Earth's Low Orbital Environmental Observing Satellite

Ten-Koh

Downlink data decoding method
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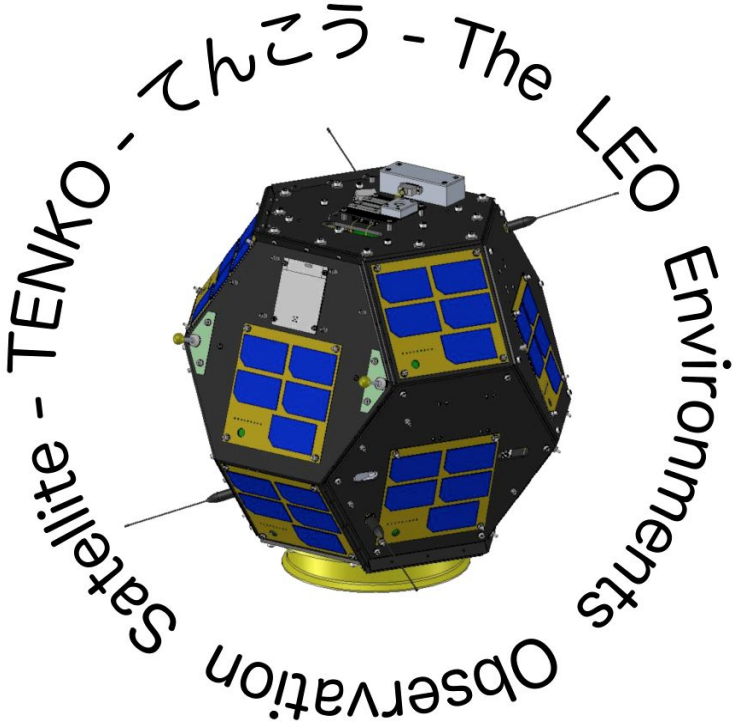

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Executive summary

This document explain the downlink data format of Ten-koh satellite for CW and FM mode. The document presents format data of housekeeping and mission data.

List of acronyms and abbreviations

ADS: Attitude Determination Subsystem.
CPD: Charged Particle Detector, one of Ten-Koh payloads.
COTS: Commercial off-the-shelf.
DLP: Double Langmuir Probe, one of Ten-Koh payloads.
ECU: Experiment Control Unit.
EPS - electrical power subsystem (of Tenkou)
GOSAT: Greenhouse gases Observing SATellite.
MM: Material mision, one of Ten-Koh payloads.

Content

CW housekeeping data decoding information

Downlink data of CW consist of satellite callsign and house keeping data in the following format:

JG6YKY: 26 bytes of housekeeping data

The 26 bytes contains the housekeeping measurements where each measurement consist of three bytes. This can be decoded according to table 1

Table-1 CW data format

Byte Number	**Data of CW**	**Example code**
1 - 3	Battery-1 current	934
4 - 6	Battery voltage	BEF
7 - 9	Battery-1 temperature	673
10 - 12	Battery-2 temperature	66E
13 -15	Battery-2 current	88B
16 - 18	Power line status	030
19 - 21	OBC-1 temperature	677
22 - 24	OBC-2 temperature	672
25	Current mission mode	N
26	TX identifier	1

The current mission mode is indicated by the following code:
n = Nominal mode
0 = ADS Mission mode
1 = DLP Mission mode with full ADS
2 = CPD/LIULIN Mission mode with full ADS
3 = DLP+CPD/LIULIN Mission mode with full ADS
4 = DLP Mission mode with partial ADS
5 = CPD/LIULIN Mission mode with partial ADS
6 = DLP+CPD/LIULIN Mission mode with partial ADS
7 = Material Mission mode

8 = Ultracapacitor Mission mode
9 = Thermal Mission mode
@ = DLP Mission mode without ADS
A = CPD/LIULIN Mission mode without ADS
B = DLP+CPD/LIULIN Mission mode without ADS

FM Power system telemetry decoding information

FM telemetry data format consists of three kind of packets: Clock, solar panels and power system voltages

Clock packet has Ten-koh time in JST according to the following format

Table-2 FM telemetry Clok packet data format

Byte	**Data in HEX**	**Example**
0	Seconds	0F
1	Minutes	10
2	Hour	0D
3	Day	01
4	Month	0C
5	Year	12

Solar panel packet has 53 bytes. The packet indicate the time of measurement and four measurements for each solar panels (Current of first array, voltage of first array, current of second array and Temperature). In one packet 6 solar panels measurement are included; thus, two packets are required to receive the 12 solar panels. The group of solar panels are indicated by the first to bytes ID.

Table-3 FM data format of solar panel telemetry

Byte	**Data**	**Example**
0-1	ID to indicate Group of SP	‘2101’ to SP1 to SP6 o ‘3100’ to SP7 to SP12
2	Sec	00

3	Min	32
4	Hour	0C
5-6	SP1 current (or SP7 current)	079D
7-8	SP1 voltage (or SP7 voltage)	04CF
9-10	SP1 current (or SP7 current)	0002
11-12	SP1 temp (or SP7 temp)	061B
...	SP... current	...
...	SP… voltage	...
...	SP... current	...
...	SP Temperature	...
46-47	SP6 current (or SP current)	079D
48-49	SP6 voltage (or SP voltage)	04CF
50-51	SP6 current (or SP current)	0002
52-53	SP6 temp (or SP temp)	061B

The third packet indicates power system voltages as indicated in the following table

Table-4 FM data format of power system telemetry

Byte number	**Data**
0-1	OBC voltage
2-3	COM1 voltage
4-5	COM2 voltage
6-7	UCP voltage
8-9	OBC current
10-11	COM1 current
12-13	COM2 current
14-15	UCP current

16-17	ADS line voltage
18-19	PL current
20-21	PL voltage
22-23	CPD voltage
24-25	ADS current
26-27	DLP current
28-29	DLP voltage
30-31	CPD current
32-33	Bat1 current
34-35	Bat voltage
36-37	Bat1 temp
38-39	Bat2 temp
40-41	Bat2 current
42-43	Bat voltage
44-45	Control Byte
46-47	OBC Temp1
48-49	OBC Temp2
49-50	Reset counter

FM Material mission decoding information

Material Mission information is composed of 2 kind of packets: 'Sign' and 'Mission Data'.
'Sign' packet is to indicate that transmitted data after this packet will be Material mission, its format is the following: "75 40 1E 01". After received the 'Sign' packet, Material Mission data can be received.

'Materil Mission Data' packet is composed of a total of 60 bytes (from 0 to 59 array) like indicated in Table-5.

Table-5 Mission Data Format

Byte Number	Data
0	Active information. Should be '55'.
1 ~ 2	Temperature Sensor_1.
3 ~ 5	Strain Gauge_1.
6 ~ 8	Reference Voltage for Strain Gauge_1.
9 ~ 11	Strain Gauge_2.
12 ~ 14	Reference Voltage for Strain Gauge_2.
15 ~ 16	Temperature Sensor_1.
17 ~ 18	Temperature Sensor_2.
19 ~ 21	Strain Gauge_3.
22 ~ 24	Reference Voltage for Strain Gauge_3.
25 ~ 27	Strain Gauge_4.
28 ~ 30	Reference Voltage for Strain Gauge_4.
31 ~ 32	Temperature Sensor_2.
33 ~ 34	Temperature Sensor_3
35 ~ 37	Strain Gauge_5.
38 ~ 40	Reference Voltage for Strain Gauge_5.
41 ~ 43	Strain Gauge_6.
44 ~ 46	Reference Voltage for Strain Gauge_6.
47 ~ 48	Temperature Sensor_3
49 ~ 50	Reference Voltage for all temperature sensor.
51	Check Sum Data.

52 ~ 59	No data. Should be '00'.

FM ADS decoding information

FM downlink data follows the format on Table-6

Table-6 ADS Mission Data Format

Byte Number	**Data**
0	Cmd1
1	Cmd2
2	Sec
3	Min
4	Hour
5	Day
6	Month
7	Year
8-9	SSN1
10-11	SSN2
12-13	SSN3
14-15	SSN4
16-17	SSN5
18-19	SSN6
20-21	SSN7
22-23	SSN8
24-25	SSN9
26-27	SSN10
28-29	SSN11
30-31	SSN12
32-33	Gyro1_x
34-35	Gyro1_y
36-37	Gyro1_z

38	Gyro1_temp
39-40	Gyro2_x
41-42	Gyro2_y
43-44	Gyro2_z
45	Gyro2_temp
46-47	Gyro3_x
48-49	Gyro3_y
50-51	Gyro3_z
52	Gyro3_temp
53-54	MAG_x
55-56	MAG_y
57-58	MAG_z
59-60	MAG_ref1
61-62	MAG_ref2
63	Status

FM CPD Mission data decoding information

The Charged Particle Detector (CPD) telemetry format consist of 2 types of data packets:

- CPD-CMOS data packets.
- CPD-Liulin data packets.

Both sensor data packets are also divided into 2 sets of telemetry data packets depending on the ECU operating mode: *payload mode* or *real time mode*. The telemetry data format for both modes are presented below.

CPD payload mode telemetry format: CMOS

When operating in payload mode, and in the case of the CMOS sensors data, the CPD telemetry data format consist of and arrange of the following data packets:

- Command sequence received data packet, which contains the configuration parameters of 26 bytes + 2 additional bytes defining the mission number (MSB and LSB). The

starting time of the data readings from CPD are included in the position of the RTC time bytes.

- Identifier of mission data packets formed by 5 bytes: *'C', 'P', 'D', MSB of mission number, LSB of mission number*;
- Final data packet composed by 9 bytes of data: *'C', 'P', 'D', '-', 'E', 'N', 'D', MSB of mission number, LSB of mission number*.

The rest of the CPD data, depending on the sensor selected, is arranged in data packets of:

- 31 packets of 64 bytes each for the CMOS sensors, plus 2 bytes of the mission number (MSB and LSB) and 1 byte referring to the data packet number.
- The data packet number 32 is formed by 16 bytes of CMOS data + 2 bytes of the mission number (MSB and LSB) and 1 byte referring to the data packet number.

For CPD-CMOS operation, the full CPD telemetry data packet for a payload mode session is shown in the figure 1.

CPD data pkt	Byte 1	Byte 2	···	Byte 27	Byte 28
Received cmd	CMD	SUP	···	MSB of miss #	LSB of miss #

CPD data packet	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Initial data packet	0x43 ('C')	0x50 ('P')	0x44 ('D')	MSB of mission number	LSB of mission number

CPD data packet	Byte 1	Byte 2	···	Byte 64	Byte 65	Byte 66	Byte 67
1	CMOS data byte 1	CMOS data byte 2	···	CMOS data byte 64	MSB of mission number	LSB of mission number	Byte of packet number

⋮

CPD data packet	Byte 1	Byte 2	···	Byte 16	Byte 17	Byte 18	Byte 19
32	CMOS data byte 1	CMOS data byte 2	···	CMOS data byte 16	MSB of mission number	LSB of mission number	Byte of packet number

Data pkt	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Last data packet	0x43 ('C')	0x50 ('P')	0x44 ('D')	0x2D ('-')	0x45 ('E')	0x4E ('N')	0x44 ('D')	MSB of mission number	LSB of mission number

Figure 1. Payload telemetry format with additional data bytes for CMOS. Only packet number 32 is shorter that the previous ones (16 bytes of CMOS data).

The CMOS sensor data order of bytes is the same as being read from CPD SPI bus as described below:

CMOS 64-byte size data packets:
Byte 1: status byte, Byte 2: sensor designation (0 to 7), Byte 3: current threshold, Byte 4: data byte, Byte 5: status byte, Byte 6: sensor designation (0 to 7), Byte 7:current threshold, Byte 8: data byte, ..., Byte 61: status byte, Byte 62: sensor designation (0 to 7), Byte 63: current threshold, Byte 64: data byte, Byte 65: MSB of mission number, Byte 66: LSB of mission number, Byte 67: packet number.

CMOS 16-byte size data packets:

Byte 1: status byte, Byte 2: sensor designation (0 to 7), Byte 3: current threshold, Byte 4: data byte, Byte 5: status byte, Byte 6: sensor designation (0 to 7), Byte 7:current threshold, Byte 8: data byte, ..., Byte 13: status byte, Byte 14: sensor designation (0 to 7), Byte 15: current threshold, Byte 16: data byte, Byte 17: MSB of mission number, Byte 18: LSB of mission number, Byte 19: packet number.

Finally, in order to have the full 2000 bytes (4 byte x 500) of data from CPD-CMOS full FIFO, the flow of bytes must be interpreted in the following way:

1. From data packet 1 to data packet 31, concatenate in sequence from byte 1 to byte 64 (remove the last 3 bytes of mission data and packet number.
2. Then concatenate with the last 16 bytes of data packet 32, starting from byte 1 to byte 16. Again, remove the last 3 bytes of mission data and packet number.

CPD payload mode telemetry format: Liulin

For the Liulin case, the data is arranged in 9 data packets. The 8 first packets contain 64 bytes + 3 extra bytes of data, while the 9th one contains 16 bytes + 4 extra bytes:

- The first 8 packets of 64 bytes each for the Liulin sensor, plus 2 bytes of the mission number (MSB and LSB) and 1 byte copy of the first byte of data from Liulin (reply[1] from the I2C reply buffer).
- The ninth data packet contains 16 bytes of Liulin data, plus 2 bytes of the mission number (MSB and LSB), 1 byte that is a copy of the first byte of data from Liulin (reply[1]

from the I2C reply buffer), and, in its last byte position, the data packet number, as in the case of CMOS sensors and DLP payload mode.

Figure 2 shows the full CPD-Liulin data packet for a payload mode of operation:

CPD data pkt	Byte 1	Byte 2	···	Byte 27	Byte 28
Received cmd	CMD	SUP	···	MSB of miss #	LSB of miss #

CPD data packet	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Initial data packet	0x43 ('C')	0x50 ('P')	0x44 ('D')	MSB of mission number	LSB of mission number

CPD data packet	Byte 1	Byte 2	...	Byte 64	Byte 65	Byte 66	Byte 67
1	Liulin data byte 1	Liulin data byte 2	···	Liulin data byte 64	MSB of mission number	LSB of mission number	Copy of Liulin byte 1

⋮

CPD data packet	Byte 1	Byte 2	...	Byte 16	Byte 17	Byte 18	Byte 19
9	Liulin data byte 1	Liulin data byte 2	···	MSB of mission number	LSB of mission number	Copy of Liulin byte 1	Byte of packet number

Data pkt	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Last data packet	0x4C ('L')	0x49 ('I')	0x55 ('U')	0x2D ('-')	0x45 ('E')	0x4E ('N')	0x44 ('D')	MSB of mission number	LSB of mission number

Figure 2. Payload telemetry format with additional data bytes for Liulin sensor. Only packet number 9 is shorter that the previous ones (16 bytes of Liulin data).

The 528 bytes of the Liulin sensor are contained all in 8 data packets of 64 bytes each and 1 data packet of 16 bytes (packets 1 to 9 in figure 6). This 528 bytes are sent by the ECU to OBC, and then to the ground station.

In order to have the 528 bytes in the correct order for post processing, the flow of bytes must be interpreted in the following way:

1. From data packets 1 to 8, concatenate all bytes removing the last 3 bytes (start from byte 1 until byte 64).
2. Continue to concatenate with data packet 9, from byte 1 to byte 16.

After following this process, an array of 528 bytes is formed resulting in a single spectrum data with the meaning of table 3:

Table 3. Liulin Spectrum interpretation

BYTE number	**Interpretation of every byte from Liulin spectrum**
Header	**Meaning**
Byte 1	“L”
Byte 2	“i”
Byte 3	“u”
Byte 4	“-”
Byte 5	“T”
Byte 6	“K”
Byte 7	“ “ (space)
Byte 8	“M” (Code of issued command)
Byte 9	LSB of BlockCounter
Byte 10	Block Counter
Byte 11	Block Counter
Byte 12	MSB of Block Counter
Channels data	
Byte 13	LSB of channel 1

Byte 14	MSB of channel1
Byte 15	LSB of channel 2
Byte 16	MSB of channel 2
...	...
Byte 523	LSB of channel 256
Byte 524	MSB of channel 256
Health data	
Byte 525	0x00 0–validdata; else – not valid data (code of possible error)
Byte 526	LSB of Timerticks
Byte 527	MSB of Timer ticks
Byte 528	Timer Overflow counts

The data bytes should be read starting from byte 13 until byte 524 by every 2 bytes, to form 256 individual channels. Then, the dose rate and Flux can be computed in the following way:

Real Exposition Time = Timer overflow counts * 8.388608 s. + Timer ticks * 0.000128 s.

```
/* Calculate Dose & Flux */

#defineKtotdose      9.3255431866952789699570815450644e-5
#defineKdose         0.335719554721030042918454935622 32

        DoseI=0; FluxI=0;

        for( i=0;i<256;i++)                          /* Cycle to read spectrum*/
        {
        if(i)DoseI=DoseI+  i*RadCh[i];
        else
        DoseI=DoseI+(RadCh[i]/2);
          FluxI = FluxI + RadCh[i];
        }

       FLUX=((float)FluxI)/2.0/Exposition; /* Flux in part/cm2.sec*/
```

```
DOSE = (float)DoseI * Kdose/Exposition;/* Dose in uGy/h */
TotDose += (float)DoseI *Ktotdose;    /*Total Dose in uGy*/
```

CPD real time mode telemetry format: CMOS

In the real time mode, the telemetry format used for the CPD-CMOS data has a similar arrange to when is downloaded from the satellite during payload mode, with the following differences:

- It has no received command containing the RTC time data.
- It has no identifier of mission data packets.
- It has no last data packet.

When removing those CPD data packets, the telemetry received during a real time session has the form shown in figure 3.

CPD data packet	Byte 1	Byte 2	...	Byte 64	Byte 65	Byte 66	Byte 67
1	CMOS data byte 1	CMOS data byte 2	...	CMOS data byte 64	MSB of mission number	LSB of mission number	Byte of packet number
⋮							
CPD data packet	Byte 1	Byte 2	...	Byte 16	Byte 17	Byte 18	Byte 19
32	CMOS data byte 1	CMOS data byte 2	...	CMOS data byte 16	MSB of mission number	LSB of mission number	Byte of packet number

Figure 3. ECU's CPD-CMOS telemetry data packets for a real operation mode of Ten-Koh satellite.

The way to arrange by concatenating the received data is the same as explained in the payload mode.

CPD real time mode telemetry format: Liulin

In the real time mode, the telemetry format used for the CPD-Liulin data has a similar arrange to when is downloaded from the satellite during payload mode, with the following differences:

- It has no received command containing the RTC time data.
- It has no identifier of mission data packets.
- It has no last data packet.

When removing those CPD-Liulin data packets, the telemetry received during a real time session has the form shown in figure 4.

CPD data packet	Byte 1	Byte 2	...	Byte 64	Byte 65	Byte 66	Byte 67
1	Liulin data byte 1	Liulin data byte 2	...	Liulin data byte 64	MSB of mission number	LSB of mission number	Copy of Liulin byte 1
⋮							
CPD data packet	Byte 1	Byte 2	...	Byte 16	Byte 17	Byte 18	Byte 19
9	Liulin data byte 1	Liulin data byte 2	...	MSB of mission number	LSB of mission number	Copy of Liulin byte 1	Byte of packet number

Figure 4. ECU's CPD-Liulin telemetry data packets for a real operation mode of Ten-Koh satellite.

In order to arrange the 528 bytes of data received during real time mode, the way to concatenate the data bytes is the same as explained in the payload mode of operation.

FM DLP mission data decoding information

The DLP format for the telemetry data consist of a basic format integrated in 2 ways, depending on the ECU mode of operation. Each telemetry format corresponding to each mode is described below.

DLP payload mode telemetry format

The DLP telemetry format used during the payload mode of operation contains data packets arranged in groups of 60 bytes and 48 bytes, plus 3 extra bytes used for the mission number (2 bytes) and one byte for packet number identification. In addition to the 3 bytes included at the end of each data packet, there are 3 more data packets containing information of DLP payload:

- The first one corresponds to the received command sequence that executes DLP payload measurements and the configuration of the DLP and/or CPD (in case the CPD+DLP mode was selected). This command sequence includes the RTC time when the missions starts sampling data, and must be taken into account during the post data processing in order to know the measured current channel(s) selected and other parameters. Besides the command received to execute payload measurements, in the

last position of this data packet there are 2 bytes corresponding to the mission number (MSB and LSB);

- The second one corresponds to the identifier of mission data packet composed of 5 bytes: *'D', 'L', 'P', MSB of mission number, LSB of mission number*;
- The last data packet composed of 9 bytes to mark the end of the DLP data: *'D', 'L', 'P', '-', 'E', 'N', 'D', MSB of mission number, LSB of mission number*.

The DLP telemetry data packet for a payload mode session is shown in the following figure.

DLP data pack	Byte 1	Byte 2	···	Byte 27	Byte 28
Received cmd	CMD	SUP	···	MSB of miss #	LSB of miss #

DLP data packet	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Initial data packet	0x44 ('D')	0x4C ('L')	0x50 ('P')	MSB of mission number	LSB of mission number

DLP data packet	Byte 1	Byte 2	···	Byte 60	Byte 61	Byte 62	Byte 63
1	DLP data byte 1	DLP data byte 2	···	DLP data byte 60	MSB of mission number	LSB of mission number	Byte of packet number

⋮

DLP data packet	Byte 1	Byte 2	···	Byte 60	Byte 61	Byte 62	Byte 63
n	DLP data byte 1	DLP data byte 2	···	DLP data byte 60	MSB of mission number	LSB of mission number	Byte of packet number

	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Last data packet	0x44 ('D')	0x4C ('L')	0x50 ('P')	0x2D ('-')	0x45 ('E')	0x4E ('N')	0x44 ('D')	MSB of mission number	LSB of mission number

Figure 5. ECU's DLP telemetry data packets for a payload operation mode of Ten-Koh satellite with 60 bytes of I-V data per packet.

From the figure 5 the "n" marked in red indicates the number of DLP data packets between the initial and last data packet, which depends on the DLP resolution that was selected. Its possible values are:

- n = 10, for the DLP low resolution case: 600 bytes divided into 10 data packets of 60 bytes each.

- n = 25, for the DLP medium resolution case: 1500 bytes of data divided into 25 data packets of 60 bytes each.**
- n = 50, for the DLP high resolution case: 3000 bytes of data divided into 50 data packets of 60 bytes each.

**In the case of the medium resolution, due to the ECU's non exact computing of the DLP data packet division, the last DLP data packet can be of length 48 (51 considering the extra 3 bytes) instead of 63, as represented in figure 6.

DLP data pack	Byte 1	Byte 2	···	Byte 27	Byte 28
Received cmd	CMD	SUP	···	MSB of miss #	LSB of miss #

DLP data packet	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
Initial data packet	0x44 ('D')	0x4C ('L')	0x50 ('P')	MSB of mission number	LSB of mission number

DLP data packet	Byte 1	Byte 2	···	Byte 60	Byte 61	Byte 62	Byte 63
1	DLP data byte 1	DLP data byte 2	···	DLP data byte 60	MSB of mission number	LSB of mission number	Byte of packet number

⋮

DLP data packet	Byte 1	Byte 2	···	Byte 48	Byte 49	Byte 50	Byte 51
n	DLP data byte 1	DLP data byte 2	···	DLP data byte 48	MSB of mission number	LSB of mission number	Byte of packet number

	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9
Last data packet	0x44 ('D')	0x4C ('L')	0x50 ('P')	0x2D ('-')	0x45 ('E')	0x4E ('N')	0x44 ('D')	MSB of mission number	LSB of mission number

Figure 6. ECU's DLP telemetry data packets for a payload operation mode of Ten-Koh satellite with 48 bytes of I-V data for the last packet.

DLP post-processing data needs to take into account not only the explained data format but also the downlink data that possibly includes the AX25 and other headers before and/or after the DLP data packets, depending on the receiving station configuration.

To read the voltage and current from the DLP received raw data, the following process must be applied:

1. Concatenate all the received packets, starting from packet 1 until packet **n**, and from byte 1 to byte 600, 1500 or 3000, depending on the resolution of the received data.
2. Once a full array of 600, 1500 or 3000 bytes is formed, create a subarray by dividing the previous formed array every 12 bytes making sure a new row is created after 12 bytes have been read.
3. A final array of 12x50, 12x125 or 12x250 will have the full information from the I-V curve of the measured data. From left to right, this array contains the voltage and current as described in table 4.

Table 4. DLP data interpretation from received raw data after the i-V array is formed.

Row number	Bytes from each row	Meaning
1	[1-2][3-4][5-6][7-8][9-10][11-12]	1-2: Reference voltage 3-4: Measured voltage 5-6: Current channel 1A 7-8: Current channel 2A 9-10: Current channel 1B 11-12: Current channel 2B
2	[1-2][3-4][5-6][7-8][9-10][11-12]	1-2: Reference voltage 3-4: Measured voltage 5-6: Current channel 1A 7-8: Current channel 2A 9-10: Current channel 1B 11-12: Current channel 2B
3	[1-2][3-4][5-6][7-8][9-10][11-12]	1-2: Reference voltage 3-4: Measured voltage 5-6: Current channel 1A 7-8: Current channel 2A 9-10: Current channel 1B 11-12: Current channel 2B
...	...	...
50/125/250	[1-2][3-4][5-6][7-8][9-10][11-12]	1-2: Reference voltage 3-4: Measured voltage 5-6: Current channel 1A 7-8: Current channel 2A

		9-10: Current channel 1B 11-12: Current channel 2B

Finally, each value of the reference voltage, measured voltage, current channel 1A, current channel 2A, current channel 1B and current channel 2B should be converted into a decimal value of the measured voltage from the ADC (analog to digital converter) by making the following conversion:

Reference voltage [V] = (5/4095)*decimal_value_of([1-2])
Measured voltage [V] = (5/4095)*decimal_value_of([3-4])
Current channel 1A [V] = (5/4095)*decimal_value_of([5-6])
Current channel 2A [V] = (5/4095)*decimal_value_of([7-8])
Current channel 1B [V] = (5/4095)*decimal_value_of([9-10])
Current channel 2B [V] = (5/4095)*decimal_value_of([11-12])

These values in voltage correspond to only the non calibrated measured data. In order to compute the final I-V product, a set of special equations and calibration data must be used. Contact Okuyama lab and Ten-Koh team staff for this purpose.

DLP real time mode telemetry format

In the real time mode, the telemetry format used for the DLP data has a similar arrange to when is downloaded from the satellite after executing the payload mode, with the following differences:

- It has no received command containing the RTC time data.
- It has no identifier of mission data packets.
- It has no last data packet.

When removing those DLP data packets, the telemetry received during a real time session has the form shown in figure 7.

DLP data packet	Byte 1	Byte 2	...	Byte 60	Byte 61	Byte 62	Byte 63
1	DLP data byte 1	DLP data byte 2	...	DLP data byte 60	MSB of mission number	LSB of mission number	Byte of packet number
⋮							
DLP data packet	Byte 1	Byte 2	...	Byte 60	Byte 61	Byte 62	Byte 63
n	DLP data byte 1	DLP data byte 2	...	DLP data byte 60	MSB of mission number	LSB of mission number	Byte of packet number

(a)

DLP data packet	Byte 1	Byte 2	...	Byte 60	Byte 61	Byte 62	Byte 63
1	DLP data byte 1	DLP data byte 2	...	DLP data byte 60	MSB of mission number	LSB of mission number	Byte of packet number
⋮							
DLP data packet	Byte 1	Byte 2	...	Byte 48	Byte 49	Byte 50	Byte 51
n	DLP data byte 1	DLP data byte 2	...	DLP data byte 48	MSB of mission number	LSB of mission number	Byte of packet number

(b)

Figure 7. ECU's DLP telemetry data packets for a real operation mode of Ten-Koh satellite: (a) the case of all data packet with 60 byte of I-V data per packet and (b) the case of the last packet containing 48 bytes of I-V data.

In the same way as with the telemetry data of the payload mode, for the real time mode the DLP post-processing data needs to take into account not only the explained data format but also the downlink data that possibly includes the AX25 and other headers before and/or after the DLP data packets.

NOTE: The process for computing the voltage valued from the raw data is the same as explained for the DLP payload mode.

Additional Information