V1.0 AMSAT-EA September 7, 2023

# HADES-D
# TRANSMISSIONS DESCRIPTION

This document describes the transmissions of HADES-D satellite.

## *Modulations used:*

HADES-D uses FSK modulation with 1000 Hz pitch spacing and an initial rate of 50 bits per second for its telemetry and regenerative digital repeater transmissions. This speed can be increased by remote control up to 2400 bps. The lowest frequency (mark) represents bit value 1, while the highest frequency (space) represents bit value 0.

Other modulations used are: FM for the phone repeater (voice), as well as for the beacon with pre-recorded voice and CW.

## *Transmission Types:*

14 types of transmissions are carried out:

Packet type 01: SAT-GROUND FSK Power Telemetry (power)
Packet type 02: SAT-GROUND FSK Temp Telemetry (temperature)
Packet type 03: SAT-GROUND FSK Status Telemetry (satellite status)
Packet type 04: SAT-GROUND FSK Power stats Telemetry
Packet type 05: SAT-GROUND FSK Temp stats Telemetry
Packet type 06: SAT-GROUND FSK Sunvector Telemetry (light sensor data)
Packet type 07: SAT-GROUND FSK Radiometer telemetry (radiometer data)
Packet type 08: SAT-GROUND FSK Deploy Telemetry (antenna deployment data)
Packet type 09: SAT-GROUND FSK Extended Power stats Telemetry
Packet type 10: Not used in this satellite
Packet type 11: Not used in this satellite
Packet type 12: SAT-GROUND FSK Ephemeris Telemetry
CW SAT- GROUND beacon (message VVV DE AM1HAD AM1HAD AM1HAD)
Digitized voice on FM SAT-GROUND (message AM1HAD)

FSK packets (all initially sent at 50 bps) are distinguished from each other by the type field.

Apart from these satellite-generated transmissions, three types of retransmissions are available as a service for ground station users:

• FM voice broadcasts (Mode 1)
• FSK / AFSK data retransmissions up to 2400 bps (AX.25, APRS…) (Also included in Mode 1)
• FSK regenerated data retransmissions at 50-2400 bps (Mode 2)

## *Frequencies and work modes*

Frequencies are as follows:

HADES-D

- 145.875 MHz uplink, Modes: FM voice (no subtone) and FSK 50/2400 bps, AFSK, AX.25, APRS 1200 / 2400 bps
- 436.666 MHz downlink, Modes: FM voice from repeater, FM voice beacon with callsign AM1HAD, FSK 50/2400 bps, CW with callsign AM1HAD

If the satellite is in FM voice/FSK data repeater mode (mode 1), it is activated by level without the need for a subtone.

For the specific case of the FSK packet regenerative repeater (Mode 2 transponder), when it is active, the received signals are sampled, being digitally restored and sent to the transmission module.

After the launch, by default, HADES-D is in mode 0 (transponder deactivated), requiring its activation by remote control.

The satellite also has a limited Storage and Forwarding capacity (byte by byte), conceptually implemented and managed solely through remote commands.

## *Transmissions format*

The format of each broadcast is as follows:

### CW beacon

The CW beacon is transmitted every 5-6 minutes, with format:

VVV DE AM1HAD AM1HAD AM1HAD

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

### FSK packets

The FSK packets generated on the satellite can be of the following types: Power (power), Temp (temperature), Status (satellite status), Power stats (power statistics), Temp stats (temperature statistics), Sunvector (sensor data). light), Radiometer (radiometer data), Deploy (antenna deployment data), Extended Power stats (extended power data) and ephemeris.

Each of them is generated at the time of its transmission and its bytes are sent in 'MSB first' format (most significant bit first).

## Encoding (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 itself, the synchronization field, the packet type (fields 1, 2 and 3 in all packets) and the CRC, which is placed 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.

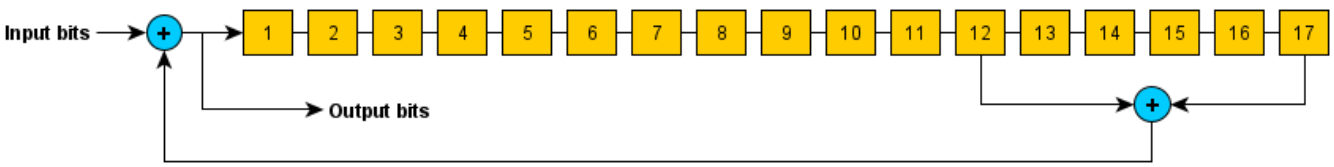


Figure 1. Shift register implementation for the multiplicative encoder.

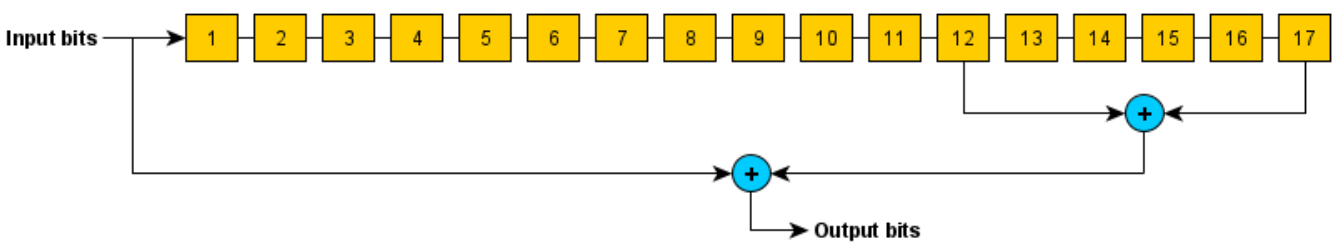

Figure 2. Shift register implementation for the multiplicative decoder.

Although it is not very usual and since 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 input (ASCII): “GENESIS-Genesis”.
Encoded Data (Hex): 0xC7434C274B1713 D76B05AAD189 9747C8.
Decoded data (ASCII): “GENESIS-Genesis”.

**CRC calculation**

The CRC checksum calculation is done using CRC-CCITT-FALSE. Figure 3 shows the shift register used for the CRC calculation algorithm. The CRC is applied starting with the type field to the end of the data in each packet.

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

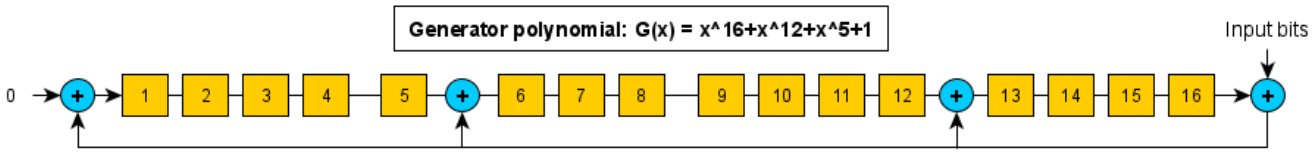


Figure 3. 16-bit shift register CRC-CCITT-FALSE.

**Example:**

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

NOTE: The CRC and Scrambler source code is available on the web

## *Packages description*

The structure of each package is described below. They all start with a 64-bit training sequence of alternating 1s and 0s, followed by two sync bytes, which allow the receiver to detect the beginning of the packet. The next field will always be the type, which makes it possible to distinguish one from the other, and the source address, which in this case will always be 8, since it is HADES-D.

The fields are always sent in MSB format first, that is, the most significant bit is the first to be sent (the one furthest to the left).

## FSK packet type 01:

The type 01 packet is sent every 3 minutes, even in low power states. It provides the power data generated as well as the most representative voltages and currents of the satellite.

| ID | Bits | FIELD NAME | MU | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |

| | | | | |
|---|---|---|---|---|
| 3 | 4 | **Type** | -- | Packet type: 1 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 8 | Spa | mW | SPA (Panel A Power) I2C |
| 6 | 8 | Spb | mW | SPB (Panel B Power) I2C |
| 7 | 8 | Spc | mW | SPC (Panel C Power) I2C |
| 8 | 8 | Spd | mW | SPD (Panel D Power) I2C |
| 9 | 8 | Spe | mW | SPE (Panel E Power) I2C - Sin uso |
| 10 | 8 | Spf | mW | SPF (Panel F Power) I2C - Sin uso |
| 11 | 12 | vbus1 | mV | VBUS1 CPU.ADC MPPT Output |
| 12 | 12 | vbat1 | mV | VBAT1 EPS.ADC |
| 13 | 12 | Vcpu | mV | VCPU CPU.ADC |
| 14 | 16 | vbus2 | mV | VBUS2 EPS.I2C |
| 15 | 12 | vbus3 | mV | VBUS3 CPU.I2C |
| 16 | 12 | vbat2 | mV | VBAT2 EPS.I2C |
| 17 | 12 | Ibat | mA | IBAT I2C (battery current input/output) I2C |
| 18 | 12 | Icpu | mA | ICPU I2C |
| 19 | 12 | Ipl | mA | IPL (Burn current) I2C, EPS |
| 20 | 8 | powerdul1 | dBm | Power detector (main signal) |
| 21 | 8 | powerdul455 | dBm | Power detector (IF) – Not used |
| 22 | 8 | Vdac | dBm | VDAC – Not used |
| 23 | 16 | **Checksum** | -- | Checksum |
| utiles | **208** | **Bits** | | |
| | **26,00** | **Bytes** | | |
| total | **288** | **Bits** | | |
| total | **36** | **Bytes** | | |
| tiempo | **5760** | **Ms** | | |

## FSK Paquet type 02: Temperature

The type 02 packet is also sent every 3 minutes and contains the different temperatures measured in the system. This packet is sent even in low power states.

| ID | Bits | FIELD NAME | MU | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 2 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 8 | Tpa | oC | TPA (Temperature Panel A) I2C |
| 6 | 8 | Tpb | oC | TPB (Temperature Panel B) I2C |
| 7 | 8 | Tpc | oC | TPC (Temperature Panel C) I2C |
| 8 | 8 | Tpd | oC | TPD (Temperature Panel D) I2C |
| 9 | 8 | Tpe | oC | TPE (Temperature Panel E) I2C - Not used |
| 10 | 8 | Teps | oC | TEPS (Temperature EPS) I2C |
| 11 | 8 | Ttx | oC | TTX (Temperature TX) I2C |
| 12 | 8 | ttx2 | oC | TTX2 (Temperature TX) NTC |
| 13 | 8 | Trx | oC | TRX (Temperature RX) NTC |

| | | | | |
|---|---|---|---|---|
| 14 | 8 | Tcpu | oC | TCPU (Temperature CPU) ADC |
| 15 | 16 | **Checksum** | -- | Checksum |
| utiles | **104** | **Bits** | | |
| | **13,00** | **Bytes** | | 8 bits -> 0.5 grades resolution 0 = -40C , 254 = >=87C 255 = ERROR |
| total | **184** | **Bits** | | |
| total | **23** | **Bytes** | | |
| tiempo | **3680** | **Ms** | | |

## FSK packet type 03: Status

The type 03 packet contains satellite status information. It is always sent, every 3 minutes, even in low power states.

| ID | Bits | FIELD NAME | MU | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet Type: 3 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 32 | Sclock | S | Local time on satellite |
| 6 | 16 | Uptime | M | Uptime (minutes) |
| 7 | 16 | Nrun | -- | CPU runs |
| 8 | 8 | Npayload | -- | Times payload (camera) was activated |
| 9 | 8 | Nwire | | Counter of times antenna deployment was tried |
| 10 | 4 | Nbusdrops | -- | Counter of bus drops |
| 11 | 4 | Lstrst | -- | Last reset reason |
| 12 | 4 | Bate | -- | Battery state 0-F (0 fully charged) |
| 13 | 4 | Mote | -- | Transponder mode<br>- Mode 0: Off<br>- Mode 1 FM->FM live audiofrequency (voice and FSK not regenerative)<br>- Mode 2 FSK->FSK regenerative |
| 14 | 8 | nTasksNotExecuted | -- | Tasks lost by scheduler |
| 15 | 8 | antennaDeployed | -- | Antenna deployed: 0 not deployed, 1 deployed, 2 unknown status |
| 16 | 8 | nExtEepromErrors | -- | Checksum failures in EEPROM since last check (recoverable) |
| 17 | 8 | failedTaskID | HEX | Id of the last task failed to execute |
| 18 | 8 | mensajeria_habilitada | | Messaging enabled yes/no |
| 19 | 8 | strfwd0 | HEX | S&F |
| 20 | 16 | strfwd1 | HEX | S&F |
| 21 | 16 | strfwd2 | HEX | S&F |
| 22 | 8 | strfwd3 | HEX | S&F |
| 23 | 16 | **Checksum** | -- | Checksum |
| utiles | **208** | Bits | | |
| | **26,00** | Bytes | | |
| total | **288** | Bits | | |
| total | **36** | Bytes | | |
| tiempo | **5760** | Ms | | |

## FSK Packet 04: Power stats

Packet type 04 contains power statistics, collected since the last reset of the satellite.

| ID | Bits | FIELD NAME | MU | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 4 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 6 | 12 | minvbus1 | mV | MIN VBUS1 CPU.ADC MPPT |
| 7 | 12 | minvbat1 | mV | MIN VBAT1 EPS.ADC |
| 8 | 12 | Minvcpu | mV | MIN VCPU CPU.ADC |
| 9 | 16 | minvbus2 | mV | MIN VBUS2 EPS.I2C |
| 10 | 12 | minvbus3 | mV | MIN VBUS3 CPU.I2C |
| 11 | 12 | minvbat2 | mV | MIN VBAT2 EPS.I2C |
| 12 | 12 | Minibat | mV | MIN IBAT I2C |
| 13 | 12 | Minicpu | mV | MIN ICPU I2C |
| 14 | 12 | Minipl | mV | MIN IPL |
| 15 | 8 | minpowerdul1 | dBm | MIN DUL1 |
| 16 | 8 | minpowerdul455 | dBm | MIN DUL455 |
| 17 | 8 | Minvdac | | MIN VDAC – Not used |
| 24 | 12 | maxvbus1 | mV | MAX VBUS1 CPU.ADC MPPT |
| 25 | 12 | maxvbat1 | mV | MAX VBAT1 EPS.ADC |
| 26 | 12 | Maxvcpu | mV | MAX VCPU CPU.ADC |
| 27 | 16 | maxvbus2 | mV | MAX VBUS2 EPS.I2C |
| 28 | 12 | maxvbus3 | mV | MAX VBUS3 CPU.I2C |
| 29 | 12 | maxvbat2 | mV | MAX VBAT2 EPS.I2C |
| 30 | 12 | Maxibat | mV | MAX IBAT I2C |
| 31 | 12 | Maxicpu | mV | MAX ICPU I2C |
| 32 | 12 | Maxipl | mV | MAX IPL |
| 33 | 8 | maxpowerdul1 | dBm | MAX DUL1 |
| 34 | 8 | maxpowerdul455 | dBm | MAX DUL455 |
| 35 | 8 | Maxvdac | | MAX VDAC – Not used |
| 42 | 12 | medvbus1 | mV | MED VBUS1 CPU.ADC MPPT |
| 43 | 12 | medvbat1 | mV | MED VBAT1 EPS.ADC |
| 44 | 12 | Medvcpu | mV | MED VCPU CPU.ADC |
| 45 | 16 | medvbus2 | mV | MED VBUS2 EPS.I2C |
| 46 | 12 | medvbus3 | mV | MED VBUS3 CPU.I2C |
| 47 | 12 | medvbat2 | mV | MED VBAT2 EPS.I2C |
| 48 | 12 | Medibat | mV | MED IBAT I2C |
| 49 | 12 | Medicpu | mV | MED ICPU I2C |
| 50 | 12 | Medipl | mV | MED IPL |
| 51 | 8 | medpowerdul1 | dBm | MED DUL1 |
| 52 | 8 | medpowerdul455 | dBm | MED DUL455 |
| 53 | 8 | Medvdac | | MAX VDAC – Not used |
| 54 | 16 | **checksum** | -- | Checksum |

| | | | | |
|---|---|---|---|---|
| utiles | **432** | **Bits** | | |
| | **54,00** | **Bytes** | | |
| total | **512** | **Bits** | | |
| total | **64** | **Bytes** | | |
| tiempo | **10240** | **Ms** | | |

## FSK Packet type 05: Temp stats

Packet type 5 contains temperature statistics since the last reset of the satellite.

| ID | Bits | FIELD NAME | MU | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 5 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 6 | 8 | Mintpa | oC | MIN TPA (Temperature Panel A) I2C |
| 7 | 8 | Mintpb | oC | MIN TPB (Temperature Panel B) I2C |
| 8 | 8 | Mintpc | oC | MIN TPC (Temperature Panel C) I2C |
| 9 | 8 | Mintpd | oC | MIN TPD (Temperature Panel D) I2C |
| 10 | 8 | Mintpe | oC | MIN TPE (TemperaturaePanel D) I2C - Not used |
| 11 | 8 | Minteps | oC | MIN TEPS (Temperature EPS) |
| 12 | 8 | Minttx | oC | MIN TTX (Temperature TX) I2C |
| 13 | 8 | minttx2 | oC | MIN TTX2 (Temperature TX) NTC |
| 14 | 8 | Mintrx | oC | MIN TRX (Temperature RX) NTC |
| 15 | 8 | Mintcpu | oC | MIN TCPU (Temperature CPU) ADC |
| 16 | 8 | Maxtpa | oC | MAX TPA (Temperature Panel A) I2C |
| 17 | 8 | Maxtpb | oC | MAX TPB (Temperature Panel B) I2C |
| 18 | 8 | Maxtpc | oC | MAX TPC (Temperature Panel C) I2C |
| 19 | 8 | Maxtpd | oC | MAX TPD (Temperature Panel D) I2C |
| 20 | 8 | Maxtpe | oC | MAX TPE (Temperature Panel D) I2C - Not used |
| 21 | 8 | Maxteps | oC | MAX TEPS (Temperature EPS) |
| 22 | 8 | Maxttx | oC | MAX TTX (Temperature TX) I2C |
| 23 | 8 | maxttx2 | oC | MAX TTX2 (Temperature TX) NTC |
| 24 | 8 | Maxtrx | oC | MAX TRX (Temperature RX) NTC |
| 25 | 8 | Maxtcpu | oC | MAX TCPU (Temperature CPU) ADC |
| 26 | 8 | Medtpa | oC | MED TPA (Temperature Panel A) I2C |
| 27 | 8 | Medtpb | oC | MED TPB (Temperature Panel B) I2C |
| 28 | 8 | Medtpc | oC | MED TPC (Temperature Panel C) I2C |
| 29 | 8 | Medtpd | oC | MED TPD (Temperature Panel D) I2C |
| 30 | 8 | Medtpe | oC | MED TPE (Temperature Panel D) I2C - Not used |
| 31 | 8 | Medteps | oC | MED TEPS (Temperature EPS) |
| 32 | 8 | Medttx | oC | MED TTX (Temperature TX) I2C |
| 33 | 8 | medttx2 | oC | MED TTX2 (Temperature TX) NTC |
| 34 | 8 | Medtrx | oC | MED TRX (Temperature RX) NTC |
| 35 | 8 | Medtcpu | oC | MED TCPU (Temperature CPU) ADC |
| 36 | 16 | **checksum** | -- | Checksum |

| | | | | |
|---|---|---|---|---|
| utiles | **264** | Bits | | |
| | **33,00** | Bytes | | |
| total | **344** | Bits | | |
| total | **43** | Bytes | | |
| tiempo | **6880** | Ms | | |

## FSK Packet type 06: Sunsensors

The Type 6 package contains samples of the light sensors. This is an initial experiment to be used in a future orientation control.

| **ID** | **bits** | **FIELD NAME** | | **DESCRIPTION** |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 6 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 96 | td[6] | S | Table of difference in seconds for samples (possible values 1,2,4,8,16,32,64,128) |
| 6 | 768 | v - valores luz[8][6] | | Table for detections (SPA, SPB, SPC, SPD, 90A, 90D), v - valores luz[8][6] - 16 bits |
| 7 | 128 | p - valores pico[8] - 16 bits | | Table for peak values (SPA, SPB, SPC, SPD, 90A, 90D), p - valores pico[8] -16 bits |
| 8 | 64 | err sensor en error[8] | | Table for sensor status (ok of error), err sensor en error[8] (1 error, 0 ok) - 8 bits |
| 78 | 16 | **checksum** | -- | Checksum |
| utiles | **1080** | **Bits** | | |
| | **135,00** | **Bytes** | | |
| total | **1160** | **Bits** | | |
| total | **145** | **Bytes** | | |
| tiempo | **23200** | **Ms** | | |

## FSK packet type 07: Radiometer

The type 7 packet contains data from the radiometer. Each sample is an average of the last minute, transmitting the information of the last 60 minutes.

| **ID** | **bits** | **FIELD NAME** | | **DESCRIPTION** |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 7 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 32 | Sclock | S | Clock in seconds for sample 0 |
| 6 | 8 | rad0 | -- | Signal level in minute 0 (menos actual) |
| 7 | 8 | rad1 | -- | Signal level in minute 1 |
| 8 | 8 | rad2 | -- | Signal level in minute 2 |
| 9 | 8 | rad3 | -- | Signal level in minute 3 |
| 10 | 8 | rad4 | -- | Signal level in minute 4 |
| 11 | 8 | rad5 | -- | Signal level in minute 5 |
| 12 | 8 | rad6 | -- | Signal level in minute 6 |

| | | | | |
|---|---|---|---|---|
| 13 | 8 | rad7 | -- | Signal level in minute 7 |
| 14 | 8 | rad8 | -- | Signal level in minute 8 |
| 15 | 8 | rad9 | -- | Signal level in minute 9 |
| 16 | 8 | rad10 | -- | Signal level in minute 10 |
| 17 | 8 | rad11 | -- | Signal level in minute 11 |
| 18 | 8 | rad12 | -- | Signal level in minute 12 |
| 19 | 8 | rad13 | -- | Signal level in minute 13 |
| 20 | 8 | rad14 | -- | Signal level in minute 14 |
| 21 | 8 | rad15 | -- | Signal level in minute 15 |
| 22 | 8 | rad16 | -- | Signal level in minute 16 |
| 23 | 8 | rad17 | -- | Signal level in minute 17 |
| 24 | 8 | rad18 | -- | Signal level in minute 18 |
| 25 | 8 | rad19 | -- | Signal level in minute 19 |
| 26 | 8 | rad20 | -- | Signal level in minute 20 |
| 27 | 8 | rad21 | -- | Signal level in minute 21 |
| 28 | 8 | rad22 | -- | Signal level in minute 22 |
| 29 | 8 | rad23 | -- | Signal level in minute 23 |
| 30 | 8 | rad24 | -- | Signal level in minute 24 |
| 31 | 8 | rad25 | -- | Signal level in minute 25 |
| 32 | 8 | rad26 | -- | Signal level in minute 26 |
| 33 | 8 | rad27 | -- | Signal level in minute 27 |
| 34 | 8 | rad28 | -- | Signal level in minute 28 |
| 35 | 8 | rad29 | -- | Signal level in minute 29 |
| 36 | 8 | rad30 | -- | Signal level in minute 30 |
| 37 | 8 | rad31 | -- | Signal level in minute 31 |
| 38 | 8 | rad32 | -- | Signal level in minute 32 |
| 39 | 8 | rad33 | -- | Signal level in minute 33 |
| 40 | 8 | rad34 | -- | Signal level in minute 34 |
| 41 | 8 | rad35 | -- | Signal level in minute 35 |
| 42 | 8 | rad36 | -- | Signal level in minute 36 |
| 43 | 8 | rad37 | -- | Signal level in minute 37 |
| 44 | 8 | rad38 | -- | Signal level in minute 38 |
| 45 | 8 | rad39 | -- | Signal level in minute 39 |
| 46 | 8 | rad40 | -- | Signal level in minute 40 |
| 47 | 8 | rad41 | -- | Signal level in minute 41 |
| 48 | 8 | rad42 | -- | Signal level in minute 42 |
| 49 | 8 | rad43 | -- | Signal level in minute 43 |
| 50 | 8 | rad44 | -- | Signal level in minute 44 |
| 51 | 8 | rad45 | -- | Signal level in minute 45 |
| 52 | 8 | rad46 | -- | Signal level in minute 46 |
| 53 | 8 | rad47 | -- | Signal level in minute 47 |
| 54 | 8 | rad48 | -- | Signal level in minute 48 |
| 55 | 8 | rad49 | -- | Signal level in minute 49 |
| 56 | 8 | rad50 | -- | Signal level in minute 50 |
| 57 | 8 | rad51 | -- | Signal level in minute 51 |

| | | | | |
|---|---|---|---|---|
| 58 | 8 | rad52 | -- | Signal level in minute 52 |
| 59 | 8 | rad53 | -- | Signal level in minute 53 |
| 60 | 8 | rad54 | -- | Signal level in minute 54 |
| 61 | 8 | rad55 | -- | Signal level in minute 55 |
| 62 | 8 | rad56 | -- | Signal level in minute 56 |
| 63 | 8 | rad57 | -- | Signal level in minute 57 |
| 64 | 8 | rad58 | -- | Signal level in minute 58 |
| 65 | 8 | rad59 | -- | Signal level in minute 59 |
| 66 | 16 | **Checksum** | -- | Checksum |
| utiles | **536** | **Bits** | | |
| | **67,00** | **Bytes** | | |
| total | **616** | **Bits** | | |
| total | **77** | **Bytes** | | |
| tiempo | **12320** | **Ms** | | |

## Paquete FSK tipo 08: Deploy

The type 8 packet contains information about the system parameters during the last deployment of the antenna.

| ID | Bits | FIELD NAME | | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 8 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 16 | v1oc | | v1oc; // read with INA-PL side |
| 6 | 16 | v1 | | v1 |
| 7 | 16 | i1 | | i1 |
| 8 | 16 | i1pk | | i1pk |
| 9 | 16 | r1 | | r1 |
| 10 | 16 | v2oc | | v2oc; //read with INA-BUS side |
| 11 | 16 | v2 | | v2 |
| 12 | 16 | r2 | | r2 |
| 13 | 32 | t0 | | t0 |
| 14 | 16 | Td | | Td |
| 15 | 4 | state_begin:1; | | state_begin:1; |
| 16 | 2 | state_end:1; | | state_end:1; |
| 17 | 1 | state_now:1; | | state_now:1; |
| 18 | 1 | enable:1; | | enable:1; |
| 19 | 8 | Counter | | counter; |
| 20 | 8 | Tmp | | tmp; // System temperature |
| 26 | 16 | **checksum** | | Checksum |
| utiles | **224** | **Bits** | | |
| | **28,00** | **Bytes** | | |
| total | **304** | **Bits** | | |
| total | **38** | **Bytes** | | |
| tiempo | **6080** | **Ms** | | |

## FSK packet type 09: Extended power stats (INA)

The type 9 packet contains extended information about power statistics in the system.

| ID | bits | FIELD NAME | MU | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **Training** | -- | 0xAAAAAAAA |
| 2 | 16 | **Sync** | -- | 0xBF35 |
| 3 | 4 | **Type** | -- | Packet type: 9 |
| 4 | 4 | **Address** | -- | Source address: 8 for HADES-D |
| 5 | 16 | v0 | raw | SPA V Instant Voltage |
| 6 | 16 | i0 | raw | SPA I Instant current |
| 7 | 16 | p0 | raw | SPA P Average power |
| 8 | 16 | vp0 | raw | SPA VP Peak voltage |
| 9 | 16 | ip0 | raw | SPA IP Peak current |
| 10 | 16 | pp0 | raw | SPA PP Peak power |
| 11 | 16 | v1 | raw | SPB V Instant Voltage |
| 12 | 16 | i1 | raw | SPB I Instant current |
| 13 | 16 | p1 | raw | SPB P Average power |
| 14 | 16 | vp1 | raw | SPB VP Peak voltage |
| 15 | 16 | ip1 | raw | SPB IP Peak current |
| 16 | 16 | pp1 | raw | SPB PP Peak power |
| 17 | 16 | v2 | raw | SPC V Instant Voltage |
| 18 | 16 | i2 | raw | SPC I Instant current |
| 19 | 16 | p2 | raw | SPC P Average power |
| 20 | 16 | vp2 | raw | SPC VP Peak voltage |
| 21 | 16 | ip2 | raw | SPC IP Peak current |
| 22 | 16 | pp2 | raw | SPC PP Peak power |
| 23 | 16 | v3 | raw | SPD V Instant Voltage |
| 24 | 16 | i3 | raw | SPD I Instant current |
| 25 | 16 | p3 | raw | SPD P Average power |
| 26 | 16 | vp3 | raw | SPD VP Peak voltage |
| 27 | 16 | Ip | raw | SPD IP Peak current |
| 28 | 16 | pp3 | raw | SPD PP Peak power |
| 29 | 16 | v4 | raw | SUN V Instant Voltage |
| 30 | 16 | i4 | raw | SUN I Instant current |
| 31 | 16 | p4 | raw | SUN P Average power |
| 32 | 16 | vp4 | raw | SUN VP Peak voltage |
| 33 | 16 | ip4 | raw | SUN IP Peak current |
| 34 | 16 | pp4 | raw | SUN PP Peak power |
| 35 | 16 | v5 | raw | BAT V Instant Voltage |
| 36 | 16 | i5 | raw | BAT I Instant current |
| 37 | 16 | p5 | raw | BAT P Average power |
| 38 | 16 | vp5 | raw | BAT VP Peak voltage |
| 39 | 16 | ip5 | raw | BAT IP Peak current |
| 40 | 16 | pp5 | raw | BAT PP Peak power |
| 41 | 16 | v6 | raw | BATP V Instant Voltage |

| | | | | |
|---|---|---|---|---|
| 42 | 16 | i6 | raw | BATP I Instant current |
| 43 | 16 | p6 | raw | BATP P Average power |
| 44 | 16 | vp6 | raw | BATP VP Peak voltage |
| 45 | 16 | ip6 | raw | BATP IP Peak current |
| 46 | 16 | pp6 | raw | BATP PP Peak power |
| 47 | 16 | v7 | raw | BATN V Instant Voltage |
| 48 | 16 | i7 | raw | BATN I Instant current |
| 49 | 16 | p7 | raw | BATN P Average power |
| 50 | 16 | vp7 | raw | BATN VP Peak voltage |
| 51 | 16 | ip7 | raw | BATN IP Peak current |
| 52 | 16 | pp7 | raw | BATN PP Peak power |
| 53 | 16 | v8 | raw | CPU V Instant Voltage |
| 54 | 16 | i8 | raw | CPU I Instant current |
| 55 | 16 | p8 | raw | CPU P Average power |
| 56 | 16 | vp8 | raw | CPU VP Peak voltage |
| 57 | 16 | ip8 | raw | CPU IP Peak current |
| 58 | 16 | pp8 | Raw | CPU PP Peak power |
| 59 | 16 | v9 | Raw | PL V Instant Voltage |
| 60 | 16 | i9 | Raw | PL I Instant current |
| 61 | 16 | p9 | Raw | PL P Average power |
| 62 | 16 | vp9 | Raw | PL VP Peak voltage |
| 63 | 16 | ip9 | Raw | PL IP Peak current |
| 64 | 16 | pp9 | Raw | PL PP Peak power |
| 54 | 16 | **Checksum** | -- | Checksum |
| utiles | **984** | **Bits** | | |
| | **123,00** | **Bytes** | | |
| total | **1064** | **Bits** | | |
| total | **133** | **Bytes** | | |
| tiempo | **21280** | **Ms** | | |

## FSK packet type 10:

Not used in this satellite.

## FSK Packet type 11:

Not used in this satellite.

## FSK Packet type 12: Ephemeris

This package contains the satellite's anniversaries. These basically consist of the TLE that is sent as a command from the Earth station as well as the calculations of its latitude, longitude and altitude that are carried out on board the satellite.

| ID | bits | FIELD NAME | | DESCRIPTION |
|---|---|---|---|---|
| 1 | 64 | **training** | -- | 0xAAAAAAAA |
| 2 | 16 | **sync** | -- | 0xBF35 |
| 3 | 4 | **type** | -- | Packet type: 12 |
| 4 | 4 | **address** | -- | Source address: 8 for HADES-D |

| | | | | |
|---|---|---|---|---|
| 5 | 32 | UTC | -- | UTC time |
| 6 | 16 | adr | | Satelllite |
| 7 | 32 | ful | | Not in use |
| 8 | 32 | fdl | | Not in use |
| 9 | 32 | tle.epoch | | TLE element |
| 10 | 32 | tle.xndt2o | | TLE element |
| 11 | 32 | tle.xndd6o | | TLE element |
| 12 | 32 | tle.bstar | | TLE element |
| 13 | 32 | tle.xincl | | TLE element |
| 14 | 32 | tle.xnodeo | | TLE element |
| 15 | 32 | tle.eo | | TLE element |
| 16 | 32 | tle.omegao | | TLE element |
| 17 | 32 | tle.xmo | | TLE element |
| 18 | 32 | tle.xno | | TLE element |
| 19 | 16 | lat | | Calculated latitude |
| 20 | 16 | lon | | Calculated longitude |
| 21 | 16 | alt | -- | Calculated height |
| 22 | 8 | cnt | | Not in use |
| 23 | 16 | **checksum** | -- | checksum |
| utiles | **512** | bits | | |
| | **64,0** | bytes | | |
| total | **592** | bits | | |
| total | **74** | **bytes** | | |
| tiempo | **11840** | ms | | |

## *Timing pattern of FSK telemetry, CW and transponder*

HADES-D has two possible operating modes, configurable via remote control: debug mode (default), where all telemetry is transmitted, and operating mode, in which preference is given to the transponder, and therefore only the ephemeris package is sent every 3 minutes.

In the case of operating in debug mode, transmissions follow a 12-minute cyclic pattern. At the beginning of each minute a status, energy or temperature packet is always sent under any circumstances. In the 30th second, if the squelch level that activates the transponder has not been broken before (it can be done just after each transmission), a voice beacon transmission, Morse (CW), etc is sent, as shown in the pattern.

Sunvector/radiometer indicates that the sunvector packet is transmitted the first time, and in the next cycle (after 12 minutes) the radiometer packet.

Pattern in debug mode:

| MIN | TLM (s0) | REPEATER | TLM (s30) | REPEATER |
|---|---|---|---|---|
| 0 | STATUS | RX>TX | VOICE | RX>TX |
| 1 | POWER | RX>TX | CW | RX>TX |
| 2 | TEMP | RX>TX | EPHEMERIS | RX>TX |
| 3 | STATUS | RX>TX | POWER STATS | RX>TX |
| 4 | POWER | RX>TX | TEMP STATS | RX>TX |
| 5 | TEMP | RX>TX | DEPLOY | RX>TX |
| 6 | STATUS | RX>TX | VOICE | RX>TX |
| 7 | POWER | RX>TX | CW | RX>TX |
| 8 | TEMP | RX>TX | EPHEMERIS | RX>TX |
| 9 | STATUS | RX>TX | SUNVECTOR/RADIOMETER | RX>TX |
| 10 | POWER | RX>TX | EXT POWER STATS (INA) | RX>TX |
| 11 | TEMP | RX>TX | | RX>TX |
| goto_0 | | | | |

Pattern in operation mode:

| MIN | TLM (s0) | REPEATER | TLM (s30) | REPEATER |
|---|---|---|---|---|
| 0 | | RX>TX | | RX>TX |
| 1 | | RX>TX | | RX>TX |
| 2 | | RX>TX | EPHEMERIS | RX>TX |
| goto_0 | | | | |

## *Transponder operation*

The transponder is turned off after the launch, and must be activated by remote control. Once active, it can be used immediately after any transmission. If it is activated after a status, power or temp transmission, it will continue to be active until the end of the minute. The status, power and temp packets always turns off the transponder.

Other packets, as well as voice and beacons are not transmitted if the transponder is in use.

The transponder works by level without the need for subtones.

## *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/

## *QSL's*

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

AMSAT EA
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28080 MADRID
SPAIN