Rotronix Ltd.
Software-Hardware-Design

Professional Mobile Radios

Computer controlled Radio-interface (CCRI)

Protocol Manual
version 01-03

Contents

Preface:

Scope of Manual

This manual contains reference information about the CCRI protocol for the Motorola Professional Mobile Radios CCRI option board. It applies to CCRI version 1.01 and radio software version R03.10.03 and later versions.

Publication Record

Issue	Publication Date	Author	Description
1.01	December 2007	Hans de Roode	First issue
1.02	January 2008	HDR	Corrected start-up description on page 16 and 21
1.02/1	January 2008	HDR	Added 'alert' f41-- command on page 14
1.02/2	August 2008	HDR	Corrected Auxiliary connector pin 1 indication

Associated Propriety Documentation:

Motorola service manual
Motorola PROIS 2.03 Manual
Motorola PROIS 2.03 Electrical Manual: (Part No: 1202899J28)

Supported Portable Radios:

GM340, GM360, GM380, GM339, GM399, PRO3100, CDM750, GM140,PRO5100, CDM1250, PRO7100, CDM1550, GM160, GM338, GM398, CDM1550LS+,GM338LS.

Alert Notices:

Within this manual, four types of alerts are given to the reader: warning,
caution, important and note. The following paragraphs illustrate each type
of alert and its associated symbol.

Warning!!
This alert is used when there is a potential risk of death or serious injury.

Caution
This alert is used when there is the risk of minor or moderate injury to people.

Important
This alert is used to warn about the risk of equipment damage or malfunction.

Note
This alert is used to highlight information that is required to ensure that procedures are performed correctly.

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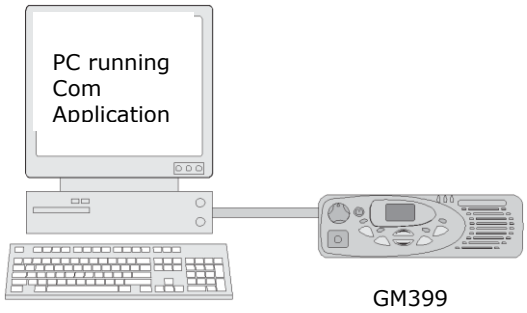
Abbreviations:

Abbreviation	Description
3DK	Third-Party Developer's Kit
ASCII	American Standard Code for Information Interchange
AVL	Automatic Vehicle Location
CCRI	Computer Controlled Radio Interface
CRC	Cyclic Redundancy Check
CTCSS	Continuous Tone Coded Squelch System
CTS	Clear to Send
DCE	Data Circuit-Terminating Equipment
DCS	Data Carrier System
DTE	Data Terminal Equipment
DTMF	Dual Tone Multi-Frequency
FEC	Forward Error Correction
FFSK	Fast Frequency Shift Keying
GPIO	General Purpose Input/Output
IPN	Internal Part Number
LED	Light-Emitting Diode
MSD	Most Significant Digit
NMEA	National Marine Electronics Association standard. Combined electrical and data specification for communication between marine electronics and GPS
PC	Personal Computer
PTT	Press To Talk
PROIS	Motorola proprietary Professional Radio Option Interface Specification
RMC	Recommended Minimum sentence C. NMEA GPS message type for the minimum recommended
RTS	Request to Send
Rx	Receive
RXD	Receive Data
SDM	Short Data Message
TX	Transmit
TXD	Transmit Data
UART	Universal Asynchronous Receiver-Transmitter
XON	Transmitter On
XOFF	Transmitter Off

Introduction:

The Computer Controlled Radio Interface (CCRI) protocol is a Rotronix Ltd proprietary command protocol embedded in the PROIS option board for the Motorola Professional Mobile Radios and GM399 radios, and used for communicating with the radio via an asynchronous serial port.

The radio is the DCE and is connected directly to the DTE, usually a PC, via the serial port.



One mode of operation is available:

- Command mode

When in Command mode, commands and response messages are passed between the PC and the radio using the CCRI protocol. CCRI commands can also be used to obtain GPS data and NMEA messages from the radio (Note: Not yet implemented). When in Command mode, communication between the PC and the radio is set to 19200 baud.

1.1 Compability

This manual supports CCRI version 1.xx and later.
The radio programming software used should be the latest released version for the Motorola Professional Mobile Radios. Refer to the Motorola authorized dealer for the latest version.

1.2 Serial ports

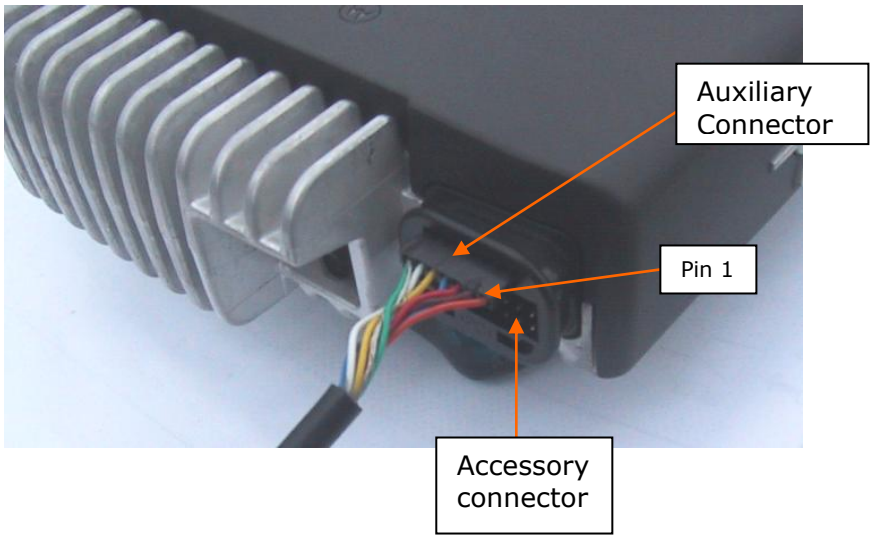
There is one port available for CCRI asynchronous serial communication with the Motorola Professional Mobile Radio (inverted 3.3V logic). The microphone and accessory port are used for the programming of the radio. The internal options connector is used for connecting to the option board.

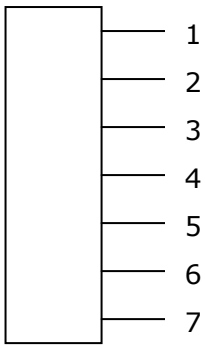
1.3 Auxiliary connector

The auxiliary connector is the interface for optional external devices that are typically connected to a radio. The auxiliary connector is a 7-way flat-socket. The auxiliary connector provides a serial port, and audio I/O.

Note The space for a mating plug is limited to 18.6 mm width and 2.6 mm in height. It is recommended that you test the plug to be used before manufacturing a cable.

If the auxiliary cable is longer than 1 meter, it is recommended that the cable is shielded. The diagram shows the recommended shielding arrangement. The earth braid wire (bare copper) should only be earthed at the radio end of the cable.



Pinout	Pin	Description	Signal type
 rear view	1	Digital ground	Digital 0V
	2	Radio speaker audio in (Public address)	Analogue 0.3 Vpp.
	3	RX audio out.	Analogue 0.2 Vpp.
	4	TX audio in.	Analogue 0.2Vpp.
	5	Asynchronous serial port - Transmit data	Digital. 3V3 CMOS.
	6	Asynchronous serial port - Receive data	Digital. 3V3 CMOS.
	7	Analogue ground	Analogue 0V.

1.4 Before Operating

Before using CCDI, the following is useful to check.

- The radio must be correctly programmed for use with the PROIS protocol .
- The serial port of the radio is connected to a serial source like an embedded application or a desk-top computer via a suitable level-shifter, e.g. 3.3V to RS232 levels.

1.5 Limitations

Important Some data applications require extended transmission times. This may be for larger file transfers or for real-time telemetry information. This may put undue stress on the radio transmitter and care must be taken to control transmission times.

Command Modes

Command mode uses the T.L. Parker Ltd proprietary Computer Controlled Radio Interface (CCRI), a command protocol embedded in the PROIS option- board firmware, it is accessed using the serial port lines from the PC. In this mode, the baud rate between the computer equipment (DTE) and the radio (DCE) is 19200 baud.
In Command mode, the PC sends command sequences to the radio and waits for a prompt before beginning the next transaction. Some commands require the radio to send a CCRI message in response. Messages sent to the radio will always be responded to by the prompt.
Unsolicited messages such as PROGRESS or ERROR messages are sent by the radio if there is a significant change in its state that the PC should be aware of. If an error is detected, an unsolicited ERROR message is sent by the radio to the PC. The radio cannot send messages that require a reply.

2.1 Entering Command Mode

The radio will change to Command mode on receipt of the "hart-beat" command (f010 Check-Sum) and stays in command mode until 2 seconds have elapsed after the last "hart-beat" has been received. When in command mode the PC has full control of the radio, display and indicators e.g. in the case of a button press, the radio will only report the event to the PC.

2.2 CCDI Command Format

All CCRI message packets take the general form:
[IDENT] [SIZE] [PARAMETERS] [CHECKSUM] <CR>

- **[IDENT]** = The message identifier. Identifiers are single ASCII characters (lower-case alphabetical) which categorizes 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, and often has multiple parts.
- **[CHECKSUM]** = An 8-bit checksum of the **[IDENT]**, **[SIZE]** and **[PARAMETERS]** fields. Expressed in two character ASCII hex notation.
- **<CR>** = The carriage return (0Dh) packet terminator.

2.3 Restrictions

- All characters in a message are printable ASCII.
- Where numeric values are represented in ASCII hex notation (two characters per byte), characters A to F are upper case.
- The minimum length of a command packet is 5 characters. For example q002F is the QUERY command where **[SIZE]** = 00 as there is no **[PARAMETERS]** field required.
- The maximum length of the [PARAMETERS] field is 40 characters. The maximum length of the command packet is therefore 45 characters.

2.4 Calculating the CCDI [CHECKSUM]

[CHECKSUM] is calculated by applying the following algorithm:

1. Take the sum, modulo-256 of all message bytes preceding the **[CHECKSUM]**.
2. Form the two's complement of the sum.
4. Convert the binary number into two ASCII hex digits, MSD first.

2.4.1 Checksum Example

s0D050800TESTHi!DA

1. Take the modulo-2 sum of all message bytes preceding [**CHECKSUM**].

   73h, 0 = 30h, D = 44h etc. therefore the sum is:
   73 + 30 + 44 + 30 + 35 + 30 + 38 + 30 + 30 + 54 + 45 + 53 + 54 + 48 + 69 + 21 = 426h

2. 426h mod 256 = 26h

3. Form the two's complement is 0 - 26h = DAh

4. Convert the binary number into two ASCII hex digits, 44h 41h.

2.5 Commands to the Radio

The following commands are available to send from the PC to control the radio.

Command	Command	Function
FUNCTION	f	controls various hardware, miscellaneous radio functions and heart-beat
GO_TO_CHANNEL	g	sets the radio to a particular channel

When a command is received without error by the option board and all parameters are valid, the command is forwarded to the radio, and an "Acknowledge" command is returned to the PC to signify that another may begin. If an error arises, the PC is notified with an appropriate "Not acknowledge" response or in the case of a parameter error, an Error-response message is send.

2.5.1 FUNCTION

The FUNCTION command provides access to various hardware and miscellaneous functions. It has the following format:

f [SIZE] [FUNCTION] [SUBFUNCTION] [QUALIFIER] [CHECKSUM]

- '**f** ' is sent as a single ASCII character and represents the FUNCTION command.
- **[SIZE]** two ASCII characters indicating the number of bytes In the PARAMETER fields.
- [**FUNCTION**] is a single ASCII characters representing the required function category.
- [**SUBFUNCTION**] is up to two ASCII characters and is used to extend the range of the [**FUNCTION**] parameter.
- [**QUALIFIER**] is an ASCII character string representing the action to be taken, depending on the value of [**FUNCTION**] and [**SUBFUNCTION**].

[FUNCTION]	[SUBFUNCTION]	[QUALIFIER]	Action
0 (functions)	0	none	Switch to **CCR mode**, needs to be send with intervals < 2 Sec.
	1	0	**Disable RX audio** (Mute radio).
		1	**Enable RX audio** (Unmute radio).
	2	0-25	**Enable volume and set level**. 0 = low, 25= max loudness.
	3	26	**Return volume control to the radio**
	4	0	**Disable Public Address Mode**.
		1	**Enable Public Address Mode**. (Enable audio input to the radio Audio Amplifier)
	6	10, 0	**Red** LED OFF
		11, 0	**Red** LED ON steady
		11, 1	**Red** LED ON steady, slow on/off
		11, 2	**Red** LED ON steady, fast on/off
		20, 0	**Green** LED OFF
		21, 0	**Green** LED ON steady

0 (functions)	6	21, 1	**Green** LED, slow on/off
		21, 2	**Green** LED, fast on/off
		30, 0	**Yellow** LED OFF
		31, 1	**Yellow** LED ON, steady
		31, 2	**Yellow** LED, slow on/off
		31, 3	**Yellow** LED, fast on/off
		40, 0	**Backlights** OFF
		41, 1	**Backlights** LED ON, steady
		41, 2	**Backlights**, slow on/off
		41, 3	**Backlights**, fast on/off
	7	20	**Speaker** Icon off
		21	**Speaker** Icon on
		30	**phone** Icon off
		31	**phone** Icon on
		40	**alarm** Icon off
		41	**alarm** Icon on
		50	**tone** Icon off
		51	**tone** Icon on
		60	**scanning** Icon off
		61	**scanning** Icon on
		70	**scan stopped** Icon off
		71	**scan stopped** Icon on
	8	0	**Microphone on, flat-audio input off**.
		1	**Microphone off, flat-audio input**
	9	0	**Transmitter off**
		1	**Transmitter on**
4 (user control)	1	**alert type:** **0 0:** 300 Hz 75 mS **0 1:** 910 Hz 75 mS **0 2:** 300 Hz 375mS **0 3:** 910 Hz 375 mS	**volume 0 -25** (0 = min, 25 = max) **26 = radio volume**
	3	**1**, max 14 ASCII char.	**Display text line 1**
		2, max 14 ASCII char.	**Display line text 2**
		3, max 14 ASCII char.	**Display text line 3**

2.5.1.1 Examples of FUNCTION commands are:

f0200D8 Enable Computer Control Radio Mode.
Also used as "heart-beat", time-out is 2 seconds.

f17 43 1 12345678901234 CS
Send text "12345678901234" to dislay line 1.

f06 41 01 10 CS
Sound alert tone 1 in radio speaker, with volume level 10
The tone is self-terminating

f04 0101CS
Mute speaker audio

f04 0100CS
Unmute speaker audio

2.5.2 GO_TO_CHANNEL

The GO_TO_CHANNEL command tells the radio to change to another conventional mode (channel) that is part of the radio code-plug. The specified channel can be assigned to a scan/vote group, or the GO_TO_CHANNEL command can load a "soft-channel" in the radio, specifying TX frequency, RX frequency. RX CTCSS frequency, TX CTCSS frequency and channel-width (12.5, 20 or 25 kHz).

The GO_TO_CHANNEL command has the following format:
g [SIZE] [ZONE] [CHANNEL_NO] [CHECKSUM]

'**g**' is sent as a single ASCII character and represents the GO_TO_CHANNEL command.
[**ZONE**] is a two-character string representing the new zone

- **ZONE = 02:**
  CHANNEL_NO is sent as two ASCII character and represents the channel number.
  Example:
  Hard-channel change to channel 1: g04020172


Note If the radio is switched to a channel with scan/vote enabled, it will adhere to the scan/vote conditions of that channel.

- **ZONE = 08:**
  Soft-channel change.
  CHANNEL_NO = (txFrequency/125) (rxFrequency/125) (txCTCSS*10) (rxCTCSS*10) 0 0

  Example: g 32 08 120610 11F350 04CE 04CE 38 00000000 9F


Note: frequencies are in Hertz.

TX = 147.650 , RX = 147.050, TX CTCSS = 123 Hz,
RX CTCSS = 123 Hz, low power, 12.5 kHz channel spacing.

The source-code of a software application is available from T.L. Parker Ltd Technical Support which will give examples of the use of the commands and calculate the checksum for any given command and parameters.
Please contact Technical Support (refer to "T.L. Parker Contact Information" on page 2).

2.6 Messages from the Radio

At switch-on of the radio, the radio sends the following message to the PC: **"Motorola GM399 date [DATE], build [BUILD]",**
Were "DATE" denotes the compile-date of the option-board and "BUILD" denotes the compile number of the option-board software

The following messages are sent from the radio to the PC. Some are solicited by commands from the PC, while others are unsolicited and are sent because of changes within the radio-status.

Command	Character	Function
ACKNOWLEDGE	+	Acknowledgement of a command
NOT ACKNOWLEDGE	-	Communication error in received command
ERROR	e	Transaction processing error
PROGRESS	p	Radio state progress report 1
PROGRESS	q	Radio state progress report 2
RADIO_SERIAL	n	Radio serial number

2.6.1 ACKNOWLEDGE

Solicited.
The ACKNOWLEDGE message advises the PC that the radio has received the command successfully.
The ERROR message has the following format:

+[SIZE] [COMMAND] [CHECKSUM]

- **[COMMAND]** is a single character representing the command sent to the radio.

2.6.2 NOT ACKNOWLEDGE

Solicited.

The "NOT ACKNOWLEDGE" message advises the PC that the option board has detected an error in the received command, this can be any of the following errors.

- **FRAMING_ERROR** **ETYPE** = 26
- **PARITY_ERROR** **ETYPE** = 14
- **DATA_OVERRUN** **ETYPE** = 18
- [**SIZE**] is more than 40 characters **ETYPE** = 03
- RX Buffer is full **ETYPE** = 07
- Checksum error **ETYPE** = 04
- Serial communication port time-out **ETYPE** = 05

The "NOT ACKNOWLEDGE" message has the following format:

-[SIZE] [ETYPE] [COMMAND] [CHECKSUM]

- **[ETYPE]** is a dual digit character representing the error detected.
- **[COMMAND]** is a single character representing the command sent to the radio.

The **FRAMING_ERROR** flag can be used for detecting out-of-sync conditions, detecting break conditions and protocol handling.

The **DATA_OVERRUN** Flag indicates data loss due to a UART-Receiver buffer full condition it occurs when the receive buffer is full (two characters),

The **PARITY_ERROR** Flag indicates that the next frame in the receive buffer had a parity error when received. If parity check is not enabled the PARITY_ERROR Flag will always be read zero.

2.6.3 ERROR

Solicited and unsolicited.

The ERROR message advises the PC that the radio has detected an error condition and cannot proceed with the current transaction. In some cases an exception condition in the radio may cause an ERROR message to be sent to the PC independently of any control transactions. This is a system error, which is an unsolicited message.

The ERROR message has the following format:

e [SIZE] [ETYPE] [ERRNUM] [CHECKSUM]

- 'e' is sent as a single ASCII character and represents the ERROR command.
- [ETYPE] is a single character representing the error category.

- [ERRNUM] is two ASCII hex characters which identify the specific error condition.

[ETYPE]	[ERRNUM]	Error description
T	3	checksum error PROIS
S	1	radio initiated power-down
S	0	radio switched successfully to CCR mode
O	Xh	Unsupported command X in hex notation
G	1	unsupported "Go to Channel" command
F	1	unsupported "Functions" command
F	6	unsupported "Functions 0" command
F	7	unsupported "Functions 4" command
R	1	PROIS start-up error
R	2	PROIS Data/Ready request not responding
R	5	PROIS buffer not emptied within the set time
R	15	PROIS buffer overflow
R	33	CCR timer (2 sec) expired radio has returned to normal operation

[ETYPE] '**R**' indicates a restart of the radio, this means that after the restart the radio is in default CCRI state, i.e. the same as after a "power-up" and switch to CCDI state.

[ETYPE] e07S0081, this is not an error-condition, but an indication that the radio switched successfully to CCR mode.

2.6.4 PROGRESS 'p'

Unsolicited.
The PROGRESS message advises the PC of the radio status when some significant change of state in the radio occurs.
When the radio is receiving a signal, this message is sent every ½ second to update the RSSI signal.

The PROGRESS message has the following format:
p [SIZE][PARA] [CHECKSUM]
'**p**' is sent as a single ASCII character and represents the PROGRESS command.
SIZE number of ASCII characters to follow including checksum
PARA = [button, upDown, volume, hook, channel, RSSI].

[PARA]	Function
Button XX	A button on the control-head of the radio has been pressed
upDown X	Key pressed or released "1" If a key is pressed, "0" otherwise
Volume XX	Volume Volume control, range is from 0 (min) to 25 (max), 26 indicates that radio is in control of the volume
Hook X	Hook "1" If a microphone is of the hook, "0" otherwise
Channel XX	Channel The channel the radio is working on. Range 01- 255, "00" indicates that the radio is in "soft-channel" mode
RSSI XX	RSSI Receive signal strength from 0 (> -50dBm) to 255 (< -123dBm)

An example of a PROGRESS response message is:
p1400026003FF0E
(ASCII string p 49 52 48 48 48 50 54 48 48 51 70 70 48 69)

p	progress command
Characters to follow	14
Button	00(no button pressed)
Up/down	0 (key is up (not pressed))
Volume	26 (under radio control)
Hook	0 (on hook)
Channel	03 (channel 3 selected)
RSSI	FF (< -123 dBm)
CC	$0E checksum

This message was sent to the PC after the channel was changed to channel 03.

2.6.4.1 Button information:

Button	Button Press
1	$01
2	$02
3	$03
4	$04
5	$05
6	$06
7	$07
8	$08
9	$09
0	$0A
*	$0B
#	$0C
P1	$11
P2	$12
P3	$13
P4	$1A
Exit	$14
Select	$15
Up	$16
Down	$17
Left	$18
Right	$19

2.6.5 PROGRESS ‘q’

Unsolicited.
The PROGRESS message advises the PC of the radio status when some significant change of state in the radio occurs.

The PROGRESS message has the following format:
q [SIZE][PARA] [CHECKSUM]
‘**q**’ is sent as a single ASCII character and represents the PROGRESS command.
SIZE number of ASCII characters to follow including checksum
PARA = **[PTT, Receive-mute].**

[PARA]	Function
PTT X	“1” If microphone PTT is pressed, “0” otherwise.
Receiver mute X	“0”, no receive, mute closed, transmitter down “1”, receiving, mute opened “3”, receiving with valid CTCSS, mute opened “4”, CTS clear to send , transmitter up and ready

An example of a PROGRESS ‘q’ response message is:
q0604C5
(ASCII string: q 48 54 48 52 67 53)

q	Progress command
Characters to follow	14
PTT	0 (PTT not pressed)
Mute	4 Clear to send, (transmitter up and ready)
CC	$C5

This message was sent after the transmitter was switched on.

2.6.6 RADIO_SERIAL

Unsolicited.
The RADIO_SERIAL message is sent to the PC when the radio is switched to Computer Control Radio Mode (command **f0200D8)**
The RADIO_SERIAL message has the following format:
n [SIZE] [SERIAL_NUMBER] [CHECKSUM]

'n' is sent as a single ASCII character and represents the RADIO_SERIAL command.
SIZE number of ASCII characters to follow including checksum
SERIAL_NUMBER is a string identifying the serial number in the radio.
CHECKSUM two complement of the whole message

An example of the RADIO_SERIAL response message is:
n02103TEQL293EE
(ASCII string: n 48 50 49 48 51 84 69 81 76 50 57 51 69 69)
This message indicates that the Radio has serial number:
103TEQL293

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