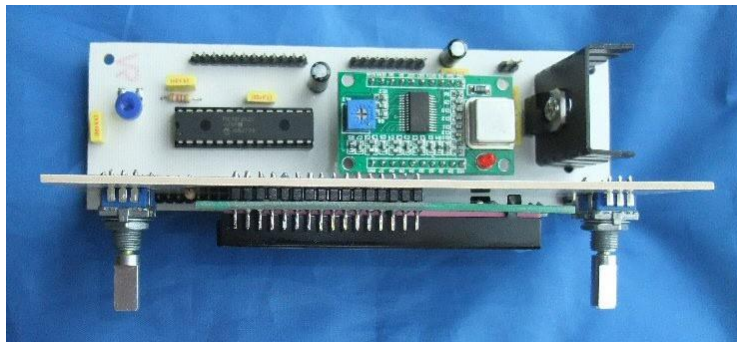


# Multi-Rock II

## User Guide and Construction Manual

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For software revision 1.0 and hardware revisions 1.1 and 1.2

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Update GW8LJJ

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## Key

- For brevity Multi-Rock II is referred to as MR2.
- The control to the left of the LCD display is referred to as rotary1 and PB1 for the rotation function and push-button function respectively. Similarly the right hand control is referred to as rotary2 and PB2.
- PB1 and PB2 perform different functions depending on press duration. The terms 'short-press' or 'long press' will be used to describe the action. Short-press - do not wait for visual feedback from the LCD. Long Press - keep held until the described indication occurs (about 3/4 second).
- Specific points that are particularly important to understanding the workings of MR2 are headed "**key points**".

### One more thing ...

If this manual seems a little daunting and you're saying "Crikey, all I want is a simple way of generating a frequency" ...

### **You've got it!**

Study Section 1 and browse over the other sections. If you don't need any extra functions for now, just ignore them!

## Multi-Rock II - Introduction

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### What is it?

Multi-Rock II (MR2) is a DDS-based signal source using a ready-assembled AD9850 DDS daughter board in conjunction with a motherboard and front panel board. The project is supplied as a kit containing all parts needed including the PCB, DDS module and pre-programmed PIC processor.

The kit is easy to construct, there are no SMD components to solder, and no wiring is involved (other than interfacing of course).

MR2 is intended to replace the original Multi-Rock kit as an LF band frequency source, but goes way beyond that by providing a stable frequency output at up to 60MHz (40MHz max. recommended) together with many optional features that can make MR2 the core of a home brew receiver or transmitter (or both).

### Do I want one?

Any experimenter or home constructor who lacks a versatile, low cost frequency source would benefit from using MR2. Even if all that's required is a basic signal generator, MR2 is a cost effective solution.

MR2 is part of the FAT-RAT range of AM transmitter and receiver kits available from [www.s9plus.com](http://www.s9plus.com). It will drive the FAT5 RF PA module and can serve as the LO in the RAT5 receiver (a small modification is needed to current RAT5 PCBs to enable the external LO to be injected).

MR2 could be used in home brew SSB projects although it has not been optimised for this function. For instance there is no concept of 'LSB' or 'USB', just 'RX','TX' or 'Standby', but otherwise the type of project it is part of is immaterial.

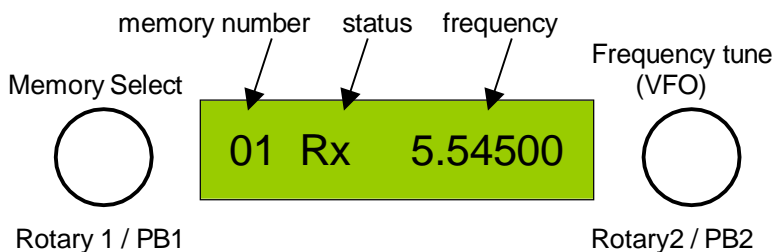
Before deciding to purchase a kit please read this manual as it is the complete reference for MR2 construction and operation. If you like what you read, you'll like what you've built!

## 1. Basic Operation

MR2 can be used as a simple frequency generator, or as the core of a home brew transmit, receive or transceive project. It is particularly suited for integrating into the FAT/RAT series of AM transmitter and receiver projects for 160m, 80m and 40m. (See [www.s9plus.com](http://www.s9plus.com)).

Before going on to explore the additional features that make MR2 more than 'just another DDS-based frequency generator', take time to familiarise yourself with its basic operation. If all that's required is a signal source, this section probably contains all you need to know.

Figure 1.1 below shows the front panel layout with rotary encoders either side of a central LCD display. (The examples in the rest of this document will just show the LCD display). The encoders and display are mounted on a front panel PCB which is attached to the main PCB by right angle header pins.



**Figure 1.1 Control knobs and typical LCD display**

The main MR2 controls are a pair of rotary encoders rotary 1 and rotary 2 and their associated push buttons PB1 and PB2. The push buttons often have a different function depending on whether they are pushed in momentarily (short-push), or held in for half a second or more (long-push).

### Key Point

Apart from the PTT and PTR (push to receive) lines, all user input is via the two rotary encoders and their integrated push-buttons

## Rotary Controls

### Memory Select

Use rotary 1 to select the memory channel. There are up to 48 memory channels available. The memories wrap round from 48 back to 1 and vice versa. The memory number is displayed on the LCD panel adjacent to the memory select knob.

[The maximum memory number is settable as is the start-up memory channel; and frequencies can be transferred from one memory to another or to all memory channels].

### **Frequency Tune**

In normal use rotary 2 works like a VFO knob. [ The frequency step is selectable, and the active memory channel can be updated with the new frequency ].

## **LCD Display**

The LCD display is a single line 16 character backlit module. This is adequate for the task, the only compromise being the abbreviation of some words in various menus.

### **Memory number**

This field indicates the active memory channel, as selected by rotary 1. Numbers below 10 have leading zeros.

### **Status**

The status display shows which mode MR2 is in i.e. transmit, receive or standby (no DDS output). Figure 1.1 shows MR2 in receive mode. [The display can also show when certain additional features are implemented such as IF offset or TX multiplier].

### **Frequency**

The frequency field is always shown in MHz with the final right hand digit representing tens of Hz.

## 2 Tuning Functions and Memory Control

There are up to 48 memory channels available. Each channel can be tuned as a VFO. The original memory frequency is maintained on channel change unless the user elects to update it with a new VFO frequency. Great use is made of the push buttons built into the rotary encoders. These are pushed in briefly (short-push) or held in to invoke a different function (long-push).

### Key Point

Restore original channel frequency : short-press PB1

Replace original channel frequency : long-press PB2

### Tuning a memory channel VFO-style (Delta-tune)

When the VFO knob is used to tune the frequency away from that stored in memory, MR2 is in delta-tune mode (like a sort of RIT). This is indicated by the '^' character appearing to the left of the frequency display.



01 Rx ^5.54600

Figure 2.1 Delta-tune

Note that once the memory is in delta-tune mode the '^' character will remain visible until delta-tune is cancelled even if the original memory frequency is re-displayed during subsequent tuning.

### Frequency Limits

The base frequency (i.e. before any offsets and multipliers have been added) is software limited to a range between 10Hz and 60MHz. Other checks also prevent these limits being exceeded after any offsets and multipliers are added.

From delta-tune mode you may wish to restore the original memory frequency or replace it with the new VFO frequency. Both operations cancel delta-tune mode.

### How to *restore* the original memory channel frequency

There are two methods:

1. Momentarily press memory push-button PB1.
2. Select an adjacent memory using the memory select knob rotary 1, then re-select the original memory.

In both cases the '^' disappears.

## How to *replace* the memory channel frequency with the VFO frequency that is currently displayed

Press and hold PB2 until the '^' disappears. The active memory now contains the new frequency. Confirm this by selecting another memory then returning.

## Altering the tuning step

*This section is probably the most challenging part of MR2 to grasp. If it's been a long day already, just remember these key points below, read about how to alter the tuning step, then move on to the next main topic.*

### Key Points

- After a configuration reset, and as initially supplied, all five step sizes (100kHz, 10kHz, 1kHz, 100Hz and 10Hz) are available by default so you can leave things unaltered for now.
- There are four step groups available as in table 2.1 below allowing you to choose the most suitable.
- See the Channel Menu description in section 5 for how to alter step groups.

### How to alter the tuning step

Short-press PB2 successively to alter the tuning step. The step selected is indicated by that digit momentarily blanking. The order of selection is highest step to lowest step within the step group before wrapping round.

momentary gap indicates 1kHz tuning step

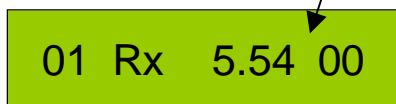


Figure 2.2 Tuning step selection

### The Step Group concept

The frequency tuning control (rotary 2) is a mechanical rotary encoder with a click action. The tuning step for each *click* can be selected 'round robin' fashion from a number of steps. The steps available depend on which one of four step groups is allocated to that channel. The step group is selected via configuration setting **C1** in the Channel Menu (See section 5). Each step group offers a different sub-set of the five step sizes 100kHz, 10kHz, 1kHz, 100Hz and 10Hz. (See table 2.1 below).

This flexibility has been provided to minimise inconvenience when changing steps in a particular situation. e.g. For AM once the memory channels have been set up, tuning in 1kHz steps and occasionally dropping to 100Hz steps for fine tuning is all that's needed, so Group 4 fits the bill. A short-push of PB2 will toggle between 1kHz and 100Hz without including the other options which would otherwise have to be stepped through.

After a configuration reset (see section 7) the step group is set to Group 1 for all channels and the default step size for each step group is re-set back to the



maximum step size per group. This is just a starting point as the last step size to be used within a group is remembered for next time. There is in fact an exception to this. The steps marked in red in table 2.1 are *not* remembered after a channel change within the step group but are available as step options within the group. There are two reasons for this, one purely technical and one for convenience. The 10Hz step in Group 1 isn't remembered after a channel change because there are only two bits available for this function (i.e. only four options) but for general use all steps may be needed. In the case of Groups 2 and 3 it was felt that the most useful starting step after a channel change would not be the smallest step available. So, if a channel is vacated with a 'red' step in use, the next higher step is stored and recalled next time.

Group	100kHz	10kHz	1kHz	100Hz	10Hz
1	#	#	#	#	#
2		#	#	#	
3			#	#	#
4			#	#	

Table 2.1 Steps available in each of the four step groups

### Step groups - suggested uses

Group 1 : (Default) : General purpose e.g. Sig. gen., and memory set-up.

Group 2 : General AM tuning

Group 3 : SSB / CW e.g. direct conversion receiver

Group 4 : AM tuning using memories as spot channels

### Same group, same step

After each channel change the step group is re-assessed. If the new channel has the same step group allocated to it, then the previously used step size is maintained (apart from 'red' steps). If the new channel has a different step group then the previously used step size for the new step group is asserted.

So, if you allocate the same step group to all channels you could have a simple system where the step size is the same on all channels until you alter it, any change affecting all channels (as they are in the same group). This is the situation when MR2 is powered up for the first time ever and after a configuration reset, where all channels are in group 1.

**Q:** Why have a choice of four step groups at all if MR2 remembers the step for each channel?

**A:** Having a choice of step groups enables you to use just the step sizes you need. As you can allocate any channel to any step group you can create up to four banks of channels each with its own range of tuning steps.

### How to alter the step group

Altering the step group is a Channel Menu function. Access the Channel Menu, item **C1** (the first that appears) and select the group required. fPlease refer to Section 5 for more details about accessing and using the Channel Menu.

## Transferring a frequency between memories

Depending on the use MR2 is being put to, it may be useful to make several memories the same so that frequencies can be adjusted from a common starting point, e.g. create three channels 10kHz apart on 40m: From a memory reset default of 5MHz, change a memory to say 7.100MHz, then copy that frequency to the next two memory channels and re-adjust from there rather than separately move each channel from 5MHz. An even easier way is this: you can delta-tune a donor channel then copy the new frequency to another channel without losing the delta tune. So, in the example on 40m, create a channel of 7.100MHz, then delta-tune it to 7.110MHz and copy that to a second channel. Then delta-tune it to 7.120MHz and copy to a third channel.

**Key Point :** Transferring memories is done with PB1 long-press.

### Memory Transfer mode - initiating

Long-press PB1 until the '>' character and another memory number appear to the right of the current memory. The arrow points to the destination memory. Initially it will indicate the same memory number as the active memory. Turn rotary 1 to select the destination memory. Figure 2.3 below shows memory 02 selected as the destination memory.



01>02 ^5.54600

Figure 2.3 Memory Transfer mode

If MR2 was in delta tune mode, that frequency is preserved and can be written to a new memory even if the original memory holds a different frequency. You can also continue to delta tune in memory transfer mode. The frequency that is indicated is the frequency that is transferred. If the number of active memories has been reduced from 48 [ more on this later] you can still transfer the frequency to any of the 48 memories. [To retrieve a frequency from a non-active memory you would need to extend the active memory numbers to include that frequency].

### Memory Transfer mode - cancelling

If you wish to cancel the transfer simply short-press PB1. The source memory is re-displayed and any delta-tune is cancelled.

### Memory Transfer mode - execute

Long-press PB1 until the '=' character appears as shown below, then release. The source memory is re-displayed and any delta-tune is cancelled. The figure below indicates memory 01 and 02 now contain the same frequency.



01=02 ^5.54600

Figure 2.4 Memory Transfer Complete

## Special Case - Copy to All Channels

01>ALL Rx 5.54600

Any memory frequency can be copied to all other channels in one operation by placing MR2 into memory transfer mode (see above), then using

Rotary 1 select 'ALL' as the destination. The 'ALL' position is located between memory 1 and memory 48 when in memory transfer mode.

Merging ... Wait

Long-press PB1 again until this message appears then release:

Upon completion of the operation MR2 will return to normal mode. You can check all memory channel frequencies are now the same by scrolling through the memories.

*Note:*

1. *The configuration settings that are associated with the donor channel are also copied to the recipient memory or memories. So for instance if the donor channel had a 455kHz IF offset, the new channel(s) will have the same.*
2. *All 47 other Channels are updated regardless of the G6 maximum memory number setting in the Global Menu.*

## Show actual DDS frequency (and control-line status)

In normal mode, short-press PB1. The display frequency will now show the actual DDS frequency in use. This works in both transmit and receive modes. This can be useful when setting up receive offset, transmit multipliers etc. as a double check that the expected output frequency is being produced. The status field on the LCD display shows 'DDS'. Short-press PB1 again to return to the normal display. The DDS display is also cancelled when the channel is changed.

Additionally the left hand side of the DDS display shows the status of the two control lines. These are discussed in more detail in section 3.

Figure 2.5 below shows control lines 1 and 2 set as low and high (0/1) respectively and the actual DDS frequency as 5MHz for the channel in use.

0/1 DDS 5.00000

Figure 2.5 DDS mode example.

## 3 Additional Functions - Introduction

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*This section introduces the additional functions that make MR2 more than just another DDS-based signal source. Browse through this section to be aware of the features that are available.*

**Detailed information on how to use these is given in section 4 :Global Menu and section 5: Channel Menu.**

Using a PIC processor to control the DDS makes it possible to also add functions that are essential or desirable in a receive or transmit signal source. For instance different types of receiver require different local oscillator frequencies. A superhet will need an IF offset. An SDR receiver will most likely need an oscillator source four times the receive frequency, but with no IF offset. Some transmitters, typically class E types, will need a 2x or 4x transmit carrier. A built-in transmit delay for relay changeover is useful. And think of the uses a couple of channel-programmable control lines could be put to such as automatic band-pass switching or antenna selection.

### Key Points

- MR2 has two modes of operation - normal mode and configuration mode.
- Configuration mode comprises two sub-menus: Global Menu and Channel Menu.
- The functions are quantified via the global menu and enabled on a per channel basis via the channel menu
- The Global and Channel Menus are described in detail in sections 4 and 5 respectively

Functions are categorised below according to their main use, starting with receive functions.

## Receive Functions

### Key point

- MR2 distinguishes between transmit and receive so that the correct oscillator settings are used in a transceive situation. This is done via a PTT line and a PTR (push-to-receive) line (active low) [more later].

If MR2 is to be used as a local oscillator (LO) source for a receiver then the receive frequency, the DDS frequency and the display frequency are unlikely to be the same unless a direct conversion receiver is being used. MR2 lets you configure an IF offset and/or a receive LO multiplier.

### IF Offset [Global Menu G1]

Superhet receivers need an LO spaced away from the receive signal by the IF frequency. Additionally, filtering and image considerations could require the local oscillator to be either high or low of the signal frequency. MR2 allows you

to set up a local oscillator up to 15MHz away from the receive frequency, on the high side or low side (if mathematically possible). The offset is configurable in 5kHz or 100kHz steps. The LCD display takes this into account to show the correct receive frequency. The IF offset can be enabled on a per channel basis via the Channel Menu **C4**.

### **Receive Oscillator Multiplier [Global Menu G2]**

SDR receivers such as SoftRock require a x4 oscillator. MR2 can provide this as well as a x2 option.

There is little need for a x2 LO but the option is retained for compatibility with the transmit oscillator setup. There is also little possibility of needing a receive oscillator multiplier and an IF offset simultaneously. [When the receive adjustment item is enabled in the Channel Menu these two functions are simultaneously effective if both are set to a value above zero].

The LCD display takes the multiplier into account to show the correct receive frequency. The multiplier is configured in the Global Menu. The multiplier can be enabled on a per channel basis via the Channel Menu.

## **Transmit Functions**

MR2 is placed in transmit mode using the PTT line. In transmit mode any receive oscillator adjustments are removed then any transmitter adjustments added.

### **Transmit Multiplier [Global Menu G3]**

The DDS output frequency can be set as x1 (default), x2 or x4. A transmit multiplier may be needed when driving Class E push-pull transmitters depending on how the anti-phase drive signal are produced The FAT5 Class E transmitter project RF PA (see [www.s9plus.com](http://www.s9plus.com)) can be directly driven by the MR2 DDS module as anti-phase outputs are provided. [The multiplier can be enabled on a per channel basis via the Channel Menu].

### **Transmit Hold-off [Global Menu G5]**

A transmit hold-off with sequential switching is available. This is a mini-TROPIC function (see the TROPIC product at [www.s9plus.com](http://www.s9plus.com)). There are two TROPIC lines that activate in sequence before MR2 produces the transmit frequency. As soon as a PTT is detected, any receive DDS output is removed and the DDS is temporarily put into standby until the hold-off sequence completes).

The delay period can be adjusted from 0ms to 250ms in 5ms increments. This is the inter-stage delay not the total delay. Total delay is effectively three times the value set. [Set-up is via the Global Menu]. This function cannot be disabled on a per-channel basis. It is effectively disabled by setting the delay to zero (default) whereby the two TROPIC lines stay inactive. Transmit enable can however be inhibited per channel using the transmit enable setting below.

### **Transmit Enable [Channel Menu C5]**

Working in conjunction with the hardware PTT line, the transmit enable option can be used to prevent any or all channels from producing a transmit signal. Any channel with transmit-enable disabled will ignore the hardware PTT.

## **Tuning and Memory Functions**

### **Frequency coverage [intrinsic]**

The DDS can be programmed to output any frequency from 10Hz to 60MHz with 10Hz resolution. (Use above 40MHz is not advised due to an increase in the number of spurs that appear although MR2 allows frequencies up to 60MHz to be set. See a AD9850 DDS datasheet for more information)

Any configuration that would result in the DDS generating a frequency greater than 60MHz produces an over-range warning and output is inhibited.

### **Tuning Steps [Channel Menu C1].**

Already introduced in section 2, tuning steps of 100kHz, 10kHz, 1kHz, 100Hz or 10Hz are available. There are four step-groups that offer a sub-set of these five step sizes. (Group 1 actually includes all five steps). Each of the 48 channels can be allocated to any step-group, allowing tuning steps not required for a particular application to be omitted.

### **Display Offset [Global Menu G8].**

The display offset adds a fixed frequency to the tuning display. This does not affect the DDS frequency, it just adds a value to the displayed frequency. A display offset is useful when a front-end converter is used. for instance the RAT5 receiver will shortly have a 10m down-converter announced. Maximum offset is 64MHz in increments of 5kHz or 100kHz. Enabling the display offset per channel is via the Channel Menu **C6**].

### **Maximum Memory [Global Menu G6].**

Up to 48 memories are available. If only say ten memories are needed MR2 can be restricted to only offer these ten memories. These are then selected in a round-robin sequence.

### **Startup Memory [Global Menu G7].**

Any memory channel from 1 to 48 can be set as the default startup memory. This is useful in conjunction with the maximum memory number setting, for instance where a number of channels in ascending frequency are applied to successive memories, but the calling channel is somewhere in the middle. This takes priority over the maximum memory number, so it is possible to define a startup memory channel higher than the maximum memory. A channel-change then drops back into the defined memory range.

## Control Functions

### **Control Lines [Channel Menu C2, C3].**

Two output lines are provided for the control of external circuitry. Any channel can have any of the four logic combinations applied to it. These lines, unlike the TROPIC lines are applied as soon as a channel is selected. There is no sequential delay, the two lines being altered simultaneously. Uses include channel initiated front end filter switching, antenna switching, or even attenuator switching on certain frequencies or bands.

### **DDS Calibration [Global Menu G4].**

The DDS module has a 125MHz oscillator that provides the DDS timing. Any error in this frequency, if uncorrected, would result in a frequency error in the DDS output. This error can be 'cal'd out' in software using this option, accessible via the Global Menu. Adjustment is from -1000 to +1000. The digits do not relate to frequency and are merely an adjustment guide. It should be possible to adjust the calibration to within 3Hz at any frequency up to 40MHz apart from very low audio frequencies where errors in the DDS frequency calculation routine may cause a greater error of typically 10Hz.

### **MR2 Reset [power-up function].**

In order to place MR2 into a known state (and as a safety net should some as yet undiscovered glitch corrupt the settings) it is possible to reset all memories and configuration settings to a default. There are three resets available:

#### **Memory Reset.**

This sets all channels to 5MHz

#### **Configuration Reset.**

This allows all Channel Menu items to a pre-determined state.

#### **DDS Calibration Reset.**

The calibration setting can be set to zero. This shouldn't be needed once MR2 has been calibrated, but just in case something corrupts the setting a means has been provided to quickly reset the adjustment back to zero.

## LCD Display Indications (in normal mode)

The LCD display is divided into three areas which are, left to right, memory number, MR2 status, and frequency (See figure 1.1). The central status area indicates the mode MR2 is in and any options have been enabled. The table below summarises these.

Function	Indication	How
Memory number	01 - 48	Automatic
Frequency	To 10Hz	Automatic
Show DDS frequency	'DDS'	Short-Press PB1
Delta-tune	" ^ "	turn Rotary 2
Tuning Step Adjust	Initial flash of digit	Short-press PB2
Rx Multiplier	'R2', 'R4' for x2, x4	Automatic
Tx Multiplier	'T2', 'T4' for x2, x4	Automatic
Standby (No Rx or Tx)	'Stby'	No PTT, No PTR
IF Offset enabled (dot)	Rx.	Automatic
Display Offset enabled (dot)	'.Rx' or' .Tx'	Automatic
Memory Transfer	'> '	Long-Press PB1
Transfer Complete	' = '	Long-Press PB1

*The next two main sections 4 and 5 describe the Global Menu and Channel Menu structure, where the display indications for those modes are covered.*



## 4 Global Menu

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*Setting up MR2 for a specific use is accomplished by means of a two-part configuration menu. The Global Menu for the most part deals with setting actual values, while the Channel Menu defines which Global settings are enabled on any particular channel*

### Key points

- There is only one Global Menu. This sets the actual values for things like IF offset
- There is a Channel Menu for each channel. Things like IF offset can be enabled on a per-channel basis

### How to access the Global Menu

First, long-press PB1, and immediately short-press PB2, then release both when the response below appears. Shortly after, item **G1** IF Offset appears.



Global Menu

The button-press order is important as pressing PB2 first accesses the Channel Menu.

### How to exit the Global Menu

In a similar way to entering the Global Menu, long-press PB1 then immediately short-press PB2, then release both when the response below appears, followed shortly after by the normal display.



Updating Config

### Global Menu Structure

There are 8 items in the Global Menu. On entering , item **G1** is always the first item to be displayed. ('G' is short for 'Global')

### Key points

- Items are selected using rotary 1 in round-robin fashion.
- The value for each item is adjusted using rotary 2.

The table below lists the eight items. Each will then be described in detail.

Item number	Function
G1	Set IF Offset value (-15MHz to 15MHz)
G2	Set Receive DDS Multiplier x1,x2,x4
G3	Transmit DDS Multiplier x1,x2,x4
G4	Frequency Calibration (-1000 to 1000)
G5	Transmit Delay (TROPIC) 0-250ms
G6	Maximum memory (1-48)
G7	Start-up Memory (1-48)
G8	Display Offset (64MHz max)

Note: **G1** and **G2** are collectively enabled per channel using **C4** Receive Adjust Enable in the Channel Menu. Leave the Receive DDS Multiplier at x1 if not required; similarly leave the IF Offset at 0.000 if not required. In the unlikely event both are needed, set a value for both. The Rx\_Mult is applied to the DDS first, then any IF offset added.

### Global G1 - IF Offset

IF offset can be adjusted from -15MHz to 15MHz. *Take care that any offset applied does not result in trying to produce a negative DDS frequency or a DDS frequency over 60MHz.* **Tip:** Tuning step is initially 5kHz. To toggle between 100kHz and 5kHz short-press PB2.

01 IFofs 0.455

Typical display, here showing an IF offset of 455kHz. Resolution is 5kHz. Display initially indicates current value.

G1 IFofs - 0.455

Adjust).

To change from positive to negative offset long-press PB2. To take effect, this needs to be enabled in the Channel Menu (**C4** Receive

### Global G2 - Receive DDS Multiplier

G2 Rx\_Mult x4

Values available are x1, x2 and x4. For x2 or x4 to take effect, this needs to be enabled in the Channel Menu (**C4** Receive Adjust).

### Global G3 - Transmit DDS Multiplier

G3 Tx\_Mult x2

Values available are x1, x2 and x4. For x2 or x4 to take effect, this needs to be enabled in the Channel Menu (**C5** Transmit Multiplier).

## Global G4 - Frequency Calibration

### G4 Freq\_Cal -233

Set MR2 to a high frequency, say 40MHz, and connect the output to a frequency counter of known accuracy. Use rotary 2 to alter the calibration setting. The adjustment range is -1000 to +1000 (the numbers do not translate directly to frequency). The adjustment takes effect in real-time so that progress can be monitored. To clear the setting use the power-on reset function. It should be possible to set MR2 within a few Hz of the desired frequency. There will not be a discernable frequency change for every change in cal setting due to rounding effects within the floating point calculation routine. After calibration, check a few frequencies within the MR2 range. They should be within a few Hz at the same temperature. The cal settings will not drift. Any apparent cal change is due to ambient temperature changes affecting the 125MHz DDS oscillator. This can amount to tens of Hz at higher DDS frequencies. For a typical room temperature variation this is not a problem.

## Global G5 - Transmit Delay (TROPIC lite)

### G5 TxDelay 85ms

TROPIC (Transmit Receive Organiser using a PIC) is self contained T/R sequencer plus-kit from s9plus.com) . A simpler version is included in MR2. Adjustment range 0-250ms in 5ms increments. The indicated value is not the total delay, it is the delay between each part of the transmit sequence. e.g. PTT / 100ms delay / TROPIC1 goes high / 100ms delay / TROPIC2 goes high / 100ms delay / MR2 DDS RF output switched on. This is a globally effective setting. To switch off, set delay to 0ms. This setting works in conjunction with the TROPIC1 and TROPIC2 lines, described elsewhere. The TROPIC lines stay low when the delay is set to zero otherwise the sequence is active. For TROPIC lines active on transmit with effectively zero delay, set the delay to 5ms. .

## Global G6 - Maximum Memory

### G6 Mem\_Max 33

Select the number of memories required from 01 to 48. Selecting 01 effectively disables memory selection, useful when MR2 is replacing a single crystal.

## Global 07 - Start-up Memory

### G7 PwrUp\_Mem 03

Select the memory displayed after power-on. This can be a number above the maximum memory. e.g. Set Mem\_Max to 10, then set memory 11 to 10MHz to compare with a reference signal at power-up before reverting to main memory group.

### Global G8 - Display Offset

G8 Dspl 10.57500

Useful when say a front end receive converter or a non tuneable first IF is used. Maximum offset is 64MHz. Resolution is 5kHz. Increments are 5kHz or 100kHz, alterable by short-pressing PB2. To take effect per channel, the offset needs to be enabled in the Channel Menu **C6**, Display Offset. The actual DDS frequency is not affected, just the display.

To save the selected settings, exit the Global Menu.

## 5 Channel Menu

---

*Setting up MR2 for a specific use is accomplished by means of a two-part configuration menu. The Global Menu for the most part deals with setting actual values, while the Channel Menu defines which Global settings are enabled on any particular channel*

### Key points

- There is only one Global Menu. This sets the actual values for things like IF offset.
- There is a Channel Menu for each channel. Things like IF offset can be enabled on a per-channel basis.

### How to access the Channel Menu

First, long-press PB2, and immediately short-press PB1, then release both when the response below appears. Shortly after the first Channel Menu item C1 Group x appears ('C' is short for 'Channel').



Channel 4 Menu

The button-press order is important as pressing PB1 first accesses the Global Menu.

### How to exit the Channel Menu

In a similar way to how the Channel Menu was entered, long-press PB2, and immediately short-press PB1, then release both when the response below appears, after which the normal display re-appears.



Updating Ch 4

### Channel Menu Structure

There are seven items in the Channel Menu. Upon entering, item **C1**, Step-Group select is always displayed first.

### Key points

- Items are selected using rotary 1 in round-robin fashion.
- The setting for each item is adjusted using rotary 2.
- The setting for all items except **C1** is either on or off

The table below lists the nine items in order. Each item will then be described. Items are prefixed "C" to distinguish them from the Global Menu items.

Item number	Function
	<b>(NB effective for current channel only)</b>
C1	Step Group select
C2	Control 1 enable
C3	Control 2 enable
C4	Receive Adjust enable (IF and/or RX mult)
C5	Transmit Multiplier enable
C6	Display Offset enable
C7	Transmit Enable

We will now go on to explore the Channel Menu in more detail.

### Default Channel Configuration

There is a default setting for the Channel Menu items. Unless the user chooses to alter any settings for a particular channel, it will conform to this default setting. (The default settings can of course be altered as will be explained shortly). A means is provided to indicate when a setting differs from the default setting. This is best illustrated in the following example :

C5 Tx\_Mult <Off>

Channel Menu item **C5** Transmit Multiplier is selected. In this example the option is 'Off' (disabled).

C5 Tx\_Mult [On]

Using rotary 2 the setting is altered to 'On' to activate the transmit multiplier as set in Global Menu item **G3**.

Notice the difference? Apart from 'Off' becoming 'On', '< >' has become '[ ]'. A setting enclosed by '< >' is the default setting that is applied to all memory channels unless they are individually altered. (Think of the arrows as pointing to all channels). A setting enclosed by '[ ]' differs from the default setting. (Think of this setting as being 'bracketed' apart from the norm for other channels).

### On / Off rotary action

Another point worth remembering is that rotary 2 works like an on/off switch. Any clockwise rotation (however many clicks) selects 'on' and any number of anti-clockwise turns selects 'off'. This is an easier method than a round-robin control where one would have to carefully restrict adjustments to a single click.

### Saving new settings

To 'Save' a new item setting, exit the Channel Menu at any time (i.e. any channel Menu settings that have been altered are updated regardless of which is being displayed when the menu is exited) . The updates only apply to the active channel (i.e. the channel shown when the Channel Menu was entered ).

### How to alter the default channel settings

There is also a way to alter any Channel Menu item for all memory channels at once, thus creating a new default setting. *This is done per menu item, not for all Channel Menu items collectively.* This gives more control and also removes the chance of inadvertently corrupting other menu settings.

Keeping the same example as above, say we have a setting for Tx\_mult as <Off> which is indicated as the global setting because of the '< >' arrows., and wish to enable it for all channels (i.e. switch it on). Initially the display would look like this:

C5 Tx\_Mult <Off>

C5 Tx\_Mult [On]

Using rotary 2, change the setting to on. The '[' ]' shows the new setting is not currently the default.

Exiting the channel Menu in the normal way at this point would only update the present channel. To alter all channels and make the new setting the default, long-press PB2 until you see this message:

Global Update ...

then release PB2, upon which MR2 copies the configuration change (for that menu item only) to all memory channels then exits back to normal mode.

A quick check of the Channel Menu for any memory channel will now show

C5 Tx\_Mult <On>.

The '< >' indicates that 'On' is now the default for the Tx\_Mult setting. Individual channels can of course be set back to '[Off]'.

In this example, assuming that Tx\_Mult was set as x2 or x4 in the Global Menu, any channel selected in normal mode will show a transmit indication as 'T2' or 'T4' instead of 'Tx' to indicate the multiplier in use.

## Channel Menu settings in detail

### C1 - Step Group

This is likely to be the most used setting and so the Channel Menu always defaults to **C1**. The step group defines which steps PB2 can select in normal mode. There are four groups. In Group 1,2,and 3 the lowest step is not remembered as the whole point of remembering the last used step per group is to provide consistent operation when changing channels. The smallest step is most likely to be used as a fine-tune, which is unlikely to be the first step needed on the next channel.

**C1 Group 1 #####**

selected but is remembered as 100Hz

The '#' symbol indicates the position after the MHz decimal point that is available. Group 1 has all 5 step sizes available. The 10Hz step can be

**C1 Group 2 \_###\_**

Group 2 comprises 10kHz, 1kHz and 100Hz steps. The 100Hz step can be selected but is remembered as 1kHz.

**C1 Group 3 \_\_###**

Group 3 comprises 1kHz, 100Hz and 10Hz steps. The 10Hz step can be selected but is remembered as 100Hz

**C1 Group 4 \_\_##\_**

Group 4 provides just the 1kHz and 100Hz steps. Both step sizes are remembered.

### C2 - Control 1

**C2 Ctrl\_1 <Off>**

information for more details.

When set to 'On', Ctrl\_1 line will go high when the memory channel that is being configured is selected. See the circuit diagram and interfacing

### C3 - Control 2

**C3 Ctrl\_2 [On]**

information for more details.

When set to 'On', Ctrl\_2 line will go high when the memory channel that is being configured is selected. See the circuit diagram and interfacing



#### C4 - Receive Adjustments

##### C4 Rx\_Adj <Off>

When set to 'On', the Global setting **G1**, IF Offset and Global setting **G2** Receive Multiplier will both be applied to this memory channel in receive mode. **G1** or **G2** is only effective for IF offsets > 0 and receive multipliers of x2 and x4.

#### C5 - Transmit Multiplier

##### C5 Tx\_Mult <Off>

When set to 'On', the Transmit multiplier x1,x2 or x4 as set in the Global Menu item **G3** will be applied to this memory channel in transmit mode. So, enabling **C5** will have no effect if **G3** is set to x1.

#### C6 - Display Offset

##### C6 DspOffs <Off>

When set to 'On', the Display Offset frequency as defined in Global Menu item **G8** will be added to the LCD displayed frequency after any other multiplier or shift has been accounted for. The DDS frequency is unaffected. A maximum value of 64MHz can be saved in **G8**. Resolution is 5kHz. Short-press PB2 to alter the tuning rate between 100kHz and 5kHz.

#### C7 - Transmit Enable

##### C7 Tx\_Enab <Off>

When set to 'Off', the memory channel is prevented from going into transmit mode. Any PTT line input puts MR2 into standby mode (DDS is off, and 'Standby' is displayed on the LCD).

## 6 Error Reporting

---

MR2 checks that the DDS is not being asked to produce a frequency greater than 60MHz or lower than 10Hz. This limit is set for the base-frequency during frequency entry; however it *can* be exceeded when the transmit or receiver multiplier, or the IF offset adjustment is enabled.

There are three error displays. In each case the screen indicates the reason for the error, and PB2 must be pressed to continue (as suggested by 'PB>' on the display). MR2 then removes the error by disabling the function causing the problem. The user should then determine what adjustment is required based on the type of error reported.

### Transmit DDS Over-range

Err: Tx>60 PB>

This indicates that in transmit mode the DDS is being told to make a frequency greater than 60MHz. This should only be possible when a x2 or x4 transmit multiplier is enabled. Short-press PB2 to acknowledge. MR2 removes the error by setting **C5** Transmit Multiplier to **Off** for the channel in use.

### Receive DDS Over-range

Err: Rx>60 PB>

This indicates that in receive mode the DDS is being told to make a frequency greater than 60MHz. This should only be possible when a x2 or x4 receive multiplier is enabled, and / or a positive IF offset is active. Short-press PB2 to acknowledge. MR2 removes the error by setting **C4** Receive Adjust to **Off** for the channel in use.

### Receive DDS Under-range

Err: IF neg PB>

This indicates that in receive mode the DDS is being told to make a frequency below 10Hz. This should only be possible when a negative IF offset is enabled for a frequency lower than the offset value. Short-press PB2 to acknowledge. MR2 removes the error by setting **C4** Receive Adjust to **Off** for the channel in use.

## 7 Resetting MR2

From time to time it may be useful to reset MR2 back to a known default state. Three resets are provided.

All resets are activated just after power-up when the software version is displayed (power-up sequence). Activation is done by momentarily pressing either PB1, PB2 or both.

MR2 is shipped with a Memory reset and Configuration reset having been performed. The Calibration **G4** will have been adjusted to calibrate the DDS module supplied. Make a note of this reading for future reference.

### Memory Reset

During the power-up sequence, momentarily press PB1. "Memory Reset..." appears in the LCD display then after a short interval MR2 starts normally.

A memory reset writes the default frequency of 5MHz into all memories. It does not change anything else.

### Configuration Reset

During the power-up sequence, momentarily press PB2. "Config Reset..." appears in the LCD display then after a short interval MR2 starts normally.

A configuration reset sets the Global Menu and Channel Menu back to a default state. It does not change the frequency settings in the memories although the actual DDS frequency may change if an IF offset or frequency multiplier etc. was previously used. The table below shows the default settings following a configuration reset

Global Menu			Channel Menu		
<b>G1</b>	IFofs	0.0	<b>C1</b>	Step Group	1
<b>G2</b>	Rx_Mult	x1	<b>C2</b>	Ctrl_1	Off
<b>G3</b>	Tx_Mult	x1	<b>C3</b>	Ctrl_2	Off
<b>G4</b>	Freq_Cal	is left unaltered	<b>C4</b>	Rx_Adj	Off
<b>G5</b>	TxDelay	0ms	<b>C5</b>	Tx_Mlt	Off
<b>G6</b>	Mem_Max	48	<b>C6</b>	Dsp_Offs	Off
<b>G7</b>	PwrUp_Mem	1	<b>C7</b>	Tx_enab	On
<b>G8</b>	Dspl	0.0			

### Calibration Reset

During the power-up sequence, momentarily press PB2 and PB1 together. "Cal Reset..." appears in the LCD display then after a short interval MR2 starts normally. Requiring to press two buttons reduces the chance of clearing the calibration by mistake.

The calibration reset merely sets **G4** to 000 and changes nothing else. There should be no reason to perform a cal reset if MR2 is working normally.

## 8. Construction and Testing

***Please read this section fully before commencing construction***

### **How hard is it to build?**

MR2 is quick and easy to build. As long as you have a soldering iron with a fine tip, thin solder (preferably no thicker than 0.7mm dia) and a steady hand you should have no difficulty. Use an iron with a temperature of 700F or a Weller #7 bit.

Take care when soldering pads that have thin track passing in between them. With a little thought it should be obvious how to position the iron tip and solder with respect to the track in order to reduce the chance of solder bridges.

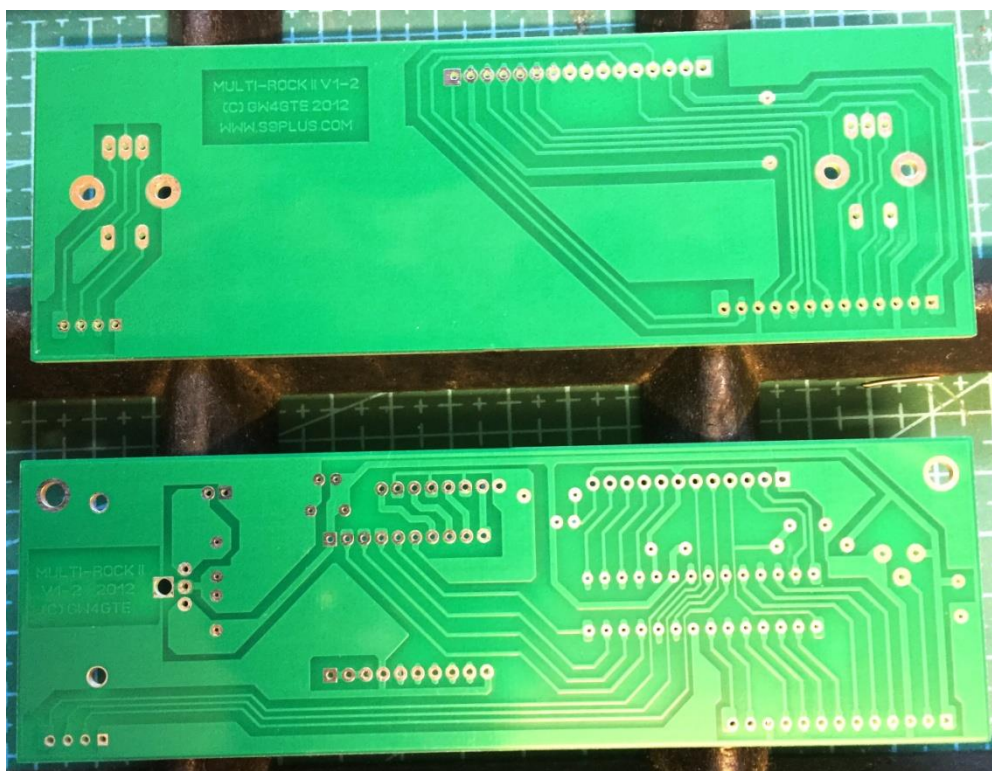
We strongly suggest you use a loupe or magnifying glass to inspect your work before power-up. (In the UK, Maplin sell suitable loupes)

### **The Components**

The kit consists of a pair of similar sized PCBs, a pre-built DDS module, an LCD display module and a small number of other components all of which are installed onto the PCBs (apart from the PTT toggle switch). The complete parts list is shown below. Print out this section and tick off the parts as you assemble the kit.

Figure 8.1 Unpopulated MR2 Display PCB Rev 1.2 (track side)

Figure 8.2 Unpopulated MR2 Main PCB Rev 1.2 (track side)



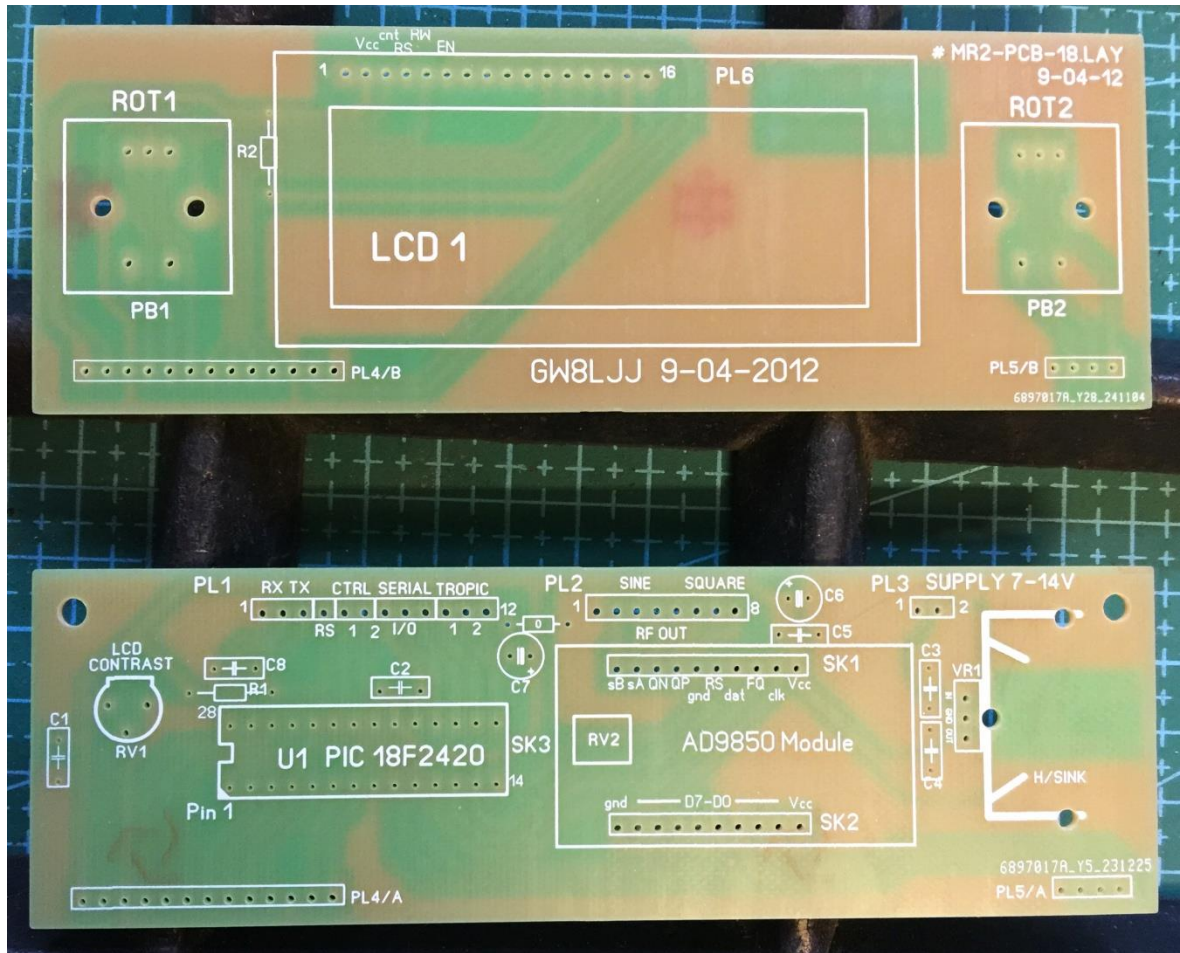


Figure 8.3 PCB Layout Rev 1.2





Figure 8.4 DDS Module (pre-assembled)

## Parts List

Note: Pin strips and socket strips are supplied uncut to length apart from PL3. Cutting the socket strips to size sacrifices a pin which is accounted for in the number of connections supplied. Place wire cutters in line with the pin axis and cut firmly and quickly in a single action.

MR2 PARTS LIST MAIN PCB	
Part #	Value / Description
SK3	28pin DIL socket.
SK1,SK2	10 pin socket strip
PL1	12 way pin strip plus female socket strip
PL2	8 way pin strip plus female socket strip
PL3	2 way pin strip plus female socket strip
R1	4k 7 ¼ W 5% or better
RV1	50K lin. 5mm pitch
C1,C2,C3,C4,C5, C8	0.1uF, 100n, 104
C6,C7	4.7uF electrolytic >10VW
VR1	7805 regulator. c/w M3 screw, nut and washer..
HS1	Heatsink.
PL4/A	13 way right angle pin-strip
PL5/A	4 way right angle pin-strip
IC1	PIC 18F2420 pre-programmed
AD9850 module	Pre-assembled DDS module
Misc	
SW1	For external Tx or Rx enabling - see notes

MR2 PARTS LIST Display PCB	
Part #	Value / Description
PL4/B	13 way male to male right angle pin strip. See notes for how
PL5/B	4 way male to male right angle pin strip. See notes for how
PL6	16 way pin strip now attached to the LCD display
LCD1	16x1 LCD display, logically addressed as 8 x 2. This maybe with a green or blue background and black text or white text. Subject to availability
ROT1	mechanical incremental rotary encoder with push button *
ROT2	mechanical incremental rotary encoder with push button *
	* including fixing nut and washer
R2 and 0	0R0 zero ohms links for LCD backlight and ground on main board

## Assembling the Main PCB

On the main PCB, fit the parts in the order listed. When attaching the pin-strips, solder the end pins first then check alignment before soldering the remaining pins.

Pin strips and header strips are supplied uncut apart from two pins which are used for PL3. Cutting the header strip sacrifices one connection and this is allowed for in the number of pins. Place the cutters along the sacrificial pin and cut quickly and firmly in a single action. You will find the header splits easily.

Do not plug in the PIC processor chip or the DDS module yet. This will be done after attaching the display PCB and initial testing is complete.

MAIN PCB Component assembly order	
Part #	Value / Description
SK3	28pin DIL socket. Pin 1 goes to RV1 side.
SK1,SK2	10 pin socket strip (female) Check DDS module for fit
PL1	12 way pin strip plus female header
PL2	8 way pin strip plus female header
PL3	2 way pin strip plus female header
R1	4k 7 1/4 W carbon film, 5% or better
RV1	50K lin. Set fully c/w (PCB Rev 1.1) or ccw (PCB Rev 1.2)
C1,C2,C3,C4, C5, C8	0.1uF, 100n, 104
C6,C7	4.7uF electrolytic >10VW
VR1	7805 TO220 regulator. c/w M3 screw, nut and washer. Align the heatsink/mounting flange with rear of HS1.
HS1	Heatsink. Adjust lugs to fit then slight bend under PCB (too much will snap the lug.) Clamp to VR1 using M3 screw, nut and washer provided

Remember to initially set RV1 fully clockwise (PCB Ver 1.1) or fully counter-clockwise (PCB Ver 1.2).

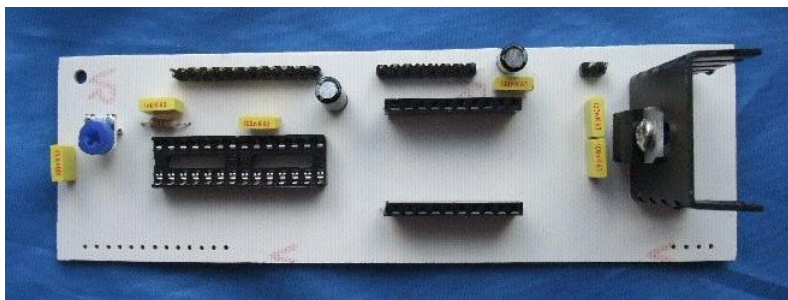


Figure 8.5 Main PCB minus PIC and DDS module  
(Old PCB shown) New boards are commercially made

## Assembling the Display PCB

Follow the construction steps 1-5 below. When attaching the pin-strips, solder the end pins first then check alignment before soldering the remaining pins.

MR2 PARTS LIST Display PCB	
Part #	Value / Description
PL4/B	13 way male to male right angle pin strip. See notes for how
PL5/B	4 way male to male right angle pin strip. See notes for how
PL6	16 way pin strip for attaching LCD1. Attach to PCB first. See assembly notes.
LCD1	16x1 LCD display, logically addressed as 8 x 2
ROT1	mechanical incremental rotary encoder with push button *
ROT2	mechanical incremental rotary encoder with push button *
	* including fixing nut and washer
R2	0R0 zero ohms link for LCD backlight (omit to save power)

### Step 1 : Soldering PL4 and PL5 pin right angle pin strips

First solder PL4/B and PL5/B to the Display PCB. The right angled pins are attached as illustrated below. As no other components are on the PCB, lay it on a flat surface during soldering to keep the pin housing pressed against the Display PCB on the component side. Solder the end pins first then re-check the pin strip is flush against the PCB. Trim the pins back once soldered taking care not to subject the soldered joint to undue force (hold the PCB loosely in the left hand whilst cutting, holding the left thumb over each pin to prevent the off-cut flying off)

Reminder: The pins with the right angle bend are soldered to the display PCB. The pin strip is mounted from the component side

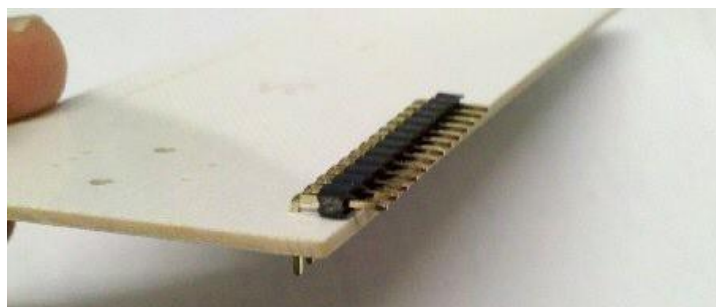


Figure 8.6 Inter-board pins on display PCB

### Step 2: Soldering PL6 straight pin strip (using the short pins)

This strip links the LCD display module to the Display PCB. Solder it to the PCB first using the short pins as illustrated below. Solder the end pins first then check the pin strip is flush to the PCB and rises perpendicular to it before soldering the remaining pins.



Figure 8.7 Display Module pin-strip

**Step 3: Now attach the LCD display to the long pins of PL6\***

**\*The pins are now attached prior dispatch to allow testing of the LCD display.**

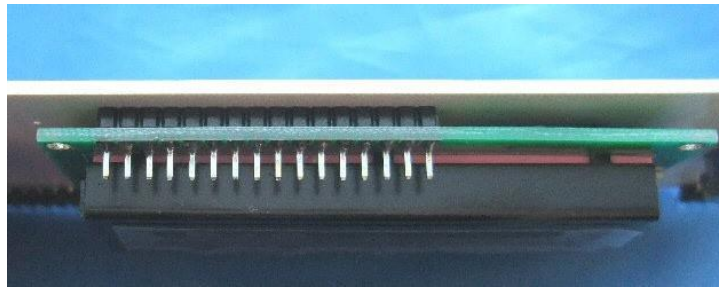


Figure 8.8 Display Module attached

**Step 4: Fit ROT1 and ROT2 Rotary encoders**

Adjust the pins and mounting lugs as required in order to pass through the PCB. Push firmly until the controls are sitting flat against the PCB. The lugs can be soldered without bending. Use plenty of solder on the lugs - the usual way to install MR2 is to attach it to an enclosure using the encoders as the fixing point.

MR2 is intended to be attached to an enclosure using the rotary encoders. Extra M8 washers are included for spacing (fitted on the encoder shafts) so that the LCD display bezel can be mounted behind a front panel cut-out without putting strain on the encoders. There are also two holes at the rear of the main PCB for additional support. These should be used as well if the equipment is likely to be subject to mechanical shock as any vibration will put strain on the PCB track holding the two PCBs together.

**Step 5: Solder the zero ohm backlight link R2.**

Finally, fit R2. This is a zero ohm link that routes 5V to the LCD backlight. Omit if no backlight is needed. External circuitry (not part of MR2) could make the LCD backlight flash to indicate some sort of alarm condition.



Figure 8.9 Completed Display PCB  
(Old PCB shown) New boards are commercially made

### PCB inspection

At this point you will be eager to solder the two PCBs together and start playing, but first use a loupe or magnifying glass to check your soldering for dry joints or bridges. Pay particular attention to the Display Module pins around PL4 and PL5 as these will be more difficult to check once the two PCBs are soldered together..

### DC tests.

Referring to the circuit diagram it should be apparent which pins go to earth and which pins go to 5V. If nothing else, at least check the 5V line is not shorted to earth. You may wish to supply power to PL3 and check the 5V regulator is working correctly, as 12V applied to the DDS and PIC won't be pretty!

### Final Assembly

Now attach the Display PCB to the Main PCB by soldering the pin strips PL4 (13 pin) and PL5 (4 pin). As before, solder the end pins then check for alignment. Be very careful not to stress the soldered connections especially when only a few pins are soldered as any leverage could easily snap the track. Once all the pins are soldered the load is spread adequately. In the unlikely event you experience any failures or intermittents later on, check here first.

To complete the assembly plug in the DDS module and the PIC processor chip. Get them the right way round first time - there are no second chances! The LED on the DDS module faces the heatsink. Pin 1 on the PIC faces RV1 (small dot above pin 1, and pin 1 always bottom left when writing is the right way up).

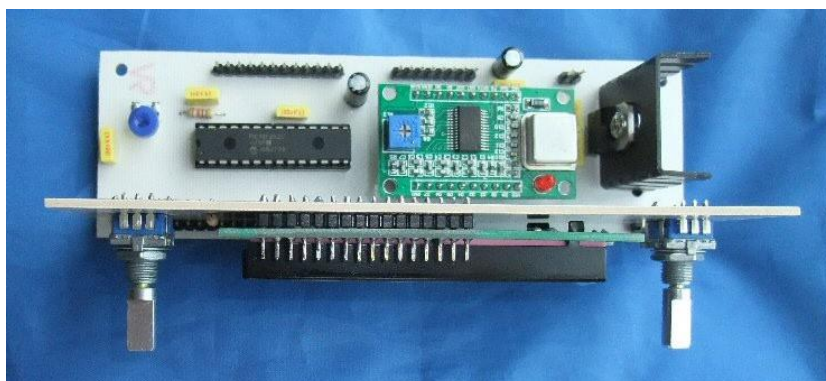


Figure 8.10 Completed MR2

## First Power-Up

Prior to shipping MR2 the DDS module and PIC chip will have been powered up and checked for correct operation. The memory channels are set to a default frequency of 5MHz. The DDS module supplied will have been calibrated, although the user may wish to adjust this to compensate for local temperature differences (The 125MHz oscillator module is not temperature stabilised). After power-up, go into the Global Menu **G4** and note the cal value for future reference in case the original cal is lost.

Apply power. If all is well, you will see this display showing the software version for about one second. (The version may differ in future). It is during this interval that MR2 resets can be performed - see section 7. If no display is evident, try adjusting RV1 for correct contrast before suspecting anything more serious. The control is quite critical to set, but can be left alone once adjusted.

Current consumption with backlight on should be approximately 250mA



MR II Ver 1.0

Following the initial display the default memory channel is displayed. This will be channel 01 following a Configuration reset, otherwise it will be whatever the startup memory channel has been set to (Global Menu, item 07)



01 Stby 5.00000

The 'Stby' indication may show 'Rx' or 'Tx' if the corresponding switches are activated.

**Note there is no output from the DDS in 'Stby' mode.**

## 9. Interfacing MR2

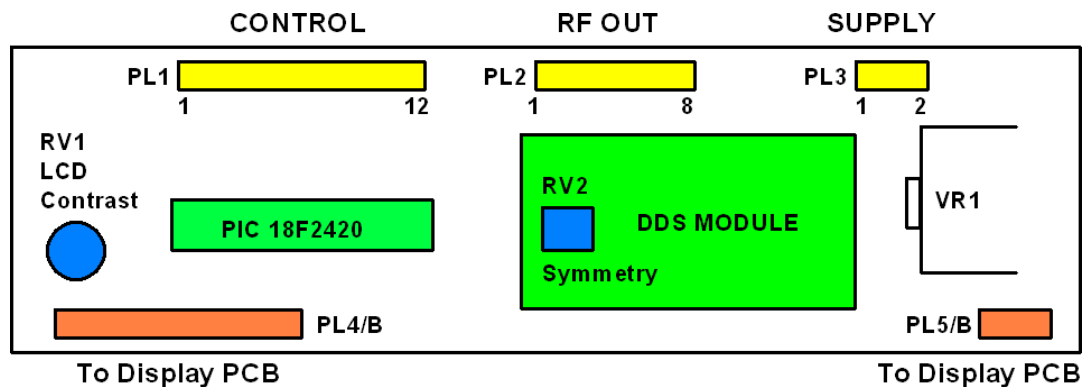


Figure 9.1 MR2 main PCB layout

PL1 Control	
Pin	Function
1	0V (earth, connected to back-plane)
2	PTR.. Sits at 5V, pull low to activate
3	PTT. Priority over PTR . Sits at 5V, pull low to activate
4	Reset (future use, although the pin is operative as a reset)
5	Control 1 output (logic level 0V or 5V)
6	Control 2 output (logic level 0V or 5V)
7	0V (earth, connected to back-plane)
8	Serial I/O Rx (Reserved for future use, do not connect)
9	Serial I/O Tx (Reserved for future use, do not connect)
10	TROPIC 1 Tx delay output (logic level 0V or 5V)
11	TROPIC 2 Tx delay output (logic level 0V or 5V)
12	0V (earth, connected to back-plane)

PL2 RF Out	
Pin	Function
1	0V (RF earth, not directly connected to back-plane)
2	Sine wave out 600mV p-p 0 degrees <b>via LPF. Use this for LO.</b>
3	0V (Rf earth, not directly connected to back-plane)
4	Sine wave out 600mV p-p 180 degrees <b>unfiltered</b>
5	0V (RF earth, not directly connected to back-plane)
6	Square wave out 5V p-p 180 degrees (not in phase with sine)
7	0V (RF earth, not directly connected to back-plane)
8	Square wave out 5V p-p 0 degrees (not in phase with sine)

PL3 Supply volts	
Pin	Function
1	0V (earth, connected to back-plane)
2	Supply Volts. 5V to 14V (larger heatsink recommended >14V)

### Connecting to PL1,2, and 3

The pin headers are supplied with mating socket strips to which wires can be soldered. We suggest using a spare piece of strip-board soldered to the socket strip to make solder pads for the wires. See the photo below for an example.

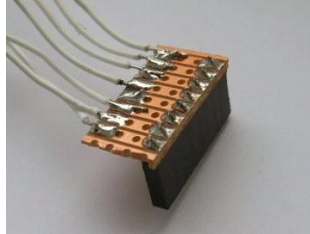


Figure 9.2 connection method

### RF Out notes (PL2)

The RF earth connections are DC connected to the ground plane but only via the 0V pins of the DDS module (so any DC checks without the DDS module in place will show these lines as floating). This is an attempt to isolate processor noise from the RF out lines (we haven't noticed a major problem - we just thought it would be a good idea!). There is no reason why the DDS module would be removed, and this should be avoided when PL2 is in use.

The output levels are load dependent, and will tend to drop in level slightly with increasing frequency, especially the sine wave via the LPF. Loading the sine wave output will affect the square wave symmetry. If no square wave output is present and the sine wave output looks normal, adjust RV2 to produce a square wave of the required symmetry.

For applications where a 1:1 MS ratio is required such as the FAT5 transmitter, adjust RV2 with care. The best way to do this would be to monitor the transmitted spectrum and adjust RV2 for minimum even harmonics. Better still set MR2 for 2Fc and use a divide by two circuit. Disable the square wave output if not needed by adjusting RV2. This will improve the sine wave purity.

There is no output when the display says 'Stby'.

All outputs appear together. For transceive applications it may be advisable to isolate the two signal paths. The TROPIC lines can be used to do this using any sort of gating one wishes. A relay board as shown in figure 8.1 below is one way.

### Buffering the output lines

Control 1 and 2 together with TROPIC 1 and 2 are un-buffered TTL level outputs direct from the PIC. Treat these carefully. Consider buffering via a transistor, possibly in turn activating a relay. A suitable relay board with TTL compatible inputs is shown below. We do not supply these at present, but they can be readily obtained off eBay at low cost (the downside is a 14+ day wait for delivery from China etc.). Also available faster locally at higher price.

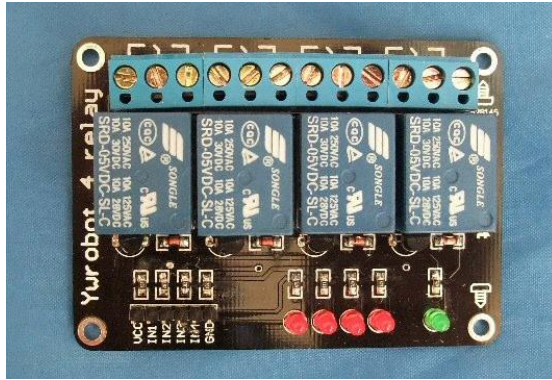


Figure 9.3 Example of relay board (not supplied)

## Transmit and Receive control

The logic level of the PTT and PTR lines control the transmit and receive status. Rx has priority over standby, and Tx has priority over receive.

State table below. 1 = off i.e. switch unconnected or o/c, as the inputs float high and are activated by pulling low.

PTT	PTR	State
1	1	Stby
1	0	Receive
0	1	Transmit
0	0	Transmit

MR2 is shipped with a single toggle switch SW1 which can be used on either the PTT or PTR line.

### Signal Generator / Transmit only

Leave PTR (PL1/2) unconnected and connect SW1 between PTT (PL1/3) and earth (PL1/1) . SW1 then switches MR2 between Standby (no output) and Tx (output). If a continuous RF level is acceptable just wire PL1/1 and PL1/3 together

### Receive only

Leave PTT (PL1/3) unconnected and connect SW1 between PTR (PL1/2) and earth (PL1/1) . SW1 then switches MR2 between Standby (no output) and Rx (output). If a continuous output is acceptable just wire PL1/1 and PL1/2 together

### Transceive

Connect PTR (PL1/2) to earth and connect SW1 between PTT (PL1/3) and earth (PL1/1)

SW1 then switches MR2 between transmit (SW1 s/c) and receive (SW1 o/c)

For receive and transmit use the Global Menu and Channel Menu settings should be adjusted accordingly



## 10. Multi-Rock with FAT5 and RAT5

MR2 can be used as a general purpose signal generator, but it is mainly designed to form part of the FAT5 / RAT5 AM transmitter and receiver projects, where it is used as the frequency source. For the FAT5 transmitter. MR2 replaces the original Multi-Rock project. RAT5 contains its own on-board local oscillator which can be replaced by MR2 providing a frequency readout and greater stability.

### Interfacing to the FAT5 RF PA Module

The bi-phase square wave outputs from MR2 can be directly connected to the RF PA Module, product code PK-09 in exactly the same way that the original Multi-Rock was used. There are however differences that should be appreciated:

The bi-phase outputs from MR2 are squared and inverted versions of the primary DDS frequency, and the M:S ratio is determined by potentiometer RV2 on the DDS module itself. The M:S ratio is also affected by the sine wave outputs as any loading here changes the level that is fed into the squarer circuit. FAT5 uses a push-pull PA which greatly reduces even harmonics in the RF output but this is only the case when the two drive signals are exactly opposite in phase. To minimise even harmonics RV2 needs to be carefully adjusted using an oscilloscope such that the M:S ratio of the square wave outputs is 1:1, with the sine wave outputs kept in a known condition, either unloaded, or constant load. Final adjustment using a spectrum analyser or SDR receiver is recommended, although any receiver that can tune to an even harmonic frequency can be used as a frequency selective sniffer. RV2 is very critical to adjust. The M:S ratio will alter with large frequency changes such as a band change. **Please do not connect MR2 to FAT5 without bearing this in mind, and in any case always use an LPF between Tx and antenna.**

There is a second solution using the MR2 Tx Mult feature. Set up MR2 to produce a Tx signal of twice the transmit frequency then feed one of the square wave outputs (PL2/6 or PL2/8) into an external divide by two circuit such as used in the original Multi-Rock. This automatically ensures the M:S ratio is 1:1 and no further adjustment is needed. We may in future offer a divider PCB or even add the divider to the RF PA module, MR2 or both. This will be demand driven so please contact us if interested.

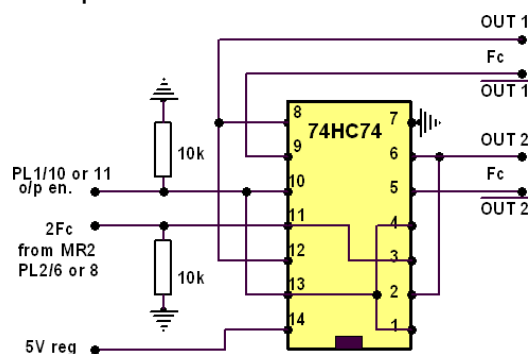


Figure 10.1 Divide by two circuit

The **NEW** PA PCB has a precision comparator so no need for twice TX frequency (see manual)

## Interfacing to the RAT5 Receiver

Starting from a standard fully working RAT5, carry out the following modifications to disable the on-board LO and provide a connection method for the new MR2-sourced LO signal:

- Disable the LO using a shorting link across L1, also allowing C16 to provide an RF ground for R3.
- Apply the MR2 sine wave signal (MR2 PL2 pin 2) to pin 12 of RAT5 U1 via a 47R and 100n in series. The resistor forms a potential divider with R3 to produce the correct RF level. The 100n isolates the standing DC voltage on U1 pin 12 .
- Remember to configure MR2 for an IF offset of 455kHz, either positive or negative.
- **If the square wave outputs from MR2 are not required elsewhere, disable by rotating RV2. This will improve the purity of the sine wave by removing harmonic crosstalk from the square wave output.**

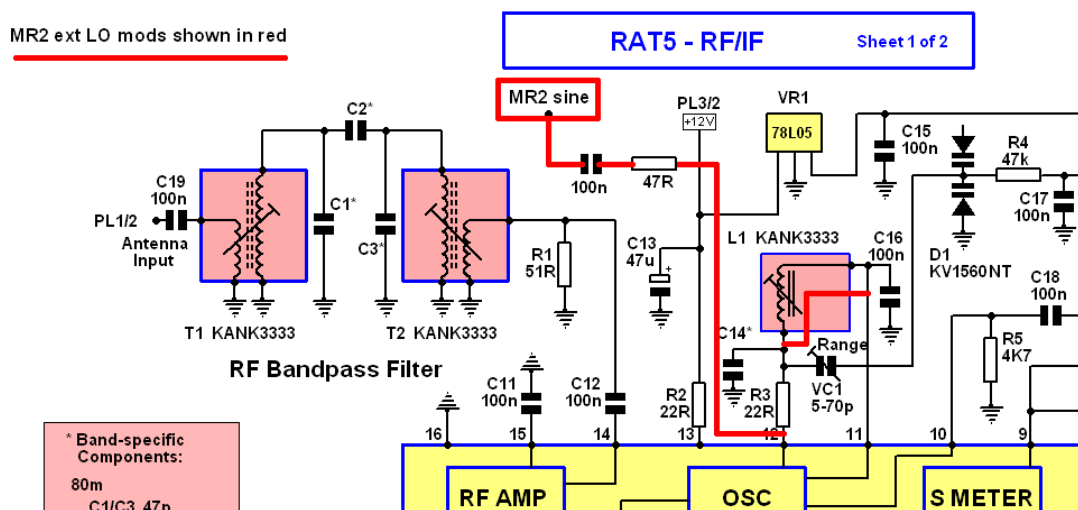


Figure 10.2 Extract from RAT5 circuit showing mods for external LO.

A more ambitious setup could use the CTRL outputs of MR2 to switch in different band-pass filters according to band making a multi-band RAT5 with auto filter switching. We may offer a 'bare-bones' RAT5 kit if demand warrants. This would omit the normal LO components and the input bandpass filters.



## 11. Circuit Description

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The circuit diagram, at least to module level consists of very little more than interconnecting lines. VR1 supplies a regulated 5V from which all circuitry is powered.

### DDS module

This really is the heart of MR2 as it contains the AD9850 DDS chip. The availability of pre-assembled DDS modules conveniently and economically gets round the challenge of soldering the 28 pin SSOP package.

To program the DDS chip a 40 bit serial data string is clocked in. This is generated by software in the PIC, adjusted for the frequency required. For each bit, either a '1' or '0' is set up on the data line while the clock line is toggled, then the next bit in the 40 bit string is set up and clocked, and so on until all 40 bits have been clocked-in, after which time the 'load' pin is toggled to activate the new frequency. This happens very quickly of course, so that the operation appears 'seamless' For a detailed description of how the DDS chip generates a waveform please consult an AD9851 data sheet (a Google search will reveal many download options).

### Sine wave outputs

The sine wave output isn't perfect, there are harmonics and spurs although these are at a low level, and at predictable frequencies.. The signal below 40MHz is reasonably clean, and is quite usable to 60MHz or more. There are two sine outputs which are in anti-phase. One output passes through a low pass filter on the PCB which cleans up the waveform considerably. Make sure you use the filtered output unless you need dual outputs in anti-phase.

### Square wave outputs

In addition to the sine wave output, the module also provides two TTL level square wave outputs, generated by passing the sine wave through a comparator, the decision level of which is controlled by RV2, 'symmetry'. RV2 can be critical to set when one requires a perfect 1:1 MS ratio, and any loading on the sine wave outputs will alter the MS ratio as well, so for more demanding square wave requirements needing a reliable 1:1 ratio it is better to use a single output at twice Fc and a divide by two circuit. MR2 can be adjusted to provide an output of two or four times the display frequency.

### PIC chip

The 18F2420 PIC chip from Microchip is a typical low power microprocessor well suited to the application. In this circuit it uses the internal 8MHz system clock, and the PLL x4 multiplier circuit to provide a system clock of 32MHz, thus there is no clock crystal evident. We can use this low accuracy source as there are no critical timings involved. The program memory, working memory and the storage for the MR2 configuration are all within the chip so no external support ICs are needed.

The software runs in a continuous loop, constantly checking the switch inputs and rotary control inputs, and reacting accordingly, depending on the function being performed such as altering a frequency, activating the PTT (Tx) line or changing a configuration setting. Around 98.5% of the PIC's 16k (8192 bytes) of program memory is used. Any future upgrades to MR2 by way of new features will almost certainly need the slightly higher cost 18F2520 variant with twice the program memory.

### **Rotary Controls ROT1, ROT2**

These are mechanical incremental rotary switches. The main benefit is low cost and the main drawback is potential problems associated with the mechanics and the laws of physics. There is a limit to how fast they can be rotated before 'cam bounce' corrupts the sequence, although the speed of operation is more than adequate. Also, we found during development that occasionally the switches would stick causing the software to hang until the control was rotated again. It was several days before a suitable solution was found that did not at the same time interfere with the 'feel' of the control.

The controls also have a push-button feature (PB1, PB2) which allows the number of controls and switches to be kept to a minimum.

### **LCD Display**

The LCD display is the same one used in other kits (CLARA) and the 16 character single line display has proved adequate for the job. There is an optional backlight that can be enabled using the zero ohm link R2, or dimmed by increasing R2 slightly.

RV1 controls the LCD contrast. Setting is a tad sensitive but it is a 'set and forget' operation and not worth the addition of a series resistor to pad the control range. Initially set fully clockwise then back off to suit.

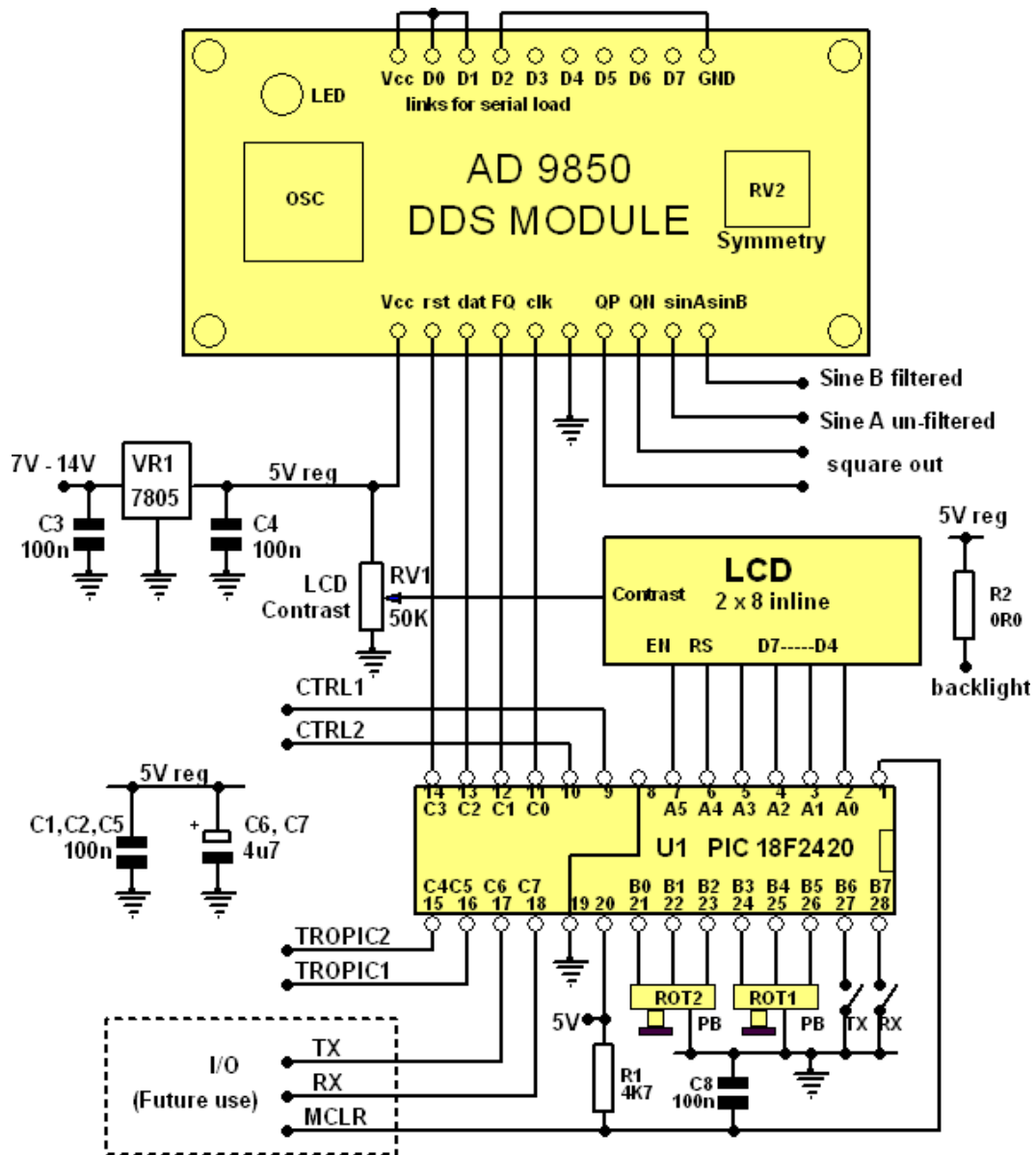


Figure 11.1 Circuit diagram

## 12. Output Spectrum

The plots below were taken using a Perseus SDR receiver in HF scan mode. The low-pass-filtered sine wave output (sine B, PL2 pin 2) was fed into the Perseus via 35dB of attenuation. The square wave output of MR2 was disabled. Apart from harmonics of the carrier frequency the traces show peaks at 8MHz intervals. This is caused by the 8MHz PIC CPU clock. All unwanted signals are better than 60dB below the carrier.

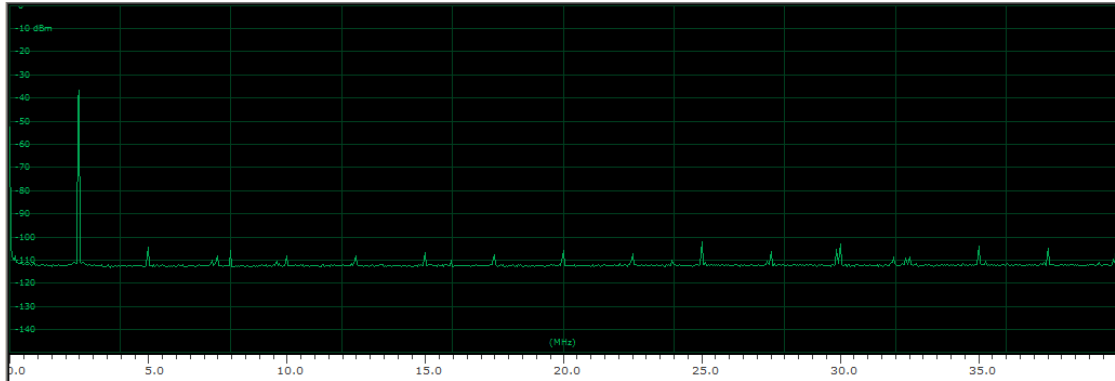


Figure 12.1 2.5MHz carrier

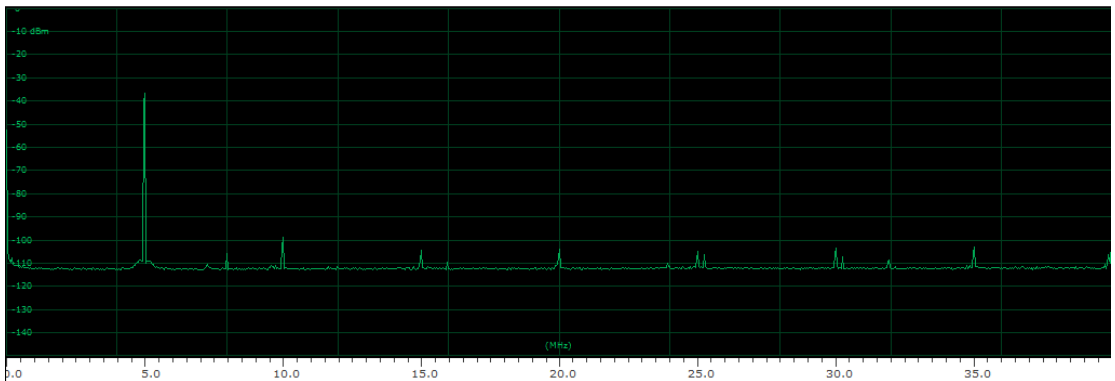


Figure 12.2 5MHz carrier

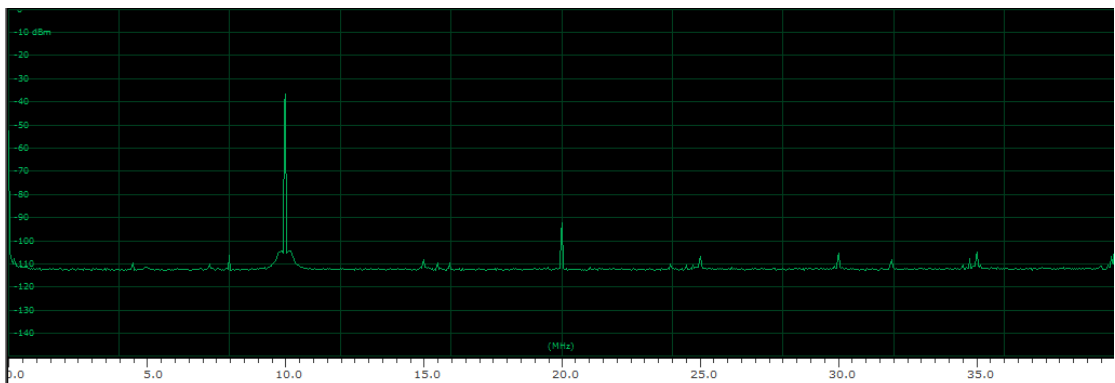


Figure 12.3 10MHz carrier

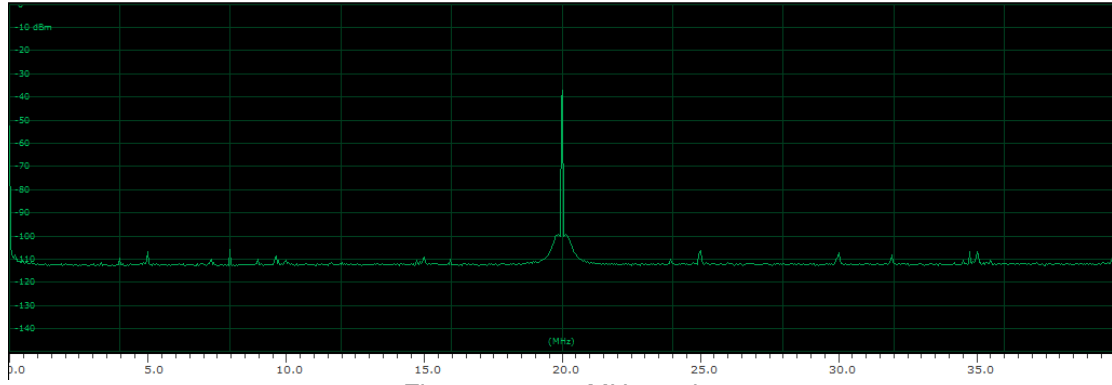


Figure 12.4 20MHz carrier

## 13. Mounting MR2 in an enclosure

MR2 is designed to be panel mounted, held in place by the retaining nuts of the two rotary switches. Extra M8 washers are provided so that the black bezel of the LCD display can be mounted behind a front panel without strain being put on the rotary switch connections. Alternatively a larger hole can be made to allow the LCD bezel to pass through the front panel. Two fixing holes to the rear of the main PCB need only be used when MR2 is likely to be subject to vibration e.g. in a portable setup, where the track holding the two PCBs together would come under strain.

If PTT and/or PTR switches are used, these can be mounted anywhere at the user's discretion as they are external to the PCB assembly.

Allow adequate space around the heatsink for cooling.

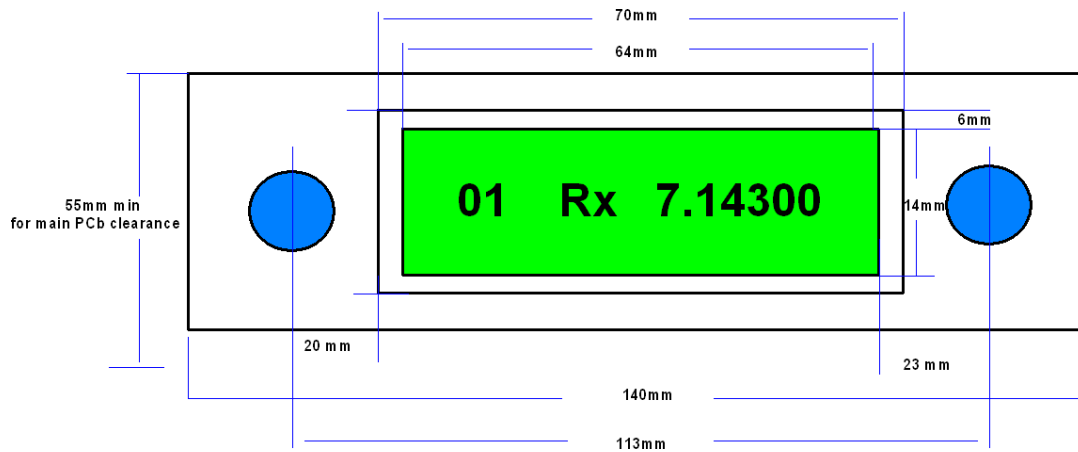


Figure 13.1 Guideline mounting dimensions to nearest mm. Spacings may vary with rotary switch alignment.

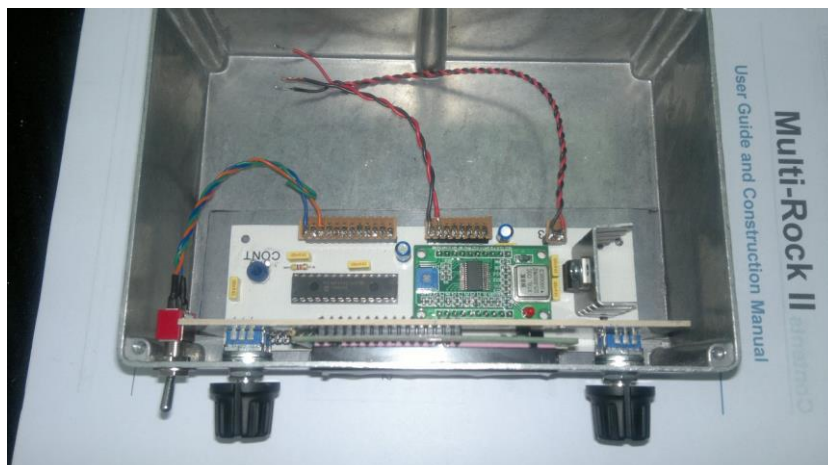


Figure 13.2 Mounting in diecast box (with impressive filing work on central pillar!)  
Box dims 170x120x55mm (photo by Tony M6ESR)

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