Appendix

Appendix 1　Structure

The satellite overview is shown in Fig.A.1. The equipment layout of internal satellite is shown in Fig.A.2. The drawing of satellite is shown in Fig.A.3.

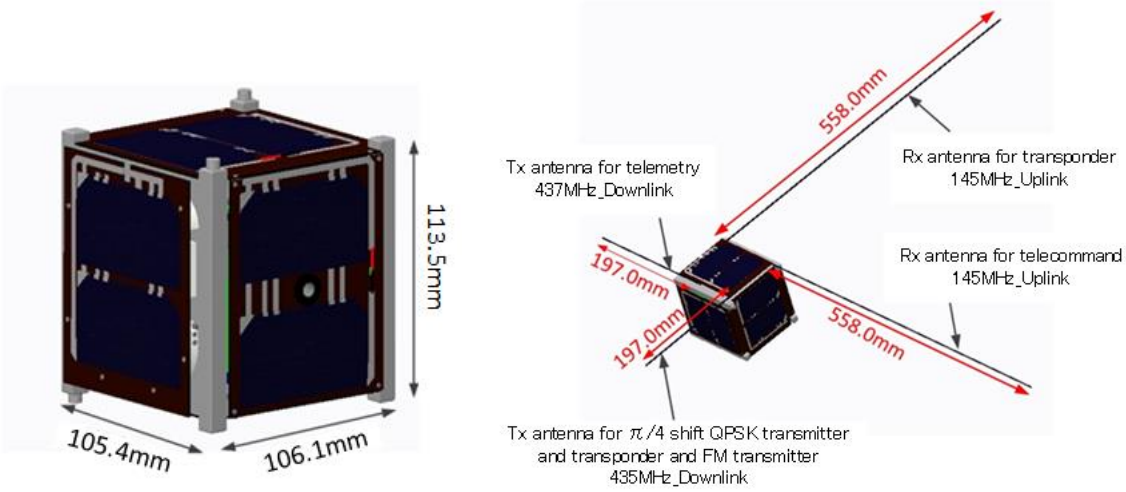

Fig.A.1 Satellite overview

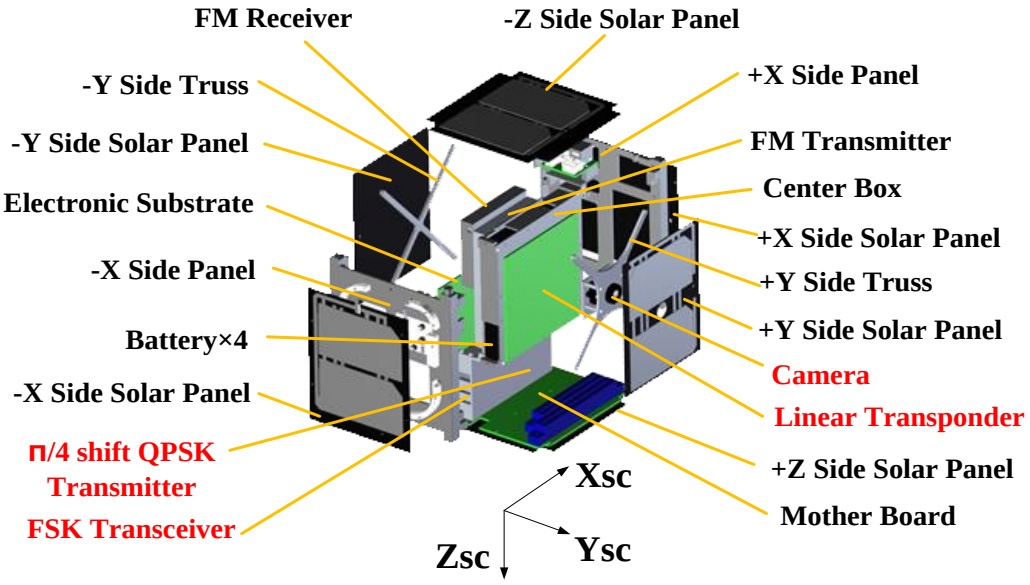

Fig.A.1 equipment layout of internal satellite

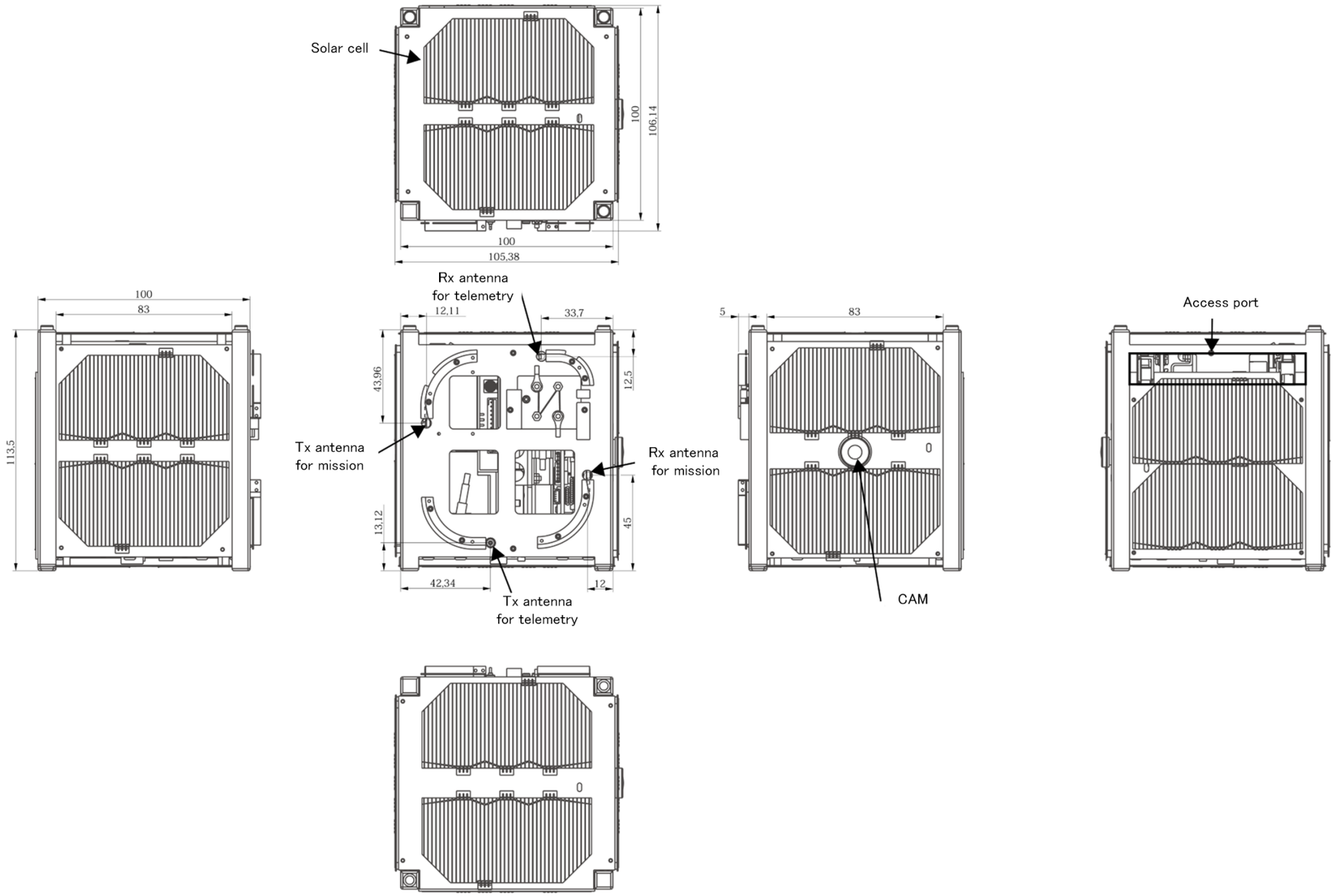

Fig.A.3 Drawing of satellite (launch configuration)

Appendix 2　Power budget

1. Power source

In the NEXUS, each two solar cell is attached to all surface. Daylight is available to charge a lithium-ion battery and the operation of each components. The specifications of Solar cells and the lithium ion battery are as shown in TableA.1 and TableA.2.

Table A.1　Solar cell

Category	Specification
Type	Triple junction (InGaP/InGaAs/Ge)
Mount type	Body mount
Number of cells	12cells (2 cells on each sides)
Arrangement	2 in series and 6 in parallel
Dimension (1 cell)	40.15mm x 80.15mm (cell area: 30.18cm^2)
Maximum efficiency	More than 27.5%
Averaged efficiency of power supply from the cells to the components	90%
Avaraged daytime/round	3897 sec/round
Averaged energy generation/ round	6386 mWh/round

Table A.2　Battery

Category	Specification
Type	Li-ion
Nominal voltage	3.7V
Nominal capacity (each battery)	1880mAh
Number of batteries	4
Arrangement	4 single-cells in parallel
Total capacity	7520mAh
Averaged efficiency of power supply from the cells to the battery	90%

2. Daylight and eclipse

Estimate of daylight time and eclipse time are as shown in TableA.3.

Table A.3　estimate of daylight and eclipse

Category	Data
Daylight	3897 [sec]
Eclipse	1980 [sec]

3. Power consumption

In the electrical power analysis, We assume the eclipse time for the mode to be used primarily during normal operation. The discharge rate and depth of discharge of the battery was calculated by the operation of the battery only. As a result we confirmed that is within a tolerance. In order to determining the maximum amount of power that can be charged during one daylight, showing the value of power analysis of CW operation (during Daylight) a phase of normal operation. Power consumption at each operation phase is shown in TableA.4, and operation time and discharge current and discharge capacity at each phase are shown in Table A.5.

Table A.4 . Power consumption at each operation phase

State	Operation mode	Consumption current [mA]	Consumption Power [mW]	Operation time[s]	Current consumption [mAh]	Power consumption [mWh]
daylight	CW operation（daylight）	219	1008	3897	221	1092
eclipse	CW operation（eclipse）	273	1008	1980	112	555
eclipse	FM downlink of 1200bps	1203	4451	1980	495	2448
eclipse	FM downlink of 9600bps	1205	4459	1980	495	2452
eclipse	QPSK downlink	1086	4019	1980	862	2210
eclipse	Digi-talker and SSTV operation	1182	4375	1980	482	2406
eclipse	CW and transponder operation	1136	4202	1980	564	2311
eclipse	CW and take a picture	1188	4397	1980	465	1970
eclipse	Sensing and antenna deployment	2432	8997	1980	175	919
eclipse	Real time image downlink	1861	6887	600	296	1148

As a result ， consumption per one battery when the battery 4 Parallel (1 series) are shown in the Table A.5.

Table A.5

State	Operation mode	Consumption current [mA]	Consumption power [mW]	Operation time[s]	Current consumption [mAh]	C	DOD [%]
Daylight	CW operation（daylight）	244	1121	245	1213	-	-
eclipse	CW operation（eclipse）	303	1121	125	540	0.0403	1.66
eclipse	FM downlink of 1200bps	1337	4946	550	2720	0.178	7.31
eclipse	FM downlink of 9600bps	1339	4954	551	2725	0.178	7.32
eclipse	QPSK downlink	1207	4466	958	2456	0.178	4.88
eclipse	Digi-talker and SSTV	1314	4861	536	2673	0.175	7.13
eclipse	CW and transponder operation	1262	4669	626	2568	0.168	8.33
eclipse	CW and take a picture	1320	4885	517	2189	0.176	6.9
eclipse	Sensing and antenna deployment	2702	9996	194	1021	0.359	2.579
eclipse	Real time image downlink	2068	7652	328	1275	0.275	4.366

The maximum amount of power that can be charged in once Daylight is 4546 [mWh].This is power generation of the solar cell in once daylight, and the amount of CW operation of normal operation phase. This result exceeds the target value, so we determined that can be operated in 4 Parallel.

Appendix 3　Link budget

It shows the link budget result of the transmitter below. From these tables, the link budget has been established.

Table A. 6　Link budget of CW/FM integrated transmitter

Downlink Bass		
Modulation Method	AFSK	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Satellite		
Transmission Frequency	f[MHz]	437
Transmitter Power	P_{TX}[W]	0.8
	P_{TX}[dBW]	-0.96910013
	P_{TX}[dBm]	29.03089987
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	-2
Effective Isotropically Radiated Power	P_E[dBm]	25.03089987
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Characteristic Transmission		
Free Space Loss	L_d[dB]	149.8352642
Polarized Wave Loss	L_p[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	152.8352642

Ground station		
Receive Antenna	Cross Yagi Anntena 2 stack	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	24
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-105.8043643
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	16
Noise Power	N[W]	1.32E-16
	N[dBW]	-158.7784968
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	22
Receive G/T	G/T[dB/K]	-5.781512504

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	1200
	B_{ps}[dBHz]	30.79181246
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	22.97
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	10.47

Downlink Bass		
Modulation Method	GMSK	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Satellite		
Transmission Frequency	f[MHz]	437
Transmitter Power	P_{TX}[W]	0.8
	P_{TX}[dBW]	-0.96910013
	P_{TX}[dBm]	29.03089987
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	-2
Effective Isotropically Radiated Power	P_E[dBm]	25.03089987
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Characteristic Transmission		
Free Space Loss	L_d[dB]	149.8352642
Polarized Wave Loss	L_p[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	152.8352642

Ground station		
Receive Antenna	Cross Yagi Anntena 2 stack	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	24
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-105.8043643
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	26
Noise Power	N[W]	2.15E-16
	N[dBW]	-156.6699632
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	22
Receive G/T	G/T[dB/K]	-5.781512504

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	9600
	B_{ps}[dBHz]	39.82271233
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	20.87
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	8.37

Table A. 7　Link budget of CW/FM integrated transmitter and FM receiver

Downlink Bass		
Modulation Method	CW	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Uplink Bass		
Modulation Method	AFSK	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Satellite		
Transmission Frequency	f[MHz]	437
Transmitter Power	P_{TX}[W]	0.1
	P_{TX}[dBW]	-10
	P_{TX}[dBm]	20
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	-2
Effective Isotropically Radiated Power	P_E[dBm]	16
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Ground Station		
Transmission Frequency	f[MHz]	146
Transmitter Power	P_{TX}[W]	50
	P_{TX}[dBW]	16.98970004
	P_{TX}[dBm]	46.98970004
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	12
Effective Isotropically Radiated Power	P_E[dBm]	56.98970004
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Characteristic Transmission		
Free Space Loss	L_d[dB]	149.8352642
Polarized Wave Loss	L_p[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	152.8352642

Characteristic Transmission		
Free Space Loss	L_d[dB]	140.3126925
Polarized Wave Loss	L_p[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	143.3126925

Ground station		
Receive Antenna	Cross Yagi Anntena 2 stack	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	24
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-114.8352642
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	0.5
Noise Power	N[W]	4.14E-18
	N[dBW]	-173.8299966
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	22
Receive G/T	G/T[dB/K]	-5.781512504

Satellite		
Receive Antenna	Mono-Pole Antenna	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	-2
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-90.3229925
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	20
Noise Power	N[W]	1.66E-16
	N[dBW]	-157.8093967
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	-4
Receive G/T	G/T[dB/K]	-31.7815125

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	25
	B_{ps}[dBHz]	13.97940009
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N[dB]	28.99
Request E_b/N	$(E_b/N)_{req}$[dB]	10.5
Request C/N	$(C/N)_{req}$[dB]	12.5
Margin	M[dB]	16.49

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	1200
	B_{ps}[dBHz]	30.79181246
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	37.49
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	24.99

Table A. 8　Link budget of π/4 shift QPSK transmitter and FM transmitter

Downlink π/4 shift QPSK		
Modulation Method	π/4 shift QPSK	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Satellite		
Transmission Frequency	f[MHz]	436
Transmitter Power	P_{TX}[W]	0.4
	P_{TX}[dBW]	-3.979400087
	P_{TX}[dBm]	26.02059991
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	-2
Effective Isotropically Radiated Power	P_E[dBm]	22.02059991
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Characteristic Transmission		
Free Space Loss	L_{dl}[dB]	149.8153652
Polarized Wave Loss	L_P[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	152.8153652

Ground station		
Receive Antenna	Cross Yagi Anntena 2 stack	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	24
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-108.7947653
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	30
Noise Power	N[W]	2.48E-16
	N[dBW]	-156.0484841
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	22
Receive G/T	G/T[dB/K]	-5.781512504

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	38400
	B_{ps}[dBHz]	45.84331224
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	17.25
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	4.75

Downlink FSK		
Modulation Method	FSK	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Satellite		
Transmission Frequency	f[MHz]	436
Transmitter Power	P_{TX}[W]	0.4
	P_{TX}[dBW]	-3.979400087
	P_{TX}[dBm]	26.02059991
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	-2
Effective Isotropically Radiated Power	P_E[dBm]	22.02059991
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Characteristic Transmission		
Free Space Loss	L_{dl}[dB]	149.8153652
Polarized Wave Loss	L_P[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	152.8153652

Ground station		
Receive Antenna	Cross Yagi Anntena 2 stack	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	24
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-108.7947653
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	30
Noise Power	N[W]	2.48E-16
	N[dBW]	-156.0484841
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	22
Receive G/T	G/T[dB/K]	-5.781512504

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	19200
	B_{ps}[dBHz]	42.83301229
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	17.25
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	4.75

Table A. 9　Link budget of transponder

Downlink Transponder		
Modulation Method	-	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Uplink Transponder		
Modulation Method	-	
Satellite Antenna	Mono-Pole Antenna	
Orbit Altitude	H[km]	500
Earth Radius	R[km]	6378.142
Elevation Angle	θ_{EL}[deg]	10
	θ_{EL}[rad]	0.174532925
Visible Limit Angle	θ[rad]	0.245150236
	θ[deg]	14.04607388
Maximun Transmission Distance	D[km]	1695.091563
Maximun Transmission Speed	c[m]	3.0E+08
Boltzmann Constant	k[W/Hz･K]	1.38E-23

Satellite		
Transmission Frequency	f[MHz]	436
Transmitter Power	P_{TX}[W]	0.5
	P_{TX}[dBW]	-3.010299957
	P_{TX}[dBm]	26.98970004
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	-2
Effective Isotropically Radiated Power	P_E[dBm]	22.98970004
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Ground Station		
Transmission Frequency	f[MHz]	146
Transmitter Power	P_{TX}[W]	10
	P_{TX}[dBW]	10
	P_{TX}[dBm]	40
Transmitter Feeding Power Loss	L_{FTX}[dB]	2
Transmission Antenna Gain	G_{ATX}[dBi]	12
Effective Isotropically Radiated Power	P_E[dBm]	50
Transmission Antenna Pointing Loss	L_{APTX}[dB]	0

Characteristic Transmission		
Free Space Loss	L_{dl}[dB]	149.8153652
Polarized Wave Loss	L_P[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	152.8153652

Characteristic Transmission		
Free Space Loss	L_{dl}[dB]	140.3126925
Polarized Wave Loss	L_P[dB]	3
Atmospheric Absorption Loss	L_A[dB]	0
Rain Loss	L_{RA}[dB]	0
Various Loss	L_V[dB]	0
Total Transmission Loss	L_{pr}[dB]	143.3126925

Ground station		
Receive Antenna	Cross Yagi Anntena 2 stack	
ReceivedAntenna Pointing Loss	L_{APRX}[dB]	0
Received Antenna Gain	G_{ARX}[dBi]	24
Received Feeding Power Loss	L_{FRX}[dB]	2
	L_{FRX}[-]	1.584893192
Received Signal Power	C[dBm]	-107.8256652
Antenna Noise Temperature	T_A[K]	300
Feeding Power Line Noise Temperature	T_F[K]	300
Receiver Noise Temperature	T_E[K]	300
Ground Station Temperature	T_0[K]	300
Noise Factor	NF[-]	2
	NF[dB]	3.010299957
Ground Station System Noise Temperature	T_S[K]	600
Ground Temperature	T_G[K]	300
Average Temperature	T_m[K]	286
Sky Noise Temperature Increase	T_{SKY}[K]	0
Maximun Signal Pass Bandwidth	B[kHz]	16
Noise Power	N[W]	1.32E-16
	N[dBW]	-158.7784968
Noise Power density	N_0[dBW/Hz]	-2.01E+02
	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	22
Receive G/T	G/T[dB/K]	-5.781512504

Satellite		
Receive antenna	Mono-Pole Antenna	
Ground Station Antenna	L_{APRX}[dB]	0
ReceivedAntenna Pointing Loss	G_{ARX}[dBi]	-2
Received Antenna Gain	L_{FRX}[dB]	2
Received Feeding Power Loss	L_{FRX}[-]	1.584893192
	C[dBm]	-97.31269255
Received Signal Power	T_A[K]	300
Antenna Noise Temperature	T_F[K]	300
Feeding Power Line Noise Temperature	T_E[K]	300
Receiver Noise Temperature	T_0[K]	300
Ground Station Temperature	NF[-]	2
Noise Factor	NF[dB]	3.010299957
	T_S[K]	600
Ground Station System Noise Temperature	T_G[K]	300
Ground Temperature	T_m[K]	286
Average Temperature	T_{SKY}[K]	0
Sky Noise Temperature Increase	B[kHz]	16
Maximun Signal Pass Bandwidth	N[W]	1.32E-16
Noise Power	N[dBW]	-158.7784968
	N_0[dBW/Hz]	-2.01E+02
Noise Power density	N_0[dBm/Hz]	-1.71E+02
Receiving Gain	G[dB]	-4
Receive G/T	G/T[dB/K]	-31.7815125

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	1200
	B_{ps}[dBHz]	30.79181246
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	20.95
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	8.45

Demodulation Loss	L_D[dB]	2
Internal Ground Station Transmission Loss	L_G[dB]	0
Ground Station Processing Loss	L_0[dB]	2
Bit Rate	B_{ps}[Hz]	1200
	B_{ps}[dBHz]	30.79181246
Bit Error Rate	P_b[-]	0.000001
Receive C/N (Received Power/Noise Power)	C/N_0[dB]	31.47
Request E_b/N	$(E_b/N_0)_{req}$[dB]	10.5
Request C/N	$(C/N_0)_{req}$[dB]	12.5
Margin	M[dB]	18.97

Appendix 4　Communication diagram

This satellite is communicated by some amateur radio station. The communication diagram is shown in Fig.A.4.

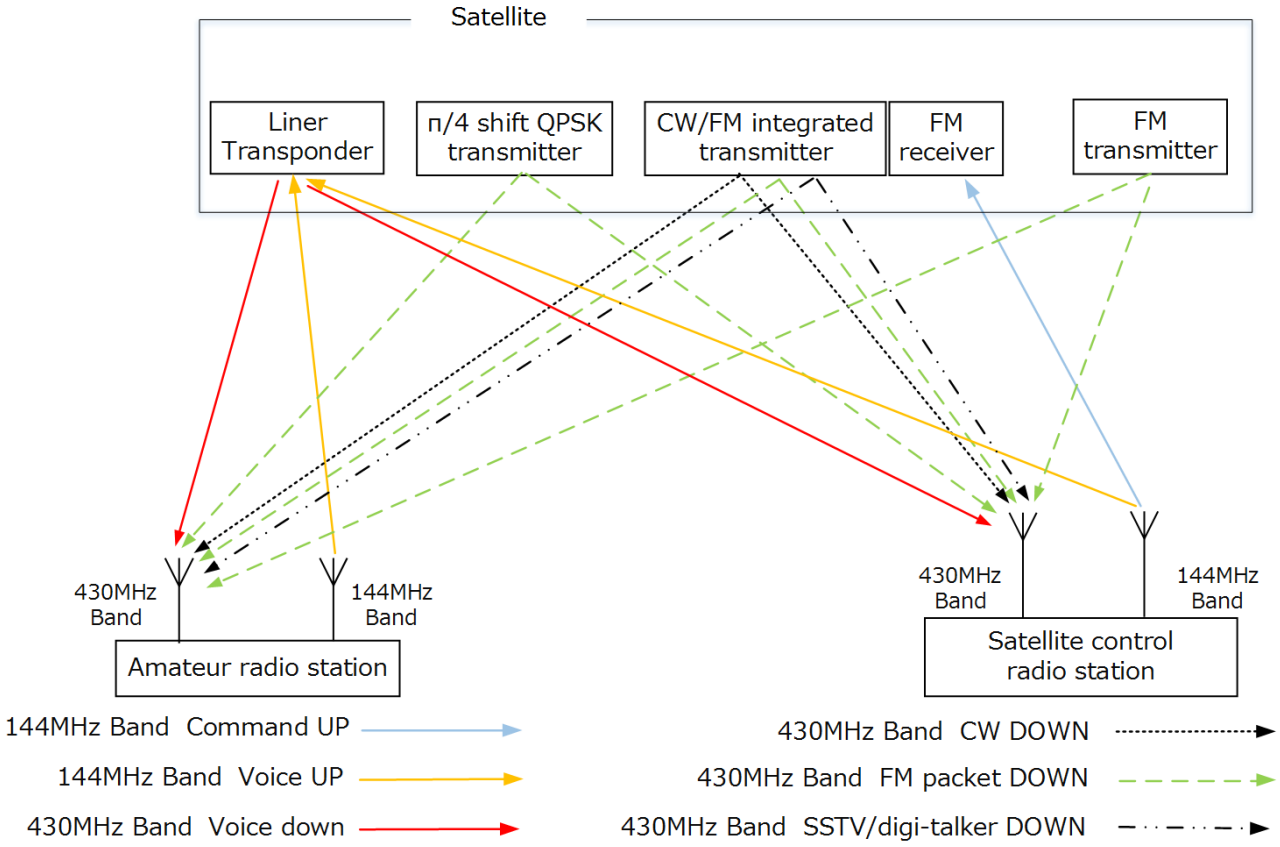

Fig.A.4 Communication diagram