

Broadcast Receiver Module covering MF, HF and VHF Band II

D/DRM1000/2.1 August 2024

DATASHEET

Features

- Pre-programmed, ready-to-use module
- Easily integrated into a wide range of products
- Covers broadcast bands from 530 kHz to 108 MHz
- Direct support for ferrite and telescopic antennas
- 1 W amplifier for small loudspeaker
- Analogue Line Output
- Low-power consumption from 3 V battery
- Low-cost, high-performance
- Integrated Multiplex Distribution Interface (MDI) functionality via the UART interface

- Receives Digital Radio Mondiale (DRM30 / DRM+)
- Receives AM and FM
- Conforms to EN 303-345 specification
- Designed to meet DRM Consortium Minimum Receiver Requirements
- Includes licence for all software and essential IPR

Applications

- Battery-powered broadcast radio
- Smartphone receiver accessory
- Portable music players
- In-car entertainment
- Wireless Speakers

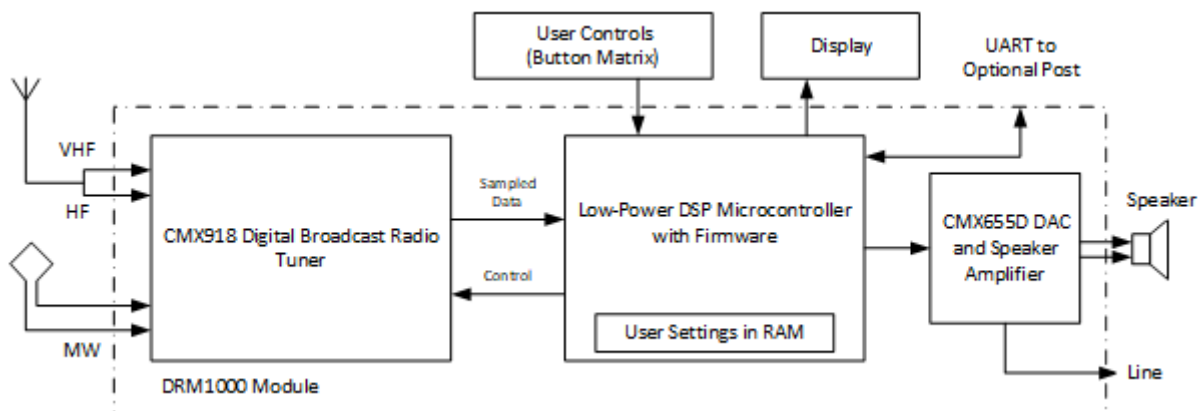


Figure 1 - Overview of Broadcast Receiver Module

1. Brief Description

The DRM1000 broadcast receiver module is a complete ‘antenna-to-audio’ solution designed for easy integration by manufacturers of broadcast receivers. Full software functionality is included for high-performance reception of AM, FM, and DRM (DRM30 and DRM+) broadcasts worldwide, across MF, HF and VHF (Band I and II). The module software supports a simple user interface comprising a small, low-cost display and push-buttons. Support is also provided for an external microcontroller via a serial interface, to provide an extended user interface and functions if desired.

The DRM1000 includes all software and essential intellectual property licences including the xHE-AAC codec required by the Digital Radio Mondiale standards. This allows manufacturers to manufacture and sell DRM capable receivers without the need for any legal or licensing arrangements with holders of essential PR utilised in the DRM radio broadcast system. This, combined with the ease of integrating the DRM1000 into a receiver design greatly simplifies the creation of a final product.

This document refers to features and functions implemented in the current module firmware version. Please refer to the document history section for specific information on firmware revision numbering. The user should also refer to the user manual for the DE9180 (demonstration board for the DRM1000); this incorporates much of the external circuitry referred to within this document. Further information on the CMX918, CMX655D and DE9180 is available via the CML website.

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2. History

Table 1 - Document history

History		
Version	Changes	Date
1.0	First Approved version	May 2024
2.0	Section 11; MDI over UART Interface functionality added to firmware Other minor edits / corrections and re-ordering of sections	July 2024
2.1	Updated the MDI (section 11) and regulatory sections (section 14)	August 2024

Information in this document is subject to change and additions may be made to this specification. Parameters marked TBD or left blank will be included in later issues.

3. Connection Diagram

Connections are made by castellations or by the user fitting pin headers along three sides of the module – on a 2.54 mm (0.1 inch) spacing. These may either be soldered directly to suitable pads on a motherboard (see section 16), or to pin headers (two 17-way plus one 8-way) which may be fitted to connect the DRM1000 to standard breadboard products.

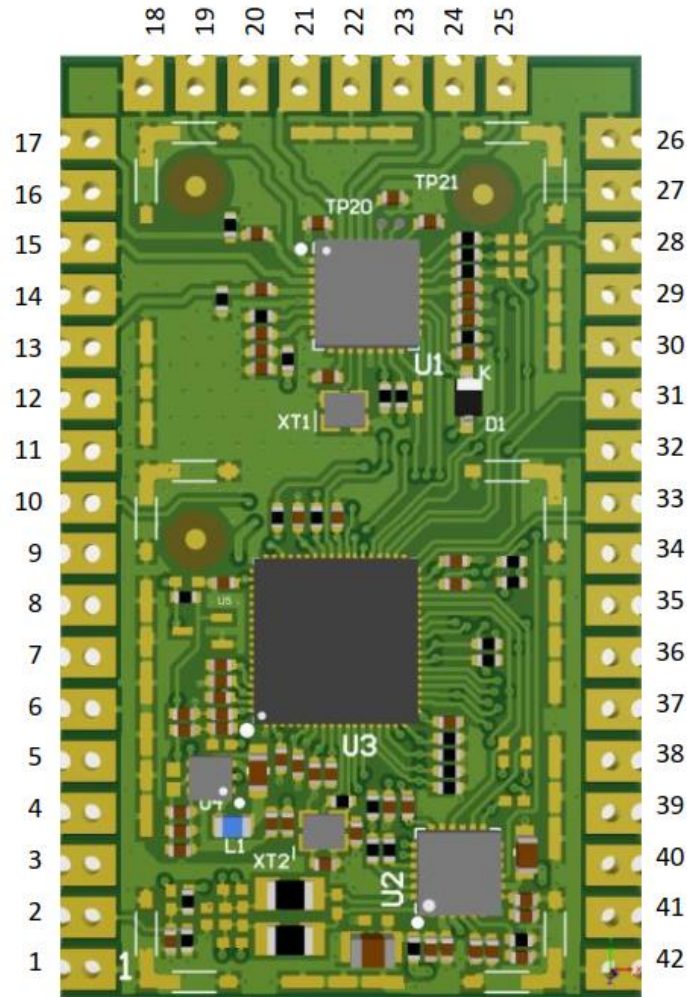


Figure 2 - Connection Diagram (Top view)

4. Pin Numbers and Signal Names

Table 2 - Pin Numbers and Signal Names

Pin Numbers and Signal Names			
Pin	Pin name	In/Out/ Power	Description
1	GND		Ground, connected to battery negative
2	LOUT	O	Line level mono output
3	SPEAKER_N	O	Balanced output to loudspeaker, 0.5 W, 4-16 Ω
4	SPEAKER_P	O	Balanced output to loudspeaker, 0.5 W, 4-16 Ω
5	RSTn	I	Reset input, active low.
6	GND		Ground, connected to battery negative
7	VDD_3V1	P	Main power from battery positive, via external regulator. See section 5
8	GPIO 0	I/O	Keyboard scan row 1. See section 9 or EWF Active when in Headless Mode
9	GPIO 1	I/O	Keyboard scan row 2. See section 9
10	GPIO 7	I/O	Output for external HF band switch ¹
11	GND		Ground, connected to battery negative
12	GND		
13	VHF_IN	I	Antenna input for VHF ('FM band') operation
14	GND		Ground, connected to battery negative
15	CBN	O	Capacitor Bank for tuning ferrite antenna
16	GND		Ground, connected to battery negative
17	HF_IN	I	Antenna input for HF (shortwave) operation
18	GND		Ground, connected to battery negative
19	CBP	O	Capacitor Bank for tuning ferrite antenna
20	GND		Ground, connected to battery negative
21	LFMF_INp	I	Ferrite antenna input for LF/MF operation. See section 7
22	GND		Ground, connected to battery negative
23	LFMF_INn	I	Ferrite antenna input for LF/MF operation. See section 7
24	GND		Ground, connected to battery negative
25	LF_LNA	O	Optional Feedback signal for LF/MF operation. See section 7
26	GND		Ground, connected to battery negative
27	GND		
28	GND		
29	GND		
30	GND		
31	1V8_MONITOR		Connected to internal 1.8 V supply via 100 k Ω resistor
32	UART_TX	O	External host / debug – connect to Rx pin of external host. Leave unconnected if no external host. See section 10
33	UART_RX	I	External host / debug – connect to Tx pin of external host. Leave unconnected if no external host. See section 10
34	I2C_SDA	I/O	Display drive. See section 9
35	I2C_CLK	O	Display drive. See section 9
36	GPIO 6	I/O	Keyboard scan column 4. See section 9 (can be used by an external host to wake from standby).
37	GPIO 5	I/O	Keyboard scan column 3. See section 9
38	GPIO 3	I/O	Keyboard scan column 1. See section 9
39	GPIO 4	I/O	Keyboard scan column 2. See section 9
40	GPIO 2	I/O	Keyboard scan row 3. See section 9
41	VDD_PA	P	Connect to VDD_3V1 if speaker amplifier is in use. See sections 5 and 8. Leave unconnected if not driving a speaker directly
42	GND		Ground, connected to battery negative

¹ The GPIO7 output may also be used for controlling the mode of an external switch mode regulator to reduce interference.

5. Power Supply

5.1. General

DRM1000 requires a single supply of nominally 3.1 V at 70 mA (connected to pin 7) for the main receiver plus up to 400 mA peak (connected to pin 41) for the speaker amplifier, if used.

5.2. Battery Options

DRM1000 may be driven from three AA or AAA cells, using a simple step-down regulator or Low-dropout regulator (as used on the DE9180).

5.3. Recommended Regulator

A switch-mode regulator is recommended for longest battery life. The chosen regulator should have a switching frequency that is outside the broadcast bands of interest. This circuitry should be screened from the ferrite rod and other antennas. The TPS62243DRV from TI is a good choice for minimising MF band interference as this has a fixed PWM mode of 2.25 MHz.

Alternatively, a linear 'low-drop-out' type may be used. For maximum battery life, a regulator should be chosen that changes to bypass mode at low battery level, as the DRM1000 will continue operating with reduced performance below 3.1 V.

6. Operation

The DRM1000 supports DRM modes A to D at MF and HF (DRM30) and mode E at VHF (DRM+).

It also supports AM and FM demodulation. Single channel AM/DRM simulcast support may be added in the future.

6.1. Reset Operation

The DRM1000 can be reset via the RSTn pin or via the UART STANDBY command. Resetting the DRM1000 will trigger a reboot only, the persistent configuration settings will be retained. Following a reset the UART interface will need to be initialised again before it can be used, see section 10.2.

6.1.1. Power-up Procedure

Apply power to the module and assert RSTn (low) for 280ms then release RSTn.

Note that the 280ms time is required to allow the module's power up sequence to complete.

6.2. General Operation

The DRM1000 should be connected to a power supply all times, so that the Emergency Warning Function (described below) can wake the unit.

For normal operation, pressing USR will wake the unit. To return the unit to standby, the USR key should be pressed.

Volume is adjusted using the VOL+ and VOL- buttons or the VOLUME_UP, VOLUME_DOWN and VOLUME_SET commands.

The band (MF/HF/VHF) is selected by repeated presses on the BAND button or the BAND_UP command.

The mode is selected by pressing the DRM/AM/FM button or the SET_DEMOD_MODE command. Button presses alternate between analogue (i.e. AMw, AMn or FM depending on band) and DRM.

The following are displayed:

- Mode (AMw/AMn/FM/DRM) and currently tuned frequency
- A measure of signal quality (weighted modulation error ratio for DRM, or RSSI for AM/FM)
- Service label – top row of text
- Any text messages being sent – second row
- If an emergency warning is being transmitted, the screen flashes with alternating colours at 1Hz.

6.3. Tuning

6.3.1. Auto-scan

DRM1000 can automatically scan all enabled bands for AM, FM, and DRM stations. This is initiated by a long press on the SCAN button or the START_SCAN command.

When the scan has completed, the number of discovered AM, FM, and DRM stations will be displayed. All discovered stations will be stored in non-volatile memory.

6.3.2. Station Selection

The STA+ and STA- buttons or STATION_UP and STATION_DOWN commands can be used to select the station. If a scan has been performed, the DRM1000 will step through the previously stored stations for the selected mode. DRM1000 will change between MF/HF/VHF as required to tune to the next saved station.

Otherwise, the DRM1000 will seek up or down until a station is detected.

Four memory buttons M1 to M4 are provided – these provide access to 4 memory locations. The current station is stored by a long press (>2s) on the required memory button. A short press on a memory button tunes to the stored station, if any; there is no action if no station has been stored. Equivalent functionality is provided by the STATION_STORE and STATION_RECALL commands.

6.4. Manual Frequency Entry

Manual frequency entry using the buttons is enabled with a short press of the SCAN button. The currently selected mode remains unchanged during this process. Frequencies entered by this method are not limited to the broadcast bands.

Once the SCAN button has been pressed, the receiver is in manual tune mode. The most significant digit of the frequency display is highlighted, and the manual tuning process starts on this digit. All digits start unchanged. If any significant digits are zero before tuning, the empty space is filled with a zero.

MF/HF examples:

- Current frequency 960 kHz, press SCAN -> **0**0960 k
- Current frequency = 1234 kHz, press SCAN -> **0**1234 k
- Current frequency = 23456 kHz -> **2**3456 k

VHF examples:

- Current frequency 87.90 MHz, press SCAN -> **0**87.90 M
- Current frequency = 103.70 MHz, press SCAN -> **1**03.70 M

Pressing the STA+ and STA- buttons increment and decrement the highlighted digit.

When pressing + when digit is 9, or – when digit is 0, the current number wraps without incrementing or decrementing the next significant figure.

Examples:

- 1396**9**, pressing ST + changes to 1396**0**.
- 0345**0**, pressing ST - changes to 0345**9**.

Once user has selected the desired most significant digit, pressing the SCAN button moves to the next significant digit, and the process repeated for the second most significant digit (1000 kHz for MF/HF, 10 MHz for VHF).

For VHF, the decimal point in the frequency is ignored – the highlighted character skips the decimal point and moves to the final fractional part.

Example:

- 09**7**.90, pressing FREQ/SCAN moves the active character to 097.**90**

The process is repeated until the least significant digit is set.

For MF/HF, the smallest tuning increment is 1 kHz, and for manual tuning in VHF, the smallest tuning increment is 0.05 MHz. Once the least significant digit has been set, pressing SCAN once more executes tuning to the specified frequency.

6.5. Emergency Warning Function

The DRM Emergency Warning Function (EWF, specified in <https://www.drm.org/wp-content/uploads/2014/07/DRM-EWF-Emergency-Warning-Overview-v2.pdf>) is implemented on DRM1000, with the following rules and restrictions:

- Audio and basic text services are provided
- Interactive text services are not supported, due to the size and nature of the display and user controls.
- Same band only (MF, HF, VHF) – for example, if tuned to DRM in MF, only other stations in MF can be switched to, in order to account for unknown antenna connections.
- Unrestricted region only.
- Unrestricted schedule only, unless the currently-tuned station has supplied time information. DRM1000 does not include a real-time clock to support scheduled services.
- Switching to a DRM service is prioritised, swapping only to AM (from MF/HF) or FM (from VHF) if DRM fails, or no DRM option is listed.
- At least one frequency must be specified in the EWF broadcast – scanning all bands searching for a particular service ID is not feasible.
- AM AMSS and FM RDS are not supported.
- If a target AM/FM frequency is specified with a service ID (via AMSS/RDS), the service ID is ignored and DRM1000 tunes to the specified frequency anyway.
- If DRM and multiple frequencies are listed, DRM1000 will search through the list for the specified service ID. If it is not found, DRM1000 will return to the original station.
- If multiple AM/FM target frequencies are listed, DRM1000 will search through each frequency until one is found above an RSSI threshold. If none are above this threshold, DRM1000 will return to the original station.
- If the specified emergency station is found (either having found the correct service ID if DRM, or AM/FM above some RSSI threshold) then DRM1000 will remain on that station and will not attempt to switch back to original station at end of announcement. This is because DRM does not guarantee signalling the end of an EWF transmission.

Only switching due to active emergency warning is supported. Other notification types have no effect. When the DRM1000 switches to the target service and the announcement type is 'Warning / alarm', the audio volume will increase by 2 level (~14 %) and the display will flash. Any user interaction during active emergency warning will stop the screen from flashing and existing volume is maintained.

If the target short ID is the same as the currently tuned short ID, no action will be taken, and the current service will continue to be decoded with no audio interruption. If the announcement type is 'Warning / alarm', the volume will increase to maximum, and the display will flash.

When in headless mode (i.e. no display attached) and an active emergency warning is detected, external GPIO 0 is sent high for one second. This allows an external processor to wake and process the audio.

The DRM1000 continues to receive the 'Announcement support and switching data entity (type 6)' whilst an announcement is active. It will switch back to the originally tuned service on this multiplex when an announcement ceases, stop the screen flashing and turn the audio volume down.

The user interface will operate as normal when an announcement is active, including to switch away from the target service or change the audio volume.

7. Antenna Design and Connection

DRM1000 supports three different antenna configurations:

1. a tuned ferrite type for MF operation (530 kHz to 1710 kHz) or air loop antenna
2. a 50 Ω unbalanced input for HF (2 MHz to 40 MHz)
3. a 50 Ω unbalanced input for VHF (40 MHz to 108 MHz)

A typical fixed application may connect antenna configuration 2 above to a long wire, and antenna 3 configuration to a VHF antenna.

For a portable application, a single antenna may be connected to inputs 2 and 3 using a simple diplexer arrangement, shown in Figure 5 below.

For efficient use with a short (high impedance) telescopic whip antenna for HF operation, a suitable external high input impedance amplifier will be required.

DRM1000 will switch automatically to the correct antenna input as above, depending on the frequency setting.

7.1. Ferrite Antenna / Air Loop Specification for MF

CMLs recommendation for the use of a ferrite rod with both primary and secondary coils is shown in Figure 3 below. The primary coil is connected between pins 21 and 23 and the secondary between pins 15 and 19.

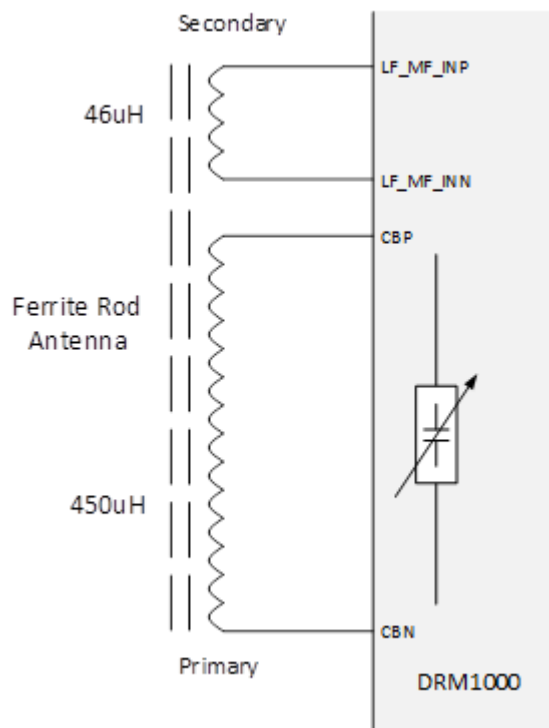


Figure 3 - Ferrite Rod Antenna Arrangement

The illustrated ferrite rod may be made with “Type 61” material. Longer ferrite rods will be more efficient than thicker ones and therefore offer greater sensitivity. The choice of dimensions will need to be balanced against increasing rod fragility and the application for which it is intended or to be fitted within.

The two windings are centrally mounted along the rod and formed from Litz wire (e.g. 10/0.04 mm) chosen for low loss.

The 450 μH primary winding is mounted between the DRM1000 CBP and CBN pins which are connected to the internal capacitor bank thereby allowing the rod to be resonated. The winding inductance is kept low to minimise coil losses and to increase 'Q'. The capacitor bank has a maximum capacitance of 235 pF which is sufficient to enable operation down to 500 kHz. The capacitor bank value is adjusted across the band from a look-up table within the Persistent Store, allowing this to be modified for different implementations. The value used is interpolated for frequencies between table entries.

The 46 μH secondary winding should be similarly formed and located 2 to 3 mm along from the primary winding. This winding is connected to the DRM1000 LFMF_INp and LFMF_INn pins. The secondary winding's function is to match the very high impedance of the primary parallel L/C resonant circuitry to the 15 k Ω differential impedance of the LNA input. Over-winding the coils concentrically may offer some performance benefit but has not been evaluated.

Location of the ferrite rod within the radios case is critical to avoid potential sources of interference, for example from switching regulators, displays, long noisy PCB traces and other clock sources. Rod orientation may also have an impact. Effective screening of such noise sources is advised should it be impractical to locate the ferrite far enough away from these sources.

Alternatively, an 'air loop' antenna of approximately 15 μH can also be used via an input transformer (Coilcraft type WB36-1SL recommended) – see Figure 4.

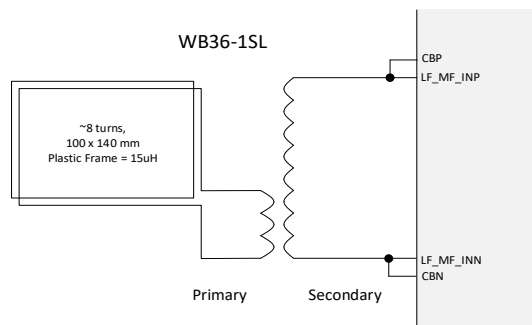


Figure 4 - Typical Air Loop Antenna

7.2. Whip Antenna

A wide range of antennas can be used with DRM1000 for portable or static applications. If a single antenna is to be used for both HF and VHF, a diplexer filter similar to that shown in should be used.

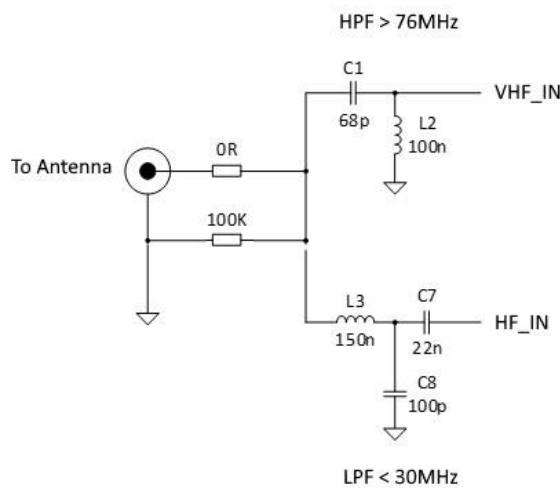


Figure 5 - Antenna Diplexer Configuration

A more complex filter may be required for operation in the presence of extremely strong out-of-band signals and is incorporated in the DE9180. ESD protection should also be included on any external antenna input (for example low capacitance diodes).

For optimum sensitivity using an electrically short telescopic whip antenna on HF, a high impedance input buffer circuit (JFET) will need to be implemented after any VHF diplexer arrangement, controlled by GPIO7.

The level at GPIO7 (pin 10) will change from logic low to high when DRM1000 is tuned to frequencies above 2 and below 40 MHz, and this signal can be used to either control an external RF switch or the supply for a high input impedance buffer for HF reception.

This signal may also be used to control the mode of a switch mode regulator supplying power to the DRM1000 (moving the switching frequency out of band to avoid MF band interference).

8. Audio Outputs

8.1. DRM1000 – Output Configuration

DRM1000 includes a Class D speaker amplifier capable of driving approximately 1 W into a 4 Ohm speaker connected between pins 2 and 3. This is a balanced output: **neither side may be connected to ground**. A standard 'stereo' TRS earphone jack may be connected, as shown in Figure 6, to deliver mono to both earpieces in parallel:

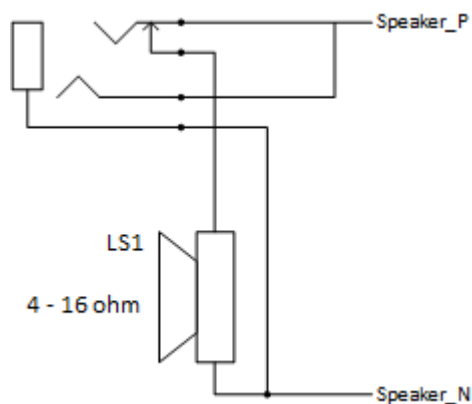


Figure 6 - DRM1000 Audio Outputs

Connections to the speaker should be kept short, as long leads may give rise to noise and harmonics of the Class D output affecting MF band reception. If speaker leads longer than a few cm are needed, LC filtering should be added close to the module output. Audio leads connected after this filter should be a maximum length of 300 cm.

An analogue low-level output is also provided at pin 1, delivering a nominal 100 mV peak. This does not require the Class D output to be active. An external amplifier input may be connected between this signal and ground.

9. Operation Using Keypad and Display

9.1. Keypad

A simple keyboard is supported for basic receiver functions: push buttons are connected as shown in Figure 7.

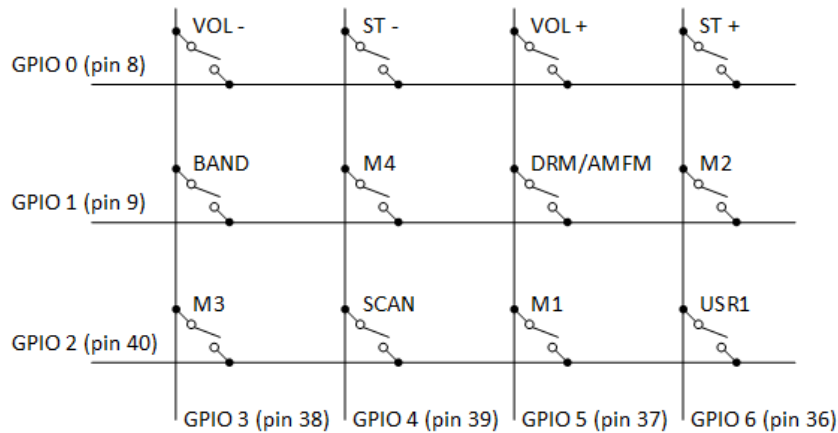


Figure 7 - Receiver Push Buttons

GPIO7 (pin 10) is available to switch an optional HF preamplifier or the power supply mode, see section 7.2. GPIO6 (pin 36) can also be used by an external microcontroller to wake module from standby. GPIO0 (pin 8) will go high in headless mode when an Emergency Warning is received.

The function of the buttons shown are:

Table 3 - Functions of the Push Buttons

Functions of the Push Buttons			
Button name	Between pins	Function: short press < 0.5s	Function: long press ≥ 2s
VOL+	7, 36	Increase volume by one step	-
VOL-	7, 37	Decrease volume by one step	-
STA+	7, 35	Step up to next scanned station. Manual tuning mode, increment selected digit.	Enter raster tuning mode: for subsequent short presses tune upward by one channel spacing. After 5s of no presses, exit raster tuning mode
STA-	7,38	Step down to next scanned station. Manual tuning mode, decrement selected digit	
MF/HF/VHF	8, 37	Increments between MF, HF1, HF2, HF3, VHF (or the subset of sub bands enabled in 12.2)	-
AM/FM/DRM	8, 36	Select between DRM mode and AM wide/AM narrow/FM mode. (FM selected automatically for VHF band, otherwise AM)	-
SCAN	39, 38	Abort scan if already started; Direct frequency entry: <ul style="list-style-type: none"> • Most significant frequency digit highlighted, incremented by Station / Service Up or Down button. • Press Scan again to move to the next digit • Continue until least significant digit, then press Scan to tune to entered frequency. • Times out and returns to previous service if not completed within 10s 	Scan all sub bands (MF, HF, VHF as enabled in section 10.8) in all modes. For DRM stations, store frequency, service identifier and first 8 bytes of service label. For analogue stations, store frequency

Functions of the Push Buttons			
Button name	Between pins	Function: short press < 0.5s	Function: long press ≥ 2s
USR	39, 35	Toggle between Standby (sleep) / Wake. In Standby mode, unit will automatically wake to receive Emergency Warning broadcasts. On Waking, the unit will tune to the last station / mode used.	Toggle between off and operational modes. On Waking, the unit will tune to the last station / mode used.
1	39, 36	Retrieve Memory 1	Store current station in Memory 1
2	8, 35	Retrieve Memory 2	Store current station in Memory 2
3	39, 37	Retrieve Memory 3	Store current station in Memory 3
4	8, 38	Retrieve Memory 4	Store current station in Memory 4

Default settings;

At first power on reset, the DRM1000 is configured for DRM mode, tuned to 17485 kHz. After use of the USR button (standby mode), a full power-on reset will recall the station / mode used in the last 'standby' state. Unless the station / mode is set by the use of the 'standby' mode, the last station / frequency / mode will be forgotten after a full power-on reset. The volume control has 14 levels and is set to level 8 as default.

Note:

AMn implements a 2.3 kHz audio filter, AMw implements a 4.5 kHz audio filter if using 9 kHz channel raster (tuned to MF and MF region set to Europe/Asia/Africa or Australia/NZ) and 5 kHz filter otherwise (MF in NA/SA and all HF, 3dB bandwidths stated).

9.2. Display

The DRM1000 software drives a 128 x 64 pixel OLED display connected to the I2C pins on the module:

- SCK pin 34
- SDA pin 33

The I2C interface runs at 400 kHz, and the module will attempt to write to the display at I2C address = 0x3C (default on recommended Solomon Systech SSD1315 driver chip, in I2C mode, with D/C# (SA0) pin tied to ground).

The following are displayed:

- Mode (AMw/AMn/FM/DRM) and currently tuned frequency
- A measure of signal quality (weighted modulation error ratio for DRM, or RSSI for AM/FM)
- Service label – top row of text
- Any text messages being sent – second row
- If an emergency warning is being transmitted, the screen flashes with alternating colours at 1 Hz

Supported display drivers include Solomon Systech SSD1306, SSD1309Z or SSD1315. Many OLED display manufacturers use these devices: examples include Midas Displays MCOT128064N2S (24mm diagonal) or MCOT128064H1V (61mm diagonal). At power-on, the device will detect if the display is present or not, and if not, will enter "headless mode" and disable any further writes to it. In headless mode, control is available via the UART serial interface. By default, the keypad is disabled when entering headless mode and the keys can be re-enabled via the UART command (0x16).

10. Support of External Host

The DRM1000 may be connected via a UART interface to an external host processor if a receiver is required to offer additional features. It is configured as a DTE, so pin 32, TXD, is an output from the DRM1000 and pin 33, RXD, is an input.

The UART connection operates at 921,600 baud , 8, N, 1. Its logic high level is 3.1 V.

Note that, to avoid damaging the module, RXD (pin 33) must not be driven high before the DRM1000 is powered up. An external host should either delay before driving this pin, or may monitor pin 31, which is connected to the internal 1.8 V power rail inside DRM1000. When pin 31 is logic high (at 1.8 V) then it is safe to drive the UART lines.

Note that these pins are CMOS logic level compatible and should not be directly connected to RS232 drivers/receivers.

10.1. Message Structure

Messages sent to the DRM1000 consist of a command byte, which may be followed by parameters. Parameters can be either a single byte or a 4-byte, little-endian word.

The module responds to all recognised commands. Responses from the module begin with an echo of the command byte, followed by a single byte error code and a 4-byte little-endian field indicating the total length of the reply (this includes the echoed command byte, error code and the length field, so the smallest possible value for this field is 6). Further data follows as appropriate.

Unrecognised opcodes are ignored silently.

10.2. Initialisation

The session should start with:

0x7F (command = UART_INIT)

The module will respond with:

0x7F (echoed command byte), 0x00 (no error), 0x06, 0x00, 0x00, 0x00 (4-byte length field = 6)

Commands may then be sent at any time, and will receive an immediate response except where indicated below:

Table 4 - Serial Command Table

Serial Commands					
Command Name	Value	Command Parameters (bytes)	Response Parameters (bytes)	Parameter Values	Notes
STANDBY	0x00	Mode (1)		0 – Deep Sleep 1 – Restart 2 - Sleep with wake on DRM emergency warning	1,5
STATION_UP	0x01	N/A			
STATION_DOWN	0x02	N/A			
TUNE_TO_STATION_ID	0x03	Station ID (4)		Station ID is an integer up to 24 bits.	
TUNE_TO_FREQUENCY	0x04	Frequency (4)		Frequency in Hz	2
SET_MODE	0x05	Mode (1)		0 – DRM 1 – FM/AM wide 2 – FM/AM narrow (AM selected in MF/HF bands, FM selected in VHF band)	
BAND_UP	0x06	N/A			
VOLUME_UP	0x07	N/A			
VOLUME_DOWN	0x08	N/A			
GET_SCANNED_STATIONS	0x09	N/A			3
GET_STATUS	0x0A	N/A	Status (415)		4
STATION_RECALL	0x0B	Slot (1)		0 - 3	
STATION_STORE	0x0C	Slot (1)		0 - 3	

Serial Commands					
Command Name	Value	Command Parameters (bytes)	Response Parameters (bytes)	Parameter Values	Notes
CMX918_REG_READ	0x0D	Address (1)	Data (1)		
CMX_918_WRITE	0x0E	Address (1) Data (1)			
STATUS_OUTPUT	0x0F	State (1)		0 - Disable 1 - Enable	4
GET_VERSION	0x10	N/A	Version (variable)	Version is an ASCII string	
CMX655D_REG_READ	0x11	Address (1)	Data (1)		
CMX655D_REG_WRITE	0x12	Address (1) Data (1)			
DISABLE_DISPLAY	0x13	State (1)		1 - Disable 0 - Enable	
GET_TUNED_FREQ	0x14	N/A	Frequency (4)	Frequency in Hz	
GET_DEMOD_MODE	0x15	N/A	Mode (1)	0 - DRM 1 - AMw 2 - AMn 3 - FM 4 - Scanner 5 - AFS Search 6 - Emergency Warning Check	
ENABLE_BUTTONS	0x16	State (1)		0 - Disable 1 - Enable	
(reserved)	0x17				
STATION_UP_CHANNEL_RASTER	0x18	N/A			
STATION_DOWN_CHANNEL_RASTER	0x19	N/A			
START_SCAN	0x1A	Band (4)		0 - scan all bands	
DATA_SERVICE_OUTPUT	0x1B	State (1)		0 - Disable 1 - Enable	7
DATA_SERVICE_REPLY	0x1C				7
GET_VOLUME	0x1D	N/A	Volume (1)	0 - 100	9
SET_VOLUME	0x1E	Volume (1)		0 - 100	
STATION_GET_ID	0x1F		StationID (4)	24 bit Station ID	11
TEXT_MSG_OUT	0x20	State (1)		0 - Disable 1 - Enable	
TEXT_MSG_SERVICE	0x21		Data (x)		12
RSSI_GET	0x22		Data (4)	32-bit signed int, -128 to +127.875	
MDI_OUTPUT	0x23	State (1)		0 - Disable 1 - Enable	
MDI_GET	0x24	N/A	Data (x)		13
(reserved)	0x25 - 0x4F				
PERSISTENT_DEVICE_CONFIG_READ	0x50	N/A	Data (247)		8
PERSISTENT_DEVICE_CONFIG_WRITE	0x51	Data (27)			8
(reserved)	0x52 - 0x5F				
AUDIO_TEST_TONE	0x60	State (1)		0 - Disable 1 - Enable	10
BUTTON_GPIO_TEST_ENABLE	0x61	State (1)		0 - Disable 1 - Enable	
BUTTON_GPIO_TEST_VALUE	0x62	N/A	GPIO data (1)		

Serial Commands					
Command Name	Value	Command Parameters (bytes)	Response Parameters (bytes)	Parameter Values	Notes
(reserved)	0x63 – 0x7E				
UART_INIT	0x7F	N/A			

Notes for Table 4 - Serial Command Table:

1. The hardware does not support switch **on** from a UART message. An external controller can take the module out of standby by driving GPIO6 (pin 36) HIGH.
2. This does not change the demodulation mode. If the persistent configuration 'restrict_tuning_to_broadcast_bands' is enabled, an attempt to tune outside the enabled broadcast bands will result in an error.
3. See section 10.3
4. See section 10.4
5. If RESTART is selected, standard command response will be followed, after a pause, by the start-up string (no length parameter)
6. Reserved
7. See section 10.5
8. See section 10.
9. Value is subject to internal rounding, so may not be exactly the same as written using the SET_VOLUME command.
10. Receiver must be in AM mode. Provides audio output on speaker or LOOUT.
11. ID contained in lower 24 bits. If no ID available, returns error code 0x4 and data 0xFFFF FFFF.
12. See section 10.6
13. See section 11.

10.3. Response to GET_SCANNED_STATIONS

The response message to GET_SCANNED_STATIONS is:

Table 5 - GET_SCANNED_STATIONS Response

GET_SCANNED_STATIONS Response		
Data field name	Bytes	Data format
Opcode	1	uint8 0x09 (opcode = SCANNED_STATIONS_GET)
Error code	1	uint8 error
Length	4	uint32 length = 10 + (24*num_stations) + service label table length
Number of stations	4	uint32 num_stations

Followed by *num_stations* instances of (maximum 100):

Mode and frequency	4	uint32 mode_freq: bits 31, 30 = mode {0=DRM, 1=AMw, 2=AMn, 3=FM} bits 29..0 = freq in Hz
Service 0 ID	4	uint32 serv0id: bits 31-25 = index of service label assigned by DRM1000. bit 24 = audio/data flag (audio = 0, data = 1) bits 23-0 = service ID (from broadcaster)
Service 1 ID	4	uint32 serv1id – details as for serv0id
Service 2 ID	4	uint32 serv2id – details as for serv0id
Service 3 ID	4	uint32 serv3id – details as for serv0id
Number of services	1	num_services_in_multiplex {1..4}
null	3	uint8

Followed by *num_stations* instances of (maximum 100):

Service Label	1 to 30	uint8, null if not defined, max 30 UTF-8 characters
null	1	uint8

Each null-terminated string is maximum 30 bytes, **not** including the null terminator. It is **not** guaranteed that the final UTF-8 character is a valid UTF-8 codepoint as it will be truncated if the broadcasted service label is longer than 30 bytes.

10.4. Response to GET_STATUS

When STATUS_OUTPUT is enabled, this data packet is delivered every 400ms (Modes A-D) or 100ms (Mode E / VHF) until STATUS_OUTPUT is disabled. If receiver mode is not DRM (*receiver_mode* ≠ 0) then all DRM-specific fields will be unchanged since the last time a DRM station was received. If no DRM station has been received since wake, then the DRM-specific fields will be zero.

Table 6 - GET_STATUS Response

GET_STATUS Response		
Data field name	Bytes	Data format
Opcode	1	uint8 0x0A (opcode = STATUS_GET)
Error code	1	uint8 error
Length	4	uint32 length = 415
Receiver mode	1	uint8 receiver_mode {0=DRM, 1=AMw, 2=AMn, 3=FM}
Frame synchronised	1	bool8 drm_frame_synced {1=sync, 0=not sync}
DRM signal detected	1	bool8 drm_signal_detected {1=detected, 0=not det}
FAC CRC valid	1	bool8 fac_crc_valid {1=valid, 0=not valid}
FAC modulation error ratio dB	4	float fac_mer_dB
FAC weighted modulation error ratio dB	4	float fac_wmer_dB
SDC CRC valid	1	bool8 sdc_crc_valid {1=valid, 0=not valid}
SDC modulation error ratio dB	4	float sdc_mer_dB
SDC weighted modulation error ratio dB	4	float sdc_wmer_dB
MSC CRC valid	1	bool8 msc_crc_valid {1=valid, 0=not valid}
MSC modulation error ratio dB	4	float msc_mer_dB
MSC weighted modulation error ratio dB	4	float msc_wmer_dB
DRM robustness mode	1	uint8 drm_robustness_mode {0=A, .. 4=E}
DRM spectrum occupancy	1	uint8 spectrum_occupancy
DRM interleaver depth	1	uint8 msc_interleaver_depth
MSC mode	1	uint8 msc_mode
SDC mode	1	uint8 sdc_mode
MSC protection high	1	uint8 msc_protection_high
MSC protection low	1	uint8 msc_protection_low
Sample rate offset (PPM)	4	float sample_rate_offset
Frequency offset (fraction of subcarrier spacing, Q15.16 fixed point fraction)	4	int32 frequency_offset
Number of services in broadcast	1	uint8 num_services {1..4}
Total Bytes	52	bytes in table

Followed by 4 instances of service information (all fields will be all zeroes if there is no corresponding service). These 4 instances are always filled from the first element.

Service ID	4	uint32 service_id (bits 19..0 are broadcast service id)
Short_ID	1	uint8 short_id
Language code	1	uint8 language
Service type	1	uint8 service_type
Service descriptor	1	uint8 service_descriptor
Audio version	1	uint8 audio_version_flag
Audio stream ID	1	uint8 audio_stream_id

Audio coding	1	uint8 audio_coding
Audio SBR flag	1	bool8 audio_sbr_flag
Audio mode	1	uint8 mode
Audio sample rate	1	uint8 sample_rate
Audio text flag	1	bool8 text_flag {1=text present, 0=no text}
Audio enhancement flag	1	bool8 enhancement_flag
Audio MPEG surround mode	1	uint8 mpeg_surround_mode
Number of associated data streams	1	uint8 num_data_streams
Service label	65	uint8 service_label[65]
Service label length (characters)	1	uint8 label_length
Total Bytes	84	bytes in table (multiply by 4)

Followed by a single instance of:

Date/time information present	1	bool have_datetime_info {1=present, 0=not}
Date (Modified Julian Calendar format)	4	uint32 mjd
Time hours	1	uint8 hours
Time minutes	1	uint8 minutes
Time offset applies	1	bool have_local_time_offset {1=offset exists, 0=not}
Time offset sense	1	bool offset_sense {0=add offset to UTC; 1=subtract}
Date/time	1	uint8 local_time_offset {hours}
PRBS frame number bits	4	uint32 prbs_frame_num_bits
PRBS frame number error bits	2	uint16 prbs_frame_num_error_bits
Frame RMS dBFS	4	float frame_rms_dbfs
RSSI	4	float cmx918_rssi
Front-end IIR notch enabled	1	bool8 frontend_iir_notch_enabled
Front-end IIR notch subcarrier index	2	int16 frontend_iir_notch_sc_idx
Total Bytes	27	bytes in table

Numbers in float format are IEEE 754 standard floating-point, 32 bit, sent least significant byte first.

Numbers in uint32, uint16, [signed] int32 and [signed] int16 formats are sent least significant byte first.

10.5. Response to DATA_SERVICE

When DATA_SERVICE_OUTPUT is enabled, multiple packets of data will be output in this format;

The header has the same format as above (6 bytes), and it is followed by 1 byte FAC Application ID, then a 21 byte SDC

Application Information Entry field, followed by a Journaline data packet.

Journaline is the ETSI standardized advanced text application for the DRM digital radio system; it is also a mandatory part of EWF - Emergency Warning Functionality. A patent license for the related Fraunhofer IIS IP is available from Fraunhofer IIS directly: Please contact <https://www.iis.fraunhofer.de/en/ff/amm/kont.html> for more information regarding licensing.

The data items are described in ETSI TS 201 980 v4.2.1 DRM System Specification, section 6.4.3.6 Application information data entity: SDC type 5

Table 7 - DATA_SERVICE Response

DATA_SERVICE Response		
Data field name	Bytes	Data format
Opcode	1	uint8 0x1C (opcode = DATA_SERVICE_REPLY)
Error code	1	uint8 error
Length	4	uint32 length
FAC Application ID	1	uint8 fac_app_id
Version Flag	1	uint8
Short ID	1	uint8
Stream ID	1	uint8
Packet Mode Indicator	1	uint8
Enhancement Flag	1	uint8
Application Domain	1	uint8
Application ID	2	uint16
Synchronous Flag	1	uint8
Generator Polynomial	4	uint32
Data Unit Indicator	1	uint8
Packet ID	1	uint8
Packet Length	1	uint8
Journaline Present	1	uint8
Journaline Version	1	uint8
Journaline Extended Header Length	1	uint8
Journaline Object ID Point of Entry	2	uint16
Journaline Additional Parameters Number	1	uint8
Journaline Additional Parameters	8	uint8 * 8
Journaline data packets	length-37	uint8 journaline_data[length-37]

This packet is then repeated from time to time (following reception of a complete Journaline packet) until DATA_SERVICE_OUTPUT is disabled.

Note that data is only output when the radio is either –

- tuned to a Journaline data service, or
- tuned to audio service with a **linked** Journaline data service (with an SDC type 9 and an SDC type 5 entity referring to the same short ID), in which case only the **first** linked data service will be output, or
- tuned to PRBS data stream

FEC on packet-mode data streams is **not** supported.

If more than one Journaline service is linked to an audio service (an unlikely scenario) then the packet output behaviour is unspecified.

Journaline Packet ID = 0 is currently supported.

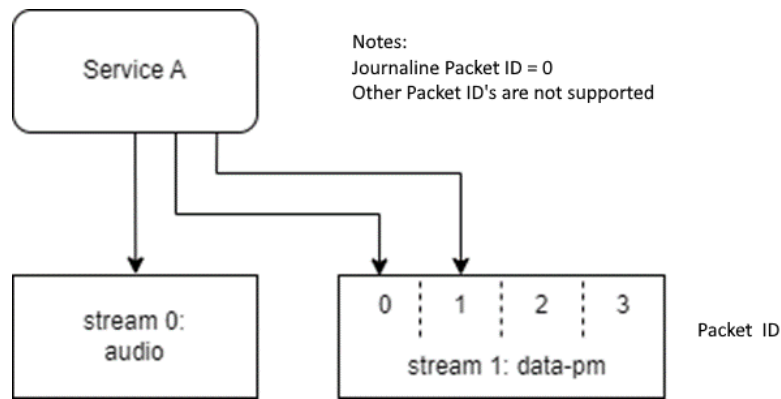


Figure 8 - Journaline Message Structure

10.6. Response to TEXT_MSG_SERVICE

When TEXT_MSG_OUT is enabled, the following data packet is sent when a complete and valid text message has been assembled by the receiver for the currently-tuned DRM service, if it contains a text message service. The packet contains either a text message or a command to the receiver to reset the display.

Table 8 - Text Message Service / Output

Text Message Service / Output		
Data field name	Bytes	Data format
Opcode	1	uint8 0x21 (opcode = TEXT_MESSAGING_GET)
Error code	1	uint8 error
Length	4	uint32 length = 8 + N, 0 ≤ N ≤ 128. If text_message_type == 1, N = 0.
Text message type	1	uint8 text_message_type {0=Text, 1=Reset display command}
Text message control field	1	uint8 text_message_control_field with following bit fields describing presentation of text message: <ul style="list-style-type: none"> - Bit 0 (LSB): Combining flag - Bit 1: Contextual flag - Bit 2: Base direction (0=LTR, 1=RTL) - Bit 3: Bidi flag (0 = no bidi text, 1 = bidi text) - Bits 4:7: RFU See section 10.8 for description of these fields. If text_message_type == 1, this field is set to zero.
Text message	0 ≤ N ≤ 128	uint8 text_bytes[N] – 0 to 128 bytes of UTF-8 encoded text, no null termination. If text_message_type == 1, N=0.

10.7. Response to MDI_OUTPUT

When MDI_OUTPUT is enabled, the following data packet is sent when the receiver is fully synced and decoding the MSC.

The packet is repeated from time to time until MDI_OUTPUT is disabled.

The receiver adheres to DCP Profile C as described in ETSI ES 102 821.

Contents for the MDI tag fields are as described in ETSI ES 102 820. All mandatory TAG items are implemented. TAG items (sdc and str<n>) with zero TAG length are omitted. No optional TAG items are supported.

Table 9 - MDI Output

MDI Output		
Data field name	Bytes	Data format
Opcode	1	uint8 0x24 (opcode = MDI_GET)
Error code	1	uint8 error
Length	4	uint32 length = 6 + N
MDI	N	MDI_GET packet of N length, consisting of: AF header - 10 bytes MDI output - variable length bytes CRC (Cyclic Redundancy Check) - 2 bytes See Section 11.2 for further information on the MDI output format

10.8. Data format for PERSISTENT_DEVICE_CONFIG_READ, PERSISTENT_DEVICE_CONFIG_WRITE

A single message, with a 247-byte data field, sets or reads all persistent store values. The data field is allocated as follows:

Table 10 - Persistent Store Configuration

Persistent Store Table Configuration		
Data field name	Bytes	Data format
subband_enabled	17	subband_en[17] (0=disabled, 1=enabled, for each of LF, MF, HF_120M, HF_90M, HF_75M, HF_60M, HF_49M, HF_41M, HF_31M, HF_25M, HF_22M, HF_19M, HF_16M, HF_15M, HF_13M, HF_11M, VHF)
mf_band_region	1	region (0 = Europe / Asia / Africa, 1 = Australia / NZ, 2 = North / South America)
vhf_band_lower_freq	2	lower_freq (units of 100 kHz)
vhf_band_upper_freq	2	upper_freq (units of 100 kHz)
hf_subband_grouping	1	grouping (0=disabled, 1=enabled)
restrict_tuning_to_broadcast_bands	1	restricted (0=disabled, 1=enabled)
fm_deemphasis_time_constant	1	time_const (0=75µs, 1=50µs)
user_interface_volume	1	ui_vol (0=two buttons, 1=rotary*)
user_interface_station	1	ui_station (0=two buttons, 1=rotary*)
pll_xtal_cap_val	1	pll_xtal_trim (register setting, 4-bit value)
rf_lf_attn	1	rf_lf_attn (CMX918 register \$3D RF_LF_ATTEN value, 8-bit value, bottom 4 bits set RF_LF_ATTEN_MIN, top 4 bits set RF_LF_ATTEN_MAX)
enable_pa_lout	1	pa_lout_enable {0 = PA disabled, LOUT disabled. 1 = PA enabled, LOUT disabled, 2 = PA disabled, LOUT enabled, 3 = PA enabled, LOUT enabled}
Splash_screen_bytes	11	uint8 splash_screen_bytes[11] UTF-8
mf_capacitor_tuning_LUT	128	mf_lut[64] (series of 64 12-bit values, for ferrite tuning look-up table)
6 instances of the following 13-byte table, for the following receiver modes in this order: - AM in LF/MF - DRM in LF/MF - AM in HF - DRM in HF - FM in VHF - DRM in VHF Each table entry is a CMX918 register, with corresponding 8-bit register value. One	78 (6 x 13)	

Persistent Store Table Configuration		
Data field name	Bytes	Data format
table is sent for each of the 6 receiver modes in the above order, for a total of 78 bytes		
rf_lf_agc_hi_threshold	1	uint8 rf_lf_agc_hi_threshold (8-bit CMX918 register val)
rf_lf_agc_low_threshold	1	uint8 rf_lf_agc_low_threshold (8-bit CMX918 register val)
rf_vhf_agc_hi_threshold	1	uint8 rf_vhf_agc_hi_threshold (8-bit CMX918 register val)
rf_vhf_agc_low_threshold	1	uint8 rf_vhf_agc_low_threshold (8-bit CMX918 register val)
if_agc_hi_threshold	1	uint8 if_agc_hi_threshold (8-bit CMX918 register val)
if_agc_low_threshold	1	uint8 if_agc_low_threshold (8-bit CMX918 register val)
rf_gc_ctl	1	uint8 rf_gc_ctl (8-bit CMX918 register val)
rf_agc_det_gc	1	uint8 rf_agc_det_gc (8-bit CMX918 register val)
rf_mix_bw	1	uint8 rf_mix_bw (8-bit CMX918 register val)
if_i_bw	1	uint8 if_i_bw (8-bit CMX918 register val)
if_q_bw	1	uint8 if_q_bw (8-bit CMX918 register val)
dpb_agc_man_g_i_0	1	uint8 dpb_agc_man_g_i_0 (8-bit CMX918 register val)
dpb_agc_man_g_q_0	1	uint8 dpb_agc_man_g_q_0 (8-bit CMX918 register val)

*not currently supported.

Note: Reading back the Persistent Device Config, without having written to it previously, may produce invalid data.

10.9. Error Codes

Table 11 - Error Codes

Error Codes	
ERROR_NONE	0
Reserved	1
Reserved	2
ERROR_INVALID_FREQUENCY	3
ERROR_NO_STATION_FOUND	4
ERROR_STATION_LOAD_FAIL_NO_STATION	5
ERROR_STATION_LOAD_FAIL_FLASH_ERR	6
ERROR_STATION_STORE_FAIL_FLASH_ERR	7
ERROR_STATION_STORE_FAIL_CURRENT_STATION_INVALID	8
ERROR_PERSISTENT_CONFIG_WRITE_INVALID_PARAM	9
ERROR_PERSISTENT_CONFIG_WRITE_FLASH_ERR	10
ERROR_PERSISTENT_CONFIG_READ_INVALID_CONFIG	11
ERROR_PERSISTENT_CONFIG_READ_FLASH_ERR	12
ERROR_SCANNER_IN_PROGRESS	13
ERROR_INVALID_DEMOD_MODE	14
ERROR_INVALID_VOLUME	15

11. Multiplex Distribution Interface (MDI)

This section specifies the behaviour of the Multiplex Distribution Interface (MDI) output from the DRM1000 over the serial (UART) interface.

The MDI output is built to comply with ETSI TS 102 820 V4.1.1, and provides an output when the -

- MDI output is enabled
- DRM1000 module is fully synced and decoding the MSC (Main Service Channel)

The MDI output is wrapped with an Application Framing (AF) header and CRC as specified in the Distribution and Communications Protocol (DCP) in ETSI TS 102 821 V1.4.1. The MDI output is suitable for streaming directly to an MDI-supporting distribution interface.

The module adheres to DCP Profile C as defined in ETSI TS 102 821 V1.4.1 Annex D.1.3.

There is a known issue in the current released version of the firmware, where there is an error in the Application Framing(AF) CRC of the MDI packet. The packet contents are proven to be correct, and the error solely resides within the CRC calculation. This issue will be resolved in future versions of firmware.

11.1. Behaviour

The DRM1000 module outputs the MDI packets over the serial (UART) interface as a single packet of variable length. When the MDI output is enabled, the following functions are temporarily disabled on the receiver -

- DRM audio decoding
- Text messaging display on screen
- Data service and Journaline output via UART
- Text messaging service output via UART

These temporarily disabled functions are re-enabled once the MDI output is disabled.

The RSSI and Status Output functions are still available when the MDI output is enabled.

11.1.1. Signal at poor SNR

The module temporarily pauses the MDI packet output at low SNR when the FAC (Fast Access Channel) and/or SDC (Service Description Channel) CRC fails.

The module resumes the MDI packet output when the SNR improves without the need to re-enable the MDI output.

Interfaces receiving the MDI packets should validate CRCs before using the data.

11.1.2. Switching between DRM and analogue mode

The module temporarily pauses the MDI packet output when switched to analogue mode. Audio in analogue mode works as normal.

The module resumes the MDI packet output when switched to DRM mode without needing to re-enable the MDI output.

11.1.3. Switching to scan mode

The module temporarily pauses the MDI packet output when in scanning mode.

The module resumes the MDI packet output when scanning is complete, without needing to re-enable the MDI output.

11.1.4. Emergency Warning Functionality (EWF)

If an active emergency warning is detected while the DRM1000 is tuned to a DRM service, the DRM1000 will attempt to switch to the specified target service. If the target service is found and this service is also a DRM service, the DRM1000 continues to output MDI packets corresponding to the contents of the target service. In this case, the GPIO0 pin is set high which indicates to an external processor that an emergency warning is active, and that the MDI output corresponds to the target service.

If the target service is an analogue service, the MDI output is paused until the DRM1000 tunes to a DRM service.

If the target service is not found, the DRM1000 returns to the original service and continues to provide the MDI output.

11.1.5. Frames failing for FAC or SDC CRC

There is no MDI packet output for frames in which the FAC or SDC CRC fails. This can cause gaps in the MDI stream. The missing frames can be determined by examination of the 'dlfc' (DRM logical frame count) field in the MDI packet. The sequence number in the Application Framing (AF) header, by contrast, always increments by 1 for every MDI packet sent.

11.1.6. DRM1000 in Standby

The DRM1000 stops the MDI packet output when put into standby mode.

The MDI output status is not persistent after going into standby and the MDI output needs to be enabled again via the UART control after the receiver wakes from standby to continue the MDI packet output.

11.2. MDI Output Format

The receiver periodically sends a UART message with opcode MDI_GET, with the following structure:

UART Opcode (OPCODE MDI_GET 1 byte)	UART Error (ERROR_NONE 1 byte)	UART Length (4 Bytes)	MDI_GET Packet (Variable Length)
--	-----------------------------------	--------------------------	-------------------------------------

Figure 9 - MDI Output Structure

11.2.1. Application Framing (AF)

The Application Framing header and CRC is wrapped around the MDI output. Contents of the Application Framing header is defined in ETSI TS 102 821 V1.4.1 section 6.1. The DRM1000 adheres to ETSI TS 102 821 V1.4.1 DCP Profile C (Annex D.1.3):

The DCP implementation supports the following features provided by DCP -

- AF layer

The DCP implementation does NOT support the following DCP features -

- PFT layer (neither addressing or fragmentation nor forward error correction)

The module supports CRC in the AF layer. The CRC flag in the AF Header is set.

The following diagram shows the structure of an MDI_GET packet -

AF Header (10 bytes)	MDI Output (LEN bytes)	CRC (2 bytes)
-------------------------	---------------------------	------------------

Figure 10 - Structure of an MDI_GET packet

11.3. Multiplex Distribution Interface

The MDI packet output from the DRM1000 follows the specification in ETSI TS 102 820 V4.1.1. Transmission of FAC and SDC is decoupled with data from the MSC in a transmitted MDI packet. No buffering of FAC and SDC is done to match the frame index of the MSC. FAC and SDC transmitted in the MDI packet is from the current frame, while the MSC transmitted in MDI packet is from the previous frame.

When parameters of the DRM multiplex are reconfigured as described in ETSI ES 201 980 V4.3.1 Section 6.4.6, the receiver is temporarily de-synchronised, the FAC reconfiguration index is used as a counter to indicate when the new configuration takes effect, upon the counter reaching zero re-synchronisation takes place. During this process the MDI output is paused.

11.3.1. Mandatory MDI TAG Items

As given in Section 5.1 of ETSI TS 102 820 V4.4.1 the following TAG items are generated.

Protocol Type and Revision (*ptr) - As defined in the specification/s.

DRM logical frame count (dlfc) - As defined in the specification/s. DRM logical frame count is taken from the number of frames seen on the receiver. No re-transmission of the MDI packets supported as there is no buffering of data from transmitted packets.

Fast access channel (fac_) - As defined in the specification/s. Length is determined by robustness mode.

Service description channel (sdc_) - As defined in the specification/s. Length is determined by the robustness mode, SDC mode and spectrum occupancy of DRM signal. Further details can be found in DRM system specification (ETSI ES 201 980 V4.3.1) section 6.4.2. Only sent on every first frame of the superframe. This is indicated by the identity field in the FAC.

Service description channel information (sdci) - As defined in the specification/s. Only includes stream description for existing MSC streams. MSC streams with no data are omitted in the MDI packet.

Robustness mode (robm) - As defined in the specifications.

Stream (str0, str1, str2 and str3) - As defined in specifications. Only existing MSC streams are included in the MDI packet. MSC streams with no data are omitted in the MDI packet.

11.3.2. Optional TAG Items

No optional TAG items are supported on the DRM1000 receiver.

11.4. MDI File

The MDI packets output by the DRM1000 over UART may not be directly compatible for replay by an MDI-supporting signal generator such as the Redwood RWC2010x, as they are missing some additional headers. The definition of these headers can be found in ETSI 102 821 V1.4.1 Annex B.3

11.5. Referenced documents

Table 12 - Referenced documents

Reference no.	Document reference	Subject	Version and/or date	Issued by
1	ETSI ES 201 980	Digital Radio Mondiale (DRM); System Specification	V4.3.1 (2023-11)	ETSI

Reference no.	Document reference	Subject	Version and/or date	Issued by
2	ETSI ES 102 820	Digital Radio Mondiale (DRM); Multiplex Distribution Interface (MDI)	V4.1.1 (2016-03)	ETSI
3	ETSI ES 102 821	Digital Radio Mondiale (DRM); Distribution and Communications Protocol (DCP)	V1.4.1 (2012-10)	ETSI

12. Persistent Store Operation

“HF bands” shall be understood to mean all HF broadcast sub-bands, from 120m to 11m.

“HF sub-band” refers to a single HF broadcast frequency range (i.e. the 75m sub-band spans 3905 kHz to 3995 kHz. The HF band spans 2305 kHz to 26095 kHz and is composed of several HF sub-bands).

“AM sub-band” refers to all sub-bands in LF, MF and HF bands.

12.1. Behaviour

If the DRM1000 fails to load a valid persistent configuration from flash (either because there is none present, or the saved data in flash has been corrupted) default settings will be loaded. Device defaults are highlighted for each parameter.

After loading a new persistent configuration to the device over UART, the new settings will take effect after a device restart.

12.2. Sub-band Enabled

All sub-bands are **enabled** by default on the receiver.

At least one AM sub-band needs to be enabled. VHF sub-band needs to be always enabled.

The behaviour is different depending on the status of restrict tuning to broadcast bands. Refer to 0 Restrict Tuning to Broadcast Bands for more details.

12.3. MF Band Region

The default MF band region on the receiver is **Europe, Asia, Africa**.

MF band regions are as defined:

Table 13 - MF Band Regions

MF Band Regions		
MF Band Region	Frequency Range (kHz)	Raster (kHz)
Europe, Asia, Africa	531 - 1602	9
Australia, New Zealand	531 – 1701	9
North, South America	530 - 1700	10

12.4. VHF Band Frequency Limits

The default VHF band limits on the receiver is **87.5 – 108.0** MHz.

Frequency input supports up to one decimal point.

The range of input values supported by upper and lower limits are as defined:

Table 14 - VHF Frequency Limits

VHF Frequency Limits	
Input	Range
VHF_band_lower_freq	76.0 – 95.0
VHF_band_upper_freq	95.0 – 108.0

12.5. HF Sub-band Grouping

HF sub-band grouping is **enabled** by default on the receiver.

When disabled, the band button will:

- Cycle all sub-bands if restrict tuning to broadcast bands is **disabled**.
- Cycle only enabled sub-bands if restrict tuning to broadcast bands is **enabled**.

When enabled, the band button will:

- Cycle by first sub-band in sub-band group if restrict tuning to broadcast bands is **disabled**.
- Cycle by first enabled sub-band in sub-band group if restrict tuning to broadcast bands is **enabled**.

The HF sub-band group is as defined:

Table 15 - HF Bands

HF Bands	
Sub-band Group	Band
HF1	120m
	90m
	75m
	60m
HF2	49m
	41m
	31m
	25m
	22m
HF3	19m
	16m
	15m
	13m
	11m

12.6. Restrict Tuning to Broadcast Bands

Restrict tuning to broadcast bands is **disabled** by default on the receiver.

The behaviour of the flag is as follows:

Table 16 - Band Restrictions

Band Restrictions	
Restrict Tuning to Broadcast Bands	Behaviour
0 (Disabled)	<p>Tuning is allowed outside of designated and disabled sub-bands using station up/down buttons, and direct frequency entry.</p> <p>Frequency range is limited to 153 kHz to 26.1 MHz, and 76.0 MHz to 108.0 MHz.</p> <p>Tuning to frequencies 26.1 MHz to 76.0 MHz is not allowed.</p> <p>Scanner will only operate in enabled and designated sub-bands.</p> <p>Emergency Warning Functionality will only operate in enabled and designated sub-bands.</p>
1 (Enabled)	<p>Tuning is only allowed for inside of designated and enabled sub-bands using station up/down buttons, and direct frequency entry.</p> <p>Scanner will only operate in enabled and designated sub-bands.</p> <p>Emergency Warning Functionality will only operate in enabled and designated sub-bands.</p>

12.7. FM De-emphasis Time Constant

The default FM de-emphasis time constant on the receiver is **50µs**.

Current available options:

Table 17 - FM Time Constant

FM Time Constant	
Time constant	Notes
75µs	Americas
50µs	World excl. Americas

12.8. CMX918 PLL Crystal Capacitor

This sets the value of the **PLL_XTAL_Caps<0:3>** field in the top 4 bits of the CMX918 register **\$97 PLL_XTAL_CTL**. This is used to tune the crystal oscillator and reduce frequency offsets.

This field must be in the range 0x0 to 0xF.

The default value on the receiver is **0x9**.

12.9. Splash Screen String

This sets the displayed string on the top row of the splash screen when the DRM1000 boots. The string can be up to 11 bytes of UTF-8-encoded text. UTF-8 characters supported for display are those specified in ETSI TS 103 771 v1.1.1, "Digital Radio Mondiale: Regional profiles".

The default value is **'DRM1000'**.

12.10. MF Capacitor Tuning Lookup Table

This is a 64-element array containing integers in the range 0-4095. The values correspond to the 12-bit value **RF_LF_LNA_IN_C** split between the CMX918 registers **\$14 RF_LF_LNA_IN_C_1** and **\$15 RF_LF_LNA_IN_C_0**. This then sets the capacitance across the CBP and CBN pins. Each value corresponds to the value of **RF_LF_LNA_IN_C** that tunes a ferrite rod antenna to resonance for 64 frequencies evenly spaced across the MF band. The frequency range is 522 kHz to 1719 kHz inclusive in 19 kHz steps. The receiver will linearly interpolate these values to optimally tune the ferrite for a given MF frequency. The current default values assume an inductor value of 525 μ H.

The default value on the receiver is –

Table 18 - MF Capacitor Tuning Lookup Table

3456, 3220, 3010, 2800, 2590, 2416, 2260, 2120, 2000, 1888, 1770, 1650, 1550, 1470, 1400, 1325, 1260, 1200, 1148, 1104, 1053, 1002, 960, 923, 880, 838, 795, 753, 720, 685, 655, 620, 585, 560, 538, 522, 498, 480, 458, 438, 418, 400, 386, 372, 358, 344, 330, 317, 305, 294, 283, 273, 262, 252, 242, 232, 220, 209, 199, 190, 180, 170, 160, 151

12.11. CMX918 AGC Parameter Sets

A set of register values controlling AGC and related behaviour on the CMX918 for each of 6 receiver demodulation modes:

- AM in MF
- DRM in MF
- AM in HF
- DRM in HF
- FM in VHF
- DRM in VHF

The definition of the MF band lower and upper frequencies follows the geographical region specified in section 12.3. The definition of the VHF band lower and upper frequencies follows the specified frequencies in section 12.4.

The registers in a parameter set are as follows. Default values for each receiver mode are listed. Values are 8-bit unsigned integers and must be in the range 0x00 to 0xFF.

Table 19 - CMX918 Registers

CMX918 Registers						
CMX918 register name	AM in MF	DRM in MF	AM in HF	DRM in HF	FM in VHF	DRM in VHF
RF_LF_AGC_HI_TH (\$11)	0xAA	0xAA	0xAA	0xAA	0xAA	0xAA
RF_LF_AGC_LOW_TH (\$12)	0x3C	0x32	0x3C	0x3C	0x3C	0x3C
RF_VHF_AGC_HI_TH (\$0D)	0x82	0x82	0x82	0xC8	0x82	0x82
RF_VHF_AGC_LOW_TH (\$0E)	0x3C	0x3C	0x3C	0x6C	0x3C	0x3C
IF_AGC_HI_TH (\$1B)	0xA0	0xDC	0x82	0x9C	0x82	0x82
IF_AGC_LOW_TH (\$1E)	0x46	0x50	0x46	0x50	0x46	0x46
RF_GC_CTL (\$0C)	0x00	0x00	0x00	0x00	0x00	0x00
RF_AGC_DET_GC (\$41)	0x04	0x00	0x04	0x00	0x04	0x04
RF_MIX_BW (\$4E)	0x0A	0x08	0x0A	0x08	0x1B	0x13

CMX918 Registers						
IF_I_BW (\$4F)	0x0A	0x00	0x0A	0x00	0x1B	0x13
IF_Q_BW (\$50)	0x0A	0x00	0x0A	0x00	0x1B	0x13
DPB_AGC_MAN_G_I_0 (\$BD)	0x80	0xB0	0x80	0xB0	0x80	0x80
DPB_AGC_MAN_G_Q_0 (\$BF)	0x80	0xB0	0x80	0xB0	0x80	0x80

13. Electrical Performance

13.1. ESD Protection



ESD Warning: This high performance RF integrated circuit is an ESD sensitive device which has unprotected inputs and outputs. Handling and assembly of this device should only be carried out at an ESD protected workstation.

LFMF_INp, LFMF_INn	250V
CBP and CBN:	500V
HF_IN, VHF_IN, LNA_FB,	500V
All other pins:	2000V

13.2. Absolute Maximum Ratings

Exceeding these maximum ratings can result in damage to the module.

Table 20 - Absolute Maximum Ratings

Absolute Maximum Ratings			
	Min.	Max.	Unit
Main Supply from battery (VDD_3V1)	0	+3.6	V
Class-D Amplifier Supply (VDD_PA)	0	+3.6	V
Current into or out of pins, connected to;			
VDD_3V1, GND		TBC	mA
VDD_PA, GND		TBC	mA
Any other connector pin		TBC	mA
Max RF Input Level		+ 10	dBm

13.3. Operating Limits

Correct operation of the module outside these limits is not implied.

Table 21 - Operating Limits

Operating Limits				
	Notes	Min.	Max.	Units
Main Supply from battery (VDD_3V1)	1	2.7	3.6	V
Class-D Amplifier Supply (VDD_PA)	–	1.6	3.6	V
Operating Temperature	–	-20	+60	°C

Notes:

Reduced performance below 3.1V

13.4. Operating Characteristics

For the following conditions unless otherwise specified: VDD_3V1 = VDD_PA = 3.1 V, GND = 0 V

$I_{IN} = I_{VDD_3V1} + I_{VDD_PA}$ = the total current to the module

Table 22 - Operating Characteristics

Operating Characteristics					
DC Parameters	Notes	Min.	Typ.	Max.	Unit
I_{IN} (standby)	1	-	0.2	-	mA
I_{IN} (AM Mode, MF)	2	-	51	-	mA
I_{IN} (AM Mode, HF)		-	51	-	mA
I_{IN} (FM Mode)		-	62	-	mA
I_{IN} (DRM30, Mode B 10 kHz)		-	53	-	mA
I_{IN} (DRM+)		-	63	-	mA
UART Digital Interface					
Logic high (1)	3	2.2	-	3.1	V
Logic low (0)	3	0	-	0.9	V
Baud Rate			921600		
Format			8,N,1		

Notes:

- Standby (from USR button)
- Volume set to 3 levels below maximum, driving a 4 Ω speaker.
- Logic levels are CMOS compatible.

13.5. RF Performance

Designed to meet DRM Consortium Minimum Receiver Requirements RF parameters:

DRM30 (HF, 9650 kHz, 10 kHz bandwidth, mode B)

Sensitivity	better than 8 dBuV / -99 dBm
Adjacent Channel 1	min 25 typ. 30 dB
Adjacent Channel 2	min 35 typ. 45 dB
Adjacent Channel 3	min 45 typ. 50 dB
Blocking	typ. 60 dB
Co-channel	min -5dB
Far off selectivity	typ. 60 dB
Linearity / IMD	typ. 40 dB

DRM+ (VHF, 98 MHz, 100 kHz bandwidth mode E)

Sensitivity	better than -102 dBm
Adjacent Channel 1	min 35 typ. 40 dB
Adjacent Channel 2	min 40 typ. 45 dB
Adjacent Channel 3	min 45 typ. 50 dB
Blocking	min 55 typ. 60 dB

Designed to meet ETSI EN 303 345-2 (AM):

LF/ MF/HF

Sensitivity	better than -65 dBm for ≥ 22 dBQ
Adjacent Channel 1	min -5 typ. 17 dB
Adjacent Channel 2	min 25 typ. 35dB
Adjacent Channel 3	min 35 typ. 38 dB
Blocking	typ. 40 dB

Designed to meet ETSI EN 303 345-3 (FM):

VHF

Sensitivity	better than -90 dBm for ≥ 40 dBQ
Adjacent Channel 2	min 3 typ. 40 dB
Adjacent Channel 3	min 17 typ. 25 dB
Adjacent Channel 4	min 30 typ. 45 dB
Blocking	min 30 typ. 40 dB

Note: Audio signal measured using ITU-R 468 filter (dBQ)

14. Regulatory

The DRM1000 meets relevant EU requirements including the harmonized standards EN 303 345-2, EN 303 345-3, EN 303 345-5 and EN 55032, however it is not currently intended for end users located within the European Union.

Note 1: manufacturers located within the EU who assemble DRM1000 into products which are then shipped outside the EU are not considered end users.

Note 2: occasional use by charities or hobbyists within the EU is permitted.

15. Application Information

Refer to the User Manual for the DE9180 Demonstration Kit, available from the www.cmlmicro.com.

16. Mechanical and PCB Footprint

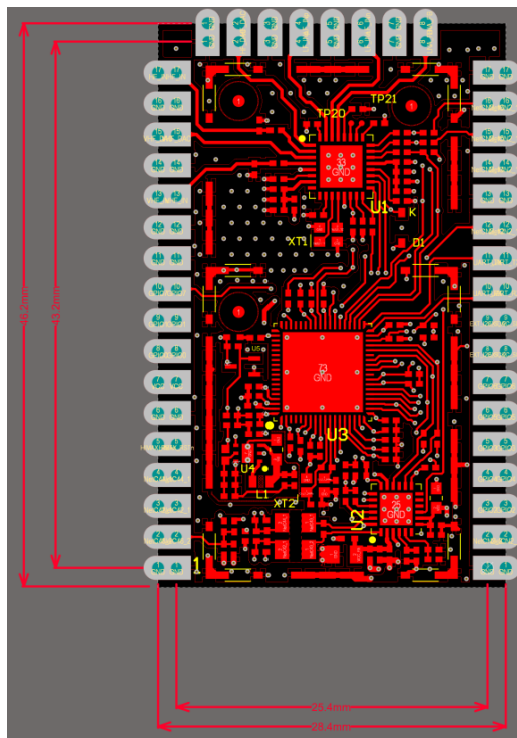


Figure 11 - Mechanical and PCB Footprint Drawing

Overall Dimensions:

Length: 46.2 mm

Width: 28.4 mm

Height: 5.0 mm

Weight: 10 g

17. Ordering Information

Order as:

DRM1000

DRM1000 module with onboard DRM processor and Audio amplifier

Handling precautions: This product includes input protection, however, precautions should be taken to prevent device damage from electrostatic discharge. CML does not assume any responsibility for the use of any circuitry described. No IPR or circuit patent licences are implied. CML reserves the right at any time without notice to change the said circuitry and this product specification. CML has a policy of testing every product shipped using calibrated test equipment to ensure compliance with this product specification. Specific testing of all circuit parameters is not necessarily performed.



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