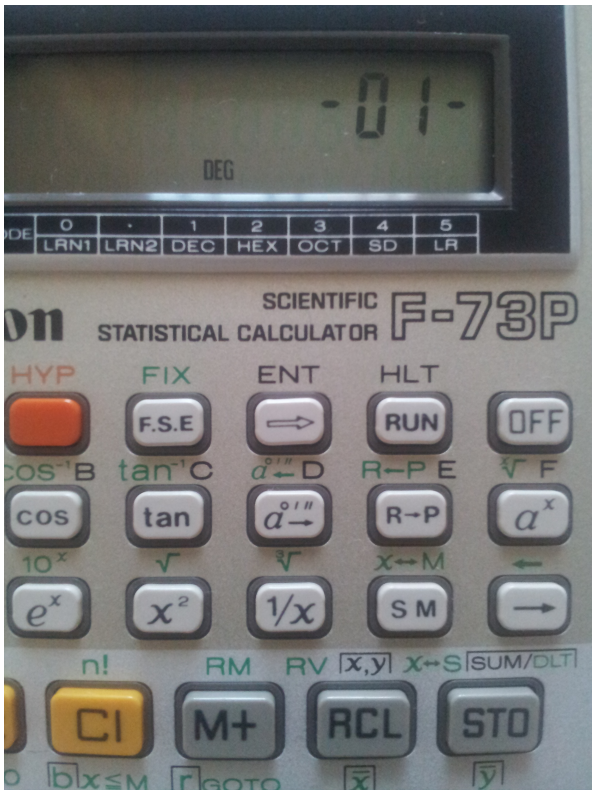
MC-II

A custom electronic calculator and embedded systems development platform



By Danny Milutinovic
Melbourne, Australia
November 9, 2018

Contents

Preface

This book is about the MC-II, a programmable, reverse polish notation custom calculator and embedded systems development platform. Part I describes how to build the MC-II using a low cost development board, graphical liquid crystal display and matrix keypad. Part II focuses on the algorithms used to implement the mathematical functions, using diagrams and flowcharts to help explain each. Part III considers some of the MC-II's advanced mathematical applications and Part IV discusses how it can be used as a development platform for embedded systems projects, as well as how to build a hand held version of the MC-II.

Each chapter builds on the material covered in the previous one and the source code is developed in stages, making it easier to follow. The programs referred to in this book are available at `https://github.com/DanielMilutinovic/MC-II`.

Part I

Getting Started

Chapter 1

Hardware and Software Development Tools

The following is a list of the hardware components required to build the MC-II. They can be purchased from electronic components distributors such as Mouser, Digi-Key and element14:

1. The DEVKIT-S12XE development board by NXP (Figure 1.1). It features the 9S12XEP100 microcontroller and is provided with a USB cable to connect it to a computer.

Figure 1.1: DEVKIT-S12XE

2. An ST7565 128x64 graphical liquid crystal display (GLCD) (Figure 1.2). The model shown is available from Core Electronics and Adafruit. Note that eleven 0.1" (2.54mm) male header pins must be soldered to the board if using this particular model; however it is simple through-hole soldering.

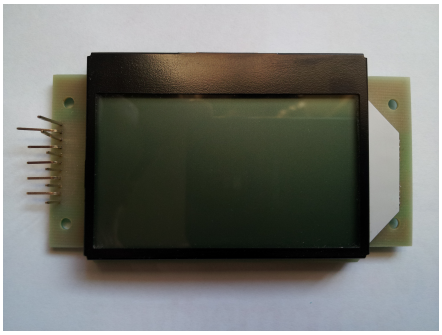


Figure 1.2: ST7565 GLCD

3. 0.1” (2.54mm) male-female jumper cables (Figure 1.3) to interface the DEVKIT-S12XE development board to the ST7565 GLCD and matrix keypad.

Figure 1.3: 0.1” male-female jumper cables

4. A matrix keypad. Standard 4x4 matrix keypads (Figure 1.4) are convenient but an 8x6 keypad (Figure 1.5) allows more functions to be added easily. Interfacing to each type of keypad is covered in Chapter 4. The 8x6 matrix keypad shown was designed by Dirk Heisswolf and manufactured by Seeed Studio. I have several 8x6 matrix keypad PCB’s left (contact me at `daniel_milutinovic@yahoo.com.au`) and the files are available at `https://github.com/DanielMilutinovic/MC-II` if you would like to order them (Seeed Studio has a minimum order of 10 PCB’s). The PCB’s can accommodate up to 64 keys (8 rows, 8 columns) but we will only use 6 columns. If making the 8x6 matrix keypad you will need to solder 0.1” (2.54mm) male header pins and 44 push buttons to the PCB. I used Omron 6x6 tactile switches, part no. B3F-1052, which work well.

Figure 1.4: 4x4 matrix keypad by EOZ, with some key labels attached

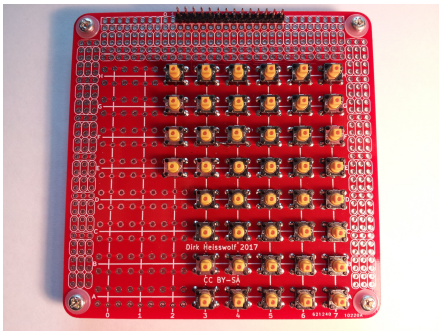


Figure 1.5: Custom 8x6 matrix keypad

The 9S12XEP100 microcontroller on the DEVKIT-S12XE development board is programmed using the CodeWarrior development software by NXP. CodeWarrior may be downloaded free of charge and there are no code size limitations for assembly language files. It features a debugger and a convenient simulation mode, which enables code to be tested without downloading it to the actual microcontroller, thereby saving the Flash memory on the device from repeated writes.