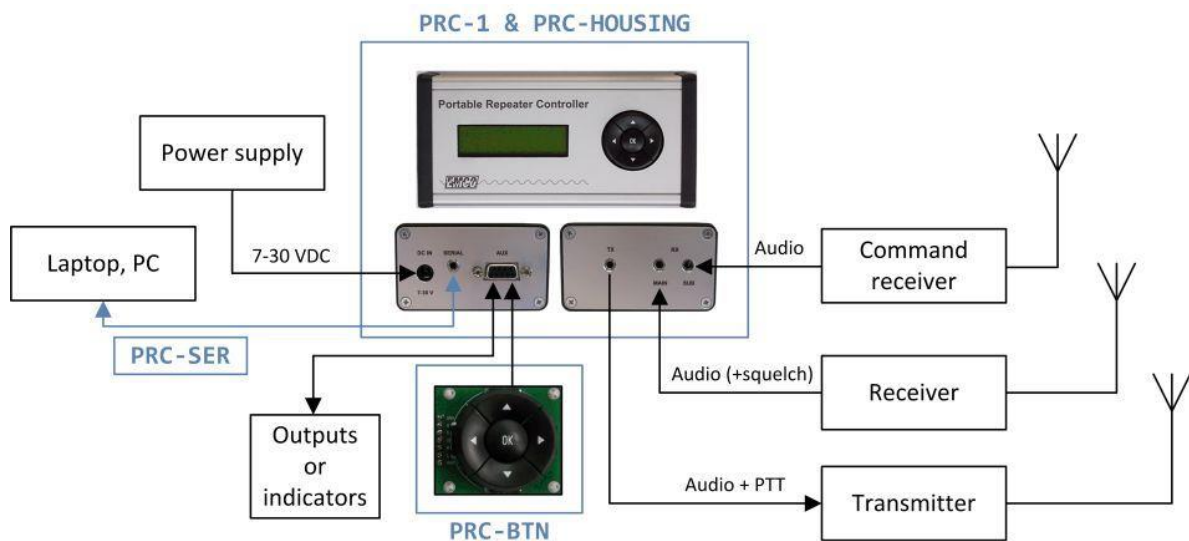


Portable Repeater Controller

Instruction Manual for firmware version 1.0



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2. Introduction

2.1 Overall Description

This microcontroller-based Portable Repeater Controller (PRC) was designed to quickly build a fully functional analogue repeater 'in the field' in less than no time. Due to its universal design it can be used all the way from classroom instruction to 24/7 repeater operation. A fully functional amateur radio repeater system is created by just connecting two radios, an antenna, a power supply and optionally filters.

Examples of where this PRC can be applied:

- Amateur radio shows and events
- Calamity and disaster communications
- Education and training in repeater usage
- Quick backup for existing repeaters
- Part of fully functional 24/7 repeaters

A summary of its features:

- Connect almost any receiver or transmitter (3.5 mm stereo connectors) (3.2)
- CTCSS for RX and TX (only when supported by transceivers) (5.4)
- 1750 Hz repeater activation (5.4)
- Internal or external squelch system (5.3)
- On-the-fly morse code generation for beacon and call (reduced volume on voice) (5.6)
- Time out timer (5.6)
- On and off timers for pre-scheduled operation (6.2)
- Temporary PTT block for antenna maintenance (6.1)
- Remote control test features (6.6)
- Supply voltage monitoring (7-30 V DC) (6.3)
- Smart energy saving power regulator, plus selectable LCD time-out (8.1 and 6.4)
- Electronically adjustable signal levels by four digital potentiometers (5.2)
- Real-time ADC audio level reading (5.2)
- AUX connector for extra set of remote buttons (8.4)
- Two multi-function I/O pins for remote controlled digital outputs or status info (6.5)
- Field serviceable by through-hole PCB design
- User upgradable firmware (with free Windows software tool) (10.1)
- 5V TTL UART interfacing (e.g. PC, laptop or Raspberry Pi) (10.2 – for version 2)
- Open communication protocol for configuration and control (10.2 – for version 2)
- Free Windows software for monitoring and configuration (for version 2)

Almost all repeater controller settings are user configurable, which enables repeater builders to create a fully tailor-made system, based on the needs, and of course, personal taste.

Configuration settings can be made in four different ways, where the combination of these four configuration options creates a flexible and versatile system:

1. With a PC connected via the serial interface. By storing different configurations on a PC, different repeater configurations can be activated by just a few mouse clicks.
2. DTMF remote control via the main receiver input.
3. DMTF remote control via a sub-band receiver input, creating a private configuration channel. Up to four controllers are addressable and can be connected to a single command receiver.
4. Locally on the controller, without any additional equipment, by using the LCD and the high quality navigation buttons. In this way, last minutes changes are possible anywhere, anytime.

2.2 Warnings

- Please check your local amateur radio regulations if (additional) licenses are required to operate your repeater system.
- The power supply of the PRC does not contain a fuse, so add one yourself somewhere in the power supply path outside the PRC.
- Do not put the transmitting antenna too close to the Portable Repeater Controller system. In case of interference, reduce the transmitter power and/or move the antenna away from the Portable Repeater Controller system until the interference disappears.
- The EEPROM in the microcontroller is guaranteed to 100 000 Write/Erase Cycles. Be careful with fast configuration changes (also disables and blocks via the AUX inputs)).

2.3 Configuration Settings, items and IDs

When this manual mentions "item NN" (for example item 20), it refers to the unique configuration settings item IDs (in this case item 20: Beacon on/off).

2.4 URL

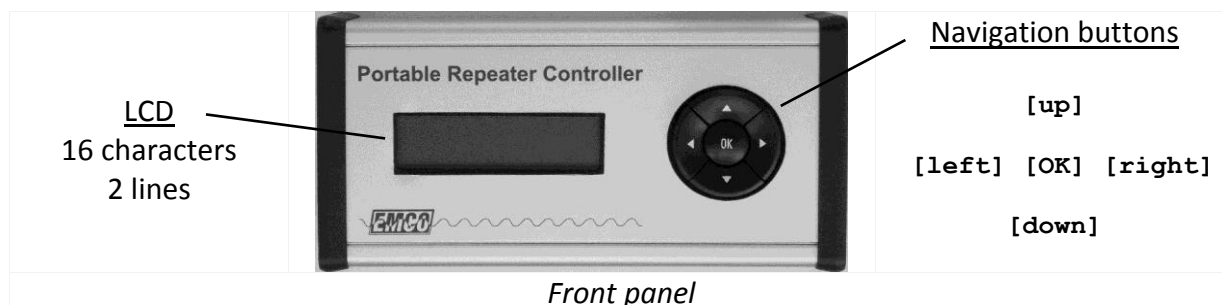
See <http://shop.emco-electronics.nl/> for the latest information about this Portable Repeater Controller project.

2.5 Abbreviations

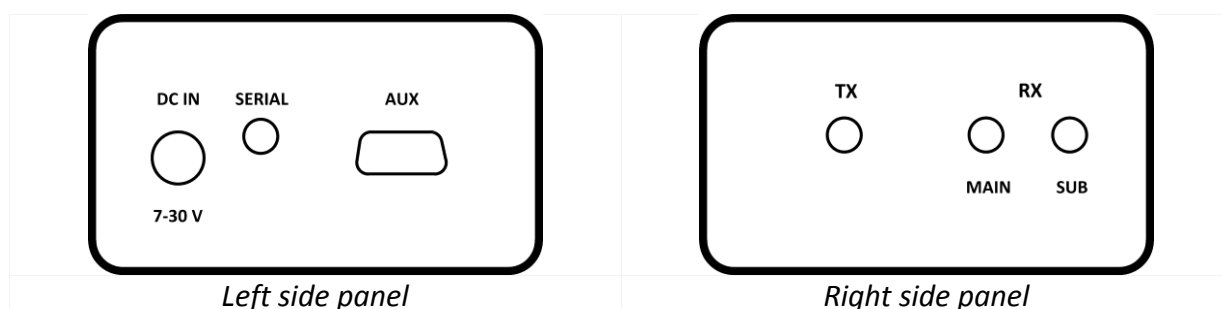
Abbreviation	Stands for
ADC	Analogue to Digital Converter of the microcontroller
CTCSS	Continuous Tone Code Squelch System (audio sub tones)
CW	Continuous Wave ("Morse code")
DC	Direct Current
DTMF	Dual-Tone Multi-Frequency
LCD	Liquid-Crystal-Display
PCB	Printed Circuit Board
PRC	Portable Repeater Controller
PTT	Push-to-talk ("on" signal to transmitter)
RX	Receiver
TTL	Transistor–Transistor Logic
TX	Transmitter
UART	Universal Asynchronous Receiver/Transmitter
WPM	Words-per-minute (CW speed)

3. Panel Description

3.1 Front Panel



3.2 Side Panel Connectors



DC IN, Serial and AUX

Connector	Function	Specification	Remark
DC IN	Power supply to the PRC.	Fits a hollow plug 5.5 / 2.1 mm. Outer ring – , inner pin: +. Voltage between 7 and 30 VDC.	Unfused. 500 mA fuse recommended.
SERIAL	Serial port connection to PC.	Fits a <i>TTL-232R-AJ</i> FTDI cable. Signal levels 5 V TTL.	Not an audio connection!
AUX	Multi-function I/O.	Fits a 9-pin male Sub-D 9 pin connector. See below for pin functions.	Not a serial communication connection!

The **DC IN** connector plug can for example be:

- Lumberg XNES/J 210
- Lumberg 1633 02 (short, only when PCB is not fitted in housing)
- For experimenting, the DELOCK 65396 DC to Terminal block adapter can be practical.

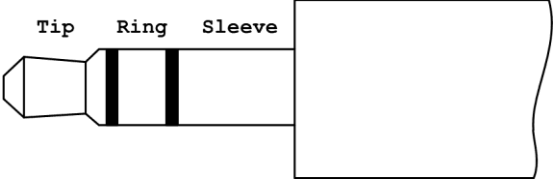
The **SERIAL** connector fits a regular 3.5 mm stereo phone plug, but is used as a 5 V UART serial port connect to a PC, and fits a *TTL-232R-AJ* FTDI cable (PRC-SER, see 5.1).

The pins of the **AUX** multi-function I/O connector have the following functions (see also 8.4):

Pin number	Function
1	Button [Left]. Connect to ground to activate. Internal pull up in PRC.
2	Button [OK]. Connect to ground to activate. Internal pull up in PRC.
3	Button [Up]. Connect to ground to activate. Internal pull up in PRC.
4	Low power + 5 V output. Maximum recommended current 250 mA.
5	Ground.
6	Button [Right]. Connect to ground to activate. Internal pull up in PRC.
7	Button [Down]. Connect to ground to activate. Internal pull up in PRC.
8	Multi-function pin AUX1 (items 74 and 92). See 6.5 how to configure.
9	Multi-function pin AUX2 (items 75 and 93). See 6.5 how to configure.

For experimenting, the DELOCK 65269 Serial to Terminal block adapter can be practical.

TX, RX main and RX sub

3.5 mm stereo plugs			
Connector	Tip	Ring	Sleeve
TX (output)	PTT	Audio out	Ground
RX MAIN (input)	Audio in	External Squelch	Ground
RX SUB (input)	Audio in	-	Ground

All audio connectors are 3.5 mm stereo phone plugs. For example

- Lumberg KLS 44
- Rean NYS 231[B][G] (B = black metal handle, G = gold plated contacts).
- For experimenting, the DELOCK 65419 Stereo Plug to Terminal block adapter can be practical.

The TX, RX main and RX sub connections are **not galvanically isolated**.

The **external squelch** is only used when the squelch is configured as External (item 73). By default the squelch is configured as Internal (item 73), where the internal analogue squelch detection circuit is used and the External Squelch connection is not required. See also 5.3.

The **PTT** is connected to an open collector of an NPN transistor. When the TX is switched on, the PTT connection is shortened to ground. There is no internal pull up resistor present in the PTT circuit.

PTT state	TX state	Electronics	
PTT on	TX on	Transistor collector to ground. PTT tip connected to ground. Low Z.	
PTT off	TX off	Transistor collector open. PTT tip floating. High Z.	

Alternatively, the PTT logic signal is available via the multi-function I/O connection AUX1 or AUX2 (item 74 or 75, select "TX On <out>"), see 6.5. This signal is high (5V) for TX on and low (0V) for TX off. The AUX1 and AUX2 lines have a 150 Ohm series resistor added between the microcontroller and the output pin.

4. Operating the Portable Repeater Controller

The PRC can be configured via the local navigation keys and the LCD. The repeater will stay fully operational during configuration.

4.1 LCD and Navigation Keys

Overview Mode

When the PRC is powered on, the LCD shows the main overview screen. In total **four overview screens** are available:

1. Main overview
2. Timers overview
3. Levels overview
4. Commands overview

With the **[left]** and **[right]** keys you navigate through these four overview screens. See 4.2 for details of the overview screens. Overview screens show read-only data. When one of the four overview screens is active, the **Overview Mode** is active.

When the **[up]** key is pressed for 5 seconds, the PTT will be unblocked (item 50, see 6.1). When the **[down]** key is pressed for 5 seconds, the PTT will be blocked.

Configuration Mode

The **Configuration Mode** can be activated by pressing **[OK]** when in overview mode. In the configuration mode, almost all configuration items can be viewed or changed. When entering the configuration mode, the last shown configuration item will be shown first.

With the **[up]** and **[down]** keys you navigate through all available configuration items. With the **[right]** key you navigate to the next 10th item, for fast navigation. With the **[left]** key you return to the overview mode. When item 99 (Exit menu) is selected, you can also leave the configuration mode and return to the overview mode by pressing **[OK]**.

Edit Mode

When a configuration item (other than 99) is selected, it can be changed by pressing the **[OK]** key. Now the **Edit Mode** is active for the selected configuration item. When a configuration item cannot be changed, the **[OK]** key will have no effect.

Important: When the **Edit Mode** is active, a cursor on the LCD blinks! Please remember!

With the **[up]** and **[down]** keys the next available value for selected configuration item is selected. For calls (items 01 to 05) and times (items 52, 54 and 56), the **[left]** and **[right]** keys can be used to navigate to the correct position before changing the configuration item.

When the item is changed correctly, press **[OK]** to leave the **Edit Mode** and return to the **Configuration Mode**. Changed items are saved automatically on leaving the Edit mode.

When in **Configuration Mode** or **Edit Mode**, if no key is pressed for 4 minutes, the **Overview Mode** will automatically become active.

In all modes, when a key is pressed for more than 1 second, it will start to repeat key presses as long as it is kept pressed.

Except for a few items, all configuration items will be stored in EEPROM and will retain their value after a power cycle. See 7.1 for which items are stored and which are not.

The table below summarizes the functions of the navigation keys in different modes:

Navigation Key	Navigation key actions in different modes:		
	Overview	Configuration	Edit
[left]	Navigate through Overview Screen.	Go back to the Overview Mode .	Move cursor left (only for calls and times).
[right]	Navigate through Overview Screens.	Go fast to next 10th configuration item.	Move cursor right (only for calls and times).
[up]	Unblock PTT when pressed for 5 seconds.	Go to next configuration item.	Select next available value for selected item.
[down]	Block PTT when pressed for 5 seconds.	Go to previous configuration item.	Select previous available value for selected item.
[OK]	Go to the previously selected item in the Configuration Mode .	Change the selected item in Edit Mode .	Go back to the Configuration Mode .

4.2 Overview screens

<u>Main Overview</u>	
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SQ/TO	SQ: Squelch detection by the internal repeater logic (item 73, see 5.3). TO: Time out active (items 46 and 47, 5.6).
TS	CTCSS RX tone detection by the repeater logic (item 41 and 42, see 5.4 and 5.6).
1750	1750 Hz detection by the repeater logic (item 40, see 5.4).
OVLMS	OVL M: Audio level overload of main RX input (see 5.2). OVL S: Audio level overload of sub RX input (see 5.2)
TX	TX active.
TXC	TX active with call (see 5.5).
TXB	TX active with beacon (see 5.5).
TXR	TX active with roger beep (see 5.5).
B	B _i - Blocked internal (item 50, see 6.1), B ^E - blocked external (see 6.5), B _i ^E - blocked internal and external.
D	D _i - Disabled internal (item 51 and see 6.1), D ^E - disabled external (see 6.5), D _i ^E - disabled internal and external.
BatLow	Input voltage below threshold (item 70, see 6.3).
Volt	Input voltage indication (item 70, see 6.3).

<u>Timers Overview</u> (see 6.2)	
-------------------------------------	--

E	Enabled (item 51).
D	D _i - Disabled internal, D ^E - disabled external, D _i ^E - disabled internal and external.
Time	Current time in HH:MM (item 56).
TimeD	Time to disable repeater, when disable timer active (item 52).
TimeE	Time to enable repeater, when enable timer active (item 54).
StateDT	State of disable timer: running (I) or stopped (-) (item 58).
StateET	State of enable timer: running (I) or stopped (-) (item 59).

<u>Levels Overview</u> (see 5.2)	
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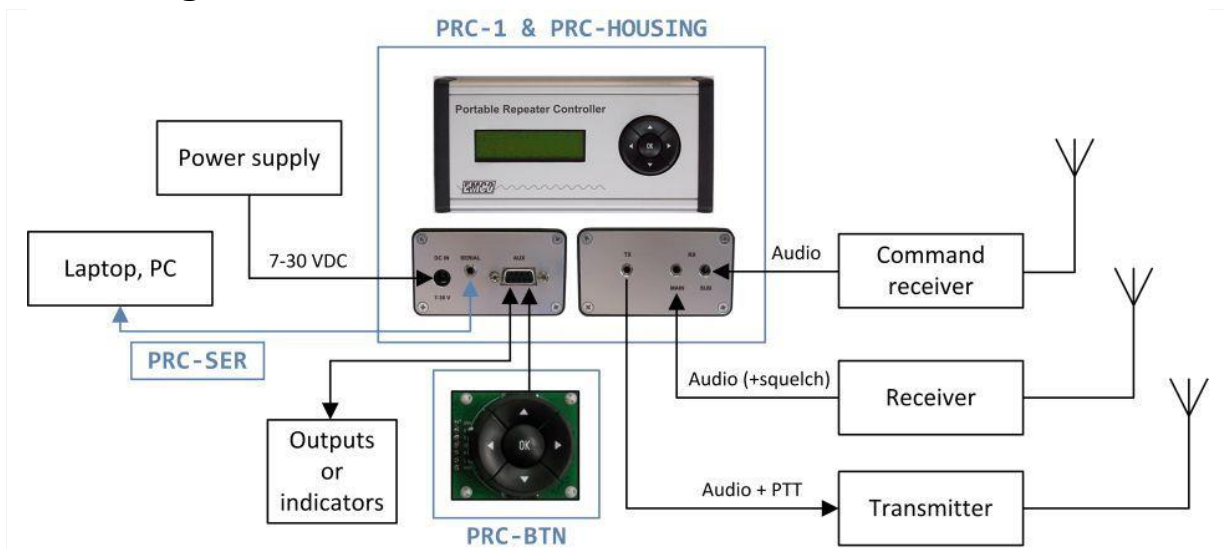
D	Selected CTCSS for main RX detected (item 41).
Ctcss	Audio level on the internal Main RX input for CTCSS. 0-99% or OVL (overload).
Main	Audio level on the internal Main RX input for DTMF. 0-99% or OVL (overload).
Sub	Audio level on the internal Sub RX input for DTMF. 0-99% or OVL (overload).

<u>Commands Overview</u> (see 6.6)	
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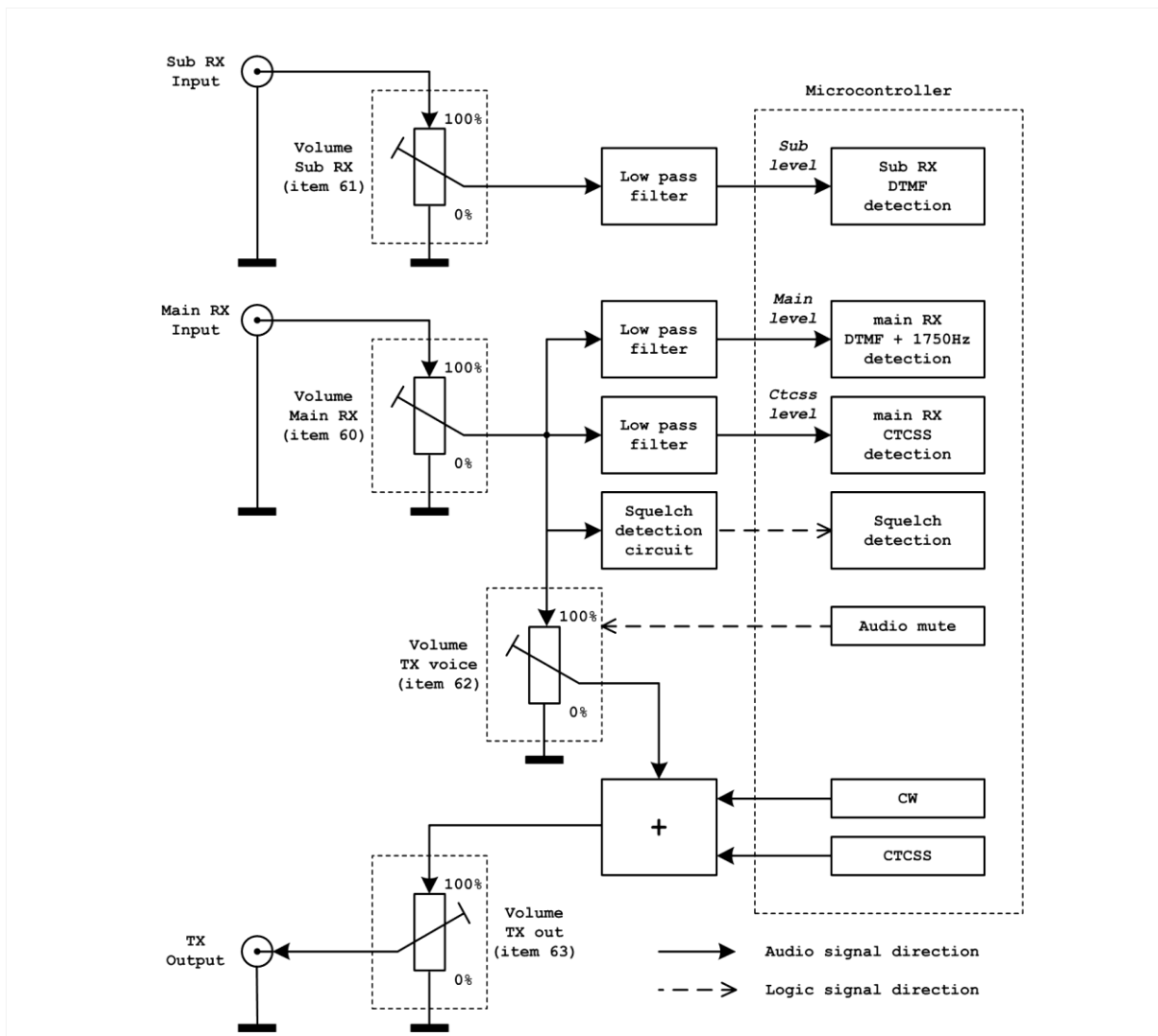
Cmd	Remote DTMF command symbols received correctly.
KeyM	DTMF key received correctly on main RX. 'x' when Cmd RX main off (item 81).
KeyS	DTMF key received correctly on Sub RX. 'x' when Cmd RX sub off (item 82).
Last	Last remote DTMF command symbols received correctly.
Master	Current active remote commanding (M - main RX, S – sub RX, P – serial PC).
Address	Command address (A, B, C or D: item 80).

5. Repeater Functions

5.1 Integration overview



5.2 Audio Levels and Digital Potmeters



The PRC contains four internal digital potmeters:

Potmeter	Item	Level adjustment function
Main RX	60	Audio input from the main receiver (audio and DTMF commands).
Sub RX	61	Audio input from the sub receiver (DTMF commands only).
TX voice	62	Mix audio with the CW and CTCSS TX signals.
TX out	63	Audio output to the transmitter.

All four potmeters can be set to a value between 0% (closed) and 100% (open) in steps of 5%. Percentages are linear potmeter values. When the TX voice potmeter is muted by the repeater logic, the configuration item value is overwritten by zero (closed).

The audio levels at the three ADC inputs are shown on the Levels Overview screen:



The numbers show the maximum values in between two screen updates as a percentage of the ADC input range or "OVL" when a value exceeds the ADC input range:

Level	Level adjustment function
Ctcss	Audio level on the internal Main RX input for CTCSS. 0-99% or OVL (overload).
Main	Audio level on the internal Main RX input for DTMF. 0-99% or OVL (overload).
Sub	Audio level on the internal Sub RX input for DTMF. 0-99% or OVL (overload).

For standard repeater operation the audio follows the following path through the PRC:

1. The audio enters the Main RX input connector.
2. The volume of the audio is adjusted by the Volume Main RX potmeter (item 60).
3. The ratio between the audio level and the CW and CTCSS TX audio signals is set by the Volume TX voice potmeter (item 62).
4. The audio is mixed with the CW and CTCSS TX audio signals (if present).
5. The volume to the transmitter is adjusted with the Volume TX out potmeter (item 63).
6. Audio leaves the TX output connector.

The PRC contains software algorithms to detect DMTF, 1750 Hz and CTCSS tones. In order to function properly, the audio input levels should be set correctly. Overdriving these levels can cause distortion and false detections. With signal levels that are too low, the algorithms will not be able to perform the detection.

When adjusting the audio levels, use the following rules:

- On the levels overview screen, the levels for DTMF, 1750 Hz and CTCSS should not exceed 100% ("OVL").
- A DMTF "1" should not exceed an audio level of 100%.
- A 1750 Hz tone on RX MAIN should not exceed an audio level of 90%.
- CTCSS RX tones on RX MAIN should have an audio level around 75%.
- Try to keep the audio level just below these audio levels.

Audio output levels

The typical input signal level is 1 Vpp with the Main RX potmeter set to 50%. With the TX voice and the TX out potmeters also set to 50%, the audio TX output level will be around 85 mVpp at open output (output impedance PRC is in the order of 5 kOhm in that case).

With open output and the TX out potmeter set to 50%, the audio TX output level from the PRC will become 30 mVpp for a 750 Hz CW tone and 20 mVpp for an 88.5 Hz CTCSS tone.

5.3 Squelch

The receiver connected to the RX MAIN input of the PRC must have a properly set squelch, so the repeater logic can determine if a signal from the receiver is present based on this squelch.

The PRC repeater logic requires a logic squelch signal, **squelch open** or **squelch closed**. This logic signal can be determined **internal** or **external**, which can be selected with configuration item 73.

Internal squelch

When the internal squelch is selected (item 73), the internal analogue squelch detection circuit in the PRC determines if the squelch of the receiver is open or closed. If this internal circuit detects an open receiver squelch, the yellow LED lights up. When the internal squelch is selected, the squelch connection on the RX MAIN audio plug (the ring connection) is not used.

External squelch

When the external squelch is selected (item 73), the logic squelch signal is taken from the RX MAIN audio plug ring connection. In this case the internal squelch detection circuit in the PRC is not used (however, the yellow light will still light up when the circuit detects a signal).

Two different external squelch modes are available, 'External high' and 'External low'. The following voltages should be present at the RX MAIN audio plug ring connection for the two different modes (the external squelch input has no internal pull up resistor):

Configuration item 73	Squelch open (audio from receiver). Squelch signal from receiver	Squelch closed (no audio from receiver). Squelch signal from receiver
External high	5 V (logic 1)	0 V (logic 0)
External low	0 V (logic 0)	5 V (logic 1)

For both the internal and external squelch signals, a hysteresis filter algorithm is present in the microcontroller. The filtered squelch signal is assigned as open when the squelch has been open for at least 0.2 seconds, and is assigned as closed when the squelch has been closed for at least 0.2 seconds.

5.4 1750 Hz and CTCSS RX/TX

The PRC supports both the 1750 Hz tone and the CTCSS (sub audio tones) as tone squelch system. The PRC can also transmit a CTCSS tone with the audio to the transmitter.

1750 Hz repeater activation

The PRC supports 1750 Hz for activation of the repeater. When a 1750 Hz audio tone appears at the main RX input for at least 0.3 seconds, the repeater will be activated.

- To turn the 1750 Hz tone activation on and off, use configuration item 40.
- When a CTCSS tone is required (see below) to keep the repeater activated, but no correct CTCSS tone is detected, the repeater will not be activated when a 1750 Hz is received even when 1750 Hz tone activation is enabled.
- When activating the repeater with a 1750 Hz tone, the audio will be muted as long as the tone is present, in order to prevent other listeners on the repeater frequency to hear the 1750 Hz tone. When the repeater is already activated, no 1750 Hz tone muting is applied.
- When using the 1750 Hz tone, adjust the TX MAIN audio volume to a correct level (see 5.2). The audio level must be high enough to make the 1750 Hz detection possible, but not too high to avoid overdriving the input of the PRC.

CTCSS repeater activation (RX)

The PRC implements the CTCSS tone squelch for 17 different sub audio tones between 67 and 123 Hz. The available CTCSS frequencies [Hz] are:

▪ 67.0	▪ 79.7	▪ 91.5	▪ 103.5	▪ 114.8
▪ 71.9	▪ 82.5	▪ 94.8	▪ 107.2	▪ 118.8
▪ 74.4	▪ 85.4	▪ 100.0	▪ 110.9	▪ 123.0
▪ 77.0	▪ 88.5			

The configuration and activation of the CTCSS tone squelch is a two-step process:

1. Enter the tone squelch frequency in configuration menu 41.
 2. Select the desired tone squelch mode in configuration menu 42:
 - *Off*: No tone squelch active (no tone required to activate the repeater).
 - *On (open only)*: Tone squelch only required to activate repeater, but once activated no tone is required to keep the repeater activated.
 - *On (continuous)*: Tone squelch required to activate the repeater and to keep it activated to keep it activated.
- When a CTCSS is detected by the PRC, a "D" (detect) will appear in front of the CTCSS audio level of the level overview screen (see 4.2). When the detected signal is used in the repeater logic, "TS" (tone squelch) will appear on the main overview screen (see 4.2)
 - The PRC RX MAIN input has the ability to detect CTCSS tone. However, many receivers implement a high-pass filter to filter out the CTCSS tones to prevent the user from hearing the low humming sound of these tones. This means if these audio signals are used as the RX MAIN input for the PRC, no detection will take place as there is nothing to detect. To overcome the problem, look for another receiver output that gives you the full audio spectrum including CTCSS frequencies (down to 67 Hz). For the more experienced radio amateur it is also possible to modify a receiver to find a point where the full audio signal can be tapped.

CTCSS transmission (TX)

It is possible to send a CTCSS tone together with the audio signal to the TX output. The configuration and activation of the CTCSS tone transmission is a multi-step process:

- Enter the tone frequency in configuration item 43.
- Enable the CTCSS transmission in configuration item 44.
- Select the desired CTCSS transmission mode for beacon transmissions in configuration item 45 (when item 44 is On):
 - *Off*: The CTCSS tone is not transmitted during beacon transmissions.
 - *On*: The CTCSS tone is also transmitted during beacon transmissions.
- Care should be taken when both receiving *and* transmitting the same tone at the same time in the PRC audio path, because both tones could mutually interfere.

5.5 Call/Beacon/Roger

Call and beacon

The PRC can transmit a repeater call sign during transmissions (the "call") or a beacon at fixed intervals (the "beacon"). The call and beacon can be entered in characters/numbers and will be sent out in morse code (CW) by the repeater logic.

The configuration and selection of a call or beacon is a two-step process:

1. Enter one or more call texts (up to 5) in configuration items 01 .. 05.
2. Select one of these call texts for the call (item 11) and one for the beacon (item 21). It is possible to select the same call text definition for both the call and the beacon.

With this two-step process the call text can be entered in advance, and changing call signs can be done instantly. The call sign text can have up to 15 characters (0 .. 9, A .. Z, / and space). Spaces at the end of the call texts (items 01 .. 05) will be ignored, spaces inside the call texts are valid.

Roger beep

A roger beep can be selected to be transmitted between the transmissions of two stations on the repeater. A selection out of five different patterns can be made (item 31).

Other settings for call, beacon and roger

The call, beacon and roger beep, can be send out in a user-tailored way. The table below shows the configuration settings that can be applied to the call, beacon and roger beep, together with some relevant information. See 5.6 how to reduce the volume of the call when audio from the receiver is present (item 15).

	Call	Beacon	Roger beep
On/off	10 Call on/off	20 Beacon on/off	30 Roger beep
Audio pitch (available frequencies in Hz)	12 Call tone	22 BCN tone	32 Roger BP tone
	(450, 500, 550, 650, 750, 900 or 1100 Hz)		
CW speed (available Speeds in WPM)	14 Call speed	24 BCN speed	-
	(8, 10, 12, 15,17, 20 or 24 WPM)		(fixed 24 WPM)
Interval in minutes	13 Call interval	23 BCN interval	-
Main screen text	"TXC"	"TXB"	"TXR"
Select text	11 Repeater call	21 BCN call	31 Roger BP char
Selectable texts	01 Call sign 1 02 Call sign 2 03 Call sign 3 04 Call sign 4 05 Call sign 5	01 Call sign 1 02 Call sign 2 03 Call sign 3 04 Call sign 4 05 Call sign 5	"T" (-) "A" (· -) "N" (- ·) "R" (· - ·) "K" (- · -)

5.6 Repeater Operation

Activation ('opening') of the repeater

- When 1750 Hz (item 40) is set to on, the repeater opens when a 1750 Hz tone is detected.
- When or CTCSS RX (item 42) is set to on, the repeater opens when the corresponding CTCSS RX tone (item 41) is detected.
- When 1750 Hz (item 40) and CTCSS RX (item 42) are both set to off, the repeater open on any signal that triggers the squelch.

CTCSS tone squelch

- When CTCSS RX (item 42) is set to On (continuous), the audio from the receiver will be muted when no corresponding CTCSS RX tone (item 41) is detected.

Deactivation of the repeater

- When no signal was received for a period of time (the TX off delay, item 48) the repeater is deactivated. When the TX off delay time is changed, first the previously set time needs to be finished before the new time becomes active.

Time out

- When the time out function (item 46) is set to on, the repeater will deactivate when an uninterrupted signal will be present longer than the time out time (item 47). When the time out time is changed, first the previously set time needs to be finished before the new time becomes active.
- When the time out timer reaches the time out time (item 47), the repeater will produce the *time out warning signal* instead of the normal roger beep (also when the roger beep is set to off). The time out warning signal consists of a fixed series of six beeps.
- The audio will be muted directly when time out timer reaches the time out time.
- The time out state will only be reset when the signal from the receiver will disappear (that is, not opening the squelch any longer).
- When the repeater has timed out, the main overview screen will show "TO".

Call transmission

- When the call transmission is set to on (item 10), the selected repeater call (item 11) will be sent out during transmissions.
- The call will be sent out on repeater activation (when not sent out for a period of 10 seconds) and thereafter with the call interval (item 13).
- The call interval (item 13) is the time in minutes between the end of the previous call transmission and the start of the next one. When the call interval time is changed, first the previously set time needs to be finished before the new time becomes active.
- When the call needs to be sent out at a reduced volume when audio from the receiver is present, the volume can be reduced (item 15) to 75, 50 or 25% of the original 100% volume level. The call volume is never reduced when item 15 is set to 100%.

Beacon transmission

- When the beacon transmission is set to on (item 20), the selected beacon call (item 21) will be sent out periodically when the repeater is not used.
- The beacon interval (item 23) is the time in minutes between the end of the previous beacon transmission and the start of the next one. When the beacon interval time is changed, first the previously set time needs to be finished before the new time becomes active.
- When the repeater call is transmitted, the beacon transmission timer is reset to the beacon interval (item 23).
- When the PRC is powered up, the beacon transmission timer is set to the beacon interval, so the beacon will not be sent directly.
- When the repeater is disabled (item 51 or with timer functions (6.2)), the beacon transmission timer is set to zero, so when the repeater is enabled again it will directly send out its beacon (when item 20 is set to on).

6. Advanced Functions

6.1 PTT block and Disable Repeater

PTT block

The PTT block function (item 50) will disable the PTT line while all other repeater functionality will continue as normal. This function can for example be used to perform some work on the antenna system while the PRC is left on.

When PTT is blocked:

- The PTT signal will be **off**, independent of the PTT state from the repeater control logic.
- All other repeater functionality will continue as normal.

To quickly block and unblock the PTT, also the **[up]** and **[down]** buttons can be used when the repeater is in overview mode (see 4.1):

- When the **[down]** key is pressed for 5 seconds, the PTT will be blocked.
- When the **[up]** key is pressed for 5 seconds, the PTT will be unblocked.

The PTT block state can be internal or external:

- In case the PRC is blocked via the menu or the buttons, the state is **blocked internal**, which is also stated on the main overview screen (see 4.2) as "B_i".
- The blocked state can also be controlled by a multi-function I/O pin, see 6.5. In this case the PRC state is **blocked external**, which is also stated on the main overview screen (see 4.2) as "B^e".
- The repeater state is blocked when it is blocked **internal** or **external** or **both**.

Disable repeater

The disable repeater function (item 51) will disable the entire repeater logic and puts the repeater in a kind of stand-by mode. When the repeater is enabled, it will function as normal.

When the repeater is disabled:

- The repeater cannot be activated and the transmitter will stay off.
- The beacon transmission timer is set to zero, so when the repeater is enabled again it will directly send out its beacon (when item 20 set to on).

Disabling the repeater has no effect on remote DTMF commands to the repeater (see 6.6), although the repeater cannot send an acknowledgement for received commands.

The disabled state can be internal or external:

- In case the PRC is disabled via the menu (or the timers, see 6.2), the state is **disabled internal**, which is also stated on the main overview screen (see 4.2) as "D_i".
- The disabled state can also be controlled by a multi-function I/O pin, see 6.5. In this case the PRC state is **disabled external**, which is also stated on the main overview screen (see 4.2) as "D^e".
- The repeater state is disabled when it is disabled **internal** or **external** or **both**.

In 6.2 is described how to enable and disable the repeater by means of two timers.

6.2 Enable/disable Timers

Besides manually enabling and disabling the repeater, it is also possible to use the two build-in timers to enable and/or disable the repeater at two scheduled points in time. A clock, together with an enable timer and a disable timer, make it possible to create a 24 hour operation schedule for the repeater. The Timers Overview screen shows the clock and both timers, and the current enabled ("Now:E") or disabled ("Now:D") state.



The clock is the time reference for both the enable and disable timer. The clock can be:

1. manually synchronized to the current time creating a real time clock, or
2. left unsynchronized to use it as a timer since the start of the PRC.

Clock

- The time of the clock can be set in hours (0-23) and minutes (0-59).
- Via the navigation buttons on the PRC the time can be set via item 56.
- Via the DTMF remote commands the hours are set via item 56 and the minutes via item 57.
- Internally the clock is seconds-based, where the seconds are set to zero when the minutes values are changed.
- The current value of the clock is shown on the bottom-left of the Timers Overview screen, where the colon between the hours and minutes blinks at 0.5 Hz.

Disable timer

- Via the navigation buttons on the PRC the disable time can be set via item 52.
- Via the DTMF remote commands the hours are set via item 52 and the minutes via item 53.
- The current value of the disable timer is shown on the top-right of the Timers Overview screen (behind "D_i" - disable internal).
- When the disable timer is **On** (item 58) and the time of the disable timer equals the time of the clock (a "time match"), the repeater will be disabled. If the repeater is already disabled, it stays disabled.
- When the disable timer has been set to **On (once)**, it will be set to **Off** at a time match.
- When the disable timer has been set to **On (continuous)** it will stay on at a time match.
- When the disable timer is manually set to off, the disable time is still visible but no disable action will be performed at a time match.
- When the disable timer is On, a small progress indicator behind the disable time is moving on the Timers Overview screen.
- When the disable timer is Off, a steady "-" is shown behind the disable time on the timers overview screen.

Enable timer

- Via the navigation buttons on the PRC the enable time can be set via item 54.
- Via the DTMF remote commands the hours are set via item 54 and the minutes via item 55.
- The current value of the enable timer is shown on the bottom-right of the Timers Overview screen (behind "E_i" - enable internal).

- When the enable timer is **On** (item 59) and the time of the enable timer equals the time of the clock (a "time match"), the repeater will be enabled. If the repeater is already enabled, it stays enabled.
- When the enable timer has been set to **On (once)**, it will be set to **Off** at a time match.
- When the enable timer has been set to **On (continuous)** it will stay on at a time match.
- When the enable timer is manually set to off, the enable time is still visible but no enable action will be performed at a time match.
- When the enable timer is On, a small progress indicator behind the enable time is moving on the Timers Overview screen.
- When the enable timer is Off, a steady "-" is shown behind the enable time on the timers overview screen.

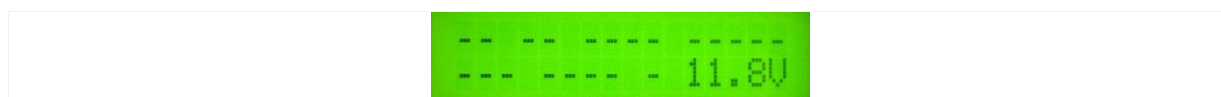
When the enable timer is set to the same value as the disable timer (and both timers are on), the disable timer will overrule to enable timer, and the repeater will be disabled.

The clock is NOT backed-up on EEPROM and will NOT remain its value after a power cycle. Therefore both timers will be disabled at startup (items 58 and 59 will be set to Off) to prevent that a wrong enable/disable schedule will be executed. However, the times of both timers (items 52 and 54) will keep their value after a power cycle.

The clock has just a base accuracy that is mainly dependent on the temperature of the clock crystal of the microcontroller. In practice an accuracy of a few seconds a day can be achieved.

6.3 Voltage monitoring

The PRC contains a simple power supply voltage monitoring system that shows the actual voltage and can give an alarm when the voltage drops below a certain threshold.



The main overview screen shows the actual input voltage of the PRC (see 4.2) with a 0.1 V resolution. Be aware that this feature is just a basic voltage indicator, not a replacement for a digital multimeter. The accuracy is about 1 or 2%, and dependent on the accuracy of the voltage regulator, a resistor network, the ADC of the microcontroller and the current through a reverse polarity protection diode.

The low battery voltage threshold can be set in configuration item 70, in steps of 0.5 V. When the voltage drops below this threshold, on the main overview screen the battery low indicator lights up (see 4.2). When the voltage is above the threshold, the battery low indicator disappears.

The battery low state can be linked to a multi-function I/O pin, see 6.5.

The battery low indication can also be used to change the roger beep into a "battery low roger beep". In configuration item 71 the roger beep in case of a battery low state can be defined:

Item 71 value	Roger beep in case of a battery low state
None	No special roger beep.
Roger B	"B" (- · · ·) in morse code.
Roger BL	"BL" (- · · · · - · · ·) in morse code.
Roger <RC>	"<RC>" (· - · - · - ·) in morse code.

When no battery low state action is required, set item 70 to "7.0 v" and item 71 to "None".

6.4 LCD backlight time out

The LCD on the PRC has a built in backlight. In order to save energy (about 0.5 W), the LCD backlight can be switched off. In configuration item 72 (LCD Backlight) the following settings can be made:

Item 72 value	LCD backlight
Off	Always off
On	Always on
10 s timeout	On when a key is pressed, off when no key pressed for 10 seconds.
20 s timeout	On when a key is pressed, off when no key pressed for 20 seconds.
30 s timeout	On when a key is pressed, off when no key pressed for 30 seconds.
60 s timeout	On when a key is pressed, off when no key pressed for 1 minute.

When one of the time out values is selected, the first button press only activates the backlight and no corresponding button action is performed.

6.5 Multi-function I/O (AUX1/AUX2)

Two pins of the AUX connector act as multi-function I/O pins, see also 3.2 for more information about the AUX connector in general. Which function a pin must perform can be selected in the following items:

AUX	Physical pin	Configuration item
AUX1	8	74 AUX1 function
AUX2	9	75 AUX2 function

Via configuration items 74 and 75 the multi-function I/O pins can be assigned to one of the six options, four output options and two input options:

Configuration item 74 / 75	Input/output	Function	High ("1")	Low ("0")
None	-	Multi-function not used.	-	-
Dig output<out>	Output	Item 92 / 93 value (see below).	On	Off
TX On <out>	Output	TX On state (PTT).	Tx on	Tx off
Low bat <out>	Output	Battery low state.	Battery low	Battery OK
Disabled <out>	Output	Disabled state.	Disabled	Enabled
			Open	Closed
Disable <in>	Input	"Disable External" input.	No disable	Disable
PTT block <in>	Input	"PTT block External" input.	No block	Block

The **output** connections are 5 V when high and 0 V when low. The AUX1 and AUX2 lines have a 150 Ohm series resistor added between the microcontroller and the (output) pin.

The **input** connections are internally equipped with a pull up resistor. Therefore the input should be normally open when "open" and connected to ground (pin 5) when "closed".

Remote controlled digital outputs

One of the output options is "Dig output<out>". When this output option is selected, the state of the output is determined by configuration item "92 Dig output 1" or "93 Dig output 2". The state can be "On" (5 V, high) or "Off" (0 V, low).

To set the outputs via the menu items on the PRC is not very useful. The real magic of these items is the possibility to remote control items 92 and 93 by DTMF commands, and therefore creating two **remote controlled digital outputs**. How to use the remote control features is described in 6.6 in more detail. An overview how to configure and operate the remote controlled digital outputs is shown in the table below:

Action	Output state	Configuration	Set value	Remote command (CMD address A)
AUX1 On	pin 8 high	74 AUX1 function "Dig output<out>"	92 Dig output 1 "On"	A 9 2 0 1 #
AUX1 Off	pin 8 low		92 Dig output 1 "Off"	A 9 2 0 0 #
AUX2 On	pin 9 high	75 AUX2 function "Dig output<out>"	93 Dig output 2 "On"	A 9 3 0 1 #
AUX2 Off	pin 9 low		93 Dig output 2 "Off"	A 9 3 0 0 #

6.6 Remote DTMF commands

Most of the configuration items cannot only be changed by the navigation buttons and the LCD, but also by means of sending DTMF command messages (see 7.1 for the list of items).

1	2	3	A
4	5	6	B
7	8	9	C
*	0	#	D

See 4.2 for the Commands Overview screen that shows status information about the remote DTMF commands.

Main and sub receiver input (items 81 and 82)

Both the RX MAIN (item 81) and RX SUB (item 82) inputs can be configured to receive DTMF command messages. When using the RX SUB receiver input you can use the remote DTMF commanding without interfering with normal repeater operation, and thereby creating a kind of private command channel. Both inputs are disabled for DTMF command messages by default (items 81 and 82).

Addressing a PRC (item 80)

Every DTMF command message starts with the address of the PRC. The address of a PRC can be A, B, C or D (as on the DTMF keypad), selectable in configuration item 80.

Normally changing the address from the default A is not required, however when you have more than one PRC at one location, you can save some hardware. When you have more than one PRC that need individual remote commanding via the RX SUB input, you can use only one command receiver by giving the PRCs different addresses (item 80) and connecting the receiver audio output to all RX SUB inputs.

If multiple PRCs have the same address (item 80) and are connected to the same receiver audio output, they will all receive and execute the same DTMF command message.

DTMF command message syntax

DTMF command messages have a fixed structure ("syntax"):

- A message has **six** DTMF symbols.
- A message starts with the **address** (A, B, C or D).
- A message ends with the # DTMF symbol.
- Symbol 2 and 3 specify the **item** (with leading zero when item < 10).
- Symbol 4 and 5 specify the **value** for the item (with leading zero when value < 10).

Address	Item		Value		Terminator
[A B C D]	[Item 10] 0..9	[Item 1] 0..9	[Value 10] 0..9	[Value 1] 0..9	[#]

Example message

The following DTMF command message example will disable the PRC (set item 51 to 0). The address of the PRC is set to C and the message is terminated with the # DTMF symbol.

C 5 1 0 0 #

Which value?

Which item number to use is relative easy to find, but the corresponding values are not. In chapter 7 for every configuration item an overview is available where all values of an item are specified.

The value "off" is mostly defined as 00, and the corresponding "on" as 01. Also minutes and hours can just be entered as their actual values.

On/off and Acknowledgements

Remote DTMF commanding can be set on or off by configuration item 81 for the RX MAIN input and item 82 for the RX SUB input:

Configuration item 81 / 82	Function
Off	Remote DTMF commanding disabled: Commands are off.
On (silent)	Remote DTMF commanding enabled. No acknowledge of a received DTMF command message.
On (call/BCN)	Remote DTMF commanding enabled. A received DTMF command message will be acknowledged by starting the call or beacon directly.

- When set to "On (call/BCN)" and a DTMF command message is received correctly, an acknowledgement will be sent out. It will only be sent out when there is an address match, all six symbols are received, and the item-value combination is valid (see chapter 7) for the valid item-value combinations.
- When the repeater is not activated and the beacon is set to "on" (item 20), the repeater will directly send out its beacon to acknowledge the received message.
- When the repeater is activated and the call is set to "on" (item 10), the repeater will directly send out its call to acknowledge the received message.

Command hierarchy

The configuration settings can only be changed from one source at a time. The available sources are:

1. The LCD with the navigation buttons
2. The serial connection to a PC (from version 2)
3. Remote DTMF command messages via the RX MAIN input
4. Remote DTMF command messages via the RX SUB input

The following hierarchy applies:

1. When the PRC is being configured via the LCD and configuration buttons in **Configuration Mode** or **Edit Mode**, the other sources are disabled. They will be re-enabled when the **Overview Mode** becomes active again.
2. When the PRC is being configured via the serial PC connection, the remote DTMF command messages are disabled.
3. Only one of the DTMF command message inputs can be active at a time.

DTMF speed

The duration of the DTMF symbols as well as the time between the symbols should be **at least 100 ms** long. Shorter times will cause false detection or missing symbols. Longer times are no problem, as long as the time between the symbols does not exceed the time out time.

Time out and Cancellation of a command message

When the time between two DTMF symbols is more than 5 seconds, the message will time out and be reset. A new DTMF command message should be started to re-enter the command.

If during a DMTF command message a "*" DTMF symbol is received before the end of the message, the message will also be reset.

Test value

Configuration item "91 Test value" contains a test value that can contain a number between 0 and 99. This value is not linked to any behavior of the repeater, but can be used to test if commands are received correctly without changing the settings of the repeater itself.

Item	Remote command example function for address A	Remote command
91	Test if DTMF commands are received correctly. Example for sending the value 71.	A 9 1 7 1 #

When this DTMF command test message is received correctly, "9171" is shown in the "Lst:" field.

7. Configuration Settings

7.1 Configuration Settings overview

-	Not accessible
R	Read only
W	Write only
RW	Read and write

ID	Menu text	Short item description	PC	LCD	DTMF
1	01 Call sign 1	Repeater call definition 1	RW	RW	-
2	02 Call sign 2	Repeater call definition 2	RW	RW	-
3	03 Call sign 3	Repeater call definition 3	RW	RW	-
4	04 Call sign 4	Repeater call definition 4	RW	RW	-
5	05 Call sign 5	Repeater call definition 5	RW	RW	-
10	10 Call on/off	Repeater call transmission on/off.	RW	RW	W
11	11 Repeater call	Repeater call selection.	RW	RW	W
12	12 Call tone	Tone frequency of the CW call.	RW	RW	W
13	13 Call interval	Repeater call transmission interval.	RW	RW	W
14	14 Call speed	Speed of the CW call transmission.	RW	RW	W
15	15 Call low lvl	Call audio level reduction.	RW	RW	W
20	20 Beacon on/off	Repeater beacon transmission on/off.	RW	RW	W
21	21 BCN call	Repeater beacon call selection.	RW	RW	W
22	22 BCN tone	Tone frequency of the CW beacon.	RW	RW	W
23	23 BCN interval	Minutes	RW	RW	W
24	24 BCN speed	Speed of the CW beacon transmission.	RW	RW	W
30	30 Roger beep	Roger beep transmission on/off.	RW	RW	W
31	31 Roger BP char	Roger beep character selection.	RW	RW	W
32	32 Roger BP tone	Tone frequency of the roger beep.	RW	RW	W
40	40 1750Hz on/off	1750 Hz tone squelch on/off	RW	RW	W
41	41 CTCSS RX tone	CTCSS RX tone squelch frequency	RW	RW	W
42	42 CTCSS RX	CTCSS RX tone squelch mode (on/off)	RW	RW	W
43	43 CTCSS TX tone	CTCSS TX tone frequency	RW	RW	W
44	44 CTCSS TX	CTCSS TX tone transmission on/off	RW	RW	W
45	45 CTCSS TX BCN	CTCSS TX tone transmission for beacon	RW	RW	W
46	46 Timeout	Time out for single transmission on/off	RW	RW	W
47	47 Timeout time	Time out time for single transmission	RW	RW	W
48	48 TX off delay	Off delay time when no signal received.	RW	RW	W
50	50 PTT blocked	PTT block on/off.	RW	RW	W
51	51 En-/disabled	Repeater enable/disable.	RW	RW	W
52	52 HH:MM disable	Disable timer hours (LCD also minutes)	RW	RW	W
53	-	Disable timer minutes (not for LCD)	RW	-	W
54	54 HH:MM enable	Enable timer hours (LCD also minutes)	RW	RW	W
55	-	Enable timer minutes (not for LCD)	RW	-	W
56	56 HH:MM clock	Clock time hours (LCD also minutes)	RW	RW	W
57	-	Clock time minutes (not for LCD)	RW	-	W
58	58 Timer disable	Disable timer on/off.	RW	RW	W
59	59 Timer enable	Enable timer on/off.	RW	RW	W

ID	Menu text	Short item description	PC	LCD	DTMF
60	60 VOL Main RX	Audio input level RX MAIN.	RW	RW	W
61	61 VOL Sub RX	Audio input level RX SUB.	RW	RW	W
62	62 VOL TX voice	Audio mix level with CW and CTCSS TX.	RW	RW	W
63	63 VOL TX out	Audio output level to TX.	RW	RW	W
70	70 LOWBAT level	Low battery level.	RW	RW	W
71	71 LOWBAT action	Low battery action.	RW	RW	W
72	72 LCD Backlight	LCD backlight time out.	RW	RW	W
73	73 SQL int/ext	Squelch internal, external high or low.	RW	RW	W
74	74 AUX1 function	AUX1 function.	RW	RW	W
75	75 AUX2 function	AUX2 function.	RW	RW	W
80	80 CMD Address	DTMF command address.	RW	RW	W
81	81 CMD Main RX	DTMF remote commanding RX MAIN on/off.	RW	RW	W
82	82 CMD Sub RX	DTMF remote commanding RX SUB on/off.	RW	RW	W
83	83 CMD PC serial	Remote serial configuration on/off.	R	RW	W
90	90 Firmware	Firmware version	R	R	-
91	91 Test value	Test value	RW	RW	W
92	92 Dig output 1	Digital output 1 on/off	RW	RW	W
93	93 Dig output 2	Digital output 2 on/off	RW	RW	W
98	98 Factory reset	Factory reset	RW	RW	-
99	99 Exit menu	Exit Configuration Mode	-	R	-

7.2 Configuration Settings Values

01..05 - Repeater call sign definitions

Description	Repeater call definitions 1, 2, 3, 4 and 5. These call definitions can be used to select the repeater call (item 11) and beacon (item 21). The call sign texts can have up to 15 characters (0 .. 9, A .. Z, / and space). Spaces at the end of the call texts (items 01 .. 05) will be ignored, spaces before and inside the call texts are allowed.
See Chapter(s)	5.5.
Default	Empty (all spaces), no call.

10 - Repeater call on/off

Description	Repeater call (item 11) transmission on/off.
See Chapter(s)	5.5, 5.6, 6.6.
Default	On

LCD text values	ID	Description
Off	00	Repeater call not transmitted by repeater logic
On	01	Repeater call transmitted by repeater logic

11 - Repeater call selection

Description	Repeater call selection. One out of five call definitions (item 1 .. 5).
See Chapter(s)	5.5.
Default	Repeater call value Call 1

LCD text values	ID	Description
<i>Value item 01</i>	01	Repeater call value Call 1 (item 1)
<i>Value item 02</i>	02	Repeater call value Call 2 (item 2)
<i>Value item 03</i>	03	Repeater call value Call 3 (item 3)
<i>Value item 04</i>	04	Repeater call value Call 4 (item 4)
<i>Value item 05</i>	05	Repeater call value Call 5 (item 5)

12 - Repeater call tone

Description	The audio frequency/pitch of the repeater call (item 11) in Hz.
See Chapter(s)	5.5
Default	750 Hz

LCD text values	ID	Description
450 Hz	01	450 Hz audio frequency
500 Hz	02	500 Hz audio frequency
550 Hz	03	550 Hz audio frequency
650 Hz	04	650 Hz audio frequency
750 Hz	05	750 Hz audio frequency
900 Hz	06	900 Hz audio frequency
1100 Hz	07	1100 Hz audio frequency

13 - Repeater call transmission interval

Description	Repeater call transmission interval in minutes.
See Chapter(s)	5.5, 5.6.
Default	5 minutes

LCD text values	ID	Description
1..99	01-99	The time in minutes between the end of the previous call transmission and the start of the next one.

14 - Repeater call transmission speed

Description	Speed of the CW call transmission in WPM.
See Chapter(s)	5.5
Default	15 WPM

LCD text values	ID	Description
8 WPM	01	CW speed of 8 words-per-minute.
10 WPM	02	CW speed of 10 words-per-minute.
12 WPM	03	CW speed of 12 words-per-minute.
15 WPM	04	CW speed of 15 words-per-minute.
17 WPM	05	CW speed of 17 words-per-minute.
20 WPM	06	CW speed of 20 words-per-minute.
24 WPM	07	CW speed of 24 words-per-minute.

15 - Call audio level reduction.

Description	Call audio level reduction, in percentage of the maximum audio level. The audio level will be reduced to this level when the call is transmitted together with repeater audio.
See Chapter(s)	5.6
Default	75%

LCD text values	ID	Description
25%	01	Audio level reduction to 25%
50%	02	Audio level reduction to 50%
75%	03	Audio level reduction to 75%
100%	04	No audio reduction

20 - Repeater call on/off

Description	Repeater beacon (item 21) transmission on/off.
See Chapter(s)	5.5, 5.6, 6.6.
Default	On

LCD text values	ID	Description
Off	00	Repeater beacon not transmitted by repeater logic
On	01	Repeater beacon transmitted by repeater logic

21 - Repeater beacon call selection

Description	Repeater beacon call selection, the call to use for the repeater beacon. One out of five call definitions (item 1 .. 5).
See Chapter(s)	5.5.
Default	Repeater call value Call 1

LCD text values	ID	Description
<i>Value item 01</i>	01	Repeater call value Call 1 (item 1)
<i>Value item 02</i>	02	Repeater call value Call 2 (item 2)
<i>Value item 03</i>	03	Repeater call value Call 3 (item 3)
<i>Value item 04</i>	04	Repeater call value Call 4 (item 4)
<i>Value item 05</i>	05	Repeater call value Call 5 (item 5)

22 - Repeater beacon tone

Description	The audio frequency/pitch of the repeater beacon (item 21) in Hz.
See Chapter(s)	5.5
Default	750 Hz

LCD text values	ID	Description
		See 12 - Repeater call tone

23 - Repeater beacon transmission interval

Description	Repeater beacon transmission interval in minutes.
See Chapter(s)	5.5, 5.6.
Default	5 minutes

LCD text values	ID	Description
1..99 min	01-99	The time in minutes between the end of the previous beacon transmission and the start of the next one.

24 - Repeater beacon transmission speed

Description	Speed of the CW beacon transmission in WPM.
See Chapter(s)	5.5
Default	15 WPM

LCD text values	ID	Description
		See 14 - Repeater call transmission speed

30 - Repeater roger beep on/off

Description	Repeater roger beep (item 31) transmission on/off.
See Chapter(s)	5.5, 6.3, 6.6.
Default	On

LCD text values	ID	Description
Off	00	Repeater beacon not transmitted by repeater logic
On	01	Repeater beacon transmitted by repeater logic

31 - Roger beep character selection

Description	The character to use for the roger beep between the transmissions of two stations operating on the repeater.
See Chapter(s)	5.5
Default	Roger beep character "T"

LCD text values	ID	Description
T	01	Roger beep character "T" (-)
A	02	Roger beep character "A" (· -)
N	03	Roger beep character "N" (- ·)
R	04	Roger beep character "R" (· - ·)
K	05	Roger beep character "K" (- · -)

32 - Repeater roger beep tone

Description	The audio frequency/pitch of the repeater roger beep (item 31) in Hz.
See Chapter(s)	5.5
Default	750 Hz

LCD text values	ID	Description
		See 12 - Repeater call tone

40 - 1750 Hz tone squelch on/off

Description	1750 Hz tone squelch on/off, to determine if the repeater requires a 1750 Hz tone to open.
See Chapter(s)	5.4.
Default	Off (not required)

LCD text values	ID	Description
Off	00	1750 Hz not required to open the repeater.
On	01	1750 Hz required to open the repeater.

41 - CTCSS RX tone squelch frequency

Description	The CTCSS tone frequency for the CTCSS tone squelch.
See Chapter(s)	5.4.
Default	88.5 Hz

LCD text values	ID	Description
67.0 Hz	01	CTCSS tone 67.0 Hz
71.9 Hz	02	CTCSS tone 71.9 Hz
74.4 Hz	03	CTCSS tone 74.4 Hz
77.0 Hz	04	CTCSS tone 77.0 Hz
79.7 Hz	05	CTCSS tone 79.7 Hz
82.5 Hz	06	CTCSS tone 82.5 Hz
85.4 Hz	07	CTCSS tone 85.4 Hz
88.5 Hz	08	CTCSS tone 88.5 Hz
91.5 Hz	09	CTCSS tone 91.5 Hz
94.8 Hz	10	CTCSS tone 94.8 Hz
100.0 Hz	11	CTCSS tone 100.0 Hz
103.5 Hz	12	CTCSS tone 103.5 Hz
107.2 Hz	13	CTCSS tone 107.2 Hz
110.9 Hz	14	CTCSS tone 110.9 Hz
114.8 Hz	15	CTCSS tone 114.8 Hz
118.8 Hz	16	CTCSS tone 118.8 Hz
123.0 Hz	17	CTCSS tone 123.0 Hz

42 - CTCSS RX tone squelch mode (on/off)

Description	CTCSS tone squelch on/off, to determine if the repeater requires the selected tone (item 41) to open.
See Chapter(s)	5.4.
Default	Tone squelch disabled

LCD text values	ID	Description
Off	00	CTCSS RX tone squelch disabled.
On (open only)	01	CTCSS only required to activate repeater, but once activated no tone is required to keep the repeater activated.
On (continuous)	02	CTCSS required to activate the repeater and to keep it activated to keep it activated.

43 - CTCSS TX tone frequency

Description	The CTCSS tone frequency to transmit
See Chapter(s)	5.4.
Default	88.5 Hz

LCD text values	ID	Description
See 41 - CTCSS RX tone squelch frequency		

44 - CTCSS TX tone transmission on/off

Description	CTCSS tone transmission on/off, to determine if the repeater transmits the selected (item 43) tone with the transmitted audio.
See Chapter(s)	5.4.
Default	Off

LCD text values	ID	Description
Off	00	CTCSS tone transmission off.
On	01	CTCSS tone transmission on.

45 - CTCSS TX tone transmission for beacon

Description	CTCSS tone is on/off during the beacon transmission, when the CTCSS tone transmission (item 44) is set to On.
See Chapter(s)	5.4
Default	Off

LCD text values	ID	Description
Off	00	CTCSS tone is not transmitted during beacon transmissions.
On	01	CTCSS tone is also transmitted during beacon transmissions.

46 - Time out for single transmission on/off

Description	When an uninterrupted signal will be present longer than the time out time (item 47), the repeater will be deactivated.
See Chapter(s)	5.6.
Default	Off

LCD text values	ID	Description
Off	00	Time out function off.
On	01	Time out function on.

47 - Time out time for single transmission

Description	Time out time in minutes.
See Chapter(s)	5.6.
Default	10 minutes

LCD text values	ID	Description
1..99 min	01-99	The time out time in minutes.

48 - Off delay time when no signal received.

Description	Time when no signal is received, after which the repeater is deactivated ("Off delay time"). Time in seconds.
See Chapter(s)	5.6.
Default	10 seconds

LCD text values	ID	Description
1..99 s	01-99	Off delay time in seconds.

50 - PTT block on/off

Description	PTT block on/off. The PTT block state via DMTF is represented as internal, as it is determined by the microcontroller and not via an external input signal.
See Chapter(s)	6.1.
Default	PTT not blocked

LCD text values	ID	Description
PTT not blocked	00	PTT block off.
PTT blocked	01	PTT block on.

51 - Repeater enabled/disabled.

Description	Repeater enabled/disabled. The repeater disabled state via DMTF is represented as internal, as it is determined by the microcontroller and not via an external input signal.
See Chapter(s)	6.1.
Default	Repeater enabled.

LCD text values	ID	Description
Disabled	00	Repeater disabled.
Enabled	01	Repeater enabled.

52 - Disable timer hours

Description	Disable timer time, hours part (24 hour format).
See Chapter(s)	6.2.
Default	0

LCD text values	ID	Description
0..23	00-23	Disable timer time, hours part.

53 - Disable timer minutes

Description	Disable timer time, minutes part.
See Chapter(s)	6.2.
Default	0

LCD text values	ID	Description
0..59	00-59	Disable timer time, minutes part

54 - Enable timer hours

Description	Enable timer time, hours part (24 hour format).
See Chapter(s)	6.2.
Default	0

LCD text values	ID	Description
0..23	00-23	Enable timer time, hours part.

55 - Enable timer minutes

Description	Enable timer time, minutes part.
See Chapter(s)	6.2.
Default	0

LCD text values	ID	Description
0..59	00-59	Disable timer time, minutes part

56 - Clock hours

Description	Clock, hours part (24 hour format).
See Chapter(s)	6.2.
Default	0

LCD text values	ID	Description
0..23	00-23	clock, hours part.

57 - Clock minutes

Description	clock, minutes part.
See Chapter(s)	6.2.
Default	0

LCD text values	ID	Description
0..59	00-59	clock, minutes part

58 - Disable timer on/off

Description	Timer for disabling the repeater on/off.
See Chapter(s)	5.6.
Default	Off. Always off after a restart, value not stored in EEPROM.

LCD text values	ID	Description
Off	00	Timer for disabling the repeater off.
On (once)	01	Timer for disabling the repeater on (once).
On (continuous)	02	Timer for disabling the repeater on (continuous).

59 - Enable timer on/off

Description	Timer for enabling the repeater on/off.
See Chapter(s)	5.6.
Default	Off. Always off after a restart, value not stored in EEPROM.

LCD text values	ID	Description
Off	00	Timer for enabling the repeater off.
On (once)	01	Timer for enabling the repeater on.
On (continuous)	02	Timer for disabling the repeater on (continuous).

60 - Audio input level RX MAIN

Description	The audio input level of the RX MAIN signal, in % of the input.
See Chapter(s)	5.2.
Level to ID	$ID = level / 5$
ID to level	$Level = ID * 5$
Default	50 %

LCD text values	ID	Description
0%	00	Level 0 %
5%	01	Level 5 %
10%	02	Level 10 %
15%	03	Level 15 %
20%	04	Level 20 %
25%	05	Level 25 %
30%	06	Level 30 %
35%	07	Level 35 %
40%	08	Level 40 %
45%	09	Level 45 %
50%	10	Level 50 %
55%	11	Level 55 %
60%	12	Level 60 %
65%	13	Level 65 %
70%	14	Level 70 %
75%	15	Level 75 %
80%	16	Level 80 %
85%	17	Level 85 %
90%	18	Level 90 %
95%	19	Level 95 %
100%	20	Level 100 %

61 - Audio input level RX SUB

Description	The audio input level of the RX SUB signal, in % of the input.
See Chapter(s)	5.2.
Level to ID	$ID = level / 5$
ID to level	$Level = ID * 5$
Default	50%

LCD text values	ID	Description
		See 60 - Audio input level RX MAIN

62 - Audio mix level with CW and CTCSS TX

Description	The audio mix level with the CW and CTCSS TX signals, in % of the input.
See Chapter(s)	5.2.
Level to ID	$ID = level / 5$
ID to level	$Level = ID * 5$
Default	50%

LCD text values	ID	Description
		See 60 - Audio input level RX MAIN

63 - Audio output level to TX

Description	The audio signal output level to the TX, in % of the input.
See Chapter(s)	5.2.
Level to ID	$ID = level / 5$
ID to level	$Level = ID * 5$
Default	50%

LCD text values	ID	Description
		See 60 - Audio input level RX MAIN

70 - Low battery level

Description	Low battery level in Volt
See Chapter(s)	6.3.
Voltage to ID	$ID = voltage * 2$
ID to voltage	$voltage = ID / 2$
Default	7.0 V

LCD text values	ID	Description
7.0 V	14	Battery voltage low level 7.0 V
7.5 V	15	Battery voltage low level 7.5 V
8.0 V	16	Battery voltage low level 8.0 V
8.5 V	17	Battery voltage low level 8.5 V
9.0 V	18	Battery voltage low level 9.0 V
9.5 V	19	Battery voltage low level 9.5 V
10.0 V	20	Battery voltage low level 10.0 V
10.5 V	21	Battery voltage low level 10.5 V
11.0 V	22	Battery voltage low level 11.0 V
11.5 V	23	Battery voltage low level 11.5 V
12.0 V	24	Battery voltage low level 12.0 V
12.5 V	25	Battery voltage low level 12.5 V
...
24.0 V	48	Battery voltage low level 24.0 V

71 - Low battery action

Description	Low battery action. Special roger beep to use in case of a low battery.
See Chapter(s)	6.3.
Default	No special roger beep.

LCD text values	ID	Description
None	00	No special roger beep.
Roger B	01	"B" (- · · ·) in morse code.
Roger BL	02	"BL" (- · · · · - · · ·) in morse code.
Roger <RC>	03	"<RC>" (· - · - · - ·) in morse code.

72 - LCD backlight time out

Description	LCD backlight time out.
See Chapter(s)	6.4.
Default	Always on

LCD text values	ID	Description
On	00	Always on
10 s timeout	01	Off when no key pressed for 10 seconds.
20 s timeout	02	Off when no key pressed for 20 seconds.
30 s timeout	03	Off when no key pressed for 30 seconds.
60 s timeout	04	Off when no key pressed for 1 minute.
Off	05	Always off

73 - Squelch internal, external high or low

Description	Squelch internal, external high or external low.
See Chapter(s)	5.3.
Default	internal

LCD text values	ID	Description
Internal	00	Use internal analog squelch detection of PRC.
External high	01	Use external logic squelch signal, squelch open is high.
External low	02	Use external logic squelch signal, squelch open is low.

74 - AUX1 function

Description	Function of the multi-functional I/O pin AUX1.
See Chapter(s)	6.5.
Default	Multi-function not used.

LCD text values	ID	Description
None	01	Multi-function not used.
Dig output<out>	02	Item 92 value.
TX On <out>	03	TX On state (PTT).
Low bat <out>	04	Battery low state.
Disabled <out>	05	Disabled state.
Disable <in>	06	"Disable External" input.
PTT block <in>	07	"PTT block External" input.

75 – AUX2 function

Description	Function of the multi-functional I/O pin AUX2.
See Chapter(s)	6.5.
Default	Multi-function not used.

LCD text values	ID	Description
None	01	Multi-function not used.
Dig output<out>	02	Item 93 value.
TX On <out>	03	TX On state (PTT).
Low bat <out>	04	Battery low state.
Disabled <out>	05	Disabled state.
Disable <in>	06	"Disable External" input.
PTT block <in>	07	"PTT block External" input.

80 - DTMF command address

Description	The DTMF command address.
See Chapter(s)	6.6.
Default	A

LCD text values	ID	Description
A	01	DTMF command address A
B	02	DTMF command address B
C	03	DTMF command address C
D	04	DTMF command address D

81 - DTMF remote commanding RX MAIN on/off

Description	DTMF remote commanding RX MAIN on/off.
See Chapter(s)	6.6.
Default	Off / disabled

LCD text values	ID	Description
Off	00	Remote DTMF commanding for RX MAIN input disabled.
On (silent)	01	Remote DTMF commanding for RX MAIN input enabled. No acknowledge of a received DTMF command message.
On (call/BCN)	02	Remote DTMF commanding for RX MAIN input enabled. A received DTMF command message will be acknowledged.

82 - DTMF remote commanding RX SUB on/off

Description	DTMF remote commanding RX SUB on/off.
See Chapter(s)	6.6.
Default	Off / disabled

LCD text values	ID	Description
Off	00	Remote DTMF commanding for RX SUB input disabled.
On (silent)	01	Remote DTMF commanding for RX SUB input enabled. No acknowledge of a received DTMF command message.
On (call/BCN)	02	Remote DTMF commanding for RX SUB input enabled. A received DTMF command message will be acknowledged.

83 - Remote serial configuration on/off.

Description	Remote serial configuration on/off.
See Chapter(s)	10.2.
Default	Disabled

LCD text values	ID	Description
Off	00	Remote serial configuration off.
On	01	Remote serial configuration on.

90 – Firmware version

Description	Shows the current firmware version.
See Chapter(s)	10.1.

91 – Test value

Description	A test value that can be used to test if commands are received correctly without changing the settings of the repeater itself.
See Chapter(s)	6.6.
Default	46

LCD text values	ID	Description
0..99	00-99	Test values.

92 - Digital output 1 on/off

Description	On/off state of the digital output AUX1, pin 8 on the AUX connector.
See Chapter(s)	6.5.
Default	Off

LCD text values	ID	Description
Off (AUX pin 8)	00	Digital output AUX1 (pin 8) off (low).
On (AUX pin 8)	01	Digital output AUX1 (pin 8) on (high)

93 - Digital output 2 on/off

Description	On/off state of the digital output AUX2, pin 9 on the AUX connector.
See Chapter(s)	6.5.
Default	Off

LCD text values	ID	Description
Off (AUX pin 9)	00	Digital output AUX2 (pin 9) off (low).
On (AUX pin 9)	01	Digital output AUX2 (pin 9) on (high)

98 – Factory reset

Description	Reset all configuration items to their default value.
See Chapter(s)	7.3.
Default	No factory reset

LCD text values	ID	Description
No reset	00	No factory reset
Reset@restart	01	A factory reset will be performed on restart (power cycle).

99 - Exit Configuration Mode

Description	Exit the Configuration Mode to go back to the Overview Mode.
See Chapter(s)	4.1.

7.3 Factory Reset

A factory reset will reset all configuration items to their default values (see 7.2) and all calls (items 1..5) will be cleared. After a factory reset all previous configuration settings will be lost.

Performing a factory reset is a three-step process:

1. Set configuration item 98 to "Reset@restart".
2. Leave the Configuration and Edit Mode and return to the Overview Mode.
3. Restart the PRC by removing the power to the PRC for at least a few seconds.

At startup the second line of the LCD will show "Factory Reset" and the factory reset is performed.

8. Hardware Specifications

8.1 Power supply

Voltage: 7-30 V DC
 Internal regulator: Smart, constant power (current reduces with rising voltage)
 Fused: No
 Recommended fuse: 500 mA

Current consumption indication of the PRC (no connections to multi-function I/O):

Input voltage [V]	I [mA] - LCD off	I [mA] - LCD on
9.0	37	96
12.0	29	72
13.8	26	63
24.0	17	38

8.2 Pin layout microprocessor

The PRC contains a Microchip 8-bit AVR RISC-based microcontroller ATmega1284P. The pin connections are as stated below:

Squelch	> PB0	1	40	PA0	<	ADC0 CTCSS
SPI CS TX Digipot	< PB1	2	39	PA1	<	ADC1 DTMF RX MAIN
PTT	< PB2	3	38	PA2	<	ADC2 DTMF RX SUB
LCD D7	< PB3	4	37	PA3	>	SPI CS RX Digipot
LCD D6	< PB4	5	36	PA4	<	ADC4 VOLTAGE
SPI MOSI	< PB5	6	35	PA5	-	
SPI MISO	> PB6	7	34	PA6	-	
SPI SCK	< PB7	8	33	PA7	<	SQL EXTERN
RESET	>	9	32	<	<	AREF
VCC	>	10	31	<>	<>	GND
GND	<>	11	30	<	<	AVCC
XTAL2	<>	12	29	PC7	>	LCD D5
XTAL1	<>	13	28	PC6	>	LCD D4
AUX2 (RXD UART 0)	<>PD0	14	27	PC5	<	BUTTON UP (TDI)
AUX1 (TXD UART 0)	<>PD1	15	26	PC4	<	BUTTON DOWN (TDO)
RXD UART 1 (PC)	> PD2	16	25	PC3	<	BUTTON OK (TMS)
TXD UART 1 (PC)	< PD3	17	24	PC2	>	BUTTON RIGHT (TCK)
TX CW (OC1A)	< PD4	18	23	PC1	<	BUTTON LEFT
LCD backlight	< PD5	19	22	PC0	>	LCD E
TX CTCSS (OC2B)	< PD6	20	21	PD7	>	LCD RS

8.3 Printed Circuit Board

Dimensions

The bare PCB has the following outer dimensions:

Length: 162.8 mm
Width: 75 mm

LEDs

The bare printed circuit board (PCB) contains three LEDs. The LEDs give the following information:

LED	Information when on
Green	Power supply voltage detected (see also 8.1).
Yellow	Internal analogue squelch detection, signal detected (see also 5.3).
Red	PTT on (see also 3.2).

Mounting

Mounting holes are available at the four corners of the PCB. Each hole is 3.2 mm in diameter and fits M3.

8.4 External navigation buttons

Via the AUX connector it is possible to connect an extra set of navigation buttons parallel to the buttons on the PCB of the PRC. Each button should be normally open and connected to ground (pin 5) when pressed. Each button connection is internally equipped with a pull up resistor.

See 3.2 for more information about the AUX connector. The table below shows the AUX connections for the extra navigation buttons.

Pin number	Function
1	Button [Left].
2	Button [OK].
3	Button [Up].
5	Ground.
6	Button [Right].
7	Button [Down].

9. Troubleshooting

When there seems to be no audio via the main receiver input:

- Read chapter 5.2, if not done already.
- Check the Main RX 3.5 mm stereo audio connector connections (see 3.2).
- Check the Main audio level on the Levels Overview screen (see 4.2 and 5.2).
- Check the potmeter settings in the main audio path (see 5.2).

When there is audio but the repeater does not 'open':

- Read chapter 5.6, if not done already.
- Check the squelch setting (item 73, Main Overview screen and see 5.3).
- Check the 1750 Hz setting (item 40, the Main Overview screen and see 5.4).
- Check the CTCSS settings (items 41 and 42, the Main Overview screen and see 5.4).
- Check if the time out is activated (items 46 and 47, Main Overview screen and see 5.6).
- Check if the repeater is not blocked (item 50, the Main Overview screen, and see 6.1).
- Check if the repeater is not disabled (item 51, the Timers Overview screen, and see 6.1 and 6.2).

When remote DTMF commanding does not seem to work:

- Be sure the LCD is in Overview mode (not in Configuration or Edit mode, see 4.1).
- Read chapter 6.6, if not done already.
- Check the audio levels on the Levels Overview screen (see 4.2 and 5.2).
- Observe the Commands Overview screen while giving DTMF commands.
- Check if the correct DTMF remote commanding input is enabled: RX MAIN (item 81) and /or RX SUB (item 82).
- Check the DTMF command address (item 80).

10. External PC communication

10.1 Firmware upgrade

The firmware of the Portable Repeater Controller (PRC) can be updated with the help of a special software update application on a Windows PC. By connecting the PRC-SER (TTL-232R-AJ FTDI) cable between the PRC and a PC (see 3.2 and 5.1) the new firmware can be downloaded. The current version of the software can be determined via the startup screen or via configuration item 90.

The firmware will only function when the download is performed with the build-in firmware update function in Portable Repeater Controllers supplied by Emco Electronics. It is not allowed to use the firmware otherwise.

At first use, connect the USB side of the cable to the Windows PC and follow the automatic install process. After successful installation the PRC-SER cable will add a new (virtual) COM port on the PC (for example COM4).

Carefully perform the following steps to update the firmware of the PRC:

1. Start the PRC Firmware Updater software (prcUpdater.exe, see website).
2. Download the latest firmware (.hex) file and store it somewhere on your PC.
3. Select this firmware file with the <Browse> button.
4. Put the serial cable between the PRC SERIAL connection (3.5 mm stereo) and the PC (USB).
5. Select the Serial COM port that connects to the PRC.
6. Turn off your PRC by removing the power.
7. Press the <Start> button.
8. Turn on your PRC, the update progress indication should start to run from 0 to 100%, both on the PRC (see image below) and in the PRC Firmware Updater software.



9. An update will take around three minutes. At progress 100% the new firmware is installed and the PRC will start automatically.
10. Close the PRC Firmware Updater software. The serial cable can also be removed.

All configuration settings that are stored in EEPROM will remain their value during the firmware update.

When the firmware update went wrong somewhere, just restart the procedure described above. No attempts should be made to update the firmware otherwise than the procedure described above!

10.2 Remote configuration and monitoring

Remote configuration and monitoring will become available in firmware version 2.



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