

# “ProgRock” Operating manual

**Pr1.00**

## 1. Introduction

This is the operating manual for the ProgRock synthesiser kit. It should be read together with the assembly instructions for the ProgRock kit and Si5351A Synth kit.

The configuration of the ProgRock kit is stored in EEPROM so that it is persisted when the power is switched off. The configuration is presented as a series of 32-bit “registers”.

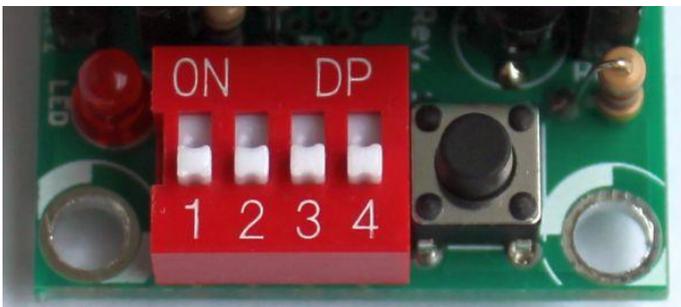
In summary: new register contents are entered one digit at a time, in Binary Coded Decimal (BCD), by setting up the digit on the 4-way DIP switch on the ProgRock board, then pressing the button to record the digit. Finally when the entire number has been entered, an “Enter” code is selected, which writes the new register value into EEPROM.

## 2. Programming

### 2.1 User Interface

The ProgRock frequencies list is programmed in Binary Coded Decimal, which is input on the 4-way DIP switch, and button. Each time you press the button briefly, the 3mm red LED will illuminate for a short time. This will give you positive feedback that your button press actually occurred and the number programmed on the DIP switch has been accepted by the microcontroller. You cannot program another digit until the red LED goes off. These basic controls (DIP switch, button, and LED) are your whole User Interface to ProgRock!

You will need to move the DIP switches with a screwdriver blade-tip – they are too small to set with your fingers!



The rest of this document assumes holding the ProgRock PCB for programming purposes in the orientation shown in these photographs.

**When programming ProgRock please remove the 1pps connection to the GPS, if you are using the GPS. It can interfere with the button debounce logic. The 1pps input should be grounded during programming of ProgRock.**

**The DIP switches should always be set to OFF at Power-up and when you have finished programming! ProgRock cannot test the Si5351A (see start-up procedure below), or do GPS calibration, when the DIP switch on the left (labelled “1” in the above photograph), is ON!**

## 2.2 Power-up procedures

On applying power to ProgRock, the red LED is illuminated for a short time.

The first operation undertaken by the ProgRock microcontroller on power up, is to check the connection to the Si5351A chip via the I2C bus. It then checks that it can read the 27MHz reference frequency (divided down) on the Clk2 output. If the I2C communication fails or the reference frequency cannot be read, then the red LED will remain illuminated. No further actions will be taken, and the switches, buttons, and bank select inputs are all ignored. If the microcontroller cannot operate the Si5351A chip, then nothing else can be done. You will need to investigate the issue and resolve it, before proceeding. The system must be reset by removing and re-applying power, to try again. **The DIP switches must be set to OFF at power-up and when using the GPS calibration option!**

You might wish to program the ProgRock frequency list without the Si5351A Synth module plugged in. For example if you have fitted SMA connectors to the Si5351A Synth module, then the 4-way DIP switch and button will be a bit hard to access with your fingers. When the Si5351A Synth module is not plugged in, the above error check will fail, and ProgRock will be stuck in the “error state” with the red LED illuminated.

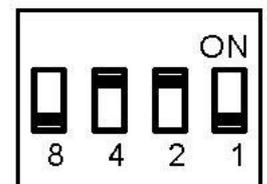
To avoid this problem, and allow you to program the frequency list without the Si5351A Synth module plugged in, you can BYPASS the error check. To bypass the error check, press the button (S2) while powering up ProgRock. When you have done this, the microcontroller will not attempt to communicate with the Si5351A chip again, until power is removed and re-applied.

Finally if all is well, you have programmed frequencies, and the Si5351A Synth module is all working properly – the microcontroller will set up the Si5351A chip to output the frequencies you chose.

## 2.3 A crash course in Binary Coded Decimal

You can skim over this section if you already know about Binary Coded Decimal.

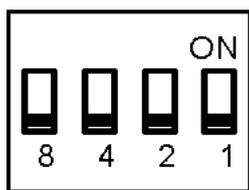
You have 4 switches in the 4-way DIP switch. Each switch can be either on or off. If it is on, the weight is 8, 4, 2 or 1 as indicated by the silk screen printed legend on the ProgRock PCB. Unfortunately the actual red switch is only labelled “1 2 3 4” and you will have to ignore that.



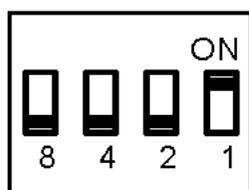
To make a number, you switch the required switches to “on” that add up to the required number.

For example, the switch configuration to (above-right) means “6”, because the “4” switch and the “2” switch are the only switches which are “on”, and  $4 + 2 = 6$ .

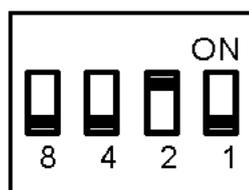
The table below shows the switch configurations for digits 0 to 9, for your reference.



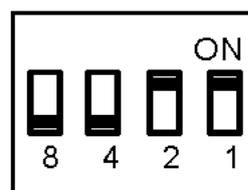
**0**



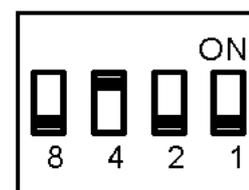
**1**



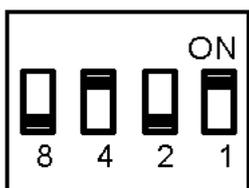
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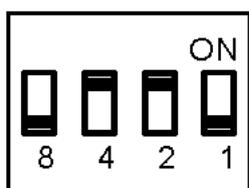
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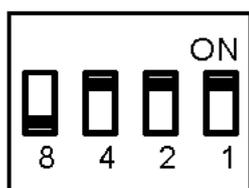
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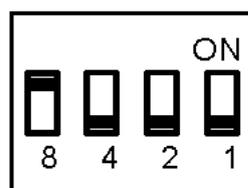
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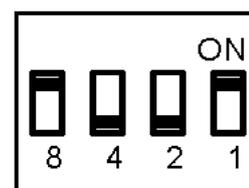
**6**



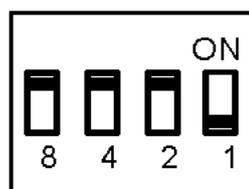
**7**



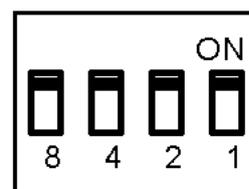
**8**



**9**



**Cancel**



**Enter**

Note the two special codes, which represent “Cancel” and “Enter”. (These are hexadecimal E and F respectively, if you want to consider them this way).

If you configure the switch for the “Cancel” command and press the button, then the current number entry is cancelled.

If you configure the switch for the “Enter” command and press the button, then the current number entry is actioned by the microcontroller – the selected frequency register is programmed with the entered number, stored in EEPROM, and programmed to the Si5351A chip if it is in the active frequency bank.

## 2.4 ProgRock register configuration

ProgRock contains 29 registers, referred to as Register ID 00 to 28. Each register stores a 32-bit number, which you can program from the switches and button. The table below lists the register mapping. To enter a frequency into a register, you must first specify the register, then the required frequency register. The digits are entered into ProgRock one digit at a time.

You set up a digit on the 4-way DIP switch then press the button briefly. The LED illuminates for a short time. Wait for the LED to extinguish. Then set up the next digit, press the button, and continue until you have completely entered all the digits needed. Finally set up the “Enter” code (all 4 switches “on”) and press the button again. This causes the entered number to be stored at the specified register location.

For example, suppose you wish to set the Clk 0 output in bank 0 to 1.5MHz. The sequence of digits you need to enter is:

0 4 1 5 0 0 0 0 0 Enter

Because “04” is the register location for Clk 0 Bank 0, and “1500000” is the desired frequency, in Hz. The total number of digit set-ups and button presses you will need to make, is 10, in this case.

**Make sure you give the button a decisive short (brief) press.** Make sure that you wait for the LED to go out, before pressing the button repeatedly! Button presses are ignored while the LED is lit. It’s a kind of very simple switch debounce, as well as an indication of the button press. This is particularly important to remember if you are entering a repeated sequence of digits, such as the zeroes in this example. You don’t need to alter the 4-way DIP switch settings after each digit entry. It is tempting to just keep hitting the button 5 times, to enter the 5 zeroes. But you **MUST WAIT** after each button press for the red LED to go out, first!

If you try to enter a register value into a register number higher than 28, your entry will simply be ignored.

If you enter an invalid frequency, which is to say, the frequency is outside the possible range of the Si5351A, then the frequency obtained at the output will not be what you want. The most likely output will be none at all.

At the end of this document is a template which you can print and use to help program the frequencies.

The following table shows the register mapping in ProgRock.

<u>Register</u>	<u>Purpose</u>
00	Reserved, do not use this register
01	EEPROM version ID. See SECTION 2.5
02	27MHz reference clock value. See SECTION 2.6
03	GPS correction threshold. See SECTION 2.7
04	Bank 0, Clk 0 – default value 10.000MHz
05	Bank 0, Clk 1
06	Bank 0, Clk 2
07	Bank 1, Clk 0
08	Bank 1, Clk 1
09	Bank 1, Clk 2
10	Bank 2, Clk 0
11	Bank 2, Clk 1
12	Bank 2, Clk 2
13	Bank 3, Clk 0
14	Bank 3, Clk 1
15	Bank 3, Clk 2
16	Bank 4, Clk 0
17	Bank 4, Clk 1
18	Bank 4, Clk 2
19	Bank 5, Clk 0
20	Bank 5, Clk 1
21	Bank 5, Clk 2
22	Bank 6, Clk 0
23	Bank 6, Clk 1
24	Bank 6, Clk 2
25	Bank 7, Clk 0
26	Bank 7, Clk 1
27	Bank 7, Clk 2
28	Calibration configuration register. See SECTION 2.8

## **2.5 Factory Reset using EEPROM Version, register 01**

Register 01 contains the EEPROM version ID. If you set this register to 0, and power down/up the system, then the EEPROM contents will be erased and returned to the factory default. The factory default sets all output frequency registers to 0, the Reference clock register 02 to “27,004,000”, GPS Correction Threshold register 03 to “5”, and the Calibration configuration register 28 to its default factory value.

If you mess everything up accidentally, you can always force this factory reset using this method, to return your microcontroller to the default factory-installed state. Key the digit sequence

0 1 0 Enter

Then cycle the power. This will enter value 0 into register 01, and when the system is rebooted, the factory reset will occur.

## **2.6 27MHz reference clock value, register 02**

The 27MHz crystal used in the Si5351A Synth Module crystal does not oscillate at exactly 27.000000MHz. It varies from one crystal to the next, but in general the frequency will be 3-5 kHz too high, e.g. 27,004,000Hz. **This is why the default reference frequency in register 02 is 27,004,000.**

If you are using the OCXO/Si5351A Synth module kit, the frequency of this oscillator tends to be about 2kHz too low, e.g. 26,998,000Hz.

If you are using GPS discipline by applying a 1pps signal from a GPS receiver, the kit will self-calibrate in less than half a minute. This will update register 02 in EEPROM. Next time ProgRock is powered up the calibrated value will be used. Thereafter, the GPS makes corrections to the reference oscillator value in register 02 to compensate for any measured temperature-induced drift in the crystal frequency.

The reference oscillator value is used in the calculation of the Si5351A registers. So it is important that it is accurate, if you need the output frequencies of ProgRock to be accurate.

If you are not using a GPS, you can manually calibrate ProgRock by entering the correct value into register 02.

It is possible that you have an accurate means to measure the 27MHz reference oscillator frequency itself by probing the correct point on the Si5351A module. However most kit builders will not have the necessary equipment, and such a measurement is not easy to make without itself risking disturbing the frequency.

The easiest method is to set the output frequency to something convenient such as 13.500000 MHz, and measure it. Measurement can either be by using an accurately calibrated frequency counter, or by setting up an accurately calibrated receiver with Argo and monitoring the output signal frequency that way.

Once you have measured the actual output frequency, you can calculate the required correction to the 27MHz reference frequency and enter it in the "Ref. Frq." configuration setting. For example, suppose you set the output frequency to 10.000000 MHz but you actually measure 10.000075. Your output frequency is 75 Hz too high. Assuming the default reference frequency (27,004,000), you should change this to  $27,004,000 * 10.000075 / 10.000000$ . So enter the new value 27,004,203 in the "Ref. Frq." setting. Be sure to write down somewhere the value you enter. If you need to re-calibrate in future, you will need to know what value you entered! Otherwise it will be necessary to do a "factory reset" (see section 2.5).

## **2.7 GPS correction threshold, register 03**

This register has a default value of 5Hz. But you can set it to anything you like. It controls how and when the microcontroller makes updates to the Si5351A output frequencies. For example, at the default setting of 5Hz, the microcontroller will only correct the Si5351A output frequencies when the 27MHz reference value has changed by more than the 5Hz threshold. The threshold is always referred to the 27MHz reference frequency, not the output frequencies.

If you set the register to have a value of 0, then the microcontroller will adjust the Si5351A output frequencies once per second, every second, depending on whether it thinks the 27MHz frequency has drifted upwards or downwards. This continuous change in output frequency may not be

desirable. It is more practical to have small jumps in output frequencies, less often – i.e. only when the reference oscillator has changed by more than a threshold.

The QRP Labs website has some notes on how to obtain excellent frequency stability with the Si5351A Synth module – please refer to the resources section below.

## **2.8 Calibration configuration register, register 28**

The value in this register is several smaller numbers, bit-packed into the available 32-bit number. These parameters control the way the GPS calibration and drift correction processes are done.

In the future I may describe these parameters and their effect. It may be possible to further optimise the way the calibration and drift correction processes are carried out.

For the time being, just leave this register alone!

## **2.9 Default frequency output of ProgRock**

At switch-on after factory reset, the Clk0 output is set up to default 10.000MHz. Clk1 and Clk2 are switched off. The reference frequency is set by default to 27.004MHz which should be approximately correct +/- 1kHz. Further calibration will be needed for your crystal as described in section 2.6 above.

# **3. Template for programming ProgRock**

On the following page is a template for programming registers in ProgRock. You could print it out and use it to assist with programming the registers for the frequencies you need.

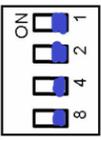
On the top row is an example. Programming the Bank 0, Clk 0 output to 17.003MHz.

The first two digits are the register number. The register number for the Bank 0, Clk 0 frequency is 04 (refer to the table in section 2.4).

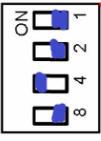
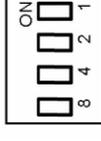
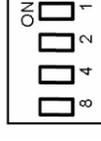
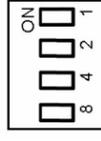
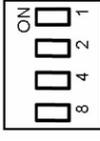
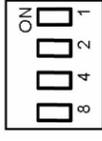
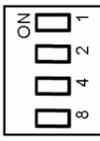
The next 8 digits are the frequency, specified in Hz: 17003000.

Finally, the “Enter” code is input (all 4 switches are “on”).

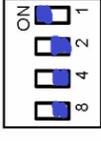
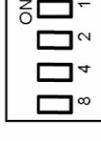
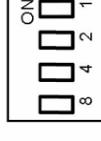
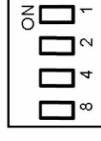
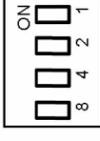
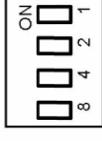
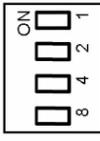
The ProgRock operator can write out the numbers required, as done here on the top line. Then write the switch configurations for each digit. Refer to the Binary Coded Decimal table in section 2.3 if necessary. For each digit, the operator should set the 4 switches of S1 as needed, then press the button briefly (S2). It will help to write a tick next to the digits which have been input, to avoid forgetting where you are, in the number.



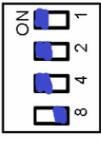
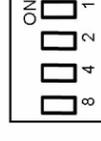
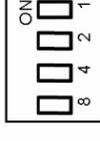
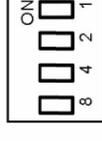
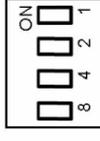
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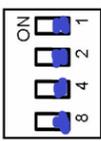
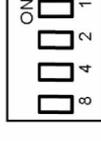
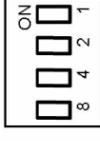
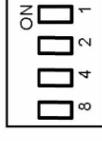
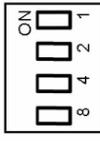
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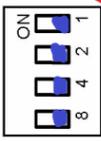
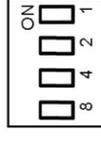
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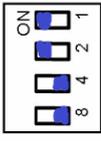
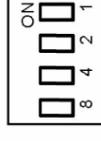
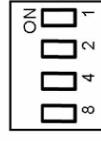
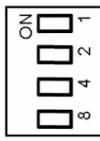
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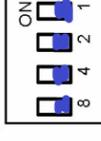
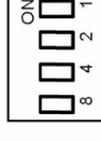
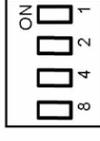
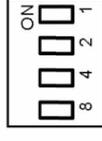
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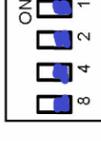
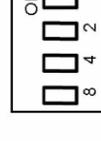
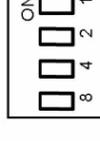
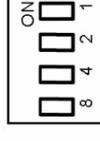
0 ✓



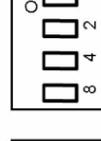
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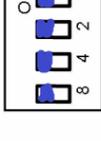
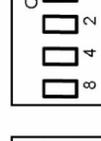
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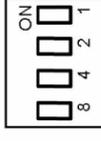
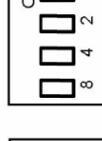
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## **4. Resources**

- Please see the kit pages at <http://qrp-labs.com/progrock> for information on latest updates and issues.
- Notes on getting excellent frequency stability from the Si5351A Synth kit:  
<http://qrp-labs.com/synth/freqstab.html>

## **5. Version History**

- 1 20-Apr-2016
  - First version
- 2 27-May-2016
  - Added Alan G8LCO description of the noise filter circuit
  - Added clarification that capacitor Cx is neither required nor supplied, and should not be fitted
  - Clarified orientation of the 4-way DIP switch; the silkscreen does not match the component print
  - Corrected several typos, missing words, incorrect words etc.
- 3 24-Jun-2016
  - Added note that very short 1pps pulse widths (e.g. 10us) do not work with this kit.
- 4 25-Jun-2016
  - Re-write of the last paragraph of section 2.6 to make the calibration procedure more clear
- 5 27-Jun-2016
  - Section 2.6: emphasise the importance of writing down the reference clock value, in case it is necessary to re-calibrate some time in future
- 6 11-Aug-2016
  - Assembly manual, section 4.3.3: Add section about not installing noise filter components when you use the OCXO
- 7 04-Oct-2016

- Added clarification that the button press should be a short one.

8 12-Jan-2017

- Corrected pin numbers of Si5351A Synth module in the circuit diagram

9 22-Feb-2017

- Separated the operating and assembly manuals