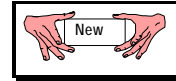


## APPENDIX N



# TELEMETRY TRANSMITTER COMMAND AND CONTROL PROTOCOL

## TABLE OF CONTENTS

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
1.0	Introduction.....	N-1
2.0	Command Line Interface .....	N-1
3.0	Initialization .....	N-2
4.0	Basic Command Set.....	N-2
5.0	Extended Command Set.....	N-7
6.0	Transmitter Communication Example.....	N-13
7.0	Non-standard Commands .....	N-13
8.0	Physical Layer(s) .....	N-13

## LIST OF TABLES

Table N-1.	Basic Command Set.....	N-2
Table N-2.	Extended Command Set.....	N-7

This page intentionally left blank.

## APPENDIX N

### TELEMETRY TRANSMITTER COMMAND AND CONTROL PROTOCOL

#### 1.0 Introduction

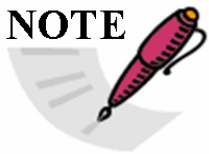
This Appendix provides standards for commands, queries, and status information when communicating with telemetry transmitters configured with communication ports. The commands are divided into two categories of “command sets” as follows:

- a. Basic. The basic command set contains the minimum (required) commands for transmitter control, query, and status.
- b. Extended. The extended command set contains optional commands that may or may not be implemented and may be shown as references.

#### 2.0 Command Line Interface

2.1 User Command Line Interface. This interface is the default upon “power up” of the transmitter. Each command or query is ended by a carriage return <CR>. Information returned from the transmitter will be followed by a carriage return <CR> and the “>” will be displayed to indicate the transmitter is ready to receive commands or queries.

#### NOTE



With regard to this standard, it is assumed that a carriage return <CR> is followed by a line feed. The transmitter will return the “OK” mnemonic for each command that is accepted. The transmitter will return “ERR” for a command or query that was interpreted as an error. Verification that a query was either accepted or found to be in error will be the response to the query. All commands are case insensitive. The transmitter will operate in half duplex mode and will echo typed characters to the command terminal.

2.1.1 Options. In addition to the required user command line interface items, the following list contains options that may or may not be implemented.

- a. Backspacing to correct typed errors.
- b. A character input to recall the last command line. The “^” character followed by a <CR> is recommended.
- c. Information returned after an accepted command. Adding information after the “OK” response is allowed. An example is:

```
>FR=1450.5<CR>  
>OK FR=1450.5<CR>  
>
```

2.2 Optional Programming Interface. If the transmitter is not commanded or queried through a terminal program (human interface), there may be an option to operate in half duplex mode so

that concatenated commands can be sent directly to the transmitter (bulk transmitter set-up). If this option is used, the transmitter will only return a single accepted “OK” response if the entire string was interpreted and accepted. When concatenating commands, the semicolon “;” is used as the delimiter for each command. If this optional programming interface is implemented, the transmitter will identify the semicolon delimiter, recognize the character string as a bulk command, and recognize the start of a new command after each delimiter.

### 3.0 Initialization

Upon successful communication initialization, the transmitter will provide the controlling terminal with (as a minimum) the manufacturer’s name, model number, and serial number of the transmitter. Other information (such as information on firmware and temperature) deemed appropriate by the manufacture is allowed. This information will be displayed only upon a successful power up and communication initialization of the transmitter. Should an unsuccessful power up occur, based upon criteria of the transmitter manufacturer, the transmitter shall return “ERR” and allow only the RE(S) command to reset the transmitter (see Table N-1 and paragraph 4.2.10).

Upon successful communication, after a power up, a communication connection, a command, or a query, the transmitter will send a carriage return followed by a “>” to signify the transmitter is ready to accept commands and queries.

### 4.0 Basic Command Set

4.1 Basic Command Set Summary. The basic command fields use a minimum two characters with the optional capability of using a maximum of four characters. If possible, the longer four character field should be used to add intuitiveness to the basic command set. The commands in the basic command set are shown in Table N-1.

<b>TABLE N-1. BASIC COMMAND SET</b>	
<b>Command</b>	<b>Function</b>
FR(EQ)	Sets or queries the carrier frequency.
MO(D)	Sets or queries the modulation mode.
DE	Sets or queries the setting of differential encoding (ON or OFF). Note: Valid in SOQPSK/FQPSK mode only.
RA(ND)	Sets or queries the setting of data randomization (ON or OFF).
RF	Sets or queries the RF output (ON or OFF).
QA(LL)	Queries the status of all basic commands.
VE(RS)	Queries, at a minimum, the manufacturer’s name, model number, and serial number of the transmitter.
SV(SAVE)	Saves the current set-up of the transmitter to on-board nonvolatile RAM.
RL(RCLL)	Retrieves a transmitter set-up from on-board nonvolatile RAM.
RE(S)	Resets the transmitter to a known configuration, restarts the internal power-up sequence.

4.2 Commands: Basic Command Set.

4.2.1 Carrier Frequency. Carrier frequency is set or queried with the “FR(EQ)” mnemonic as described below.

- a. Set Frequency. Use “FR(EQ) XXXX.X <CR>” where XXXX.X is the commanded frequency in MHz in 0.5 MHz steps. If the command is accepted, an “OK <CR>” is issued as a response.

In the event of an incorrect commanded carrier frequency (for example the commanded frequency is out of the tuning range of the transmitter), the transmitter will default to the currently set carrier frequency before the command was issued. The transmitter will then return “ERR FR(EQ) XXXX.X <CR>” where XXXX.X is the prior frequency set in the transmitter.

- b. Query Frequency. “FR(EQ) <CR>” queries the currently set carrier frequency and returns “FR(EQ) XXXX.X <CR>” where XXXX.X is the current set frequency in MHz.

4.2.2 Modulation Mode. Modulation mode is set or queried with the “MO(D)” mnemonic.

- a. Set Modulation Mode. Use “MO(D) X <CR>” where X corresponds to the modulation mode. If the command is accepted, an “OK <CR>” is issued as a response.

<b>Command</b>	<b>Modulation Type</b>
MO(D) 0	PCM/FM
MO(D) 1	SOQPSK-TG/FQPSK-JR/FQPSK-B
MO(D) 2	ARTM CPM
MO(D) 6	Modulation off (carrier only)

In the event of an incorrect commanded modulation mode, the transmitter will default to the previous modulation mode and return “ERR MO(D) X <CR>” to indicate the error and the current modulation mode. The “MO(D) 6” command turns off the modulation for carrier only mode. Modulation will return upon a new commanded modulation mode. If the transmitter is in single mode, only single mode commands are valid and the above error response will be sent should an invalid modulation mode command be sent. The same logic applies when the transmitter is in dual mode.

- b. Query Modulation Mode. “MO(D) <CR>” queries the currently set modulation mode and returns “MO(D) X <CR>” where the integer X is represented in the above table.

4.2.3 Differential Encoding. Differential encoding is set or queried with the “DE” mnemonic. For additional information, the reader is referred to Chapter 2 (paragraph 4.3.1.1) and Appendix M.

- a. Set Differential Encoding. Use “DE X <CR>” where X corresponds to a 1 or 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Differential Encoding
DE 0	On
DE 1	Off

Setting differential encoding only applies to SOQPSK-TG/FQPSK-JR/FQPSK-B (MOD 1) modulation. If an incorrect command is received or if differential encoding is commanded while the transmitter is in either PCM/FM or ARTM CPM mode, the transmitter will default to no differential encoding and return “ERR DE 0 <CR>” indicating an error with the current setting of differential encoding.

- b. Query Differential Encoding. “DE <CR>” queries the currently set differential encoding status and returns “DE X <CR>” where integer X is represented in the above table.

4.2.4 Data Randomization. Data randomization is set or queried with the “RA(ND)” mnemonic. For additional information, see Chapter 2, paragraph 2.4.3, and Appendix A.

- a. Set Data Randomization. Use “RA(ND) X <CR>” where X corresponds to a 1 or 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Randomization
RA(ND) 0	On
RA(ND) 1	Off

In the event of an incorrect data randomization command, the transmitter will default to its current setting and return “ERR RA(ND) X <CR>” to indicate the error and the currently set state.

- b. Query Modulation Mode. “RA(ND) <CR>” queries the currently set randomization and returns “RA(ND) X <CR>” where integer X is represented in the above table.

4.2.5 RF Output. RF output is set or queried with the “RF” mnemonic.

- a. Set RF Output. Use “RF X <CR>” where X corresponds to a 1 or 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	RF Output
RF 0	On
RF 1	Off

In the event of an incorrect RF output command, the transmitter will maintain its current state and return “ERR RF X <CR>” to indicate the error and return the current RF output setting for the transmitter.

- b. Query RF Output. “RF <CR>” queries the currently set RF output and returns “RF X <CR>” where X corresponds to the numbers in the above table.

4.2.6 Query all. The “query all” command is executed with the “QA(LL)” mnemonic.

- a. Query Transmitter Configuration. The command “QA(LL) <CR>” requests the current setting of all basic commands. The transmitter response will contain, as a minimum, the following:

- (1) Carrier Frequency. [FR(EQ) XXXX.X]
- (2) Modulation Mode. [MO(D) X]
- (3) Differential Encoding setting. (DE X)
- (4) Randomization setting. [RA(ND) X]
- (5) RF Output setting. (RF X)

- b. Status of Other Commands. If other commands are implemented in the transmitter beyond the basic set, a complete status should be given for each implemented command.

4.2.7 Version. The “version” command is executed with the “VE(RS) <CR>” mnemonic.

- a. Query Transmitter Version. “VE(RS) <CR>” requests the current version of the transmitter. The response will contain (at a minimum) the following information about the transmitter:

- (1) Manufacturer Name
- (2) Model Number
- (3) Serial Number

- b. Formatting and Delimiting the Fields. It is left up to the transmitter manufacturer to format and delimit the above fields and, if chosen, add additional information to the response.

4.2.8 Save. The “save” command is executed with the “SV(SAVE)” mnemonic.

For “Save Transmitter Set-Up”, “SV(SAVE) X<CR>” saves the current settings of the transmitter to register “X” in nonvolatile RAM within the transmitter. If only one location is available, the value of “X” is 0 (zero). There is no limit to the number of storage registers within the transmitter.

4.2.9 Recall. The recall command is executed with the RL(RCLL) mnemonic.

For “Recall Transmitter Set-up”, “RL(RCLL) <CR>” retrieves and restores the transmitter set-up from register “X” in nonvolatile RAM within the transmitter. Values of “X” start at 0 (zero). The register location should be used exclusively for the default set-up and not be available to store and retrieve set-ups.

4.2.10 Reset. The transmitter can be reset with the “RE(S)” mnemonic.

- a. Reset Transmitter. “RE(S) <CR>” resets the transmitter by reinitializing the transmitter. The transmitter will use the following basic settings as a base configuration.

<b>Transmitter Setting</b>	<b>Command</b>	<b>Result</b>
Carrier frequency	[FR(EQ)]	Lowest valid frequency within the tuning range
Modulation mode	[MO(D)]	MO(D) 0, PCM/FM
Differential encoding	(DE X)	DE 0, Differential encoding off
Randomization	[RA(ND) X]	RA(ND) 0, Randomization off
RF output	(RF X)	RF 0, RF output off

- b. Example Command use. The Reset Transmitter command would be used if communication to the transmitter could not be established, if commands were not being recognized, or if some other unknown transmitter state was experienced.



## 5.0 Extended Command Set

5.1 Extended Command Set Summary. The extended command set includes commands and queries not in the basic commands set. Although the extended set does not include all possible commands, its use provides a standard way of implementing known features of transmitters. This standard will be updated at appropriate intervals should new capabilities arise. Commands in the extended command set are shown in Table M-2.

<b>TABLE N-2. EXTENDED COMMAND SET</b>	
<b>Command</b>	<b>Function</b>
DP(OL)	Sets or queries data polarity (NORM or INV).
DS(RC)	Sets or queries the data source (INT or EXT).
ID(P)	Sets or queries the internal data pattern (one of five possible settings).
CS(CLKS)	Sets or queries the clock source (INT or EXT).
IC(R)	Sets or queries the internal clock rate.
FC(FEC)	Sets or queries forward error correction (ON or OFF).
FC(FEC) YYYY	Set specific forward error correction (ON or OFF).
RP(RPWR)	Sets or queries the output RF power (HI or LO).
TE(MP)	Queries the internal temperature (in Celsius).
DV(DEV)	Deviation sensitivity for PCM/FM mode.
SP(SLP)	Low power consumption mode, sleep mode.

### 5.2 Commands: Extended Command Set.

5.2.1 Data Polarity. Data polarity is set or queried with the “DP(OL)” mnemonic.

- a. Set Data Polarity. Use “DP(OL) X <CR>” where X corresponds to a 1 or 0. Actual data polarity, when referenced to the input clock, does not need to be known, this command either inverts the incoming data or does not. If the command is accepted, an “OK <CR>” is issued as a response.

<b>Command</b>	<b>Polarity</b>
DP(OL) 0	Normal
DP(OL) 1	Inverted

In the event of an incorrect data polarity command, the transmitter will maintain its current setting and return “ERR DP(OL) X <CR>” to indicate the error and return the current data polarity setting for the transmitter.

- b. Query Data Polarity. “DP(OL) <CR>” queries the current data polarity and returns “DP(OL) X <CR>” where integer X is represented in the above table.

5.2.2 Data Source. Data source is set or queried with the “DS(RC)” mnemonic.

- a. Set Data Source. Use “DS(RC) X <CR>” where X corresponds to a 1 or 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Source
DS(RC) 0	External
DS(RC) 1	Internal

In the event of an incorrect data source command, the transmitter will return “ERR DS(RC) X <CR>” to indicate the error and return the currently set data source state.

- b. Query Data Source. “DS(RC) <CR>” queries the currently set data source and returns “DS(RC) X <CR>” where integer X is represented in the above table.

5.2.3 Internal Data Pattern. The internal data pattern is set or queried with the “ID(P)” mnemonic.

- a. Set Internal Data Pattern. Use “ID(P) X” where X corresponds to the internal data pattern. If the command is accepted, an “OK <CR>” is issued as a response.
- b. Example Internal Data Patterns. Example patterns are shown below.

Command	Pattern
ID(P) 9	$2^9-1$ (511 bits)
ID(P) 11	$2^{11}-1$ (2047 bits)
ID(P) 15	$2^{15}-1$ (32767 bits)
ID(P) 20	$2^{20}-1$ (1048575 bits)
ID(P) 23	$2^{23}-1$ (8388607 bits)

Selection of which patterns to implement is left up to the manufacturer. In order for the ID command to be valid, the data source must first be set to “internal.” If the data source is not pre-selected to internal or if an incorrect mnemonic is used, an error will occur. If an error occurs, the transmitter will return “ERR DS(RC) X <CR>” to indicate the error and return the current data source setting for the transmitter.

- c. Query Internal Data Pattern. “ID(P) <CR>” queries the currently set internal data pattern and returns “ID(P) X <CR>” where integer X is represented in the above table.
- d. Example Command Use. This feature can be used for system characterization and troubleshooting. A known bit pattern can be used to test and characterize telemetry systems end-to-end or isolate baseband signal problems to the transmitter.

5.2.4 Clock Source. The clock source is set or queried with the “CS(CLKS)” mnemonic.

- a. Set Clock Source. Use “CS(CLKS) X <CR>” where X corresponds to a 1 or 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Source
CS(CLKS) 0	External
CS(CLKS) 1	Internal

Internal data must first be selected before this command can be valid. If this is not done prior to the command and/or an incorrect input value is given, the result would constitute an incorrect clock source command. In the event of an incorrect command, the transmitter will return “ERR CS(CLKS) X <CR>” to indicate the error and the current clock source setting for the transmitter.

- b. Query Clock Source. “CS(CLKS) <CR>” queries the currently set clock source and returns “CS(CLKS) X <CR>” where integer X is represented in the above table.
- c. Example Command Use. Internal data can be clocked either with an external or internal clock. This command allows the user to clock the known data with an existing external clock or select the internal clock for more flexibility.

5.2.5 Internal Clock Rate. The internal clock rate is set or queried with the “IC(R)” mnemonic.

- a. Set Internal Clock Rate. Use “IC(R) XX.XXX <CR>” where XX.XXX corresponds to the clock frequency in MHz. Actual range for the clock frequency is left to the manufacturer but should correspond to the specified useable input clock frequency range. Resolution should be +/-1 kHz. Accuracy for the internal clock is left to the manufacturer but should correspond to internal values for the transmitter. If the command is accepted, an “OK <CR>” is issued as a response.

Internal clock source must be selected first in order for this command to be valid. This requirement and/or an incorrect input value would constitute an incorrect internal clock rate command. In the event of an incorrect command, the transmitter will identify the error, default to its current state, and return “ERR CS(RC) X <CR>” where “X” indicates indicate the current clock source for the transmitter.

- b. Query Internal Clock Rate. “IC(R) <CR>” queries the currently set internal clock rate and returns “IC(R) XX.XXX” where XX.XXX is the current set internal clock rate in MHz.

**5.2.6 Forward Error Correction.** Forward error correction is set or queried with the “FC(FEC)” mnemonic. If a type of forward error correction is implemented in the transmitter, this command will enable or disable or query the current setting.

- a. **Set Forward Error Correction.** Use “FC(FEC) X <CR>” where X corresponds to a 1 or 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Source
FC(FEC) 0	Disable
FC(FEC) 1	Enable

In the event of an incorrect Forward Error Correction command, the transmitter will return “ERR FC(FEC) X <CR>” to indicate the error and return the current forward error correction setting for the transmitter.

- b. **Query Forward Error Correction Setting.** “FC(FEC) <CR>” queries whether or not FEC is set. The current setting is returned with “FC(FEC) X <CR>” where integer X is represented in the above table.

**5.2.7 Multiple Forward Error Correction.** In the event that more than one version of FEC is implemented in the transmitter, a second mnemonic “FC(FEC) YYYY” will be added, where YYYY refers to the type of FEC implemented.

- a. **Set Specific Forward Error Correction.** Use “FEC YYYY X <CR>” where X corresponds to 0 through 9 for 10 different types, if required, of that specific forward error correction. If the command is accepted, an “OK <CR>” is issued as a response.
- b. **Examples of FEC codes.** The following table is provided for reference.

Command	Type
TPC	Turbo Product Code
RS	Reed-Solomon Code
LDPC	Low Density Parity Check Code

Error reporting and querying will be done in the same fashion as paragraph [5.2.6](#). To turn off multiple forward error correction, the “FC(FEC) 0 <CR>” will be issued.

5.2.8 RF Power (Hi/Low). High output power or low output power is set or queried with the “RP(RPWR)” mnemonic. Low output power is determined to be the lower of two output power settings.

- a. Set RF Output Power. Use “RP(RPWR) X <CR>” where X corresponds to a 1 or a 0. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Output RF Power Level
RP(RPWR) 0	Low
RP(RPWR) 1	High

- b. Query RF Output Power Level. “RP(RPWR) <CR>” queries the currently set output RF power level and returns “RP(RPWR) X <CR>” where integer X is represented in the above table.

In the event of an incorrect RF Power command, the transmitter will return “ERR RP(RPWR) X” to indicate the error and return the current RF Power setting for the transmitter.

- c. Example use. The low setting could be used for lab testing or ground checks when transmitter and receive antennas are co-located. The high power setting is for normal, over-the-air telemetry transmission.

5.2.9 Internal Temperature. Internal temperature is only a query with the “TE(MP)” mnemonic.

Using the Query Internal Temperature “TE(MP)” will query the current internal temperature of the transmitter and returns “TE(MP) XXX” where XXX is the current internal Celsius temperature of the transmitter.

5.2.10 Deviation Sensitivity. The sensitivity to an analog input can be set or queried with the “DV(DEV)” mnemonic.

- a. Set Deviation Sensitivity. Use “DV(DEV) X.XX <CR>” where X.XX corresponds to the deviation sensitivity in MHz/V. Range of the sensitivity adjustment is left up to the transmitter manufacturer. If the command is accepted, an “OK <CR>” is issued as a response.

PCM/FM mode must be selected first in order for this command to be valid. If this is not done prior to the command and/or an incorrect value would constitute an incorrect deviation sensitivity command. In the event of an incorrect command, the transmitter will return “ERR DV(DEV) X.XX <CR>” to indicate the error and the current deviation sensitivity setting for the transmitter.

- b. Query Deviation Sensitivity. “DV(DEV) <CR>” queries the deviation sensitivity and returns “DV(DEV) X.XX <CR>” where X.XX corresponds to the deviation sensitivity in MHz/V.

5.2.11 Low Power Consumption, Sleep Mode. The transmitter can be placed into a mode of low input power consumption with the “SP(SLP)” mnemonic.

- a. Set Low Power Mode. Use SP(SLP) X where X corresponds to a 1 or 0 as shown in the following table. If the command is accepted, an “OK <CR>” is issued as a response.

Command	Source
SP(SLP) 0	Full Operation Mode
SP(SLP) 1	Sleep Mode

Sleep mode powers down all nonessential circuitry within the transmitter to reduce input power consumption. Note, in order to return from “sleep” mode, the transmitter must monitor and recognize the SP(SLP) 0 command. In the event of an incorrect command, the transmitter will return “ERR SP(SLP) X <CR>” to indicate the error and the current power mode setting for the transmitter.

- b. Query Power Mode. “SP(SLP) <CR>” queries the power mode setting and returns “SP(SLP) X <CR>” where integer X is represented in the above table.

## 6.0 Transmitter Communication Example

A typical terminal window is shown below for clarity. Transmitter communication initialization is assumed.

```

>FR 1435.5
>OK
>FR
>FR 1435.5
>MO 0
>OK
>DE 1
>ERR DE 0
>MO 7
>ERR MOD 0
>RGDW
>ERR
>TE
>TE 085
>QA
>FR 1435.5
>MO 0
>DE 0
>RA 1
>RF 1
>

```

## 7.0 Non-standard Commands

### NOTE



This paragraph is reserved for transmitter commands that fall outside of the commands and command structure discussed above. Additions to this section will be made as non-standard commands are derived and found applicable to this standard.

## 8.0 Physical Layer(s)

The above command sets are independent of the physical layer over which the commands are transferred. The command set should be implemented in such a way that it can be translated over any physical layer interfacing with the transmitter.

8.1 Serial Interface. Should a three-wire serial interface be chosen, it should be implemented via a three wire serial interface compatible with EIA232 (<http://www.eia.org/>). The intent of this standard is not to force complete EIA-232 compliance; Rather, the intent is to establish a serial communication interface with the transmitter so that any terminal program, such as Windows® HyperTerminal, or Linux Minicom, can be used to communicate with the transmitter. A transmit (Tx) and receive (Rx) line will be supplied with an associated ground return; the choice of connector pin-out being left up to the manufacturer. The serial interface will operate at one of

the common transfer rates. Typical baud rates are 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200 baud. The default shall be 9600 baud. Should operation at another baud rate be desired, a command must be implemented to accommodate this capability. The command shall have the form BD(BAUD) as described below.

- a. Baud Rate. Serial communication baud rate shall be set or queried with the “BD(BAUD)” mnemonic.
- b. Set Baud Rate. Use “BD(BAUD) X <CR>” where X corresponds to a number (0-9) in the following table. If the command is accepted, an “OK” <CR>” is issued as a response.

Command	Rate
BD(BAUD) 0	300
BD(BAUD) 1	600
BD(BAUD) 2	1200
BD(BAUD) 3	2400
BD(BAUD) 4	4800
BD(BAUD) 5	9600
BD(BAUD) 6	19200
BD(BAUD) 7	38400
BD(BAUD) 8	57600
BD(BAUD) 9	115200

- c. Query Baud Rate. “BD(BAUD) <CR>” queries the set baud rate of the transmitter and returns “BD(BAUD) X <CR>” where integer X is represented in the above table.

In the event of an incorrect baud rate command, the transmitter will return “ERR BD(BAUD) X” to indicate the error and return the current baud rate setting for the transmitter.

Communication should be compatible with a terminal set-up consisting of one of the above baud rates with 8 data bits, 1 stop bit, 1 start bit, and no parity. ASCII characters will be transmitted and received. No hardware or software handshaking should be implemented and connector pin-out is left to the manufacturer.

\*\*\*\* END OF APPENDIX N \*\*\*\*