RX) NTC
16	8	tcpu	oC	TCPU (Temperature CPU) ADC
17	16	**checksum**	--	Checksum
Useful	**136**	**bits**		
	17,00	**bytes**		8 bits -> 0.5 degrees each value starting 0 = <=-40C and 254 = >=87C 255 = ERROR
Total	**288**	**bits**		
Total	**36**	**bytes**		
Time	**360**	**ms**		

FSK Packet Type 03: Status

Type 03 contains satellite status information. It is always transmitted, even in low-power states.

ID	bits	VARIABLE	MU	DESCRIPTION
1	128	**Training**	--	0xAAAAAAAA
2	16	**Sync**	--	0xBF35
3	8	**Size**	41,00	Data length (including CRC bytes)
4	4	**Type**	--	Packet Type: 3
5	4	**Address**	--	Source Address: 5 for HADES-L
6	32	Sclock	s	Local time at satellite (seconds since deployment)
7	32	Uptime	s	uptime in seconds
8	16	Nrun	--	Number of CPU starts
9	8	npayload	--	Number of payload starts
10	8	nwire	--	Number of deployments attemps
11	8	ntransponder	--	Not used
12	4	npayloadFails	--	Number of errors communicating with payload
13	4	lstrst	--	Last reset cause
14	4	bate	--	maquina estados bateria 0-6
15	4	mote	--	Not used
16	8	systems_status		subsystems status
17	8	nTasksNotExecuted	0-255	Tasks lost by scheduler
18	8	antennaDeployed	0-1	Antenna deployed: 0 not deployed, 1 deployed, 2 unknown status
19	8	nExtEepromErrors	0-255	Checksum failures in EEPROM since last check (recoverable)
20	8	failedTaskID	0-255	Id of the last task failed to execute
21	8	Messaging enabled	0-1	Messaing enabled
22	8	strfwd0 / last id	0-255	S&F
23	16	strfwd1 / last cmd	0-255	S&F
24	16	strfwd2 / last value	0-255	S&F
25	8	strfwd3	0-255	S&F num tcmds
26	8	rx_percentage	0-100	rx_percentage
27	8	telemetry_percentage	0-100	telemetry_percentage
28	8	transponder_percentage	0-100	transponder_percentage
29	8	ptt_hp_percentage	0-100	ptt_hp_percentage
30	8	ptt_lp_percentage	0-100	ptt_lp_percentage
31	8	ple_percentage	0-100	ple_percentage
32	8	bwe_percentage	0-100	bwe_percentage
33	8	vbat_higher_than_vbus_percentage	0-100	vbat_higher_than_vbus_percentage
34	8	payload_frames	0-255	num of frames received from the payload (Lofith)
35	8	not used	0-255	ot used
36	8	frames_last_batch	0-255	num of frames received in the last payload activation
37	16	**checksum**	--	checksum

Useful	**328**	bits		
	41,00	bytes		
Total	**480**	bits		
Total	**60**	bytes		
Time	**600**	ms		

FSK Packet Type 04: Power ranges

Type 04 contains the power ranges collected since the satellite's last reset.

ID	bits	FIELD NAME	MU	DESCRIPTION
1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	35,00	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 4
5	4	**address**	--	Source Address: 5 for HADES-L
6	32	**sclock**	S	System clock at time of tx
7	12	minvbus1	mV	MIN VBUS1 CPU.ADC MPPT
8	12	minvbat1	mV	MIN VBAT1 EPS.ADC
9	12	minvcpu	mV	MIN VCPU CPU.ADC
10	4	free	--	
11	8	minvbus2	mV	MIN VBUS2 EPS.I2C (VBUS in EPS)
12	8	minvbus3	mV	MIN VBUS3 CPU.I2C (VBUS in CPU) I2C
13	8	minvbat2	mV	MIN VBAT2 EPS.I2C (Payload Voltage) EPS.I2C
14	8	minibat	mV	MIN IBAT I2C (Battery Current) I2C
15	8	minicpu	mV	MIN ICPU I2C (CPU board current) I2C
16	8	minipl	mV	MIN IPL (Deployment current) I2C, EPS
17	12	maxvbus1	mV	MAX VBUS1 CPU.ADC MPPT
18	12	maxvbat1	mV	MAX VBAT1 EPS.ADC
19	12	maxvcpu	mV	MAX VCPU CPU.ADC
20	4	free	--	
21	8	maxvbus2	mV	MAX VBUS2 EPS.I2C (VBUS in EPS)
22	8	maxvbus3	mV	MAX VBUS3 CPU.I2C (VBUS in CPU) I2C
23	8	maxvbat2	mV	MAX VBAT2 EPS.I2C (Payload Voltage) EPS.I2C
24	8	maxibat	mV	MAX IBAT I2C (Battery Current) I2C
25	8	maxicpu	mV	MAX ICPU I2C (CPU board current CPU) I2C
26	8	maxipl	mV	MAX IPL (Deployment current) I2C, en placa EPS
27	8	ibat_rx_charging	mA	last measured ibat when rx and charging
28	8	ibat_rx_discharging	mA	last measured ibat when rx and discharging
29	8	ibat_tx_low_power_charging	mA	last measured ibat when tx in low power and charging
30	8	ibat_tx_low_power_discharging	mA	last measured ibat when tx in low power and discharging
31	8	ibat_tx_high_power_charging	mA	last measured ibat when tx in high power and charging

32	8	ibat_tx_high_power_discharging	mA	last measured ibat when tx in high power and discharging
33	16	**checksum**	--	checksum
Useful	**280**	**bits**		
	35,00	**bytes**		
Total	**432**	**bits**		
Total	**54**	**bytes**		
Time	**540**	**ms**		

FSK Packet Type 05: Temp ranges

Type 05 contains the ranges of the temperatures measured in the system since the satellite's last reset.

ID	bits	VARIABLE	MU	DESCRIPTION
1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	27,00	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 5
5	4	**address**	--	Source Address: 5 for HADES-L
6	32	**sclock**	S	system clock at time of tx
7	8	mintpa	oC	MIN TPA (Temperature Panel A) I2C
8	8	mintpb	oC	MIN TPB (Temperature Panel B) I2C
9	8	mintpc	oC	MIN TPC (Temperature Panel C) I2C
10	8	mintpd	oC	MIN TPD (Temperature Panel D) I2C
11	8	mintpe	oC	MIN TPE (Temperature Panel D) I2C - Not used
12	8	minteps	oC	MIN TEPS (Temperature EPS)
13	8	minttx	oC	MIN TTX (Temperature TX) I2C
14	8	minttx2	oC	MIN TTX2 (Temperature TX) NTC
15	8	mintrx	oC	MIN TRX (Temperature RX) NTC
16	8	mintcpu	oC	MIN TCPU (Temperature CPU) ADC
17	8	maxtpa	oC	MAX TPA (Temperature Panel A) I2C
18	8	maxtpb	oC	MAX TPB (Temperature Panel B) I2C
19	8	maxtpc	oC	MAX TPC (Temperature Panel C) I2C
20	8	maxtpd	oC	MAX TPD (Temperature Panel D) I2C
21	8	maxtpe	oC	MAX TPE (Temperature Panel D) I2C - Not used
22	8	maxteps	oC	MAX TEPS (Temperature EPS)
23	8	maxttx	oC	MAX TTX (Temperature TX) I2C
24	8	maxttx2	oC	MAX TTX2 (Temperature TX) NTC
25	8	maxtrx	oC	MAX TRX (Temperature RX) NTC
26	8	maxtcpu	oC	MAX TCPU (Temperature CPU) ADC
27	16	**checksum**	--	Checksum
useful	**216**	bits		
	27,00	bytes		
total	**368**	bits		
total	**46**	bytes		
time	**460**	ms		

FSK Packet Type 06: Not used

Packet type 6 is not used in this satellite

FSK Packet Type 07: Lofith Experiment data

Packet type contains the data for the Lofith Composites experiment:

1	256	training	--	0xAAAAAAAA
2	16	sync		0xBF35
3	8	size	23, 0	Data size (from this field to character 13, including it)
4	4	type		Tipo de paquete: 7
5	4	address		Source Address: 5 for HADES-L
6	8	total_frames		Total number of frames being transmitted
7	8	frame_number		Current frame
8	32	timestamp		Satellite clock when the sample was taken
9	16	gauge_value (canal 1)		Sensor value (galga sometida a stress)
10	16	gauge_reference_value (canal 2)		Galga sin estresar
11	16	vbus_reference_voltage (canal 3)		Reference value
12	16	sensor_temp		Temperature measured in payload
13	16	sat_temp		CPU Satellite temperatura (to use as reference)
14	16	cont_1		Radiation counter 1
15	16	cont_2		Radiation counter 2
16	16	checksum	--	checksum
useful	184	bits		
	23,0	bytes		
total	464	bits		
	58,0	bytes		
time	2320	ms		

FSK Packet Type 08: Deploy

Type 08 contains information about the system parameters during the last antenna deployment.

1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	31,00	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 8
5	4	**address**	--	Source Address: 5 for HADES-L
6	16	v1oc		v1oc;
7	16	v1		v1
8	16	i1		i1
9	16	i1pk		i1pk
10	16	r1		r1
11	16	v2oc		v2oc;

12	16	v2		v2
13	16	r2		r2
14	32	t0		t0
15	16	td		Td
16	8	state begin:1;		state_begin:1;
17	8	state_end:1;		state_end:1;
18	8	state_now:1;		state_now:1;
19	8	enable:1;		enable:1;
20	8	counter		counter;
21	8	tmp		tmp; // System temperature
22	16	**checksum**		checksum
useful	**248**	**bits**		
	31,00	**bytes**		
total	**400**	**bits**		
total	**50**	**bytes**		
time	**500**	**ms**		

FSK Packet Type 09: Extended power stats (INA)

Type 09 contains extended information about the system's power.

ID	bits	FIELD NAME	MU	DESCRIPTION
1	128	**Training**	--	0xAAAAAAAA
2	16	**Sync**	--	0xBF35
3	8	**Size**	123,00	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 9
5	4	**address**	--	Source Address: 5 for HADES-L
6	16	v0	raw	SPA V Instant Voltage
7	16	i0	raw	SPA I Instant Current
8	16	p0	raw	SPA P Mean Power
9	16	vp0	raw	SPA VP Peak Voltage
10	16	ip0	raw	SPA IP Peak Current
11	16	pp0	raw	SPA PP Peak Power
12	16	v1	raw	SPB V Instant Voltage
13	16	i1	raw	SPB I Instant current
14	16	p1	raw	SPB P Mean Power
15	16	vp1	raw	SPB VP Peak Voltage
16	16	ip1	raw	SPB IP Peak Current
17	16	pp1	raw	SPB PP Peak Power
18	16	v2	raw	SPC V Instant Voltage
19	16	i2	raw	SPC I Instant current
20	16	p2	raw	SPC P Mean Power
21	16	vp2	raw	SPC VP Peak Voltage
22	16	ip2	raw	SPC IP Peak Current
23	16	pp2	raw	SPC PP Peak Power

24	16	v3	raw	SPD V Instant Voltage
25	16	i3	raw	SPD I Instant current
26	16	p3	raw	SPD P Mean Power
27	16	vp3	raw	SPD VP Peak Voltage
28	16	ip	raw	SPD IP Peak Current
29	16	pp3	raw	SPD PP Peak Power
30	16	v4	raw	SUN V Instant Voltage
31	16	i4	raw	SUN I Instant current
32	16	p4	raw	SUN P Mean Power
33	16	vp4	raw	SUN VP Peak Voltage
34	16	ip4	raw	SUN IP Peak Current
35	16	pp4	raw	SUN PP Peak Power
36	16	v5	raw	BAT V Instant Voltage
37	16	i5	raw	BAT I Instant current
38	16	p5	raw	BAT P Mean Power
39	16	vp5	Raw	BAT VP Peak Voltage
40	16	ip5	Raw	BAT IP Peak Current
41	16	pp5	Raw	BAT PP Peak Power
42	16	v6	Raw	BATP V Instant Voltage
43	16	i6	Raw	BATP I Instant current
44	16	p6	Raw	BATP P Mean Power
45	16	vp6	Raw	BATP VP Peak Voltage
46	16	ip6	Raw	BATP IP Peak Current
47	16	pp6	Raw	BATP PP Peak Power
48	16	v7	Raw	BATN V Instant Voltage
49	16	i7	Raw	BATN I Instant Current
50	16	p7	Raw	BATN P Mean Power
51	16	vp7	Raw	BATN VP Peak Voltage
52	16	ip7	Raw	BATN IP Peak Current
53	16	pp7	Raw	BATN PP Peak Power
54	16	v8	Raw	CPU V Instant Voltage
55	16	i8	Raw	CPU I Instant Current
56	16	p8	Raw	CPU P Medium Power
57	16	vp8	Raw	CPU VP Peak Voltage
58	16	ip8	Raw	CPU IP Peak Current
59	16	pp8	Raw	CPU PP Peak Power
60	16	v9	Raw	PL V Instant Voltage
61	16	i9	Raw	PL I Instant Current
62	16	p9	Raw	PL P Mean Power
63	16	vp9	Raw	PL VP Peak Voltage
64	16	ip9	Raw	PL IP Peak Current
65	16	pp9	Raw	PL PP Peak Current
66	16	**Checksum**	--	checksum
useful	**984**	**Bits**		

	123,00	**Bytes**		
total	**1136**	**Bits**		
total	**142**	**Bytes**		
time	**1420**	**Ms**		

FSK Packet Type 10: Not used

This packet type is not used in this satellite.

FSK Packet Type 11: Digital CODEC2 Voice

Type 11 contains digital voice frames encoded with CODEC2.

ID	bits	FIELD NAME		DESCRIPTION
0	128	**training**	--	0xAAAAAAAA
1	16	**frame 0 sync**	--	0xBF35 (for each frame)
2	8	**frame 0 size**	37	Data size (from this field)
3	4	**frame 0 type**	--	Packet Type: 11 (for each frame)
4	4	**frame 0 address**	--	Source Address: 5 for HADES-L
5	8	**frame 0 number**		0
6	280	**frame 0 codec2 data**		280 bits raw (codec2 raw data)
1	16	**frame 1 sync**	--	0xBF35 (for each frame)
2	8	**frame 1 size**	37	Data size (from this field)
3	4	**frame 1 type**	--	Packet Type: 11 (for each frame)
4	4	**frame 1 address**	--	Source Address: 5 for HADES-L
5	8	**frame 1 number**		1
6	280	**frame 1 codec2 data**		280 bits raw (codec2 raw data)
1	16	**...**	--	0xBF35 (for each frame)
2	8	**…**	37	Data size (from this field)
3	4	**...**	--	Packet Type: 11 (for each frame)
4	4	**...**	--	Source Address: 5 for HADES-L
5	8	**…**		frame i
6	280	**...**		280 bits raw (codec2 raw data)
1	16	**frame n sync**	--	0xBF35 (for each frame)
2	8	**frame n size**	37	Data size (from this field)
3	4	**frame n type**	--	Packet Type: 11 (for each frame)
4	4	**frame n address**	--	Source Address: 5 for HADES-L
5	8	**frame n number**		n
6	280	**frame n codec2 data**		280 bits raw (codec2 raw data)

FSK Packet Type 12: Ephemeris

This packet contains the satellite's ephemerides. These consist essentially of the TLE, which is sent as a command from the ground station, as well as the onboard calculations of the satellite's latitude, longitude, and altitude.

ID	bits	FIELD NAME		DESCRIPTION

1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	64,0	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 12
5	4	**address**	--	Source Address: 5 for HADES-L
6	32	UTC	--	Time UTC
7	16	adr		Satellite address
8	32	ful		Not used
9	32	fdl		Not used
10	32	tle.epoch		TLE element
11	32	tle.xndt2o		TLE element
12	32	tle.xndd6o		TLE element
13	32	tle.bstar		TLE element
14	32	tle.xincl		TLE element
15	32	tle.xnodeo		TLE element
16	32	tle.eo		TLE element
17	32	tle.omegao		TLE element
18	32	tle.xmo		TLE element
19	32	tle.xno		TLE element
20	16	lat		Calculated latitude
21	16	lon		Calculated longitude
22	16	alt	--	Calculated heigh
23	8	cnt		Not used
24	16	**checksum**	--	checksum
useful	**512**	bits		
	64,0	bytes		
total	**664**	bits		
total	**83**	**bytes**		
time	**830**	ms		

FSK Packet Type 13: Random PN9 Data (Link performance)

This packet is used to determine the downlink quality. It is a fixed-data packet generated randomly.

ID	**bits**	**FIELD NAME**		**DESCRIPTION**
1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	255	Data length (for this packet this value is 255, although data size is 256)
4	4	**type**	--	Packet Type: 13
5	4	**address**	--	Source Address: 5 for HADES-L
6	2048	**random_data [0..255]**		(256 bytes) n times repetead (always the same data) - 1 time by default
useful	**2056**	bits		
	257,0	bytes		
total	**2208**	bits		

total	**276**	**bytes**		
time	**2760**	ms		

FSK Packet Type 14: Time series

The time series packet displays data for several variables over the last 90 minutes. Its structure is as follows:

ID	bits	FIELD NAME		DESCRIPTION
1	128	**training**	--	0xAAAAAAAA
2	16	**sync**	--	0xBF35
3	8	**size**	38	Data length (including CRC bytes)
4	4	**type**	--	Packet Type: 14
5	4	**address**	--	Source Address: 5 for HADES-L
6	32	sclock	s	system clock for sample 0
7	8	variable	--	00=peak signal, 01=noise, 02=vbat1, 03=tcpu, 04=tpa, 05=(tpa+tpb+tpc+tpd)/4
8	8	byte_00	--	byte_00 oldest, lost each 60 minutes (circular queue). Each sample is taken every 3 minutes
9	8	byte_01	--	byte_01
10	8	byte_02	--	byte_02
11	8	byte_03	--	byte_03
12	8	byte_04	--	byte_04
13	8	byte_05	--	byte_05
14	8	byte_06	--	byte_06
15	8	byte_07	--	byte_07
16	8	byte_08	--	byte_08
17	8	byte_09	--	byte_09
18	8	byte_10	--	byte_10
19	8	byte_11	--	byte_11
20	8	byte_12	--	byte_12
21	8	byte_13	--	byte_13
22	8	byte_14	--	byte_14
23	8	byte_15	--	byte_15
24	8	byte_16	--	byte_16
25	8	byte_17	--	byte_17
26	8	byte_18	--	byte_18
27	8	byte_19	--	byte_19
28	8	byte_20	--	byte_20
29	8	byte_21	--	byte_21
30	8	byte_22	--	byte_22
31	8	byte_23	--	byte_23
32	8	byte_24	--	byte_24
33	8	byte_25	--	byte_25
34	8	byte_26	--	byte_26
35	8	byte_27	--	byte_27
36	8	byte_28	--	byte_28

37	8	byte_29	--	byte_29 newest one
38	16	**checksum**	--	checksum
useful	**304**	bits		
	38,0	bytes		
total	**456**	bits		
	57,0	bytes		
time	**570**	ms		

FSK Packet Type 15: ICM Messages

Packet type 15 contains string messages of the ICM game. Those messages are a small story it can be collected.

ID	**bits**	**VARIABLE**		**DESCRIPTION**
1	128	Training	--	0xAAAAAAAA
2	16	Sync	--	0xBF35
3	4	Type	--	Packet type: 15
4	4	Address	--	Source Address: 5 for HADES-L
5	32	Sclock	s	System clock at transmission time
6	8	message_number	--	message_number[0..9]
7	744	data	--	char 0 - char 92 (messages are 98 chars fixed length)
8	16	checksum	--	checksum
Useful	808	bits		
	101,0	bytes		
Total	952	bits		
	119,0	bytes		
time	4760	ms		

Telemetry timing pattern

The transmissions follow a cyclic pattern shown in the sequence columns of the table below, one for low battery and another for fully charged battery. They occur in 20-second slots. If a slot is occupied when a transmission is about to start (for example, because a previous transmission has not finished or the transponder is active), the transmission will be attempted in the next slot, but no transmission in the sequence is skipped.

HADES-L TRANSMISSION PATTERN		
Low battery		Battery charged
Each 20 seconds		Each 20 seconds
tx_status	00:00	tx_status
	00:20	tx_transponder
tx_temp	04:20	tx_temp
tx_power	04:40	tx_power
	05:00	tx_power_ranges
	05:20	tx_temp_ranges
	05:40	tx_payload
	06:00	tx_deploy
	06:20	tx_ine
	06:40	tx_voice_codec2
	07:00	tx_ephemeris
tx_status	07:20	tx_status
	07:40	tx_pn9
	08:00	tx_time_series (peak)
	08:20	tx_time_series (moda)
	08:40	tx_time_series (vbat1)
	09:00	tx_time_series (vtempc)
	09:20	tx_time_series (tpc)
	09:40	tx_icm

More information

More information can be found on the AMSAT EA website, in the Projects section: https://www.amsat-ea.org/proyectos/