“丰台少年二号”暨“少年梦想二号”卫星使用手册

CAS-5A Amateur Radio Satellite

User's Manual

Ver. 2.0

Fengtai OSCAR-118

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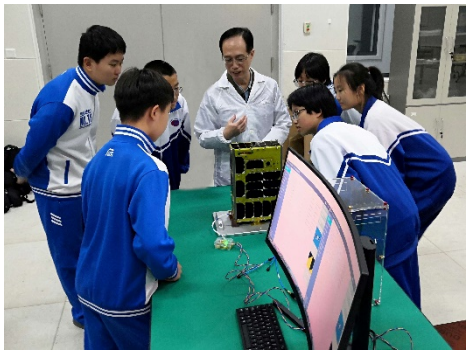
The CAMSAT CAS-5A amateur radio satellite was piggybacked on the Smart Dragon-3 Y1 launch vehicle and launched from the sea launch platform in the Yellow Sea at UTC 06:35:02 on December 9, 2022. After 724 seconds, the satellite successfully separated from the launch vehicle and entered the intended orbit. The satellite orbit is a circular sun-synchronous orbit with an altitude of 543 kilometers and an inclination of 97.53 degrees, the running cycle is 95.575minutes. AMSAT has designated CAS-5A satellite as Fengtai-OSCAR 118 (FO-118).

The CAS-5A was launched aboard an SD-3 rocket

The CAMSAT team works at the rocket plant

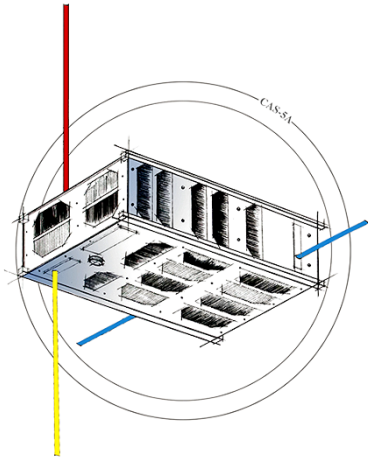
The functions of CAS-5A satellite include UHF CW telemetry beacon, GMSK telemetry data transmission, V/U mode linear transponder, V/U mode FM transponder, H/U mode linear transponder, three visible light band space cameras.

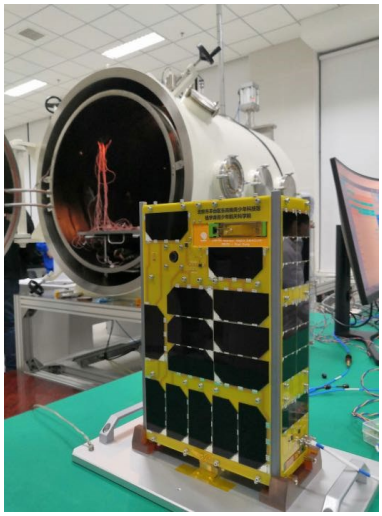



Students and teachers participating in the CAS-5A project

After the satellite completes the in-orbit test and works normally, the space camera photo download will be open to amateur radio enthusiasts all over the world. When the relevant remote control command is received by the satellite, the GMSK telemetry channel will be used to downlink the photo catalog and photo data, and the telemetry data will stop sending at that time.

CAS-5A satellite adopts a 6U CubeSat structure with a mass of about 7kg, an on-orbit envelope size of 366x226x100mm (antennas not included) with six sides body-mounted solar panels and a three-axis stabilized attitude control system is used, long-term power consumption is about 10 Watts.





1、Technical specifications:

- **VHF antenna:** 1/4 wavelength whip antenna
- **UHF antenna:** two 1/4 wavelength whip antenna
- **HF antenna:** whip antenna
- **CW telemetry beacon:**

  ●Frequency: 435.570MHz ●RF power: 20dBm ●CW rate: 22wpm

- **GMSK telemetry:**

  ●Frequency: 435.650MHz ●RF power: 25dBm ●Data rate: 4800/9600bps

- **V/U mode linear transponder:**

  ●Uplink frequency: 145.820MHz ●Downlink frequency: 435.540MHz

  ●RF power: 23dBm ●Bandwidth: 30kHz ●Spectrum inverted

- **V/U mode FM transponder:**

  ●Uplink frequency: 145.925MHz ●Downlink frequency: 435.600MHz

  ●RF power: 23dBm ●Bandwidth: 16kHz

- **H/U mode linear transponder:**

  ●Uplink frequency: 21.435MHz ●Downlink frequency: 435.505MHz

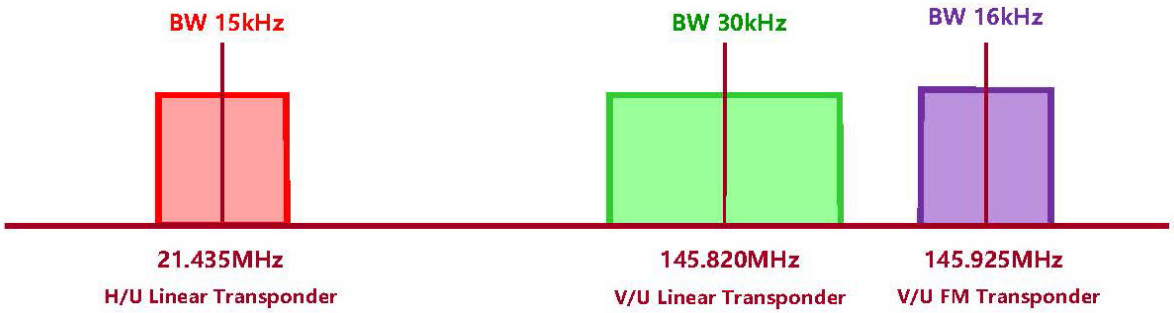
  ●RF power: 23dBm ●Bandwidth: 15kHz ●Spectrum normal

- **Photo download remote control:**

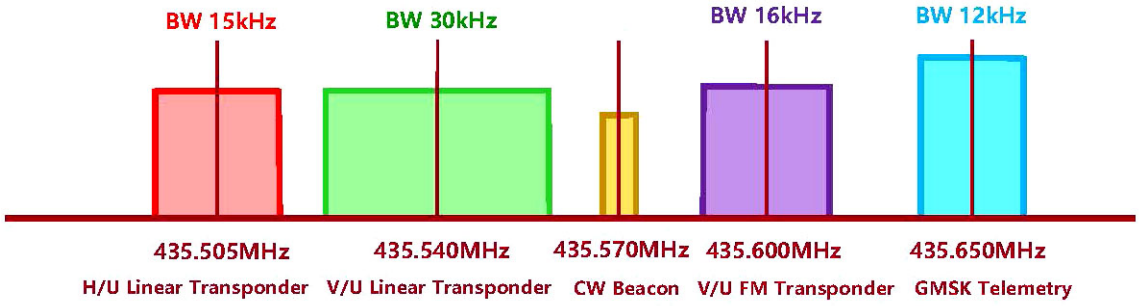
  ●Frequency: 145.975MHz

  ●RF modulation: FM, frequency deviation ±3kHz

  ●Subcarrier: DTMF (dual-tone multi-frequency)



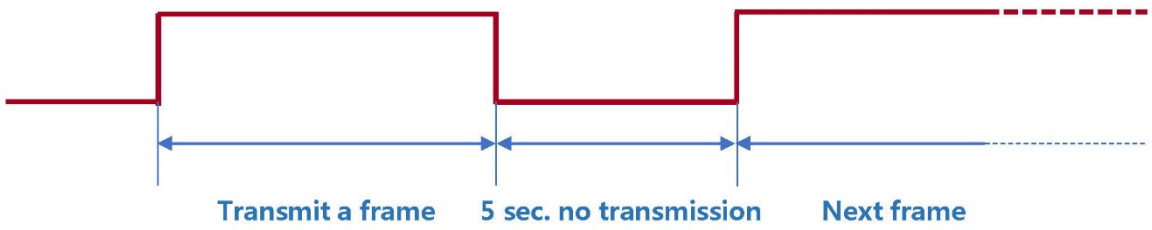
CAS-5A Satellite receiving spectrum



CAS-5A Satellite transmitting spectrum

2、CW Telemetry Beacon Description:

(1) CW beacon sending sequence



- Send stop interval time: 5s
- CW sending rate: 22wpm

(2) CW beacon frame format

Sending order	Sending content	Description	Remarks
1	**BJ1SO**	Satellite call sign	Send in standard Morse code
2	**CAS5A**	Telemetry information start identifier	
3	**CAS5A**	Telemetry information start identifier	
4	**CH1**	Telemetry channel 1	
5	**CH2 ~ CH31**	Telemetry channel 2~Telemetry channel 31	Send this channel information, see [Digital Code Table] below
6	**CAMSAT**	Telemetry information end flag	Send in standard Morse code
7	**CAMSAT**	Telemetry information end flag	

The telemetry data (CH2 to CH31) are coded as follows:

Digital Code Table

Digital	Code
0	**T**
1	**A**
2	**U**
3	**V**
4	**4**
5	**E**
6	**6**
7	**B**
8	**D**
9	**N**

(3) CW beacon telemetry information and data analysis

Channel	Parameter name	Type	Value range		Parsing algorithm	Unit
			Mini.	Max.		
CH1	Current operating mode	state	000	999	**XYZ:** **X:** 4=4800bps, 9=9600bps GMSK telemetry rate **YZ:** 01 = All asleep 02 = Beacon on (send every 5 minutes) 03 = Beacon on (send every 5 seconds from mode 3 to mode 10) 04 = Beacon on + AX.25 telemetry 05 = Beacon on + AX.25 telemetry + V/U linear transponder 06 = Beacon on + AX.25 telemetry + V/U linear transponder + H/U linear transponder 07 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder 08 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder + H/T linear transponder 09 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder + H/T linear transponder + heater 1 10 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder + H/T linear transponder + heater 1 + heater 2 **(H/T linear transponder is not valid in CAS-5A)**	--
CH2	CW telemetry frame transmission counter	data	000	255	Every time a frame is sent, the CW telemetry frame counter is incremented by 1, and starts counting from 000 when it is full	Time
CH3	Remote control command receiving counter	data	000	255	Every time a remote control command is received, the counter is incremented by 1, and start counting from 000 when it is full	Time
CH4	Primary power supply voltage	data	000	999	U=N/10	V

Channel	Parameter name	Type	Value range		Parsing algorithm	Unit
			Mini.	Max.		
CH5	3.8V bus voltage	data	000	999	U=N/100	V
CH6	5.5V bus voltage	data	000	999	U=N/100	V
CH7	Battery voltage	data	000	999	U=N/10	V
CH8	Solar array current	data	000	999	I=N/100	A
CH9	Primary bus current	data	000	999	I=N/100	A
CH10	Total load current	data	000	999	I=N/100	A
CH11	VHF receiver current	data	000	999	I=N	mA
CH12	UHF transmitter1 current	data	000	999	I=N	mA
CH13	UHF transmitter2 current	data	000	999	I=N	mA
CH14	Reserved	data	000	999	I=N	mA
CH15	VHF AGC voltage	data	000	999	U=N/100	V
CH16	UHF transmitter1 RF power	data	00	99	P=600+N	mW
CH17	UHF transmitter2 RF power	data	000	999	P=N/100	mW
CH18	Reserved	data	000	999	P=N/100	mW
CH19	IHU temperature	data	000	999	**XYZ** When X is 0-2, it represents a positive temperature; X is 3-4, it represents a negative temperature.	℃
CH20	Battery 1 temperature	data	000	999		℃
CH21	Battery 2 temperature	data	000	999		℃
CH22	UHF1 PA temperature	data	000	999		℃

Channel	Parameter name	Type	Value range		Parsing algorithm	Unit
			Mini.	Max.		
CH23	UHF2 PA temperature	data	000	999	T=N (N≤300) T=-1x (N-300) (N>300) For example: 000 : 0℃ 025 : 25℃ 125 : 125℃ 301 : -1℃ 311 : -11℃ 391 : -91℃ 421 : -121℃	℃
CH24	Camera 3 temperature	data	000	999		℃
CH25	Camera 1 temperature	data	000	999		℃
CH26	+X Cabin Plate Inner Temperature	data	000	999		℃
CH27	-X Cabin Plate Inner Temperature	data	000	999		℃
CH28	PCDU Temperature	data	000	999		℃
CH29	DC/DC Temperature	data	000	999		℃
CH30	+Z Cabin Plate Inner Temperature	data	000	999		℃
CH31	-Z Cabin Plate Inner Temperature	data	000	999		℃

3、GMSK telemetry data：

(1) GMSK telemetry frame format and communication protocol

CAS-5A satellite GMSK telemetry data is sent in the AX.25 UI frame format. Callsign is BJ1SO.

The user data of each frame is 167 bytes, and the allocation is as follows:

Function code	Telemetry data content
7Byte	160Byte
W0~W6：0x0100010001007E	W7~W166

(2) GMSK telemetry data format and analysis method

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
1	W7	6Byte	Satellite time	W1-Year: 00～99, representing 2000～2099 W2-Month: 01～12, representing January to December W3-Day: 01～31, representing 1st～31st W4-Hour: 00～23, representing 0:00～23:00 W5-minute: 00～59, representing 0 minutes～59 minutes W6-second: 00～59, representing 0 seconds～59 seconds
2	W13	1Byte	IHU total reset counter	W1 is an integer. Restart counting from 0 after counting up

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
				Range: 0～255
3	W14	1Byte	Battery status	b7~b1: reserved, all values are 0 b3: Battery heater 2 switch state (0 off/1 on) b2: Battery heater 1 switch state (0 off/1 on) b1: Battery discharge switch state (0 off/1 on) b0: Battery discharge switch off allowable state (0 energy disabled/1 enabled)
4	W15	1Byte	Remote control frame reception counter	W1 is an integer. Restart counting from 0 after counting up Range: 0～255
5	W16	1Byte	Remote control command execution counter	W1 is an integer. Restart counting from 0 after counting up Range: 0～255
6	W17	1Byte	Telemetry Frame Transmission Counter	W1 is an integer. Restart counting from 0 after counting up Range: 0～255
7	W18	1Byte	IHU status 1	b7: IHU flash2 read and write failure (0 normal/1 fault) b6: Remote control command CRC correctly identified (0 error/1 correct) b5: IHU flash1 read and write failure (0 normal/1 failure) b4: CPU I/O acquisition watchdog switch flag (0 off/1 on) b3: reserved, value 0 b2: ADC Software Watchdog Switch Flag (0 Off/1 On) b1: Temperature measurement software watchdog switch sign (0 off/1 on) b0: Remote control software watchdog switch sign (0 off/1 on)
8	W19	1Byte	Reserved	W1 is an integer. Restart counting from 0 after counting up Range: 0～255

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
9	W20	1Byte	I2C bus status	b7~b5: reserved, all values are 0 b4: Temperature1-I2C fault (0 normal/1 fault) b3: Temperature2-I2C fault (0 normal/1 fault) b2: Temperature3-I2C fault (0 normal/1 fault) b1: ADC-I2C fault (0 normal/1 fault) b0: Clock-I2C fault (0 normal/1 fault)
10	W21	1Byte	Reserved	W1 is an integer. Restart counting from 0 after counting up Range: 0～255
11	W22	1Byte	Reserved	W1 is an integer. Restart counting from 0 after counting up Range: 0～255
12	W23	1Byte	Reserved	W1 is an integer. Restart counting from 0 after counting up Range: 0～255
13	W24	1Byte	IHU status 2	b7: Board-to-board communication failure (0 normal/1 fault) b6: Flash2 read and write failure of the camera board (0 normal/1 failure) b5: Flash1 read and write failure of the camera board (0 normal/1 failure) B4: Antenna deployment master switch state (0 off/1 on) b3: UHF antenna 1 deployment state (0 undeployed/1 deployed) b2: UHF antenna 2 deployment state (0 undeployed/1 deployed) b1: VHF antenna deployment status (0 undeployed/1 deployed) b0: HF antenna deployment state (0 undeployed/1 deployed)
14	W25	1Byte	IHU status 3	b7~b3: Reserved, all values are 0 b2: Satellite Separation Status (0 Not Separated /1 Separated) b1: Reserved, value 0

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
				b0: Delay telemetry switch state (0 off/1 on)
15	W26	1Byte	+X cabin plate inner temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
16	W27	1Byte	-X cabin plate inner temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
17	W28	1Byte	PCDU Temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
18	W29	1Byte	DC/DC Temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
19	W30	1Byte	+Z cabin plate inner temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
20	W31	1Byte	-Z cabin plate inner temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
21	W32	1Byte	+X solar array temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
22	W33	1Byte	-X solar array temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
23	W34	1Byte	+Y solar array temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
24	W35	1Byte	-Y solar array temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
25	W36	1Byte	+Z solar array temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
26	W37	1Byte	-Z solar array temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
27	W38	1Byte	Battery pack 1 temperature 1	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
28	W39	1Byte	Battery pack 1 temperature 2	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
29	W40	1Byte	Battery pack 2 temperature 3	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
30	W41	1Byte	Battery pack 2 temperature 4	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
31	W42	1Byte	IHU temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
32	W43	1Byte	UHF1 PA temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
33	W44	1Byte	Camera 3 temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
34	W45	1Byte	Camera 1 temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
35	W46	1Byte	Camera 2 temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
36	W47	1Byte	UHF2 PA temperature	b7 of W1 is the sign bit, 0 is positive, 1 is negative; b6~b0 are numerical bits Range: -100 ~ +100(℃)
37	W48	2Byte	Battery voltage	W1 is the integer part, W2 is the decimal part (1 decimal place)

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
				Range: 0 ~ 15.0(V)
38	W50	2Byte	Primary power supply voltage (12V)	W1 is the integer part, W2 is the decimal part (1 decimal place) Range: 0 ~ 15.0(V)
39	W52	2Byte	5.0V bus voltage	W1 is the integer part, W2 is the decimal part (2 decimal places) Range: 0 ~ 10.00(V)
40	W54	2Byte	3.8V bus voltage	W1 is the integer part, W2 is the decimal part (2 decimal places) Range: 0 ~ 5.00(V)
41	W56	2Byte	IHU 3.3V voltage	W1 is the integer part, W2 is the decimal part (2 decimal places) Range: 0 ~ 5.00(V)
42	W58	2Byte	Total solar array current	W1W2 is an integer Range: 0 ~ 3000(mA)
43	W60	2Byte	Primary bus current	W1W2 is an integer Range: 0 ~ 2000(mA)
44	W62	2Byte	Total load current	W1W2 is an integer Range: 0 ~ 1000(mA)
45	W64	2Byte	IHU current	W1W2 is an integer Range: 0 ~ 500(mA)
46	W66	2Byte	Reserved	W1W2 is an integer Range: 0 ~ 1000(mA)
47	W68	2Byte	HF receiver current	W1W2 is an integer Range: 0 ~ 1000(mA)
48	W70	2Byte	Reserved	W1W2 is an integer Range: 0 ~ 2000(mW)

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
49	W72	2Byte	UHF transmitter 2 current	W1W2 is an integer Range: 0 ~ 1000(mA)
50	W74	2Byte	H/T AGC voltage	W1 is the integer part, W2 is the decimal part (2 decimal place) Range: 0 ~ 5.00(V)
51	W76	2Byte	UHF transmitter 1 current	W1W2 is an integer Range: 0 ~ 1000(mA)
52	W78	2Byte	UHF1 RF power	W1W2 is an integer Range: 0 ~ 3000(mW)
53	W80	2Byte	UHF2 RF power	W1W2 is an integer Range: 0 ~ 3000(mW)
54	W82	2Byte	VHF receiver current	W1W2 is an integer Range: 0 ~ 1000(mA)
55	W84	2Byte	VHF AGC voltage	W1 is the integer part, W2 is the decimal part (2 decimal place) Range: 0 ~ 5.00(V)
56	W86	6Byte	Delayed telemetry start time	W1-Year: 0 ~ 99, representing 2000 ~ 2099 W2-Month: 01 ~ 12, representing January to December W3-Day: 01 ~ 31, representing 1st ~ 31st W4-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W5-minute: 00 ~ 59, representing 0 minute ~ 59 minutes W6-second: 00 ~ 59, representing 0 second ~ 59 seconds
57	W92	3Byte	Delayed telemetry interval setting	W1-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W2-Minute: 00 ~ 59, representing 0 minute ~ 59 minutes W3-second: 00 ~ 59, representing 0 second ~ 59 seconds

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
58	W95	3Byte	Frequency of delayed telemetry setting	W1W2W3 is an integer Range: 0 ~ 16777215
59	W98	2Byte	The camera controller operating current	W1W2 is an integer Range: 0 ~ 500(mA)
60	W100	2Byte	The operating voltage of the camera controller	W1 is the integer part, W2 is the decimal part (2 decimal place) Range: 0 ~ 5.00(V)
61	W102	2Byte	Total camera current	W1W2 is an integer Range: 0 ~ 2000(mA)
62	W104	1Byte	Camera working status	b7: Camera controller power switch status (0 off/1 on) b6: reserved, value 0 b5: Camera 1 power switch status (0 off/1 on) b4: Camera 1 delayed photography switch status (0 off/1 on) b3: Camera 2 power switch status (0 off/1 on) b2: Camera 2 delayed photography switch status (0 off/1 on) b1: Camera 3 power switch status (0 off/1 on) b0: Camera 3 delayed photography switch status (0 off/1 on)
63	W105	2Byte	Camera 1 photo counter	W1W2 is an integer Range: 0 ~ 2047
64	W107	2Byte	Camera 2 photo counter	W1W2 is an integer Range: 0 ~ 2047
65	W109	2Byte	Camera 3 photo counter	W1W2 is an integer Range: 0 ~ 2047
66	W111	6Byte	Camera 1 Delayed Photography start time	W1-Year: 0 ~ 99, representing 2000 ~ 2099

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
				W2-Month: 01 ~ 12, representing January to December W3-Day: 01 ~ 31, representing 1st ~ 31st W4-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W5-minute: 00 ~ 59, representing 0 minute ~ 59 minutes W6-second: 00 ~ 59, representing 0 second ~ 59 seconds
67	W117	3Byte	Camera 1 Delayed Photography interval setting	W1-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W2-Minute: 00 ~ 59, representing 0 minute ~ 59 minutes W3-second: 00 ~ 59, representing 0 second ~ 59 seconds
68	W120	1Byte	Camera 1 Frequency of delayed Photography setting	W1 is an integer Range: 0 ~ 60
69	W121	6Byte	Camera 2 Delayed Photography start time	W1-Year: 0 ~ 99, representing 2000 ~ 2099 W2-Month: 01 ~ 12, representing January to December W3-Day: 01 ~ 31, representing 1st ~ 31st W4-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W5-minute: 00 ~ 59, representing 0 minute ~ 59 minutes W6-second: 00 ~ 59, representing 0 second ~ 59 seconds
70	W127	3Byte	Camera 2 Delayed Photography interval setting	W1-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W2-Minute: 00 ~ 59, representing 0 minute ~ 59 minutes W3-second: 00 ~ 59, representing 0 second ~ 59 seconds
71	W130	1Byte	Camera 2 Frequency of delayed Photography setting	W1 is an integer Range: 0 ~ 60
72	W131	6Byte	Camera 3 Delayed Photography start time	W1-Year: 0 ~ 99, representing 2000 ~ 2099

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
				W2-Month: 01 ~ 12, representing January to December W3-Day: 01 ~ 31, representing 1st ~ 31st W4-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W5-minute: 00 ~ 59, representing 0 minute ~ 59 minutes W6-second: 00 ~ 59, representing 0 second ~ 59 seconds
73	W137	3Byte	Camera 3 Delayed Photography interval setting	W1-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W2-Minute: 00 ~ 59, representing 0 minute ~ 59 minutes W3-second: 00 ~ 59, representing 0 second ~ 59 seconds
74	W140	1Byte	Camera 3 Frequency of delayed Photography setting	W1 is an integer Range: 0 ~ 60
75	W141	1Byte	Satellite current operating mode	W1 is an integer Range: 0 ~ 10 01 = All asleep 02 = Beacon on (send every 5 minutes) 03 = Beacon on (send every 5 seconds from mode 3 to mode 10) 04 = Beacon on + AX.25 telemetry 05 = Beacon on + AX.25 telemetry + V/U linear transponder 06 = Beacon on + AX.25 telemetry + V/U linear transponder + H/U linear transponder 07 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder 08 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder + H/T linear transponder 09 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U linear transponder + H/T linear transponder + heater 1 10 = Beacon on + AX.25 telemetry + V/U linear transponder + FM transponder + H/U

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
				linear transponder + H/T linear transponder + heater 1 + heater 2 **(H/T linear transponder is not valid in CAS-5A)**
76	W142	2Byte	Satellite device switch status	b15~b10: Reserved, all values are 0 b9: GMSK telemetry data rate (0-9.6kbps/1-4.8kbps) b8: RF power status (0 low power / 1 high power) b7: V/U FM transponder switch state (0 off/1 on) b6: V/U linear transponder switching state (0 off/1 on) b5: UHF beacon switch status (0 off/1 on) b4: UHF GMSK telemetry switch state (0 off/1 on) b3: H/U linear transponder switching state (0 off/1 on) b2: H/T linear transponder switching state (0 off/1 on) b1: HF beacon switch status (0 off/1 on) b0: Working mode status (0 auto/1 manual)
77	W144	6Byte	48 hours reset time	W1-Year: 00 ~ 99, representing 2000 ~ 2099 W2-Month: 01 ~ 12, representing January to December W3-Day: 01 ~ 31, representing 1st ~ 31st W4-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W5-minute: 00 ~ 59, representing 0 minutes ~ 59 minutes W6-second: 00 ~ 59, representing 0 seconds ~ 59 seconds
78	W150	2Byte	Attitude quaternion q0	W_1W_2: Q0L Q0H q0=((Q0H<<8)|Q0L)/32768
79	W152	2Byte	Attitude quaternion q1	W_1W_2: Q1L Q1H q1=((Q1H<<8)|Q1L)/32768

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
80	W154	2Byte	Attitude quaternion q2	W_1W_2: Q2L Q2H q2=((Q2H<<8)|Q2L)/32768
81	W156	2Byte	Attitude quaternion q3	W_1W_2: Q3L Q3H q3=((Q3H<<8)|Q3L)/32768
82	W158	1Byte	Camera 1 resolution	W1 is an integer Range: 0 ~ 7 0: 800×480; 1: 1280×720; 2: 320×240; 3: 1440×896; 4: 640×480; 5: 1920×1080; 6: 800×600; 7: 1024×768
83	W159	1Byte	Camera 1 image quality	W1 is an integer Range: 0 ~ 2 0: Highest quality; 1: Medium quality; 2: Low quality
84	W160	1Byte	Camera 2 resolution	W1 is an integer Range: 0 ~ 7 0: 800×480; 1: 1280×720; 2: 320×240; 3: 1440×896; 4: 640×480; 5: 1920×1080; 6: 800×600; 7: 1024×768
85	W161	1Byte	Camera 2 image quality	W1 is an integer Range: 0 ~ 2 0: Highest quality; 1: Medium quality; 2: Low quality
86	W162	1Byte	Camera 3 resolution	W1 is an integer Range: 0 ~ 7 0: 800×480; 1: 1280×720; 2: 320×240; 3: 1440×896; 4: 640×480; 5: 1920×1080; 6: 800×600; 7: 1024×768

Sending order	Starting position	Data length	Telemetry data function description	Telemetry data parsing algorithm
87	W163	1Byte	Camera 3 image quality	W1 is an integer Range: 0 ~ 2 0: Highest quality; 1: Medium quality; 2: Low quality
88	W164	3Byte	The current delayed telemetry interval setting	W1-Hour: 00 ~ 23, representing 0:00 ~ 23:00 W2-Minute: 00 ~ 59, representing 0 minute ~ 59 minutes W3-second: 00 ~ 59, representing 0 second ~ 59 seconds

4、Space camera photo data：

CAS-5A satellite can store up to 60 photos taken by the space cameras. When the number of stored photos exceeds 60, the newly taken photo data will overwrite the old photo data, first in, first out. There are eight photo resolutions, from 320x240 to 1920x1024 and three image compression qualities. Users can download the photo catalog information to learn about the photos stored on the satellite, and select the photos to download.

Numbering	Photo Resolutions
0	800×480
1	1280×720
2	320×240
3	1440×896
4	640×480
5	1920×1080
6	800×600
7	1024×768

Numbering	Photo Qualities
0	High
1	Medium
2	Low

(1) photo catalog information

CAS-5A satellite photo catalog information Includes two AX.25 frames are stored in the flash memory on the satellite in the following format.

1)First frame:

Function code	Photo catalog information content
7Byte	249Byte
W0~W6：0x020002000101E7	W7~W255

2)Second frame:

Function code	Photo catalog information content
7Byte	231Byte
W0~W6：0x020002000201E7	W7~W237

Photo catalog information content			
Article 1 Photo catalog information	**Article 2 Photo catalog information**	**……**	**Article 60 Photo catalog information**
8Byte	8Byte	……	8Byte

3)The format of each photo catalog information is shown in the following table:

1Byte	1Byte	1Byte	1Byte	1Byte	1Byte	1Byte		1Byte
Year	Month	Day	Hour	Minute	Second	bit7~Bit3	Bit2~Bit0	1Byte
Photograph time						Camera number	Photo counter	

a) **Year, month, day, hour, minute, and second:** the time when the photo data starts to be stored.

b) **Camera number:** 00001B: Camera 1; 00010B Camera 2; 00011B: Camera 3

c) **Photograph counter:** start counting from 1, and restart counting from 1 when it is full. 0 is the initial state, which means that no photo has been taken yet. 1~2047 is the photo count value.

(2) Photo data format

When the CAS-5A satellite receives the DTMF remote control command to download the photo, the corresponding photo data will be divided into 240-byte frames (the last frame may be less than 240 bytes) and sent in the format of AX.25 UI frames. After receiving it, the ground station combines all the data in the order of receiving it, which is a photo data in JPG format。

(3) DTMF remote control command format

The remote control of downloading CAS-5A satellite space camera photo data uses DTMF subcarrier modulation and FM radio frequency modulation system. The remote control command codes are shown in the following table

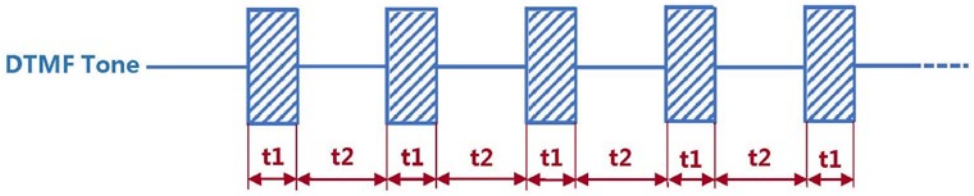
1) Remote control command:

	DTMF Remote command code	Functions performed
1	*ABC#	Download photo catalog information
2	*B01# ~ *B60#	Download photo 01 ~ 60

2) Sequence of sending a remote control command:

Each remote control command is composed of a 5-digit DTMF code, starting with * and ending with #. The duration of sending each digit of DTMF command is not less

than 100ms, and the interval between sending each DTMF code of the same command is greater than 200ms and no more than 3 seconds.



Parameter	Min (ms)	Max (ms)
t1	100	3000
t2	200	3000