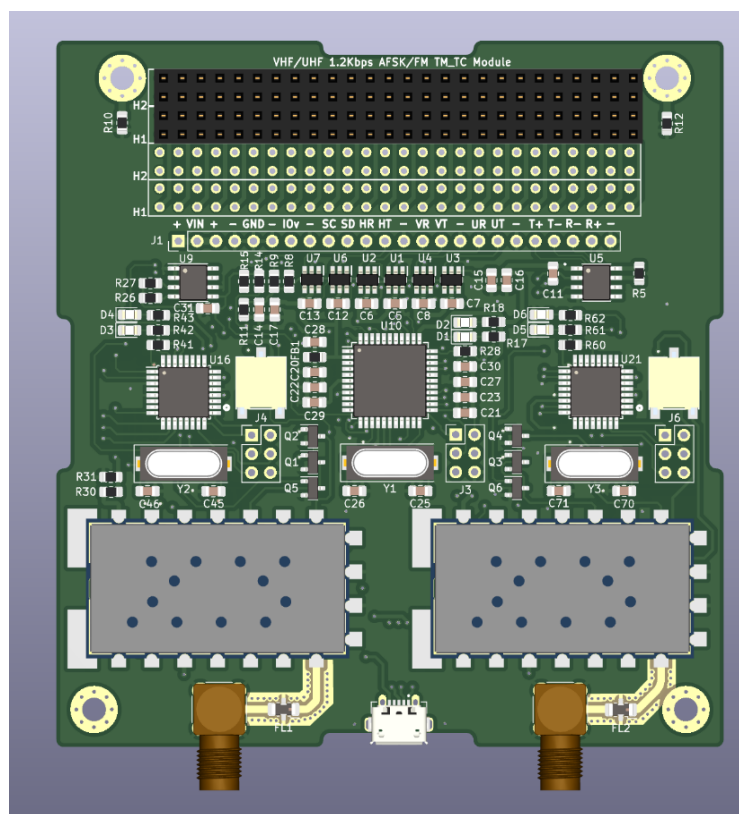# VHF/UHF AFSK/FM 1200 bps Telemetry Telecommand Module

User Manual & ICD

Document Reference

Document Type	User Manual of VHF/UHF AFSK/FM 1200 bps Telemetry Telecommand Module
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Version	v1, Initial Draft
Document Classification	HEX20 Confidential
Total no: of pages	8

Change Records

Date	Version No.	Page Nos.	Change Approved by	Brief Description of Change
18-Jan-2023	v1	8		Baseline Document

## *VHF/UHF AFSK/FM 1200 bps Telemetry Telecommand Module*

VHF / UHF CubeSat TTC Module is a cubesat compatible radio module operating in half duplex mode. The communication bit rate is 1200 bits / sec. The radio is interfaced to CDH using asynchronous 9600 baud TTL UART operating at I/O voltage level of selectable 3.3V / 5V. This radio modem works in sub-carrier mode AFSK/FM. The packet format is compatible with the AX.25 UI frame. The tones used for AFSK sub-carrier are BEL202 Modem standard 1200 Hz and 2200 Hz. The radio will be normally in receive mode and once any packet on programmed frequency is received, it will decode the packet, strip off the AX.25 headers and forward the raw packet via the CDH UART. For sending a packet, CDH can send the packet to radio via UART and once the CR (Carriage Return) ASCII character is sent, the radio frames it with AX.25 headers and modulates the packets,and toggle radio into TX mode to radiate the packet. The RF output power is selectable 1W or 2W. The RF output is passed via a low pass filter to ensure spectrum cleanliness and emission mask requirements such that harmonic and spurious related components are at least 45dB down with respect to the main carrier frequency level. The frequency of the operation can be set within 1KHz resolution. The radio requires DC voltage between 5V to 12V. The PC104 pin-map can be defined by the user through wiring jumper cables between required PC104 pin and fixed header. There is also a configuration UART in-order to set the radio frequency, deviation and sensitivity. This allows inflight reconfigurability of operating parameters in event of on-orbit interference.

* NOTE : *Band, Power and RF SMA Connector orientation must be specified before ordering.*

VHF / UHF CubeSat TTC Module Specification

VHF Frequency Range	*144 - 146 MHz*
UHF Frequency Range	*434 - 438 MHz*
Frequency Resolution	*1 KHz*
RF Transmitter Power Output	*1 Watt / 30 dBm or 2 Watt / 33 dBm **
RF Receiver Sensitivity	*-110 dBm*
RF Data Rate	*1.2 Kbps*
RF Modulation	*AFSK / FM*
RF Packet Format	*AX.25*
Power Supply	*6V DC Typical @ 1.5A current max*
PC104 Pin-Map	*Jumper Selectable by User*
CDH Data Interface	*9600 bps TTL UARTs for VHF & UHF*
Radio Operation Mode	*Half Duplex*
Housekeeping /Config Port	*9600 bps TTL UART*
Optional Housekeeping/Config Port	*I2C/RS422 Interface*

TTC Board Block Diagram
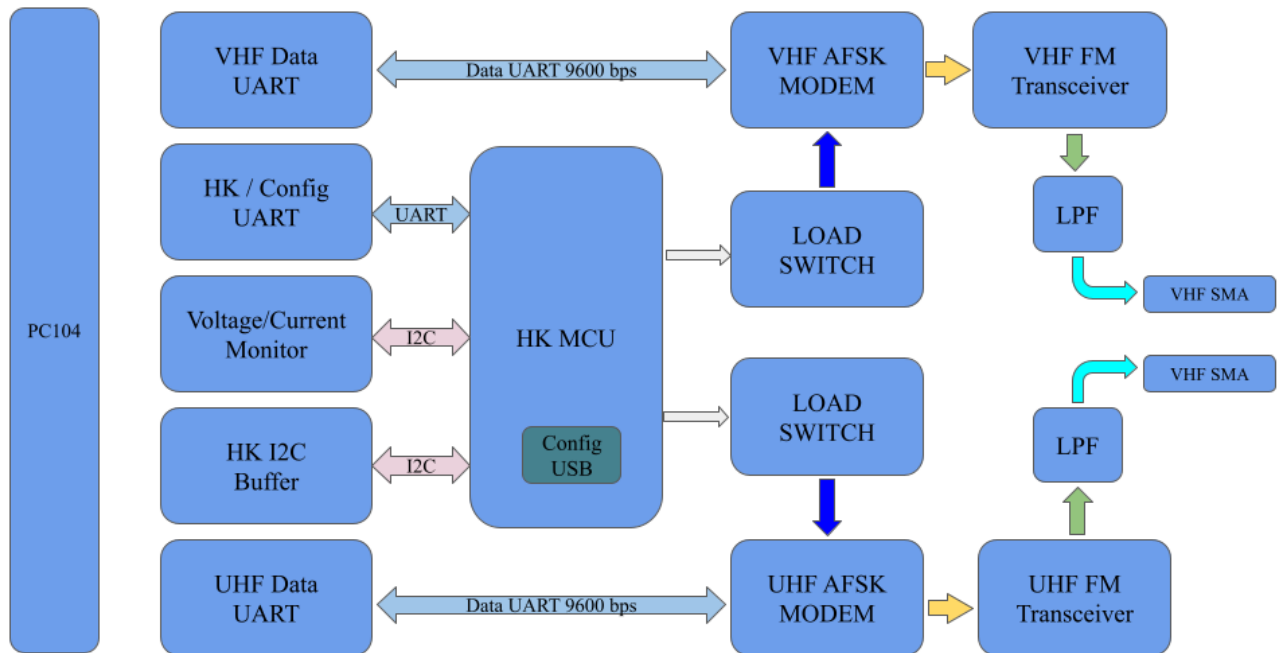
TTC Board PC104 Pin Map

Pin no.	Signal	Pin no.	Signal	Pin no.	Signal	Pin no.	Signal
Stack - H1				Stack - H2			
1	CDH_3V3/IO Voltage Level	2	CDH_3V3/IO Voltage Level	1	UHF_VCC_6	2	UHF_VCC_6
3		4		3	TTC_CMD_RX	4	TTC_CMD_TX
5		6		5	UHF_DATA_RX	6	UHF_DATA_TX
7		8		7	VHF_DATA_RX	8	VHF_DATA_TX
9		10		9		10	
11	TTC_I2C_SCL	12	TTC_I2C_SDA	11	UHF_VCC_6	12	
13		14		13		14	
15		16		15		16	
17		18		17		18	
19		20		19		20	
21		22		21		22	
23		24		23		24	
25	GND	26		25		26	
27		28		27		28	
29		30		29		30	
31		32		31		32	
33		34		33		34	
35	GND	36	GND	35		36	
37	GND	38		37		38	
39		40		39		40	
41		42		41		42	
43		44		43		44	
45		46		45		46	
47	GND	48	GND	47		48	
49		50		49		50	
51		52		51		52	

Note : All UART pin direction and sense is with respect to the comms board
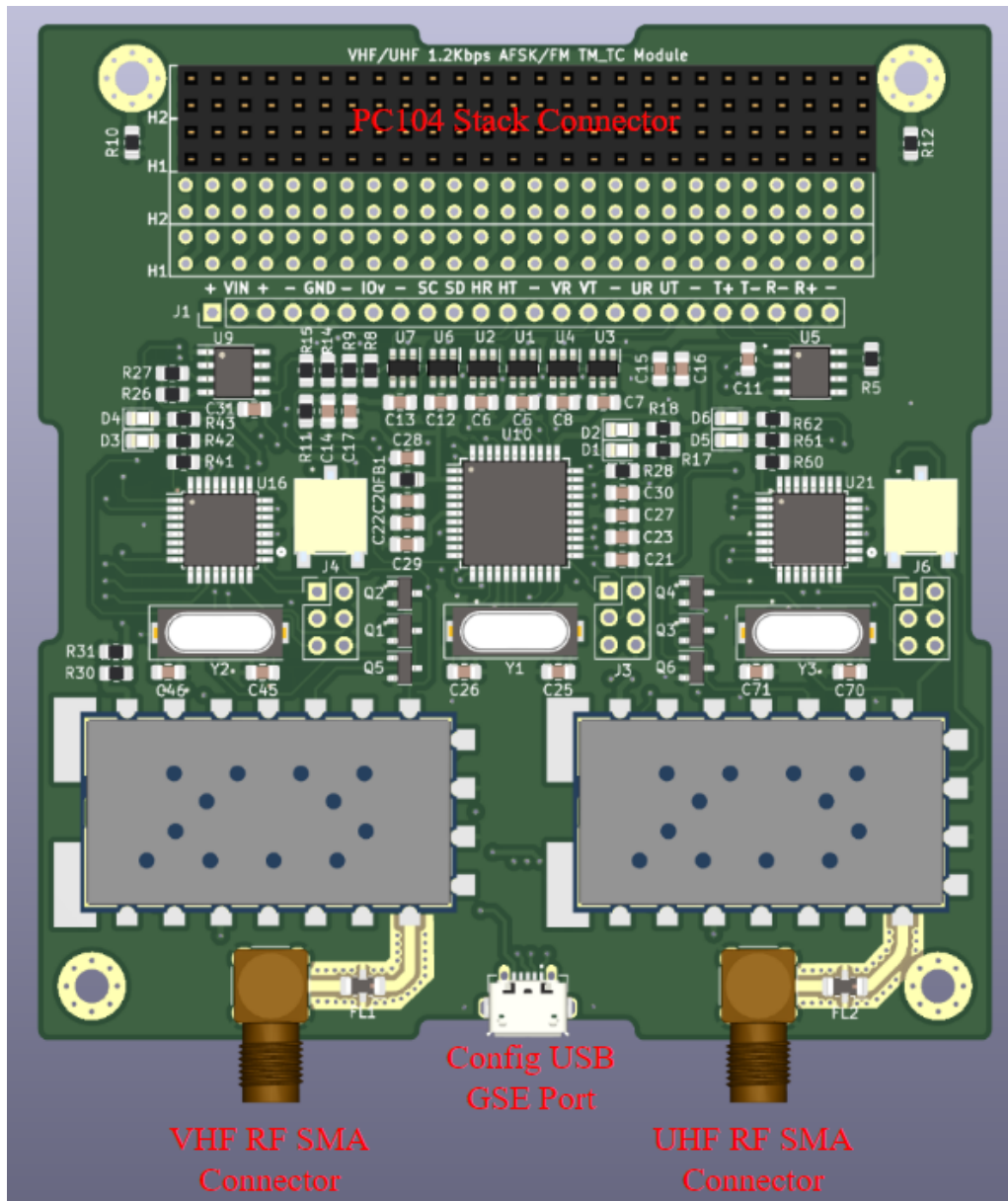
TTC Module Concept of Operation

The TTC module works with a DC supply of 6V. Upon power up the main house keeping microcontroller initialises the peripherals and waits for command from OBC via HK CMD UART. The HK UART is at TTL level and operates at 9600 bps with 8N1 mode. The OBC should send commands to turn ON the VHF / UHF Modem prior to operation. Once VHF/UHF is turned ON, OBC can send data frames via either VHF DATA UART or UHF DATA UART with Carriage Return as delimiter. Once a delimiter character is encountered, the modem takes the data frame , forms the AX.25 packet , modulates and transmits it via Antenna. The TTC Module will be normally in receive mode and once it receives a valid command with proper call sign , it deframes the AX.25 header and forwards the data frame via corresponding DATA UART. The OBC can send commands via UART for obtaining housekeeping information like voltage, current, power, radio power amplifier temperature, RSSI, lock Status,etc. The TTC module responds with corresponding HK values. The operating frequency, deviation, call sign etc can be set via commands and will be stored in on-board EEPROM for retrieval after power down or restart.

The various UARTs and modes of operation are summarised in the table below. All command and data UART has "\n" character as delimiter.

UART Type	UART Baud Rate & Format	Purpose
HK_CMD_UART	9600 bps 8N1	House-keeping Telemetry & Configuration
VHF_DATA_UART	9600 bps 8N1	VHF Telemetry Transmission & Telecommand Reception
UHF_DATA_UART	9600 bps 8N1	UHF Telemetry Transmission & Telecommand Reception
CONFIG_USB_UART_PORT	9600 bps 8N1	GSE port with verbose outputs

The HK UART has a command response protocol for communicating with OBC. The commands, functionalities and response are summarised in the table below.

Command	Response	Functionality
vhf_on	-	Turn ON VHF Module
vhf_off	-	Turn OFF VHF Module
uhf_on	-	Turn ON UHF Module
uhf_off	-	Turn OFF UHF Module
vhf_tx_test	-	Turn on the VHF Carrier for 3 seconds & Turn back off. Can be used for spectrum measurements
uhf_tx_test	-	Turn on the UHF Carrier for 3 seconds & Turn back off. Can be used for spectrum measurements
set_vhf_high_power	-	Set the VHF module RF output to +33 dBm / 2W
set_vhf_low_power	-	Set the VHF module RF output to +30 dBm / 1W
set_uhf_high_power	-	Set the UHF module RF output to +33 dBm / 2W
set_uhf_low_power	-	Set the UHF module RF output to +30 dBm / 1W
get_vhf_squelch_val	0 -1024	Returns the squelch status value from VHF Module

get_uhf_squelch_val	0-1024	Returns the squelch status value from UHF Module
get_vhf_temp	00.00 temp in degree celsius	Returns the VHF power amplifier temperature
get_uhf_temp	00.00 temp in degree celsius	Returns the UHF power amplifier temperature
get_ttc_volt	00.00 in volts	Returns the TTC module DC bus voltage in volts
get_ttc_curr	0000.00 in mA	Returns the TTC module DC current consumption in mA
get_ttc_pow	0000.00 in mW	Returns the TTC module DC power consumption in mW

The TTC module PC104 pin-out can be modified by the user through jumper wiring between the required pin of parallel PC104 stack connector and J1 connector. The pinout of the J1 connector is specified in the following table. I2C & RS422 ports are optional for housekeeping telemetry and configuration settings.

Pin Number	*Pin Name*	*Pin Function*
1	VIN_+	Input DC Supply 6V
2	VIN_+	Input DC Supply 6V
3	VIN_+	Input DC Supply 6V
4	GND	Input DC Supply Return
5	GND	Input DC Supply Return
6	GND	Input DC Supply Return
7	IO_VOLTAGE	CDH I/O Voltage reference 3.3/5 V DC
8	GND	CDH I/O Voltage Return
9	SCL	HK I2C SCL, pulled up to IO_VOLTAGE
10	SDA	HK I2C SDA, pulled up to IO_VOLTAGE
11	CMD UART RX	Command TTL UART RX input pin
12	CMD UART TX	Command TTL UART TX output pin
13	GND	Command TTL UART Return
14	VHF DATA UART RX	VHF DATA TTL UART RX input pin
15	VHF DATA UART TX	VHF DATA TTL UART TX output pin

16	GND	VHF DATA TTL UART Return
17	UHF DATA UART RX	UHF DATA TTL UART RX input pin
18	UHF DATA UART TX	UHF DATA TTL UART TX output pin
19	GND	UHF DATA TTL UART Return
20	RS422 TX +	HK UART RS422 Driver out TX+
21	RS422 TX -	HK UART RS422 Driver out TX-
22	RS422 RX -	HK UART RS422 Receiver in RX-
23	RS422 RX +	HK UART RS422 Receiver in RX+
24	GND	HK UART RS422 Return

The mounting holes are not grounded by default. The user can ground the mounting holes by soldering 0 ohm, 0805 SMD resistor to R10, R12, R13 & R16.

The DC power consumption of TTC modules under various operation modes at room temperature are tabulated below.

Operation Mode	DC Current (mA) @ 6 V DC	DC Power (W)
VHF : OFF , UHF : OFF (Standby)	63	0.37
VHF : RX , UHF : OFF	138	0.83
VHF : TX , UHF : OFF	620	3.7
VHF : OFF, UHF : RX	160	0.96
VHF : OFF, UHF : TX	540	3.23
VHF : RX, UHF : RX	235	1.41
VHF : TX, UHF : TX	1082	6.5
VHF : RX, UHF : TX	615	3.68
VHF : TX, UHF : RX	715	4.28