GENESIS TRANSMISSIONS DESCRIPTION

The GENESIS satellites employ an ASK 50 bps with two level (OOK) modulation for telemetry as well as Morse 32 WPM for beacon transmissions. Retransmissions are available as well, as described below.

Summary of transmissions:

GENESIS satellites perform 4 types of transmissions:

- CW beacon (each 180 seconds) with 20 different messages in English and Spanish
- ASK Packet type 1: Frequent telemetry (each 60 seconds)
- ASK Packet type 2: Infrequent telemetry (each 180 seconds)
- ASK Packet type 3: Historic/statistics telemetry (each 180 seconds) (reset each 12 hours)

Apart from these satellite generated transmissions, two types of retransmissions are available as user service for ground stations:

- CW user regenerative retransmissions
- ASK free format datagram regenerative retransmissions

These two transmissions will not be detailed as they are free format. Input signals are sampled at one hundred times per second. If they are 6dB over noise, they will be digitally regenerated and put in the transmission module.

Repeating capabilities are only available when the satellites are not transmitting CW beacons or telemetry.

Store and Forward capabilities inside GENESIS are implemented for testing purposes and managed only through command packets sent from mission control. 4 bytes are available for this functionality.

Format of each transmission is as follows:

CW Beacon

CW is sent at 32 WPMs each 3 minutes. An example of transmitted message is:

GENESIS L: VVV DE AM2SAT AM2SAT GENESIS L HI HI
GENESIS N: VVV DE AM3SAT AM3SAT GENESIS N HI HI

Other 19 messages are sent with greetings from Space in Spanish and English languages.

*CW may not be sent in case of low energy status.

ASK packets

ASK non-command packets in GENESIS are of three different types: frequent, infrequent, and statistical/historic. The three packets are generated at the same timestamp, although sent in different times. Generating them at the same time allows having coherent data between them. Bytes are sent in LSB (Least Significant Bit) first format.

Packet Data Scrambling

A scrambling process is performed in all the ASK packets to avoid large sequences of 0 or 1 to destroy the mean level of the decoder receiving them. The only fields that are not scrambled are the training and sync bytes (fields 1, 2, 3 in all packets) and the CRC ones at the end.

Scrambling and descrambling algorithms are based on multiplicative scrambler. The implemented scramble can be defined by the following polynomial: $G(x) = x^{17} + x^{12} + 1$. Figures 2 and 3 show the multiplicative scrambler and descrambler, respectively.

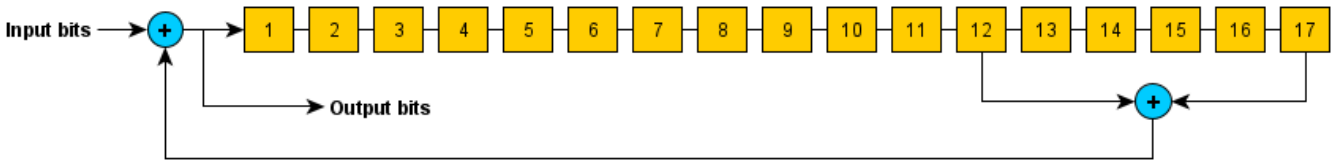

Figure 1. Shift-register implementation for the multiplicative scrambler.

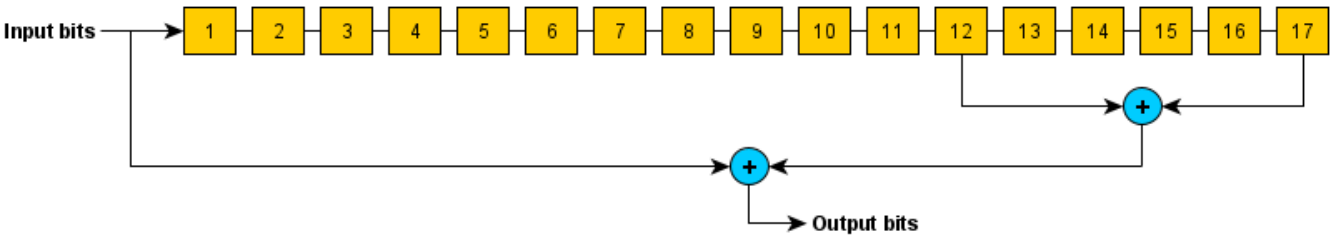

Figure 2. Shift-register implementation for the multiplicative descrambler.

Even though this is not usual, and since not all the fields of the packet are scrambled, we are resetting the shift registers for each packet we receive. The initial state of the shift registers (assuming that we use a 32 bits variable for the implementation) is 0x2C350000 and we only apply the shift register to the scrambled bits.

Example:

Input data (ASCII): "GENESIS-Genesis".
Scrambled data (Hex): 0xC7434C274B1713 D76B05AAD189 9747C8.
Descrambled data (ASCII): "GENESIS-Genesis".

CRC calculation

CRC checksum is CRC-CCITT-FALSE. Figure 3 shows the shift-register implementation of the CRC algorithm.

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

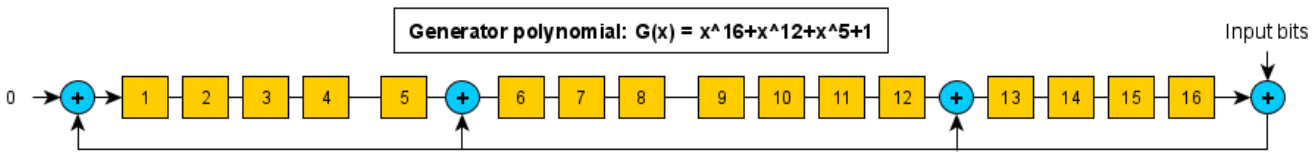

Figure 3. Shift-register for 16 bits CRC-CCITT-FALSE.

Example:

- **Input string**: "EASAT-2".
- **CRC output**: 0x7D58.

Packets

Fields are sent **LSB first**. Our ASK convention is that the presence and absence of the carrier indicates a "1" and "0", respectively.

ASK Packet type 1: Frequent telemetry

Packet type 1 corresponds to the most frequent telemetry. It is sent every 60 seconds, even in states of low energy. It provides the more representative parameters regarding the status of the satellite.

Table 1 GENESIS Frequent telemetry packet description

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	Type	--	Packet type (0x1)
5	4	Address	--	0 for GENESIS-L, 1 for GENESIS-N
6	2	Seq	--	Sequence number (unimplemented)
7	5	Free	--	Unimplemented
8	10	Ixp	uA	XP panel current
9	10	Ixn	uA	XN panel current
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	Receiver power detector
19	5	DAC	--	Receiver gain control DAC
20	16	checksum	--	Packet checksum

Table 2 GENESIS Frequent telemetry packet summary

Useful data	**152**	**bits**
Useful data	**19**	**bytes**
Full packet length	**216**	**bits**
Transmission time	**4320**	**ms**

ASK Packet type 2: Infrequent telemetry

Packet type 2 related to less frequent telemetry parameters sends useful information like currents, number of resets or the uptime. This type of packet is sent each 180 seconds (3 minutes).

Table 3 GENESIS Infrequent telemetry packet description

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	Type	--	Packet type (0x2)
5	4	Address	--	0 for GENESIS-L, 1 for GENESIS-N
6	2	Seq	--	Sequence number (unimplemented)
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
22	16	nrun	--	CPU runs
23	8	checksume2p	HEX	EEPROM checksum
24	16	uptime	minutes	Uptime
25	12	nmotor	--	Ion thruster 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	Ion Thruster status
30	4	busdrop	--	VBUS drop counter
31	4	lastreset	HEX	Last reset reason WD PD POR BOR
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

Infrequent telemetry packets may not be sent in case of low energy.

Table 4 GENESIS Infrequent telemetry packet summary

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

ASK Packet type 3: Historic/statistics telemetry

Packet type 3 contains statistics and data that has been stored along the orbit, regarding maximum and minimum voltages, currents, and temperatures.

Table 5 GENESIS historic/statistics telemetry packet description

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	Type	--	Packet type (0x3)
5	4	Address	--	0 for GENESIS-L, 1 for GENESIS-N
6	2	Seq	--	Sequence number (unimplemented)
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 in packet type 3 are reset each 12 hours. This packet may not be transmitted in case of low energy.

Table 6 GENESIS historic/statistics telemetry packet summary

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

Telemetry, CW, and transponder timing pattern

Telemetry sending follows a 3 minutes pattern. At the beginning of each minute a frequent packet is sent. At second 8, if minute is the first, an infrequent packet is sent as well. If minute is the second, a historic/statistics one, and if minute is the third, a CW beacon is transmitted. The cycle repeats all the time. Length comparison between the different types of transmissions and the time available for repeating data is as follow:

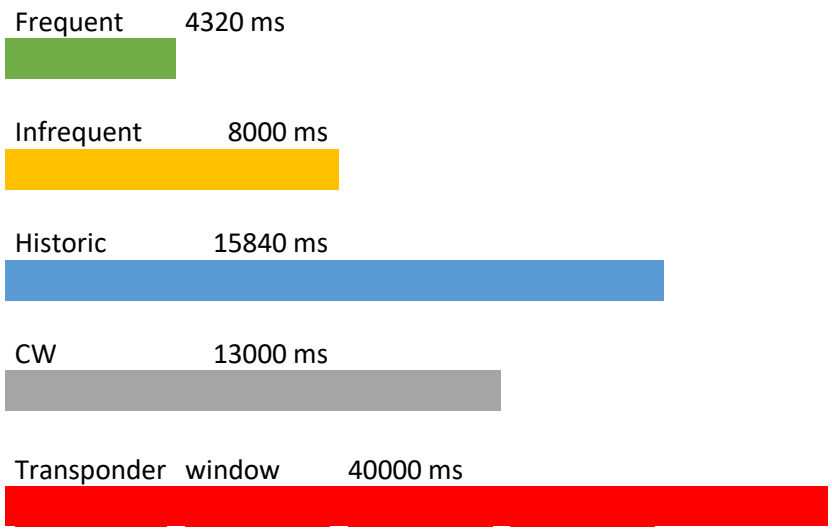

Table 7 Telemetry 3 minutes cycle pattern

4	8	12	16	20	24	…	60
Frequent		Infrequent				…	
4	8	12	16	20	24	…	60
Frequent		Historic				…	
4	8	12	16	20	24	…	60
Frequent		CW				…	

Transponder Operation

The transponder may be used right after the CW beacon. Any data complying with the 2-level ASK modulation (including morse) is allowed, up to 50 bps.

More information

More information, updates and ground station implementation can be found at AMSAT EA webpage, projects section:

https://www.amsat-ea.org/proyectos/

QSLs

Reception of telemetry will be awarded with a printed QSL. Please send your reports to genesis@amsat-ea.org or by post to:

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