AISTECH

Access to Intelligent Space Technologies

Aistechsat-3

Aistechsat-3 TLM codes, modulation and format

81404-Amateur Community Shared Information

Issue:		V1.0	
	Name	Date	Signature
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1. Document Control Data

1.1 Document Change Log

Reason for change	Issue	Revision	Date
All New	0	1	18/03/2019
Reviewed and first release	1	0	18/03/2019

1.2 Applicable Documents

ID	Document Title	Issue	Date
AD01			

1.3 Reference Documents

ID	Document Title	Issue	Date
RD01			

1.4 Acronyms and Abbreviations

Acronym / Abbrev.	Description
AD	Applicable Document
AOCS	Attitude and Orbital Control System
ASM	Application Specific Messages
BPSK	Binary Phase-shift keying
CCSDS	Consultative Committee for Space Data Systems
CRC	Cyclic redundancy check
CSP	Cubesat Protocol
ECSS	European Cooperation for Space Standardization
EPS	Electric Power System
GFSK	Gaussian frequency shift Keying
GSSB	GomSpace Sensor Bus
HMAC	Hash message authentication code
LHCP	Left-Handed Circular Polarization
OBC	On board Computer
RDP	Remote Desktop Protocol

Acronym / Abbrev.	Description
RF	Radio Frequency
RHCP	Right-handed circular polarization
Rx	Receiver
TC	Telecommand
TM	Telemetry
Tx	Transmitter
UHF	Ultra High Frequency
XTEA	Extended Tiny Encryption Algorithm

2.   Physical layer

The description of the TTC component at the physical layer level is shown in the table below:

TTC Characteristics	
TTC frequency	436,730 MHz
S/C EIRP	30 dBm
S/C antenna	Monopole
S/C polarization	Linear, orientation depends on the attitude of the S/C

Table 1. Aistechsat-3 TTC physical layer characteristics

3. Data link layer

The description of the TTC component at the data link layer level is shown in the table below:

TTC Characteristics	
Modulation	GFSK
Bitrate	4800 / 9600 bps
Sync word	0x930B51DE
Frame format	ASM+Golay (AX100 mode 5)
Bit encoding	NRZ, most significant bit first
Scrambling	CCSDS randomization
Channel coding	Reed-Solomon (255, 223)

Table 2. Aistechsat-3 TTC data link layer characteristics

4. Network layer

The CSP (Cubesat Space Protocol) protocol developed by GOMSpace has been implemented on the network layer of the satellite to transmit the packets.

The CSP library can be found in https://github.com/libcsp/libcsp.

The characteristics of Aistechsat-3 are shown below:

Priority	Source	Destination	Destination Port	Source Port	Reserved	HMAC	XTEA	RDP	CRC	Data
2 bits	5 bits	5 bits	6 bits	6 bits	4 bits	1 bit	1 bit	1 bit	1 bit	Variable
0x02	0x01	0x0F	0x0E	Variable	Variable	0x00	0x00	0x00	0x00	Variable

Table 3. Aistechsat-3 TTC network layer characteristics for CSP

5. Application layer

The application layer is specific for the house keeping and beacon service, more information can be found in https://gomspace.com/shop/subsystems/command-and-data-handling/nanomind-a3200.aspx in the A3200 manual.

Protocol Version	Beacon Type	Version	Satellite ID	Data Element 1	Data Element 2	…	Data Element N
8 bits	8 bits	8 bits	16 bits	64 + M bits	64 + M bits	64 + M bits	64 + M bits
UINT8	UINT8	UINT8	UINT16				

Table 4. Aistechsat-3 TTC Application layer characteristics

Each data element has the next format.

Checksum	Timestamp	Source	Data
16 bits	32 bits	16 bits	Variable
UINT16	UINT32	UINT16	

Table 5 Aistechsat-3 data element characteristics

5.1   Beacons Description

Aistechsat-3 is transmitting 7 different types of beacons each 10, 30 or 60 seconds.

- **Type 10 – Platform Beacon** each 30 seconds.
- **Type 11 – UHF Antenna Telemetry Beacon** each 30 seconds.
- **Type 20 – ADCS Beacon 0** each 10 seconds.
- **Type 21.- ADCS Fine Sun Sensor Beacon** each 60 seconds.
- **Type 22 – ADCS Beacon 2** each 60 seconds.
- **Type 23 - ADCS Beacon 3** each 60 seconds.
- **Type 26 - ADCS Beacon 6** each 60 seconds.
- **Type 30 – Payload Beacon** each 60 seconds.

5.1.1   Beacons telemetry content

5.1.1.1   Type 10 – Platform Beacon

Element(s)	Name	Type [range]
0	fs_mounted	bool
1	ram_image	bool
2	temp_mcu	int16
3	temp_ram	int16
4	i_GSSB1	uint16
5	i_GSSB2	uint16
6	i_Flash	uint16
7	i_PWM	uint16
8	resetcause	uint32
9	bootcause	uint32
10	bootcount	uint16
11	clock	uint32
12	uptime	uint32
13	last_rssi	int16
14	last_rferr	int16
15	bgnd_rssi	int16
16	tx_duty	uint8
17	tot_tx_count	uint32
18	tot_rx_count	uint32
19	tot_tx_bytes	uint32
20	tot_rx_bytes	uint32
21	boot_count	uint16
22	boot_cause	uint32
23	tx_bytes	uint32
24	rx_bytes	uint32
25	active_conf	int8
26	tx_count	uint32
27	rx_count	uint32
28	temp_brd	int16
29	temp_pa	int16
30-32	vboost	uint16 [0-2]

Element(s)	Name	Type [range]
33	vbatt	uint16
34-39	curout	uint16 [0-5]
40-42	curin	uint16 [0-2]
43	cursun	uint16
44	cursys	uint16
45-50	temp	int16 [0-5]
51-58	out_val	uint8 [0-7]
59	battmode	uint8
60	pptmode	uint8
61	wdtI2cS	uint32
62	wdtGndS	uint32
63	bootcount	uint32
64	cntWdtI2c	uint32
65	cntWdtGnd	uint32
66-67	cntWdtCsp	uint32 [0-1]
68-69	wdtCspC	uint32 [0-1]
70-75	latchups	uint16 [0-5]
76	bootcause	uint8

Table 6. Beacon type 10 contents

5.1.1.2   Type 11 – UHF Antenna Telemetry Beacon

Element(s)	Name	Type [range]
0	temp_isis_A	uint16
1	arm_isis_A	uint8
2	ign_isis_A	uint8
3	ind_bu_isis_A	uint8
4	depl_isis_A	uint8
5	time_isis_A	uint8
6	depl_a_isis_A	uint8
7	act_1_isis_A	uint8
8	act_2_isis_A	uint8
9	act_3_isis_A	uint8
10	act_4_isis_A	uint8
11	time_1_isis_A	uint16
12	time_2_isis_A	uint16
13	time_3_isis_A	uint16
14	time_4_isis_A	uint16
15	temp_isis_B	uint16
16	arm_isis_B	uint8
17	ign_isis_B	uint8
18	ind_bu_isis_B	uint8
19	depl_isis_B	uint8
20	time_isis_B	uint8
21	depl_a_isis_B	uint8
22	act_1_isis_B	uint8
23	act_2_isis_B	uint8
24	act_3_isis_B	uint8
25	act_4_isis_B	uint8
26	time_1_isis_B	uint16
27	time_2_isis_B	uint16
28	time_3_isis_B	uint16
29	time_4_isis_B	uint16

Table 7. Beacon type 11 contents

5.1.1.3   Type 20 – ADCS Beacon 0

Element(s)	Name	Type [range]
0	extmag_temp	float
1-3	mag	float [0-2]
4-6	extmag	float [0-2]
7-12	suns	float [0-5]
13-18	suns_temp	int16 [0-5]
19-21	gyro	float [0-2]
22-24	gyro_trend	float [0-2]
25	gyro_temp	float
26-28	extgyro	float [0-2]
29	extgyro_temp	float
30	extgyro_valid	uint8
31-33	torquer_duty	float [0-2]
34	status_mag	int8
35	status_exmag	int8
36	status_css	int8
37	status_gyro	int8
38	status_bdot	int8
39	status_run	int8
40	looptime	uint16
41	maxlooptime	uint16
42-43	bdot_rate	float [0-1]
44-46	bdot_dmag	float [0-2]
47	bdot_detumb	uint8
48	acs_mode	int8
49	acs_dmode	int8
50	ads_mode	int8
51	ads_dmode	int8
52	ephem_mode	int8
53	ephem_dmode	int8

Table 8. Beacon type 20 contents

5.1.1.4   Type 21.- ADCS Fine Sun Sensor Beacon

Element(s)	Name	Type [range]
0-2	extmag	float [0-2]
3-5	gyro	float [0-2]
6-8	torquer_duty	float [0-2]
9-12	wheel_speed	float [0-3]
13-16	wheel_cur	uint16 [0-3]
17-20	wheel_temp	int16 [0-3]
21-28	fss_temp	float [0-7]
29	spin_mode	int8
30	status_ukf	int8
31	status_sgp4	int8
32	status_igrf	int8

Table 9. Beacon type 21 contents

5.1.1.5   Type 22 – ADCS Beacon 2

Element(s)	Name	Type [range]
0-12	ukf_X	float [0-12]
13-24	ukf_Pdiag	float [0-11]
25-36	ukf_Zpred	float [0-11]
37	ukf_ineclipse	uint8
38	ephem_jdate	double
39-41	ephem_reci	float [0-2]
42-44	ephem_veci	float [0-2]

Table 10. Beacon type 22 contents

5.1.1.6   Type 23 - ADCS Beacon 3

Element(s)	Name	Type [range]
0-3	ctrl_refq	float [0-3]
4-7	ctrl_errq	float [0-3]
8-10	ctrl_errrate	float [0-2]
11-13	ctrl_M	float [0-2]
14-17	ctrl_mwspeed	float [0-3]
18-21	ctrl_mwtorque	float [0-3]
22-25	ukf_q	float [0-3]
26-28	ukf_w	float [0-2]
29-31	ephem_reci	float [0-2]
32-34	ephem_veci	float [0-2]

Table 11. Beacon type 23 contents

5.1.1.7 Type 26 - ADCS Beacon 6

Element(s)	Name	Type [range]
0	fs_mounted	bool
1	bootcount	uint16
2	bootcause	uint32
3	clock	uint32
4	temp_mcu	int16
5	temp_ram	int16
6	i_GSSB1	uint16
7	i_GSSB2	uint16
8	i_Flash	uint16
9	i_PWM	uint16
10	swload_cnt1	uint16
11	gssb1_pwr_en	bool
12	gssb2_pwr_en	bool
13	flash_pwr_en	bool
14	pwm_pwr_en	bool
15	extmag_temp	float
16-21	suns_temp	int16 [0-5]
22	gyro_temp	float
23	extgyro_temp	float
24-27	wheel_temp	int16 [0-3]
28-31	wheel_cur	uint16 [0-3]

Table 12. Beacon type 26 contents

5.1.1.8 Type 30 – Payload Beacon

Element(s)	Name	Type [range]
0	cur_1v2	uint16
1	cur_2v5	uint16
2	cur_3v3_fpga	uint16
3	cur_3v3_adc	uint16
4	cur_5v0_board	uint16
5	cur_3v3_board	uint16
6	cur_3v3_sd	uint16
7	avg_fps_10sec	uint16
8	avg_fps_1min	uint16
9	avg_fps_5min	uint16
10	plane_count	uint32
11	frame_count	uint32
12	crc_corrected	uint32
13	last_icao24	uint32
14	last_lat	float
15	last_lon	float
16	last_alt	uint32
17	last_ts	uint32
18	bootcount	uint32
19	bootcause	uint16
20	current_time	uint32
21	tot_frames	uint32
22	tot_planes	uint32
23	tot_crc_cor	uint32
24	fpga_crc_cnt	uint32

Element(s)	Name	Type [range]
25	coretemp	int16
26	softadctemp	int16
27-29	femtemp	int16 [0-2]
30-32	femadctemp	int16 [0-2]
33	corevcc	uint16
34	vccaux	uint16
35	vccbram	uint16
36	vccpint	uint16
37	vccpaux	uint16
38	vccoddr	uint16
39	vrefp	uint16
40	vrefn	uint16
41	unixtime	uint64
42-44	fem1v3b	uint16 [0-2]
45-47	fem-lna1-ma	uint16 [0-2]
48-50	fem-lna2-ma	uint16 [0-2]
51-53	fem1v3ama	uint16 [0-2]
54-56	fem1v8ma	uint16 [0-2]
57-59	fem1v3a	uint16 [0-2]
60-62	fem1v8	uint16 [0-2]
63-65	fem1v3bma	uint16 [0-2]
66	uptime	uint32
67-69	loads	uint32 [0-2]
70	freeram	uint32
71	procs	uint16
72	ps1v8mw	uint16
73	ps1vmw	uint16
74	ps3v3mw	uint16
75	pl1v8mw	uint16
76	pl1vmw	uint16
77	ram1v35mw	uint16
78	pl3v3mw	uint16
79	softvin7	uint16
80	boot_count	uint32

Table 13. Beacon type 30 contents

6. GNU Radio Code

A GNU Radio demodulator and decoder is made available in github for the Amateur community

https://github.com/mndza/gr-sattools