



XW-2 Satellites Digital Telemetry Encoding Format

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The following includes digital telemetry transmission format and measurement equation of CAMSAT – DFH XW-2 series of six amateur radio satellites. The digital telemetry signals of XW-2 satellites work on GMSK modulation scheme, the baseband transmission is AX.25 UI frames. XW -2A through 2D satellites’ telemetry transmission rate is 9.6kbps and 19.2kbps switchable, the telemetry transmission rate of XW-2E and 2F is 9.6kbps only.

1、XW-2A、2B、2C and 2D digital telemetry fames and equations

Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
1	Primary power supply voltage	Data	W0	8bits, Unsigned binary integers $6 \times (3.3/255) \times N(\text{Measured value})$ (V)	10V~13V
2	Primary power supply current	Data	W1	8bits, Unsigned binary integers $0.15 \times (3.3/255) \times N(\text{Measured value})$ (A)	0.10A~0.20A
3	DC / DC converter output voltage	Data	W2	8bits, Unsigned binary integers $1.6 \times (3.3/255) \times N(\text{Measured value})$ (V)	3.8V
4	DC / DC converter output current	Data	W3	8bits, Unsigned binary integers $0.2 \times (3.3/255) \times N(\text{Measured value})$ (A)	0.2A~0.6A



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
5	OBC power voltage	Data	W4	8bits, Unsigned binary integers $4 \times 2.4/256 \times N(\text{Measured value}) \text{ (V)}$	3.3V
6	OBC temperature	Data	W5	8bits, Unsigned binary integers $N-64 \text{ (}^\circ\text{C)}$	-64 $^\circ\text{C}$ ~125 $^\circ\text{C}$
7	RF power amplifier temperature	Data	W6	8bits, Unsigned binary integers $N-64 \text{ (}^\circ\text{C)}$	-64 $^\circ\text{C}$ ~125 $^\circ\text{C}$
8	Command transmission counter	Data	W7B7~B5	Display in decimal	0~7
9	Current operating mode	Status	W7B4~B2	001:Mode 1 (CW Beacon, Transmit Per 6 minutes) 010:Mode 2 (CW Beacon, Continuously) 011:Mode 3 (CW Beacon + Linear Transponder) 100:Mode 4 (CW Beacon + Telemetry) 101:Mode 5 (CW Beacon + Telemetry + Linear Transponder) 110:Mode 6 (Inter-satellite Link) 111:Mode 7 (Test Mode)	001~111B
10	Reserved	—	W7B1~W8B0	—	—
11	Reserved	—	W9	—	—
12	CPU Reset Counter	Data	W10	Display in decimal	0~FFH
13	Receiver AGC voltage	Data	W11	8bits, Unsigned binary integers $(3.3/255) \times N(\text{Measured value}) \times 1.3 \text{ (V)}$	0~3.3V
14	RF forward power	Data	W12	8bits, Unsigned binary integers XW-2A: $1.71 \times N(\text{Measured value}) \text{ (mW)}$ XW-2B: $1.81 \times N(\text{Measured value}) \text{ (mW)}$ XW-2C: $1.71 \times N(\text{Measured value}) \text{ (mW)}$ XW-2D: $1.54 \times N(\text{Measured value}) \text{ (mW)}$	0~330mW
15	RF reflected power	Data	W13	8bits, Unsigned binary integers XW-2A: $1.71 \times N(\text{Measured value})/10 \text{ (mW)}$ XW-2B: $1.81 \times N(\text{Measured value})/10 \text{ (mW)}$ XW-2C: $1.71 \times N(\text{Measured value})/10 \text{ (mW)}$ XW-2D: $1.54 \times N(\text{Measured value})/10 \text{ (mW)}$	<33mW



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
16	Reserved	—	W14	—	—
17	Reserved	—	W15	—	—
18	Reserved	—	W16	—	—
19	Reserved	—	W17	—	—
20	Reserved	—	W18	—	—
21	Reserved	—	W19	—	—
22	Reserved	—	W20	—	—
23	Reserved	—	W21	—	—
24	Reserved	—	W22B7	—	—
25	Reserved	—	W22B6	—	—
26	Reserved	—	W22B5	—	—
27	Reserved	—	W22B4	—	—
28	Reserved	—	W22B3	—	—
29	CRC check result	Status	W22B2	1: Correct, 0: Error	0~1B
30	Reserved	—	W22B1B0	—	—
31	AX.25 frame receipted counter	Data	W23B7~B4	Display in decimal	0~FH
32	Instruction forwarding counter 1	Data	W23B3~B0	Display in decimal	0~FH
33	Instruction received counter 1	Data	W24B7~B4	Display in decimal	0~FH
34	Instruction execution counter 1	Data	W24B3~B0	Display in decimal	0~FH
35	Instruction received counter 2	Data	W25B7~B4	Display in decimal	0~FH
36	Instruction execution counter 2	Data	W25B3~B0	Display in decimal	0~FH
37	Downlink telemetry frame received counter	Data	W26B7~B4	Display in decimal	0~FH
38	Downlink telemetry frame transmitted counter	Data	W26B3~B0	Display in decimal	0~FH
39	Inter-satellite Instruction received counter	Data	W27B7~B4	Display in decimal	0~FH
40	Inter-satellite Instruction transmitted counter	Data	W27B3~B0	Display in decimal	0~FH
41	Instruction execution counter 3	Status	W28W29	16bits	0~65535
42	Write flash success flag	Status	W30B7	0: Succeed, 1: Failure	0~1B
43	Telemetry transmission rate flag	Status	W30B6	0: (19200bps), 1: (9600bps)	0~1B



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
44	Instruction execution counter 4	Data	W30B5	0: Succeed, 1: Failure	0~1B
45	Reset Count flash write enable flag	Status	W30B4	1: On, 0: Off	0~1B
46	Flash enable flag	Status	W30B3	1: On, 0: Off	0~1B
47	Power on operating mode	Status	W30B2~B0	001:Mode 1 (CW Beacon, Transmit Per 6 minutes) 010:Mode 2 (CW Beacon, Continuously) 011:Mode 3 (CW Beacon + Linear Transponder) 100:Mode 4 (CW Beacon + Telemetry) 101:Mode 5 (CW Beacon + Telemetry + Linear Transponder) 110:Mode 6 (Inter-satellite Link) 111:Mode 7 (Test Mode)	001~111B
48	I2C software watchdog switch flag	Status	W31B7	0: On, 1: Off	0-1B
49	I2C reconnecting initialized counter	Data	W31B6~B4	Display in decimal	0-7H
50	TC software watchdog switch flag	Status	W31B3	0: On, 1: Off	0-1B
51	TC software watchdog reset times counter	Data	W31B2~B0	Display in decimal	0-7H
52	ADC software watchdog switch flag	Status	W32B7	0: On, 1: Off	0-1B
53	ADC software watchdog reset times counter	Data	W32B6~B4	Display in decimal	0-7H
54	Temperature measurement software watchdog switch flag	Status	W32B3	0: On, 1: Off	0-1B
55	Temperature software watchdog reset times counter	Data	W32B2~B0	Display in decimal	0-7H
56	Inter-satellite software watchdog switch flag	Status	W33B7	0: On, 1: Off	0-1B
57	Inter-satellite software watchdog reset times counter	Data	W33B6~B4	Display in decimal	0-7H
58	SPI software watchdog switch flag	Status	W33B3	0: On, 1: Off	0-1B
59	SPI reconnecting initialized counter	Data	W33B2~B0	Display in decimal	0-7H
60	Reserved	—	W34B7	—	—
61	Inter-satellite link frequency	Data	W34B6~B4	001: Inter-satellite link frequency 1 010: Inter-satellite link frequency 2	001-110B



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
				011: Inter-satellite link frequency 3 100: Inter-satellite link frequency 4 101: Inter-satellite link frequency 5 110: Inter-satellite link frequency 6	
62	Flash successfully configured flag	Status	W34B3	0: Succeed, 1: Failure	0-1B
63	Telemetry data packet counter	Data	W34B2~B0	Display in decimal	0~7H
64	CPU analog acquisition watchdog switch flag	Status	W35B7	0: On, 1: Off	0-1B
65	CPU analog acquisition frequency counter watchdog reset	Data	W35B6~B4	Display in decimal	0-7H
66	PLL software watchdog switch flag	Status	W35B3	0: On, 1: Off	0-1B
67	PLL software watchdog reset times counter	Data	W35B2~B0	Display in decimal	0-7H
68	Satellite Number	Status	W36B7~B4	001: XW-2A 010: XW-2B 011: XW-2C 100: XW-2D	1-6
69	Software version number	Status	W36B3~B0	Display in decimal	0-15
70	Check flag	Status	W37B7	0: Correct, 1: Error	0-1B
71	Instruction identifies	Status	W37B6	0: Correct, 1: Error	0-1B
72	Reserved	—	W37B5~W39	—	—

2、XW-2E and 2F digital telemetry frames and equations

Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
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XW-2 Satellites Digital Telemetry Encoding Format

Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
1	Primary power supply voltage	Data	W0	8bits, Unsigned binary integers $6 \times (3.3/255) \times N(\text{Measured value})$ (V)	6V~8.6V
2	Primary power supply current	Data	W1	8bits, Unsigned binary integers $0.15 \times (3.3/255) \times N(\text{Measured value})$ (A)	0.2A~0.33A
3	DC / DC converter output voltage	Data	W2	8bits, Unsigned binary integers $1.6 \times (3.3/255) \times N(\text{Measured value})$ (V)	3.8V
4	DC / DC converter output current	Data	W3	8bits, Unsigned binary integers $0.2 \times (3.3/255) \times N(\text{Measured value})$ (A)	0.2A~0.6A
5	OBC power voltage	Data	W4	8bits, Unsigned binary integers $4 \times 2.4/256 \times N(\text{Measured value})$ (V)	3.3V
6	OBC temperature	Data	W5	8bits, Unsigned binary integers N-64 (°C)	-64 °C~125 °C
7	RF power amplifier temperature	Data	W6	8bits, Unsigned binary integers N-64 (°C)	-64 °C~125 °C
8	Battery discharge switch status	Status	W7B7	0: On, 1: Off	0~1B
9	Battery charge switch status	Status	W7B6	0: On, 1: Off	0~1B
10	Current operating mode	Status	W7B5~B2	0001:Mode 1 (CW Beacon, Transmit Per 6 minutes) 0010:Mode 2 (CW Beacon, Continuously) 0011:Mode 3 (CW Beacon + Linear Transponder) 0100:Mode 4 (CW Beacon + Telemetry) 0101:Mode 5 (CW Beacon + Telemetry + Linear Transponder) 0110:Mode 6 (Inter-satellite Link) 0111:Mode 7 (Test Mode) 1000: Mode 8 (Mode 5+2 Channels Heater) 1001: Mode 9 (Mode 5+4 Channels Heater)	001~111B
11	Battery charge and discharge current	Data	W7B1~W8B0	10bits, Lower 9 bits unsigned binary integers $(2.4/512 \times N(\text{Measured value}) - 1.5) / (0.025 \times 100)$ (A) Positive = discharge, negative = charge	-0.6~0.36A



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
				Absolute value is the current value	
12	Battery output voltage	Data	W9B7~W10B6	10bits, Unsigned binary integers $4.3 \times 2.4/512 \times N(\text{Measured value})$ (V)	0~10.4V
13	CRC check result	Status	W10B5	0: Correct, 1: Error	0~1B
14	Instruction identifies	Status	W10B4	0: Correct, 1: Error	0~1B
15	Autonomous operation switch	Status	W10B3	0: On, 1: Off	0~1B
16	Battery anomaly mode enable flag	状态	W10B2	1: On, 0: Off	0~1B
17	Reserved	—	W10B1~B0	—	—
18	Receiver AGC voltage	Data	W11	8bits, Unsigned binary integers $(3.3/255) \times N(\text{Measured value}) \times 1.3$ (V)	
19	RF forward power	Data	W12	8bits, Unsigned binary integers $1.58 \times N(\text{Measured value})$ (mW)	0~330mW
20	RF reflected power	Data	W13	8bits, Unsigned binary integers $1.58 \times N(\text{Measured value})/10$ (mW)	<33mW
21	Solar array output current	Data	W14	8bits, Unsigned binary integers $2.4/256 \times N(\text{Measured value})/(0.033 \times 100)$ (A)	0~0.72A
22	Battery pack temperature (Central)	Data	W15	8bits, Unsigned binary integers N(Higher 8 bits)-64 (°C)	-64 °C~125 °C
23	Battery pack temperature (edges)	Data	W16	8bits, Unsigned binary integers N(Higher 8 bits)-64 (°C)	-64 °C~125 °C
24	+X panel temperature	Data	W17	8bits, Unsigned binary integers N(Higher 8 bits)-64 (°C)	-64 °C~125 °C
25	+Y panel temperature	Data	W18	8bits, Unsigned binary integers N(Higher 8 bits)-64 (°C)	-64 °C~125 °C
26	-Y panel temperature	Data	W19	8bits, Unsigned binary integers N(Higher 8 bits) - 64 (°C)	-64 °C~125 °C



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
27	-Z panel temperature	Data	W20	8bits, Unsigned binary integers N(Higher 8 bits) - 64 (°C)	-64 °C~125 °C
28	Reserved		W21		
29	UHF antenna deployment status	Status	W22B7	0: no deploy, 1: deployed	0~1B
30	VHF antenna deployment status	Status	W22B6	0: no deploy, 1: deployed	0~1B
31	Antenna deployment master switch status	Status	W22B5	0: On, 1: Off	0~1B
32	UHF antenna deployment switch status	Status	W22B4	0: On, 1: Off	0~1B
33	VHF antenna deployment switch status	Status	W22B3	0: On, 1: Off	0~1B
34	CRC check result	Status	W22B2	1: Correct, 0: Error	0~1B
35	Reserved	—	W22B1B0	—	—
36	AX.25 frame receipted counter	Data	W23B7~B4	Display in hexadecimal	0~FH
37	Reserved	—	W23B3~B0	—	—
38	OC Instruction received counter	Data	W24B7~B4	Display in hexadecimal	0~FH
39	OC Instruction execution counter	Data	W24B3~B0	Display in hexadecimal	0~FH
40	Data instruction received counter	Data	W25B7~B4	Display in hexadecimal	0~FH
41	Data instruction execution counter	Data	W25B3~B0	Display in hexadecimal	0~FH
42	Reserved	—	W26B7~B4	—	—
43	Downlink telemetry frame transmitted counter	Data	W26B3~B0	Display in hexadecimal	0~FH
44	Inter-satellite Instruction received counter	Data	W27B7~B4	Display in hexadecimal	0~FH
45	Inter-satellite Instruction transmitted counter	Data	W27B3~B0	Display in hexadecimal	0~FH
46	Current index number	数据	W28W29	16bits	0~65535
47	Write flash success flag	Status	W30B7	0: Succeed, 1: Failure	0~1B
48	Antenna deployment enable flag	Status	W30B6	1: On, 0: Off	0~1B
49	State flag	Status	W30B5	1: On, 0: Off	0~1B
50	Reset Count flash write enable flag	Status	W30B4	1: On, 0: Off	0~1B
51	Data Authentication Status	Status	W30B3	1: Correct, 0: Error	0~1B
52	Power on operating mode	Status	W30B2~B0	001:Mode 1 (CW Beacon, Transmit Per 6 minutes) 010:Mode 2 (CW Beacon, Continuously) 011:Mode 3 (CW Beacon + Linear Transponder) 100:Mode 4 (CW Beacon + Telemetry)	001~111B



XW-2 Satellites Digital Telemetry Encoding Format

Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
				101:Mode 5 (CW Beacon + Telemetry + Linear Transponder) 110:Mode 6 (Inter-satellite Link) 111:Mode 7 (Test Mode)	
53	Reserved	—	W31B7~B4	—	—
54	TC software watchdog switch flag	Status	W31B3	0: On, 1: Off	0-1B
55	TC software watchdog reset times counter	Data	W31B2~B0	Display in hexadecimal	0-7H
56	ADC software watchdog switch flag	Status	W32B7	0: On, 1: Off	0-1B
57	ADC software watchdog reset times counter	Data	W32B6~B4	Display in hexadecimal	0-7H
58	Temperature measurement software watchdog switch flag	Status	W32B3	0: On, 1: Off	0-1B
59	Temperature software watchdog reset times counter	Data	W32B2~B0	Display in hexadecimal	0-7H
60	Inter-satellite software watchdog switch flag	Status	W33B7	0: On, 1: Off	0-1B
61	Inter-satellite software watchdog reset times counter	Data	W33B6~B4	Display in hexadecimal	0-7H
62	Reserved	—	W33B3~W34B7	—	—
63	Inter-satellite link frequency	Data	W34B6~B4	001: Inter-satellite link frequency 1 010: Inter-satellite link frequency 2 011: Inter-satellite link frequency 3 100: Inter-satellite link frequency 4 101: Inter-satellite link frequency 5 110: Inter-satellite link frequency 6	001-110B
64	Flash successfully configured flag	Status	W34B3	0: Succeed, 1: Failure	0-1B
65	Telemetry data packet counter	Data	W34B2~B0	Display in hexadecimal	0~7H
66	Battery reconnected enable state	Status	W35B7	1: On, 0: Off	0~1B
67	Battery reconnected counter	Data	W35B6~B3		0~FH
68	Reserved	—	W35B2~B0	—	—
69	Battery voltage threshold 1	Data	W36W37	$N(\text{Measured value})/100$	
70	Battery voltage threshold 2	Data	W38W39	$N(\text{Measured value})/100$	
71	Battery voltage threshold 3	Data	W40W41	16bits 数, $N(\text{Measured value})/100$	
72	Battery voltage threshold 4	Data	W42W43	$N(\text{Measured value})/100$	



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Channel	Name of Parameter	Type	Data Structure	Description and Equation	Data Range
73	Battery voltage threshold 5	Data	W44W45	$N(\text{Measured value})/100$	
74	Battery voltage threshold 6	Data	W46W47	$N(\text{Measured value})/100$	
75	Battery voltage threshold 7	Data	W48W49	$N(\text{Measured value})/100$	
76	Battery voltage threshold 8	Data	W50W51	$N(\text{Measured value})/100$	
77	Battery voltage threshold 9	Data	W52W53	$N(\text{Measured value})/100$	
78	Battery voltage threshold 10	Data	W54W55	$N(\text{Measured value})/100$	
79	Battery voltage threshold 11	Data	W56W57	$N(\text{Measured value})/100$	
80	Battery voltage threshold 12	Data	W58W59	$N(\text{Measured value})/100$	
81	Battery voltage threshold 13	Data	W60W61	$N(\text{Measured value})/100$	
82	Battery voltage threshold 14	Data	W62W63	$N(\text{Measured value})/100$	
83	Battery voltage threshold 15	Data	W64W65	$N(\text{Measured value})/100$	
84	CPU analog acquisition watchdog switch flag	Status	W66B7	0: On, 1: Off	0-1B
85	CPU analog acquisition frequency counter watchdog reset	Data	W66B6~B4	Display in hexadecimal	0-7H
86	PLL software watchdog switch flag	Status	W66B3	0: On, 1: Off	0-1B
87	PLL software watchdog reset times counter	Data	W66B2~B0	Display in hexadecimal	0-7H
88	Satellite Number	Status	W67B7~B4	001: XW-2A 010: XW-2B 011: XW-2C 100: XW-2D 101: XW-2E 110: XW-2F	1-6
89	Software version number	Status	W67B3~B0	Display in decimal	0-15
90	CPU Reset Counter	Data	W68	Display in hexadecimal	0~FFH
91	Reserved	—	W69	—	—