FM Packet Telemetry Format

For CubeSat “SEEDS”

English Version

Nihon University CubeSat Project

Revision	Date	Authored by	Notes
1	06/22/2006	Nobuaki Kinoshita	FM Packet Telemetry Format
2	01/09/2008	Kosuke Arita	Revised for 2nd SEEDS
3	21/04/2008	Kosuke Arita	Considered calibration result of sensors Revised some mistakes

FM packet telemetry format for SEEDS

SEEDS has three type of FM packet telemetry format.

1. Test FM (Transmit the data with FM packet just after sensing.)
2. FM Downlink (Transmit the data that is read form EEPROM with FM packet. The data in EEPROM was stored previous mission.)
3. Any Characters Downlink (Transmit any letters up to 16 characters by uplink command)

Please get FM packet in hex number and remove “4A 51 31 59 47 55 3E 4A 51 31 59 47 56 3A” part that is converted “JQ1YGU>JQ1YGV:” into hex number. Following format is not included “4A 51 31 59 47 55 3E 4A 51 31 59 47 56 3A” part.

FM packet telemetry format:

11 22 33 33 44 44 44 44 55 55 66 66 77 77 88 88 99 AA BB BB CC CC DD DD EE EE FF FF GG GG HH HH II II JJ JJ KK KK LL LL MM MM NN NN OO OO PP PP QQ QQ TT TT UU UU VV VV WW WW XX XX YY YY ZZ ZZ aa aa bb bb cc cc dd dd

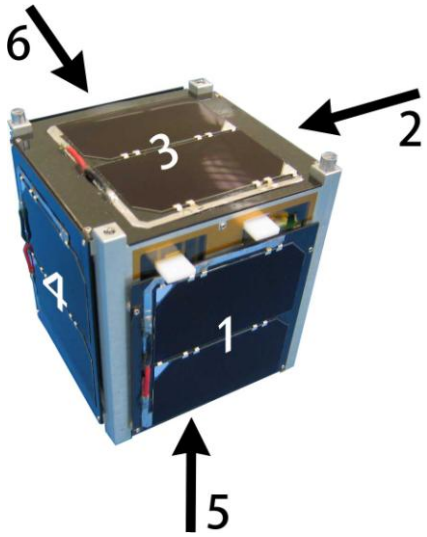
FM Packet (Test FM or FM Downlink)			
Data	**Digit Number**	**Designation**	**Conversion Equation**
$1_1 1_0$	2	**(Test FM) not in use (FM Downlink) Types of transmitted data and EEPROM number that SEEDS read**	First, convert binary digit into hex number. For Example, $(F8)_{16}$ ==> $(1_4 1_3 1_2 1_1 1_0 0_2 0_1 0_0)_2$. Next, check the status according to following criteria. 1_4 System status* (0 or 1) 1_3 Internal temperature* (0 or 1) 1_2 Gyro sensor and geomagnetism sensor* (0 or 1) 1_1 The current from solar cell* (0 or 1) 1_0 External temperature* (0 or 1) 0_2 0_1 TBD 0_0 the number of ROM that SEEDS read (0 or 1) [* 0: N/A (“0” is filled in the data block)] [* 1: The sensor data is stored]
$2_1 2_0$	2	**(Test FM) not in use (FM Downlink) Page address, that SEEDS read, in EEPROM**	First, convert binary digit into hex number. Next, use only least significant bit. The value means page address which SEEDS read. For Example, $(88)_{16}$ ==> $(1_4 0_3 0_2 0_1 1_0 0_2 0_1 0_0)_2$. Because the value of 0_0 is zero, page address in EEPROM is 0.
$3_3 3_2 3_1 3_0$	4	**(Test FM) not in use (FM Downlink) ROM address, that SEEDS read, in EEPROM**	This part represents ROM address which SEEDS read. The scope of data is between 0000 and FFFF.
$4_7 4_6 4_5 4_4 4_3 4_2 4_1 4_0$	8	**Satellite time**	$(4_7 \times 16^7 + 4_6 \times 16^6 + 4_5 \times 16^5 + 4_4 \times 16^4 + 4_3 \times 16^3 + 4_2 \times 16^2 + 4_1 \times 16^1 + 4_0 \times 16^0) / 2$ [s]
$5_3 5_2 5_1 5_0$	4	**MPU reset times (EPS)**	$5_3 \times 16^3 + 5_2 \times 16^2 + 5_1 \times 16^1 + 5_0 \times 16^0$ [times]
$6_3 6_2 6_1 6_0$	4	**MPU reset times (FMR)**	$6_3 \times 16^3 + 6_2 \times 16^2 + 6_1 \times 16^1 + 6_0 \times 16^0$ [times]
$7_3 7_2 7_1 7_0$	4	**MPU reset times (C&DH)**	$7_3 \times 16^3 + 7_2 \times 16^2 + 7_1 \times 16^1 + 7_0 \times 16^0$ [times]

Data	Digit Number	Designation	Conversion Equation
$8_3 8_2 8_1 8_0$	4	**MPU reset times (CW)**	$8_3 \times 16^3 + 8_2 \times 16^2 + 8_1 \times 16^1 + 8_0 \times 16^0$ [times]
$9_1 9_0$	2	**ROM number that SEEDS stored at last time**	First, convert binary digit into hex number. Next, use only least significant bit.
$A_1 A_0$	2	**Page address that SEEDS stored at last time**	First, convert binary digit into hex number. Next, use only least significant bit.
$B_3 B_2 B_1 B_0$	2	**ROM address that SEEDS stored at last time**	This part represents ROM address which SEEDS read. The scope of data is between 0000 and FFFF.
$C_3 C_2 C_1 C_0$	4	**Temperature (The top of solar cell 1)**	$-0.18936\times(5\times(C_2\times16^2+C_1\times16^1+C_0\times16^0)/4096)^2$ $-37.767\times(5\times(C_2\times16^2+C_1\times16^1+C_0\times16^0)/4096)$ $+125.76$ [deg. C]
$D_3 D_2 D_1 D_0$	4	**Temperature (The top of solar cell 2)**	$-0.008324\times(5\times(D_2\times16^2+D_1\times16^1+D_0\times16^0)/4096)^2$ $-39.376\times(5\times(D_2\times16^2+D_1\times16^1+D_0\times16^0)/4096)$ $+128.75$ [deg. C]
$E_3 E_2 E_1 E_0$	4	**Temperature (The top of solar cell 3)**	$-0.16644\times(5\times(E_2\times16^2+E_1\times16^1+E_0\times16^0)/4096)^2$ $-38.12\times(5\times(E_2\times16^2+E_1\times16^1+E_0\times16^0)/4096)$ $+127.38$ [deg. C]
$F_3 F_2 F_1 F_0$	4	**Temperature (The top of solar cell 4)**	$-0.19416\times(5\times(F_2\times16^2+F_1\times16^1+F_0\times16^0)/4096)^2$ $-37.757\times(5\times(F_2\times16^2+F_1\times16^1+F_0\times16^0)/4096)$ $+126.93$ [deg. C]
$G_3 G_2 G_1 G_0$	4	**Temperature (The top of solar cell 5)**	$-0.19718\times(5\times(G_2\times16^2+G_1\times16^1+G_0\times16^0)/4096)^2$ $-37.966\times(5\times(G_2\times16^2+G_1\times16^1+G_0\times16^0)/4096)$ $+125.64$ [deg. C]
$H_3 H_2 H_1 H_0$	4	**Temperature (The top of solar cell 6)**	$-0.44743\times(5\times(H_2\times16^2+H_1\times16^1+H_0\times16^0)/4096)^2$ $-35.879\times(5\times(G_2\times16^2+H_1\times16^1+H_0\times16^0)/4096)$ $+123.57$ [deg. C]
$I_3 I_2 I_1 I_0$	4	**Solar cell 1 current**	$5\times(I_2\times16^2+I_1\times16^1+I_0\times16^0)$ /4096×90.90909 [mA]
$J_3 J_2 J_1 J_0$	4	**Solar cell 2 current**	$5\times(J_2\times16^2+J_1\times16^1+J_0\times16^0)$ /4096×90.90909 [mA]
$K_3 K_2 K_1 K_0$	4	**Solar cell 3 current**	$5\times(K_2\times16^2+K_1\times16^1+K_0\times16^0)$ /4096×90.90909 [mA]
$L_0 L_2 L_1 L_0$	4	**Solar cell 4 current**	$5\times(L_2\times16^2+L_1\times16^1+L_0\times16^0)$ /4096×90.90909 [mA]
$M_0 M_2 M_1 M_0$	4	**Solar cell 5 current**	$5\times(M_2\times16^2+M_1\times16^1+M_0\times16^0)$ /4096×90.90909 [mA]
$N_0 N_2 N_1 N_0$	4	**Solar cell 6 current**	$5\times(N_2\times16^2+N_1\times16^1+N_0\times16^0)$ /4096×90.90909 [mA]
$O_3 O_2 O_1 O_0$	4	**Li-ion batteries voltage**	$5\times(O_2\times16^2+O_1\times16^1+O_0\times16^0)/4096$ [V]
$P_3 P_2 P_1 P_0$	4	**Bus voltage**	$5\times(P_2\times16^2+P_1\times16^1+P_0\times16^0)$ /4096 [V]
$Q_3 Q_2 Q_1 Q_0$	4	**Gyro sensor (x axis)**	$-0.0011537\times(5\times(Q_2\times16^2+Q_1\times16^1+Q_0\times16^0)$ /4096)^2 $+0.88832\times(5\times(Q_2\times16^2+Q_1\times b16^1+Q_0\times16^0)$ /4096) -2.2173 [rad/s]
$R_3 R_2 R_1 R_0$	4	**Gyro sensor (y axis)**	$9.7079\times10^{-5}\times(5\times(R_2\times16^2+R_1\times16^1+R_0\times16^0)$ /4096)^2 $+0.88422\times(5\times(R_2\times16^2+R_1\times16^1+R_0\times16^0)$ /4096) -2.2133 [rad/s]
$S_3 S_2 S_1 S_0$	4	**Gyro sensor (z axis)**	$-0.0018095\times(5\times(S_2\times16^2+S_1\times16^1+S_0\times16^0)$ /4096)^2 $+0.88805\times(5\times(S_2\times16^2+S_1\times16^1+S_0\times16^0)$ /4096) -2.2032 [rad/s]
$T_3 T_2 T_1 T_0$	4	**Geomagnetic sensor (x axis)**	$5\times(T_2\times16^2+T_1\times16^1+T_0\times16^0)/4096-2.5$ [gauss]
$U_3 U_2 U_1 U_0$	4	**Geomagnetic sensor (y axis)**	$5\times(U_2\times16^2+U_1\times16^1+U_0\times16^0)/4096-2.5$ [gauss]
$V_3 V_2 V_1 V_0$	4	**Geomagnetic sensor (z axis)**	$5\times(V_2\times16^2+V_1\times16^1+V_0\times16^0)/4096-2.5$ [gauss]

Data	Digit Number	Designation	Conversion Equation
$W_3W_2W_1W_0$	4	**Temperature (Li-ion battery 1)**	$0.15797 \times (5 \times (W_2 \times 16^2+W_1 \times 16^1+W_0 \times 16^0) /4096)^2$ $-39.553 \times (5 \times (W_2 \times 16^2+W_1 \times 16^1+W_0 \times 16^0) /4096)$ $+129.59$[deg. C]
$X_3X_2X_1X_0$	4	**Temperature (Li-ion battery 2)**	$0.18923 \times (5 \times (X_2 \times 16^2+X_1 \times 16^1+X_0 \times 16^0) /4096)^2$ $-39.27 \times (5 \times (X_2 \times 16^2+X_1 \times 16^1+X_0 \times 16^0) /4096)$ $+128.33$[deg. C]
$Y_3Y_2Y_1Y_0$	4	**Temperature (Gyro sensor [x axis])**	$10.292 \times (5 \times (Y_2 \times 16^2+Y_1 \times 16^1+Y_0 \times 16^0)/4096)^6$ $-173.25 \times (5 \times (Y_2 \times 16^2+Y_1 \times 16^1+Y_0 \times 16^0)/4096)^5$ $+1194.3 \times (5 \times (Y_2 \times 16^2+Y_1 \times 16^1+Y_0 \times 16^0)/4096)^4$ $-4312.6 \times (5 \times (Y_2 \times 16^2+Y_1 \times 16^1+Y_0 \times 16^0)/4096)^3$ $+8600.5 \times (5 \times (Y_2 \times 16^2+Y_1 \times 16^1+Y_0 \times 16^0)/4096)^2$ $-9020.1 \times (5 \times (Y_2 \times 16^2+Y_1 \times 16^1+Y_0 \times 16^0)/4096)$ $+3962.8$ [deg. C]
$Z_3Z_2Z_1Z_0$	4	**Temperature (Gyro sensor [y axis])**	$-0.19176 \times (5 \times (R_2 \times 16^2+R_1 \times 16^1+R_0 \times 16^0)/4096)^2$ $-37.747 \times (5 \times (R_2 \times 16^2+R_1 \times 16^1+R_0 \times 16^0)/4096)$ $+125.06$ [deg. C]
$a_3a_2a_1a_0$	4	**Temperature (Gyro sensor [z axis])**	$-0.81874 \times (5 \times (a_2 \times 16^2+a_1 \times 16^1+a_0 \times 16^0)/4096)^2$ $-34.744 \times (5 \times (a_2 \times 16^2+a_1 \times 16^1+a_0 \times 16^0)/4096)$ $+122.46$ [deg. C]
$b_3b_2b_1b_0$	4	**Temperature (Digi-talker)**	$-0.084633 \times (5 \times (b_2 \times 16^2+b_1 \times 16^1+b_0 \times 16^0)/4096)^2$ $-37.991 \times (5 \times (b_2 \times 16^2+b_1 \times 16^1+b_0 \times 16^0)/4096)$ $+124.25$ [deg. C]
$c_3c_2c_1c_0$	4	**Temperature (Transmitter)**	$-0.38082 \times (5 \times (c_2 \times 16^2+c_1 \times 16^1+c_0 \times 16^0)/4096)^2$ $-36.125 \times (5 \times (c_2 \times 16^2+c_1 \times 16^1+c_0 \times 16^0)/4096)$ $+121.31$ [deg. C]
$d_3d_2d_1d_0$	4	**Temperature (Receiver)**	$-0.062626 \times (5 \times (d_2 \times 16^2+d_1 \times 16^1+d_0 \times 16^0)/4096)^2$ $-38.305 \times (5 \times (d_2 \times 16^2+d_1 \times 16^1+d_0 \times 16^0)/4096)$ $+126.89$ [deg. C]

Any Characters Downlink
JQ1YGU>JQ1YGV:ABCDEFGHIJKLMNOP (SEEDS can transmit up to 120 characters by uplink command)

The number of solar cells and the coordinate system of SEEDS



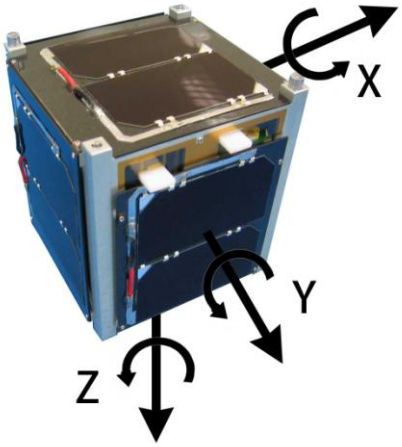


Fig.1 The number of solar cells of SEEDS

Fig.2 The coordinate system of SEEDS

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