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Red text indicates required commands for our interfacing requirements
Link Communications, Inc.

COMPUTER CONTROLLED RADIO PROTOCOL SPECIFICATION

TIMS Work Product ID: --------

Owner: Edmond Chow

Approver(s) – Signature & Date

……..……

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Table of Contents

1 INTRODUCTION

1.1 Purpose of Document

The purpose of this document is to specify the Computer Controlled Radio protocol version 2.00 used in Tait TM8100 mobile.

1.2 Scope of Document

This document specifies the terminal to DTE protocol only.
It does not specify the on-air Conventional Data Protocol (CDP).
This document applies to analogue radio terminals.
This document does not apply to digital radio terminals.

1.3 Document Conventions

The following conventions are used throughout this document:

1.3.1 Requirements

All requirements as specified in this document are identified by a tag-name printed in (green) ***BOLD_ITALICS.*** The requirements' text immediately follows the tag-name on the next line.

The tag-name has the following format:
<type>_<deliverable>_identifier-text>, where;

<type> =	**F**	(Function)	Behaviour of system
	P	(Performance)	Performance of the system
	C	(Characteristic)	Characteristics of the system

<deliverable> =

	CCRPROT	(CCR Protocol)

<identifier> = Free text format

All references to tags have the same tag string, except they are not in bold and Italics. They are printed in blue and are linked to the actual requirement.

1.3.2 Background information

Information not to be considered as requirements, but rather as background information is printed in *Italics, preceded* by [INFO: and terminated with]

For example:

[INFO: this is background information]

1.3.3 Number Bases

Hexadecimal numbers are marked as such with the C programming language notation prefix '0x'.

1.4 References

[CCR_T2016_PROTOCOL]	*T201x Computer Controlled Radio Protocol, Issue 0.06, Project M808*, Tait Electronics Ltd, 24th February 2000.
[CCR_T2016_Design]	*T2016 - SID Implementation Document, Issue 0.02, Project M808*, Tait Electronics Ltd, 17th April 2000.
[CDPPROT]	*Conventional Data Protocol Specification, Issue 1.01 FINAL*, Tait Electronics Ltd, 19th June 2003.
[CCDI_TOP_CONV]	*Computer Controlled Data Interface TOP Orca Conventional*, Issue 0.10, Enhancement and Support, Tait Electronics Ltd, 10 October2002.

[CCDI_NM_REQS] *Network Management Requirements for the CCDI Protocol – Draft*, Jan Noordhof, Tait Electronics Ltd, 24 January 2002.

1.5 Glossary

Term	***Definition***
AVL	Automatic Vehicle Location
CCDI	Computer Controlled Data Interface
CDP	Conventional Data Protocol (Tait proprietary OTA protocol)
FEC	Forward Error Correction
FFSK	Fast Frequency Shift Keying (of audio subcarrier)
GFI	General Format Information (for an SDM)
OTA	Over The Air
SDM	Short Data Message
SFI	Specific Format Information (for an SDM)
THSD	Tait High Speed Data
TOP	Tait Orca Portable

1.6 Document History

Date	***Document Version***	***CCR Version***	***Author***	***Comment***
03/10/03	0.01	2.00	Edmond Chow	Created for TM8100 mobile.
20/10/03	1.00	2.00	Edmond Chow	Updated following review.

2 OVERVIEW

2.1 Protocol Overview

The Computer Controlled Radio protocol (CCR) is intended to provide a means of controlling a radio unit from some form of Data Terminal Equipment (DTE) via a serial interface.

2.2 Scope

This specification applies to version 2.00 and later of the protocol only. Appendix 1 contains historical information concerning earlier versions of the protocol

3 REQUIREMENTS

3.1 Serial Communication Parameters

The RS232 communication between the DTE and the RU requires the following parameters:

In Command and Transparent mode;

Baud rate = 1200, 2400, 4800, 9600, 14400 or 19200 baud.
Number of data bits = 8
Parity = none
Number of stop bits = 1

3.2 Programmable Parameters

The following programmable parameters are used in the RU to specify CCDI Operation.

Option	Usage
Data Option (CCDI Enable)	If enabled, CCDI command processing is enabled. If disabled, CCDI command processing is disabled.
Transparent Mode Enabled	If disabled, CCDI 'Transparent Mode' command will not be accepted.
XON Character	Character used to signify XON during transparent mode operation. (only relevant if software handshake is selected)
XOFF Character	Character used to signify XOFF during transparent mode operation. (only relevant if software handshake is selected)
Transparent Mode Auto Start	If enabled, the RU will power up in transparent mode
Transparent Mode Baud Rate	The baud rate while the RU is in transparent mode.
Disable Transparent Mode Escape Sequence	If enabled, the RU will ignore reception of any incoming escape sequence. If disabled, the RU will act upon reception of the escape sequence and will exit transparent mode.
SDM Option (SDM Tx Rx Enable)	If enabled, SDM transmission and reception is enabled. If disabled, SDM transmission and reception is disabled.
SDM Auto Acknowledge	If enabled, an auto-acknowledge signal will be generated in response to incoming SDM's. If disabled, no auto-acknowledge signal will be generated in response to incoming SDM's
SDM Auto Acknowledge Delay	The delay between reception of a SDM and the initiation of the sending of an auto-acknowledge signal. Typically from 100ms to 12s in steps of 100 ms.
SDM Wait for Acknowledgement	The period of time the RU will wait after sending an SDM to receive an auto-acknowledge before re-sending the SDM. Typically from 1 to 20 seconds in steps of 1 second.
Data Identity	Identity for receiving an SDM. Up to 8 characters from A to Z, 0 to 9 and *.
Data Lead-in Delay	Delay after transmission start prior to transmitting data. Typically 40ms to 5.1s in steps of 20ms.
Ignore Subaudible Signalling	If enabled, all incoming data transmissions are processed regardless of subaudible signalling. If disabled, the RU only processes incoming data transmissions for which the subaudible signalling is valid.

3.3 Command Protocol

The DTE is connected to the RU via RS232 serial link. Command and response messages are generated

between the DTE and the RU.

3.4 Command Description

This section details the standard messages.

3.4.1 Message Format

All COMMAND MODE message packets take the general form:

[IDENT][SIZE][PARAMETERS][CHECKSUM]<CR>

[IDENT]	The message identifier. Identifiers are single ASCII characters which categorise the message type.
[SIZE]	The number of characters which make up the [PARAMETERS] field. [SIZE] is an 8-bit number expressed in ASCII-hex notation (two characters).
[PARAMETERS]	An optional field, depending upon the command. Parameter values are generally character strings unless explicitly stated otherwise. Parameter type is dependent upon the command - there is no explicit type definition.
[CHECKSUM]	An 8-bit checksum of fields [IDENT], [SIZE] and [PARAMETERS]. It is expressed in ASCII-hex notation (two characters).
<CR>	The packet terminator. It is the ASCII “carriage return” character (0Dh).

General characteristics of the message format worth noting are:

* All characters in a message are printable ASCII.
* Where numeric values are represented in ASCII-hex notation (two characters per byte), digits A...F are upper case.
* The minimum length of a command packet is 5 characters i.e. when [SIZE] = 00. For example, c003D is the CANCEL command which is 5 characters.
* The maximum length of the [PARAMETERS] field is 32 characters. The maximum length of the command packet is therefore 37([SIZE]=”20") characters.

3.4.1.1 Calculating [CHECKSUM]

[CHECKSUM] is calculated by applying the following algorithm:

1. Take the modulo-2 sum of all message bytes preceding [CHECKSUM].
2. Retain bits 0...7, discarding any higher order bits resulting from the summation.
3. Form the two’s complement of the remainder.
4. Convert the binary number into two ASCII-hex digits, MSD first.

3.5 CCR Mode

CCR mode will override all normal operation except for a few digital i/o lines. CCR mode will block the following operations:

- Channel selection
- Scanning
- Emergency

3.6 Messages to RU

The following messages are sent from the DTE to the RU;

Message	Cmd	Function	
Rssxxxxxxxxxcc	R	Go to receive frequency	
Essxxxxxxxxxcc	T	Load transmit frequency	
Hssxcc	H	Set bandwidth	
Jssxxcc	J	Set volume level	
Assxxxxcc	A	Receive ctcss value	

Bssxxxxcc	B	Transmit ctcss value	
Fssxxxxxxxxxaaaacc	F	Go to receive frequency and set rx ctcss.	
Sssxxxxxcc	S	Encode Selcall sequence	
Isstplcc	I	Set Selcall Parameters	
Nsspxxxxxcc	N	Set ANI	
Mssxcc	M	Quick Commands	
Qssxcc	Q	Query Commands	
Esscc	E	Exit CCR Mode	

In all cases, if the command is received without error by the RU and all parameters are valid, the command will be executed and the prompt will be returned to the DTE. If an error arises, the DTE will be notified with an appropriate response.

3.6.1 Go to Receive frequency: Rssxxxxxxxxxcc

Where

- ASCII letter R denotes the go to Receive frequency
- ASCII number xxxxxxxxx is the receive frequency.
- ASCII hex numbers CC is the checksum.

Description: On receipt of this command the radio checks the format and does a range check on the frequency. If valid the radio sends an ACK response and then initialises the synthesiser with the new frequency. The control head should allow 20ms for the synthesiser to settle at the new frequency. If the command is invalid a NAK response will be sent and the receiver will remain at the last selected frequency. If the radio is transmitting then a NAK response will be sent.

Effect: This command has immediate effect with the receiver retuning to this channel. If the synthesiser is out of lock then a NAK response will be sent.

3.6.2 Load Transmit frequency: Tssxxxxxxxxxcc

Where

- ASCII letter T denotes the Load Transmit Frequency command.
- ASCII number xxxxxxxxx is the transmit frequency.
- ASCII hex numbers CC is the checksum.

Description: On receipt of this command the radio checks the format and does a range check on the frequency. If valid the radio sends an ACK response. If the command is invalid a NAK response will be sent and the transmit frequency will not change. If the radio is transmitting then a NAK response will be sent.

Effect: This command loads the transmit frequency into a memory location for use when the PTT or Selcall encoder is next active. The radio will not transmit if the synthesiser is out of lock.

3.6.3 Set Bandwidth: Hssxcc

Where

- ASCII letter H denotes the Set Bandwidth command.
- ASCII number x is the Bandwidth Index

'0' - Narrowband	'2' – Wideband
'1' - Mediumband	

- ASCII hex numbers CC is the checksum.

Description: This command sets the operating transmit/receive bandwidth. If the index number is out of range the radio will not act on the command and sends a NAK (range error) back.

Effect: This command has immediate effect.

3.6.4 Set Volume Level: Jssxxcc

Where

- ASCII J denotes the set Volume Level command.
- ASCII hex numbers xx is a volume level value in the range of 0-255.
- ASCII hex numbers CC is the checksum.

Description: This command sets the volume level for received audio. If the index number is out of range the radio will not act on the command and sends a NAK (range error) back.

Effect: This command has immediate effect.

3.6.5 Receive CTCSS value: Assxxxxcc

Where

- ASCII A denotes the receive CTCSS value load command.
- ASCII numbers xxxx is a receive CTCSS frequency in 0.1Hz.
- CC is the checksum .

Description: This command disables (if xxxx=0) or enables RX CTCSS (if xxxx>0). If the frequency is out of range the radio will not act on the command and send a NAK (range error) back.

Effect: This command has immediate effect and will close the mute to signals without a valid CTCSS tone.

3.6.6 Transmit CTCSS value: Bssxxxxcc

Where

- ASCII character B denotes the transmit CTCSS value to be sent on transmit.
- ASCII number xxxx is a transmit CTCSS frequency in 0.1Hz
- CC is the checksum.

Description: This command disables (if xxxx=0) or enables TX CTCSS (if xxxx>0, see appendix). If the reference number is out of range the radio will not act on the command and send a NAK (range error) back to the radio. If the radio is transmitting then a NAK response will be sent.

Effect: This command loads the value into memory ready for the next PTT or Selcall encode activity.

3.6.7 Go to Receive frequency and set Rx CTCSS: Fssxxxxxxxxxaaaacc

Where

- ASCII letter r denotes the go to Receive frequency
- ASCII number xxxxxxxxx is the receive frequency in Hz.
- ASCII number aaaa is a receive CTCSS frequency in 0.1Hz.
- ASCII hex numbers CC is the checksum .

Description: This command merges the Fssxxxxxxxxxcc and the Axxxxc commands into one to save unnecessary overhead when running operation is implemented by the control head. The command has immediate effect with the receiver retuning to this frequency

Note: The command is processed in the following order: set receive frequency first then CTCSS. If any of the 'sub-commands' cause an error a NAK is sent back to the radio. However, if the error occurs in the CTCSS part the receiver frequency will still be set to the new value. If the radio is transmitting then a NAK response will be sent.

Effect: This command has immediate effect with the receiver retuning to this channel and disabling/activating CTCSS.

3.6.8 Encode Selcall sequence: Sssxx..xxcc

Where

- ASCII letter S denotes the Transmit Selcall tone sequence.
- Xx..xx is the tone sequence
- CC is the checksum .

The Set Selcall Parameter command (see below) allows the user to change the Selcall parameter defaults.

Description: This command will turn the transmitter on and send the Selcall string following a short delay (network 0 lead-in delay). When the Selcall transmission is complete the ACK will be sent back to the radio. Until then all other commands are ignored and the control head should wait for an up to 2 seconds for the ACK. If the number of tones is incorrect the command is rejected (NAK-format error). It is also rejected if either the receive or the transmit frequencies have not yet been initialised (sequence error).

Effect: This command has immediate effect, provided that the receiver and transmitter frequency values have been initialised and the radio is not transmitting at the time (PTT active causes busy error)

3.6.9 Set Selcall Parameters: Isstplcc

Where

- ASCII letter I denotes the set Selcall parameter command.
- 't' specifies the Tone Set to use this can be one of the following:

'0' – CCIR	'5' – ZVEI-III
'1' – EIA	'6' – PZVEI
'2' – EEA	'7' – NATEL
'3' – ZVEI_I	'8' – DZVEI
'4' – ZVEI_II	

- 'p' specifies the Tone Period to use. In accordance with the SigTec M1708 documentation, this can be one of the following:

'1' – 20ms	'5' – 60ms
'2' – 33ms	'6' – 70ms
'3' – 40ms	'7' – 100ms
'4' – 50ms	

- 'L' sets the number of tones in the Rx and TX sequence. Permitted values are 5, 6, 7 and 8.

Description: This command allows the user to modify the Selcall default parameters. If any of the command parameters are out of range a NAK (range error) will be sent back to the control head.

Effect: This command loads the value into memory. The Selcall modem is immediately re-initialised with the new decode parameter map. These new parameters will be applied for the next Selcall decode/encode sequence.

3.6.10 Set ANI: Nsspxx..xxcc

Where

- ASCII letter N denotes the Automatic Number Identification command.
- P denotes the ANI position with regard to PTT pressed. Allowed values are:
  - '0' – disables ANI. In this case the tone sequence xx..x is not required.
  - '1' – leading ANI. ANI is sent soon after PTT is pressed
  - '2' – trailing ANI. ANI is sent when PTT is released
  - '3' – combination of 1 and 2
- xx..xx is the 5-8 tone sequence. It is optional if p is set to 0
- CC is the checksum .

Description: This command disables or enables ANI. If p is not '0', the tone sequence gets stored.
If the number of tones (xx...xx) does not match the currently configured length then the command is rejected (NAK- format error). It is also rejected if p is out of range (range error).

Effect: If enabled the ANI tones get stored and any subsequent use of the PTT button will activate ANI.

Note: If a Set Selcall Parameter command changes the number of tones ('L' parameter – see above) then a matching Set ANI command should follow.

3.6.11 Monitor commands: Mssxcc

Where

- ASCII letter M indicates it is a short command.
- X maps to a list of quick commands
- CC is the checksum .

Description: This specifies a range of single character sub-commands. An undefined sub-command will cause a NAK (undefined command error)

3.6.11.1 Override all mute functions (mute open): M01Dcc

Description: This command opens mute.
Effect: Immediate

3.6.11.2 Close mute to previous level (mute shut): M01Ecc

Description: Where E denotes mute re-enabling.
Effect: Immediate

3.6.12 Transmitter power output High: Pssxcc

Where

- x is a index to transmit power level

'1' – Very low power	'3' – Medium power
'2' – Low power	'4' – High power

- cc is the checksum

Description: The transmitter power output level is set to high.
Effect: On next PTT or Selcall activity. Will not have immediate effect if transmitter is already on.

3.6.13 Query commands: Qssxcc

Where

- ASCII letter Q indicates it is a query command as opposed to a set-up command.
- x maps to a list of quick commands
- CC is the checksum .

Description: Like the Quick command the Query command specifies a single character sub-command. But unlike the Quick command the format of the response is not an ACK or NAK, unless the sub-command is undefined (undefined command error). The response formats are described below.
Effect: These commands invoke an immediate reply.

3.6.13.1 Radio Pulse: QssPcc

Description: The radio pulse command allows to check that the radio is still responding. The control device may use the radio pulse command every ten seconds in the absence of other activity.

Response: The radio will send back one of two responses:

- QssPcc (same as command) if the radio has got its minimum configuration which typically consists of the receive command]R…[.
- QssDcc is returned if the radio has loaded its default set-up and has not yet received an]R…[(receive frequency) command. The control head may use this to check that the radio has powered up and is ready for set-up commands.

3.6.14 Exit CCR Mode command: Esscc

Description: The radio will initiate a software reset (same as for "^").

Effect: This command is immediate.

3.7 Messages from RU

The following messages may be returned to the DTE.

Message	Cmd	Function	
Vssxx..xxcc	V	Selcall decode sequence	
Msspcc	MP	Ptt exceeds max transmit limit	
Mssrcc	MR	CCR initialised	
+ssxcc	+X	ACK	
-ssrxcc	-r	NAK	
Qssx..cc	Q	Query command response.	

Note that in all cases, the prompt character will be issued after the RU response to terminate the transaction and signify that another may begin.

3.7.1 Selcall decode sequence: Vssxx..xxcc

Where

- ASCII letter V denotes the Selcall decode message
- Xx..xx is the decoded tone sequence according to set format.
- C is the checksum as defined.

Description: The radio will send this response when the Selcall modem has received a tone sequence with the currently configured number of tones.

3.7.2 PTT exceeds max transmit limit MssPcc

Where

- P denotes a PTT being applied which has exceeded the default TOT
- cc is the checksum.

Description: The radio uses this response to advice the control head that PTT has reached the transmitter active timeout limit (90 seconds). After another short delay (10 seconds) the radio will turn the transmitter off.

3.7.3 CCR Initialised MssRcc

Where

- R denotes a radio has completed software reset.

Description: The radio is initialised to CCR default settings and is now ready to receive set-up commands.

3.7.4 ACK - NAK RESPONSE MESSAGES

The radio checks a received command to see if it is valid. These checks are performed in the following order:

- internal buffer overflow while receiving the command (prompts an immediate NAK)
- valid terminator <CR>. Unless this is present no further checks are done and no response is sent back to the control head
- checksum test
- valid command letter
- data length check
- range check on message data and format where appropriate (see comments on individual commands)
- correct sequence of commands where appropriate (see comments on individual commands)

3.7.4.1 ACK

Once the command is verified an ACK response is sent back (except for Q commands – see above). Only in some cases the ACK may be delayed but usually it is sent back immediately. The format of the ACK is "+ssxcc"

Where
- the ASCII + character indicates that the command was accepted
- X echoes back the command letter (R,T,A,B,S,M,…)

3.7.4.2 NAK

If the command does not verify a NAK response is sent back. The format of the NAK is
"-ssrxcc"
Where
- the ASCII - character indicates that the command was rejected
- 'r' indicates the reason for rejecting the command. The reasons are:
  - '01' Invalid command
  - '02' checksum error
  - '03' parameter error in command
  - '04' Invalid terminating error.
  - '05' Radio is busy.
  - '06' Command is not accepted.
- X echoes back the command letter, but only if the checksum in the command was correct.

4 APPENDIX 1 – Historical Information

4.1 CCR Version 0.06: T2016 implementation.

4.1.1 PROTOCOL

This section contains the basic command structure, inter unit protocol and the physical interface specification. Any communications will be referred to as a signalling packet or packet. X is used in packet formats to denote variable values.

4.1.2 BASIC COMMAND FORMAT

This document refers to messages from the control head to the radio as "commands" and for message from the radio to the control head as "responses". The proposed format of commands and responses are as follows:

a) All signalling packets will be delimited with the ASCII character "] " at the beginning and end with " [".
b) To maintain efficiency packets will be of a variable length within the delimiters.
c) The last two characters in the packet prior to the delimiter will be an 'ASCIIised' checksum based on the LSB of the sum of all the previous byte values excluding the initial delimiter.
d) Each command is acknowledge by the radio. In most cases this is done by an ACK or NAK type message described below.
e) No response is expected by the radio for radio initiated messages to the control device.

4.1.3 DEFAULT SETTINGS

a) At power-up the radio initialises following default settings:
b) TX frequency = 000.0000 MHz
c) RX frequency = 000.0000 MHz
d) TX CTCSS = none
e) RX CTCSS = none
f) Transmit off and inhibited until valid TX frequency received
g) RX audio muted until valid RX frequency received
h) Selcall tone set is ZVEI-I with 40ms tone period and 5 tone sequence (no gaps)

4.1.4 Control device to radio commands

Message	Cmd	Function	
]RFXXXXXCC[	R	Go to receive frequency	
]TFXXXXXCC[	T	Load transmit frequency	

]AXXCC[	A	Receive ctcss value	
]BXXCC[	B	Transmit ctcss value	
]rFXXXXXAACC[	r	Go to receive frequency and set rx ctcss.	
]SXXXXXCC[	S	Encode Selcall sequence	
]ITPLCC[	I	Set Selcall Parameters	
]NPXXXXXCC[	N	Set ANI	
]MXCC[	M	Quick Commands	
]QXCC[	Q	Query Commands	

4.1.5 Radio to control device messages

Message	Cmd	Function	
]VXX…XXCC[	V	Selcall decode sequence	
]MPCC[	MP	Ptt exceeds max transmit limit	
]MRCC[	MR	Radio reset complete	
]+XCC[	+X	ACK	
]-rXCC[	-r	NAK	

4.1.6 PHYSICAL INTERFACE SPECIFICATION

This section describes the basic electrical interface and the parameters, which are to be used to send the command and message packets over the wire link between the Control device and the radio.

The radio will accept (see note A) standard RS232 polarity levels allowing a terminal emulation to access the radio. The radio will accept (see note A) either full RS232 levels or TTL levels of the same polarity. The minimum level of the positive voltage is +3.5V

The suggested format is 4800 baud with 8 data bits and one stop bit, No parity. A character - including the start bit - thus takes about 2.08ms to transmit (21ms for a frequency change command, provided there are no inter-character delays)

Note:

- A Tait or third party interface board fitted into the radio must provide communications signal inversion circuits as per the standard Tait control head. This allows the radio to accept standard RS232 polarity signals.
- For most applications an interface board will be required to provide hand signals to the external control device. Details of the interface connections available within the radio are provided in the product service manual.