MV0198 User Manual

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Revision History

Revision	Description	Author
1.4	Updated to highlight the differences when MV0198 is used with MV0182 revisions containing MA2150 Silicon. Specifically Table 4, Table 5 have been updated and section 5 has been added Corrected documentation references to include PCB Revision R2	David Nicholls
1.3	Added section 4.1 which highlights the performance limitations of the current measurement system.	David Nicholls
1.2	Corrected bug in Table 5 (VDD_MIPI nominal voltage should be 1.8V rather than 0.9V)	David Nicholls
1.1	Updated based on first review feedback	David Nicholls
1.0	First Internal Draft for review	David Nicholls

1 Introduction

This document is the System Reference Manual for the MV0198 power measurement daughter-card. It provides a description of how the board functions and discusses the performance and capability of the system.

This revision of the System Reference Manual specifically refers only to the MV0198-R1 and MV0198-R2 PCB revisions.

As this board is a daughter-card for the MV0182 Evaluation Board, this document should be read in conjunction with the MV0182 reference manual.

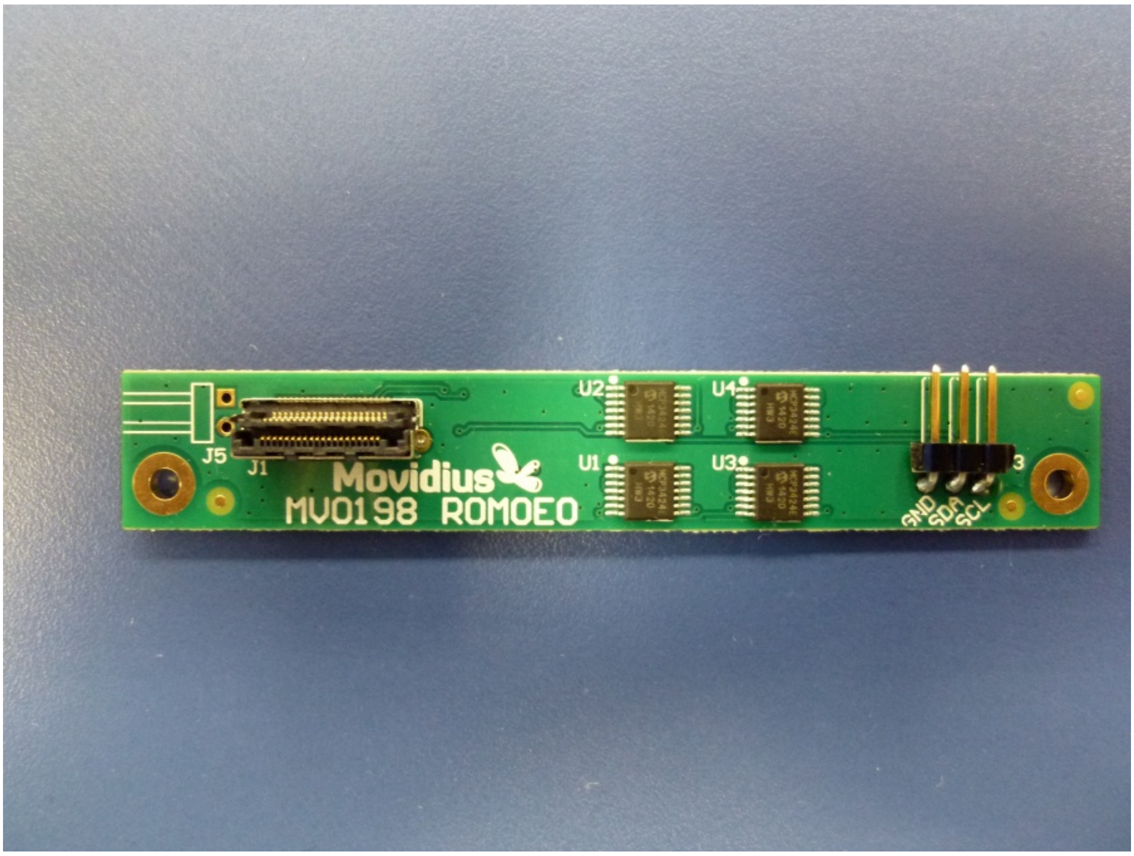

Figure 1: The MV0198 Daughtercard

2 MV0198 Board Specification

This section covers the specifications of the MV0198 board and provides a high level description of the key features of the board.

2.1 Key Top-Level Features

	Feature	
ADC	Microchip MCP3424 Quad Channel 18 bit Sigma Delta ADC (x 4)	
ADC Performance	12 Bit	240 samples per second
	14 Bit	60 samples per second
	16 Bit	15 samples per second
	18 Bit	3.75 samples per second
ADC FSD	2.048V (MCP3424 has an internal voltage reference)	
Max Burden Voltage	10mV	
Interface	I2C Interface to MV0182 Motherboard (I2C2 bus)	
Current Rails	13 Current Measurement Rails	
Voltage Rails	2 Voltage Measurement Rails (VDDCV_V, VDD_MIPI_V)	
Debug	3 pin I2C debug header for Aardvark monitor connection	
Optional External Interface	It is possible to disconnect the MV0182 I2C interface by inserting jumper J5. When this jumper is in place, it is possible to directly query the ADCs using an external Aardvark interface	
Power	Powered from 5V supply fed by Motherboard interface J1	

Table 1: Key Top Level Features

2.2 Movidius PCB Revision System

This section is intended to allow the user to correctly identify the MV0198 board revision and serial number. The Movidius board revision system is comprised of three components as follows:

Field	Description
RX	PCB Revision Number. Directly relates to the Printed Circuit Board. Any design change to the PCB will result in an increment of this field
MX	Mechanical Revision Number. This relates to a component change which changes the mechanical characteristics of the board. Example: Changing a pin header to a shrouded header would increment this field.
EX	Electrical Revision Number. This reflects any electrical modification to the design which does not involve a PCB change. Examples: Changing resistor values, or green wire modification of an existing design.

Table 2: PCB Revision Numbering System

All designs start at **R0M0E0** and increment fields as necessary from there.

The PCB silkscreen will contain the base revision for the PCB and supplemental labels are used thereafter to increase the MX or EX fields.

2.3 Reference Documentation

Document	Description
MV0182 Schematics	Part of the design release package of MV0182
MV0182 User Manual	Part of the design release package of MV0182
MV0198 Schematics	Part of the design release package of MV0198
TI INA210 Datasheet	Datasheet for TI INA210 Voltage Amplifier
Microchip MCP3424 Datasheet	Datasheet for MCP3424 ADC

Table 3: Reference Documentation

3 Theory of Operation

This section describes the method by which this system is able to monitor the current consumption of the Myriad processor on the MV0182 development board.

The current measurement function is split between the motherboard (MV0182) and its daughtercard (MV0198). This facilitates the design of a range of different possible power measurement daughtercards. For example it is possible to design alternative daughtercards which might support higher sample rate ADCs or alternative host interfaces such as USB.

3.1 MV0182 Power Measurement Features

The MV0182 motherboard facilitates current measurement by using shunt resistors on each of the supply rails to the Myriad 2 processor. Each shunt resistor is dedicated to a specific power rail of the Myriad 2 processor and as such only measures the current directly used by the processor on that rail.

To avoid the problems associated with burden voltage a closely coupled differential amplifier is used to amplify the voltage across the shut resistor. This design allows the system to make use of very tiny shunt resistances and thereby avoid any issues around excessive burden voltage.

By design the system aims to never exceed a burden voltage of 10mV under maximum current conditions.

The differential amplifier used on the MV0182 board is the INA210 which multiplies the current across the shunt resistance by a factor of 200. Each rail to be measured has a dedicated INA210 voltage amplifier associated with it. It is the output of these amplifiers that is fed to the MV0198 daughtercard.

It is the responsibility of the MV0198 daughtercard to convert this signal to a digital value using ADCs.

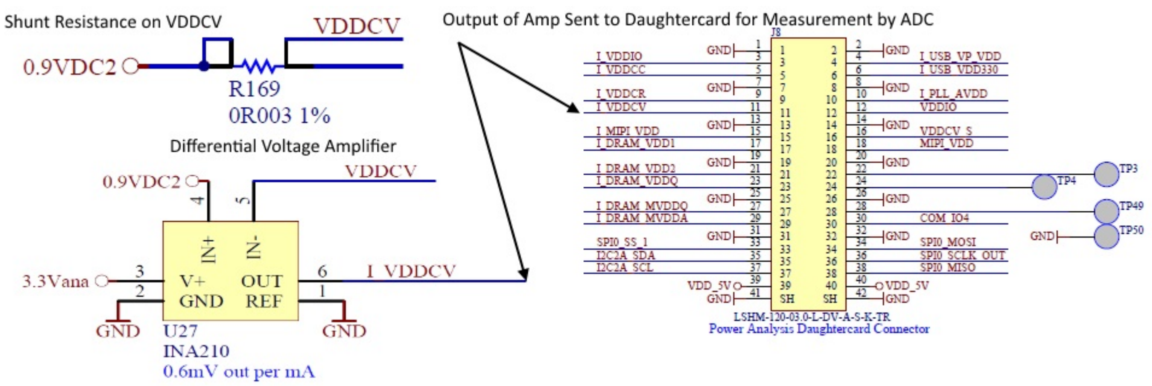

Figure 2: MV0182 Schematic Reference

The schematic snippet above illustrates the power measurement functionality implemented on the MV0182 by using the VDDCV rail as an example.

VDDCV uses a 3 milli-Ohm shunt resistor to measure the rail current.

The voltage across this resistor is fed to the INA210 differential amplifier which multiplies it by 200.

The output of the amplifier (I_VDDCV) is fed to J8 the daughtercard connector for the MV0198 ADC board.

For example:

If there is a load of 500mA on VDDCV;

*The voltage across the resistor will be 0.5A * 0.003R => 1.5mV*

*The output of the INA210 will be 1.5mV * 200 => 300mV*

As such the 500mA current results in an output to the ADC of 300mV.

This relationship can be summarized by saying that the I_VDDCV output of the MV0182 will present 0.6mV for every mA of current load on the VDDCV rail. This relationship is noted in text on the schematic for each rail for convenience.

Depending on the choice of shunt resistor each rail will have a similar current to voltage relationship and this is the only parameter that the current measurement software needs to know for each MV0182 rail.

Note: There are 13 power rails to the MV0182 processor. As there was spare capacity on the connector two additional signals are provided on the interface. These signals are used to allow the MV0198 daughtercard to measure the voltage on VDDCV and VDD_MIPI. The choice of which rails to monitor was quite arbitrary, but having VDDCV voltage is useful as this allows for power estimation by measuring both the voltage and current of this rail.

3.2 MV0198 Power Measurement Features

The function of the MV0198 daughtercard is simply to provide analog to digital conversion of the current sense voltages presented by the MV0182 motherboard.

In total there are 13 power rails to the Myriad 2 processor and a further 2 Voltage rails making 15 rails to be monitored in total.

This is achieved using 4 instances of the Microchip MCP3424 Quad Channel 18-bit Sigma Delta ADC.

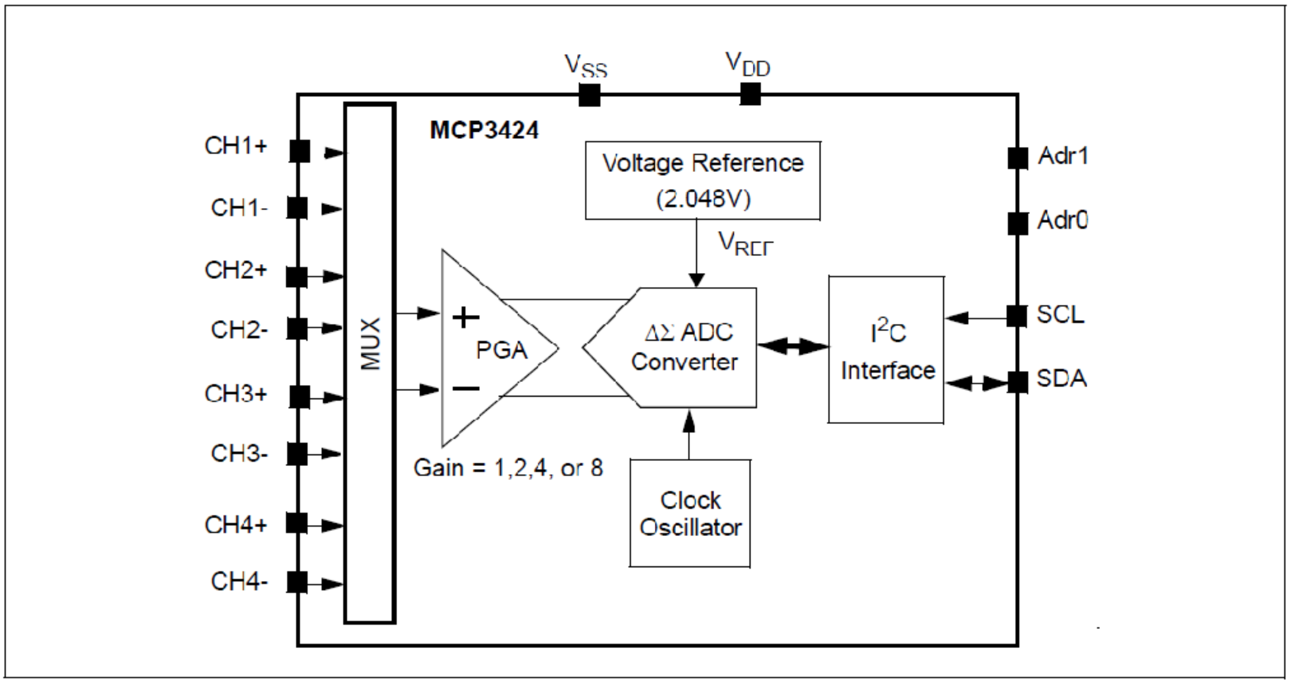

Figure 3: MCP3424 Functional Block Diagram

The MCP3424 has an internal 2.048V calibrate reference which is used as the ADC reference voltage. This represents the full scale deflection of the ADC and is the maximum voltage that can be measured.

The MCP3424 is configured by I2C and has the following configuration options:

- **Channel Selection 1, 2, 3, 4**
- **GAIN: x1, x2, x4, x8**
- **Resolution: 12, 14, 16, 18 Bits**
- **Operation Mode: Oneshot or Continuous**

Please see the MCP3424 datasheet for further details on programming the ADC.

3.2.1 I2C Address Map and Channel Map of the MV0198 ADC Devices

ADC ID	7-Bit I2C Addr	Chan #	Rail Name	Type	mV per mA
MCP3424_A	0x6E	1	VDDCR	CURRENT	20
		2	VDDCV	CURRENT	0.6
		3	DRAM_VDD1	CURRENT	20
		4	MIPI_VDD	CURRENT	20
MCP3424_B	0x6D	1	DRAM_VDD2	CURRENT	10
		2	DRAM_VDDQ	CURRENT	20
		3	DRAM_MVDDQ	CURRENT	2
		4	DRAM_MVDDA	CURRENT	20
MCP3424_C	0x6A	1	USB_VDD330	CURRENT	20
		2	USB_VP_VDD	CURRENT	20
		3	VDDIO	CURRENT	10
		4[1]	VDDCC (MA2100)	CURRENT	2
			VDDIO_B (MA2150)	CURRENT	20
MCP3424_D	0x6B	1	RESERVED	RESERVED	N/A
		2	PLL_AVDD	CURRENT	20
		3	VDDCV	VOLTAGE	Direct Feed
		4	MIPI_VDD	VOLTAGE	Direct Feed

Table 4: MV0198 I2C and Channel Descriptions

1 MCP3424_C channel 4 has a dual role. On boards which are populated with MA2100 this represents the current on the VDDCC rail, however on MA2150, this power rail no longer exists, so the channel is instead used to reflect the current on the new MA2150 VDDIO_B rail.

4 MV0198 Resolutions and Limitations

The following table provides a breakdown of the theoretical[2] max performance of the MV0198 power measurement system. Specifically it aims to illustrate two key characteristics of the board, the max measurable current per rail and the theoretical maximum resolution defined as the current measurable per LSB of the ADC.

The max measurable current is simply a function of the selected shunt resistor. Our design goal is to limit burden voltage to 10mV; when using an INA210 this equates to 2.0V at ADC which is less than its max of 2.048V. As such this is the limit that sets our I_max parameter.

Example:

VDDCC has a shunt resistor of 0.01 Ohms

Thus:

I_MAX = 0.010V / 0.01 R => 1A

Similarly a measure of the maximum potential performance is obtained by looking at the significance of the LSB of the ADC for each rail.

MV0182 Limitations					MV0198 ADC LSB µA			
RAIL	**V_nom**	**Ohms**	**I_max (mA)**	**Mv/Ma**	**12 Bit**	**14 Bit**	**16 Bit**	**18 Bit**
VDDCV	0.9	0.003	3333.3	0.6	1666.7	416.7	104.2	26.0
VDDCC[3]	0.9	0.01	1000.0	2.0	500.0	125.0	31.3	7.8
VDDIO_B[4]	1.8	0.1	100.0	20.0	50.0	12.5	3.1	0.8
VDDCR	0.9	0.1	100.0	20.0	50.0	12.5	3.1	0.8
VDDIO	1.8	0.05	200.0	10.0	100.0	25.0	6.3	1.6
MIPI_VDD	1.8	0.1	100.0	20.0	50.0	12.5	3.1	0.8
PLL_AVDD	1.8	0.1	100.0	20.0	50.0	12.5	3.1	0.8
DRAM_MVDDQ	1.2	0.01	1000.0	2.0	500.0	125.0	31.3	7.8
DRAM_MVDDA	1.8	0.1	100.0	20.0	50.0	12.5	3.1	0.8
DRAM_VDD1	1.8	0.1	100.0	20.0	50.0	12.5	3.1	0.8
DRAM_VDD2	1.2	0.05	200.0	10.0	100.0	25.0	6.3	1.6
DRAM_VDDQ	1.2	0.1	100.0	20.0	50.0	12.5	3.1	0.8
USB_VDD330	3.3	0.1	100.0	20.0	50.0	12.5	3.1	0.8
USB_VP_VDD	0.9	0.1	100.0	20.0	50.0	12.5	3.1	0.8

2 In many cases this theoretical maximum is below the noise floor of the system and as such this value is a limit rather than a specification feature.

3 VDDCC rail only exists when measuring the power of MV0182 boards containing MA2100 silicon

4 VDDIO_B rail only exists when measuring the power of MV0182 boards containing MA2150 silicon

MV0182 Limitations					MV0198 ADC LSB µA			
RAIL	V_nom	Ohms	I_max (mA)	Mv/Ma	12 Bit	14 Bit	16 Bit	18 Bit
VDDCV_V[5]	0.9	N/A	N/A	N/A	1000.0	250.0	62.5	15.6
MIPI_VDD_V	1.8	N/A	N/A	N/A	1000.0	250.0	62.5	15.6

Table 5: MV0198 Max Current and Resolution

4.1 MV0198 Current Measurement Accuracy

While the MV0198 power measurement daughtercard is a very useful tool for quickly gaining a picture of the power profile of your application, it is not a substitute for high end lab equipment. As such it is important to highlight that, while the details in Table 5 may suggest microAmp level precision, this is merely a reflection of the resolution of the ADC rather than an indication that the power measurement system has an overall accuracy to that level.

There are many factors which limit the overall performance of the system, such as the opamp offset error, output swing limitations, device noise and overall system noise. Previous versions of this document only referenced this limitation as a footnote and may not have given it sufficient prominence. In particular it may not have been obvious that the system is particularly optimized for high current measurement and doesn't have sufficient accuracy to be reliable for low current measurement.

The following table details the expected performance characteristics of the overall combination of MV0182 & MV0198

Current Range	Expected Performance
> 10mA	+/- 500µA
< 10mA	Not suitable for low current measurement. Recommended alternative is to use a high end digital multimeter to measure the voltage across the shunt resistor on MV0182

In many cases individual systems may have performance characteristics exceeding the values specified above, and as such users may decide to assume a higher level of precision than the listed spec. In these cases, it is the responsibility of the user to cross check the results using high end equipment, to ensure they are reliable

5 VDDCV_V, MIPI_VDD_V rails are voltage rails so the presented values are in units of µV not µA

5 MV0198 Differences between usage for MA2100 and MA2150 Silicon

The MV0198 power measurement daughtercard is a general purpose power measurement solution. As of MV0182 PCB revision R4 the MV0182 board may contain either MA2100 or MA2150 silicon.

From a power measurement perspective the key change here relates to the fact the MA2150 no longer has a power rail VDDCC but it has an additional I/O power rail called VDDIO_B.

In order to provide maximum power measurement capability the MV0182 boards are configured to use the voltage on J1 pin 5 to represent either the current of VDDCC on boards with MA2100 or VDDIO_B on boards with MA2150.

Please see updated Table 4: MV0198 I2C and Channel Descriptions and Table 5: MV0198 Max Current and Resolution for details of the specifications in relation to this.

6 Known Limitations MV0198

This section details the known issues with the MV0198 design. It documents the severity of each issue any known workarounds if applicable.

The scope of this document is limited to the hardware features of this board. It makes no reference to any software or driver limitations, as any such issues are documented as part of the general MDK software deliverable package.

6.1 Design Errata

6.1.1 MV0198-R1 1

Name	Conflicting I2C Addresses for U2, U4
Severity	Medium
Description	In the released MV0198-R1 schematic, U2, U4 have I2C 7-Bit addresses of 0x68 and 0x69 respectively. These values conflict with other devices on the MV0182-R3 PCB revision and as such they need to be modified.
Limitation	No limitation as of electrical revision R1M0E1 PCB revision R2M0E0 and later include this correction in the base design.
Solution	This issue is fully resolved as of PCB electrical revision R1M0E1. For U2 Address changed to 0x6E: - Ra3 and Ra4 not Mounted - Ra1 and Ra2 Mounted For U4 Address changed to 0x6D: - Rb2, Rb3 and Rb4 Not Mounted - Rb1 Mounted

NOTE: The I2C addresses presented in this document relate to the corrected version of this design (R1M0E1)

6.1.2 MV0198-R1 2

Name	J3 and J5 Headers not mounted by default
Severity	Low
Description	In the released MV0198-R1 design the pin headers for J3 and J5 were not mounted by default. This removes some of the debug capability of the board.
Limitation	No limitation as of electrical revision R1M0E1 PCB revision R2M0E0 and later include this correction in the base design.
Solution	This issue is fully resolved as of PCB electrical revision R1M0E1. J3 and J5 have header pins mounted as of this electrical revision.