**Microcontroller-on-Module**

**STM32 Edition v1 (MoM-S1)**

Board Architecture Specification v0.4

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Contents

[List of Figures and Tables 3](#_Toc523928889)

[Revision History 4](#_Toc523928890)

[Overview 5](#_Toc523928891)

[Licensing 5](#_Toc523928892)

[Functional Description 7](#_Toc523928893)

[Modularity 7](#_Toc523928894)

[Daughterboard 7](#_Toc523928895)

[Power Distribution 7](#_Toc523928896)

[Reconfigurable IO 8](#_Toc523928897)

[Detailed Implementation 9](#_Toc523928898)

[Mechanical 9](#_Toc523928899)

[Form Factor 9](#_Toc523928900)

[Height and Clearance 9](#_Toc523928901)

[Mounting Holes 10](#_Toc523928902)

[Enclosure 10](#_Toc523928903)

[Environmental 10](#_Toc523928904)

[Temperature 10](#_Toc523928905)

[Shock and Vibration 10](#_Toc523928906)

[Compliance 10](#_Toc523928907)

[Reliability 10](#_Toc523928908)

[Electromagnetic Interference (EMI) 10](#_Toc523928909)

[Power 10](#_Toc523928910)

[Voltage Tree 10](#_Toc523928911)

[Rating 11](#_Toc523928912)

[Enables 11](#_Toc523928913)

[Externally Powering Rails 11](#_Toc523928914)

[Protection Circuitry 12](#_Toc523928915)

[Sequencing 12](#_Toc523928916)

[Processor 12](#_Toc523928917)

[Configuration 12](#_Toc523928918)

[Clocking 13](#_Toc523928919)

[Interfaces 13](#_Toc523928920)

[USB 13](#_Toc523928921)

[User IO 13](#_Toc523928922)

[LEDs 13](#_Toc523928923)

[Connectors 14](#_Toc523928924)

[Interface Connector 14](#_Toc523928925)

[Filtering and ESD Protection 14](#_Toc523928926)

[Hardware Version 14](#_Toc523928927)

[Debug 15](#_Toc523928928)

[Test Points 16](#_Toc523928929)

[Bring-up and Testing Procedures 17](#_Toc523928930)

[Future Revisions 18](#_Toc523928931)

[Appendix A: Glossary of Terms 19](#_Toc523928932)

# List of Figures and Tables

[Figure 1 - MoM-S1 Architecture Drawing 5](#_Toc523928933)

[Figure 2 - MoM-S1 Mechanical Dimensions 9](#_Toc523928934)

[Figure 3 - MoM-S1 vs Arduino Footprint 9](#_Toc523928935)

[Figure 4 - MoM-S1 Voltage Tree 11](#_Toc523928936)

[Figure 5 - ST-LINK/V2 and Tag-Connect Hardware 13](#_Toc523928937)

[Table 1 - Voltage Rails on MoM-S1 7](#_Toc523928938)

[Table 2 - Maximum Component Height 9](#_Toc523928939)

[Table 3 - Voltage Regulators 11](#_Toc523928940)

[Table 4 - MCU Specification 12](#_Toc523928941)

[Table 5 - Interface Connector Pinout and Key 14](#_Toc523928942)

[Table 6 - Test Points 16](#_Toc523928943)

[Table 7 - Glossary of Terms 19](#_Toc523928944)

# Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Version | Date | Author | Description |
| v0.0 | 07/27/18 | MS | Initial Version |
| v0.1 | 08/03/18 | MS | Updated Detailed Implementation and Test Points |
| v0.2 | 08/09/18 | MS | Added Overview, Functional Description and Glossary of Terms  Added HW\_VER to Detailed Implementation  Added captions and List of Figures and Tables |
| v0.3 | 08/24/18 | MS | Updated max temperature to 70C  Updated Power section for Enables, Externally Powering Rails and Protection Circuitry  Updated Test Points with voltage regulator enables |
| v0.4 | 09/05/18 | MS | Updated Figure 1 to be more descriptive  Scrubbed Glossary of Terms and minor spelling corrections |

# Overview

The Microcontroller-on-Module STM32 Edition v1 (also known as MoM-S1) is the first in a series of prototype-ready modules focused on making a cheap, modular, open-source solution that can be used to quickly develop and build a custom hardware solution for your product. An overall architecture diagram is shown in Figure 1 below:



Figure - MoM-S1 Architecture Drawing

As a hardware prototyping engineer, I found myself designing several systems with the same major components over and over, namely:

* Power distribution
* Serial interfaces
* Microcontroller (MCU)

Over the past decade, several wonderful open-source hardware platforms have become wildly popular on the market (Arduino, Beaglebone, etc…). However, I found that many times these systems either were physically too large to use in a professional prototype, lacked the necessary horsepower or were cost prohibitive. The MoM family of modules is focused on making something smaller than an Arduino Nano that is faster, has more memory and more IO while remaining relatively cheap.

The MoM modules are designed for advanced hobbyists and professionals who want to build a professional prototype or even production circuit board. As MoM modules cover all shapes and sizes of microcontrollers (ATSAM, STM32, MSP430…) they will not be integrated into a unified IDE such as the Arduino IDE. Rather, example firmware projects will be provide using either the manufacturer’s IDE or raw source code.

MoM modules can be used with their associated daughterboard as a development kit for various architectures or can be integrated into a user’s custom PCB solution for their prototype or product.

## Licensing

The MoM-S1 module, the daughterboard and all associated hardware, firmware and software associated with the MoM project shall be released under the TBD

This means that TBD.

All hardware designs shall be done in Altium’s Circuit Maker design tool and files shall be released on the MoM Github repository (<https://github.com/msx-consulting/mom>).

Modules will also be made available for purchase through an online site for those wishing to buy the hardware directly from us.

# Functional Description

The following section covers the overall functionality available on the MoM-S1 module.

## Modularity

The MoM-S1 as a module is by its nature highly flexible. It can used in any custom PCB design a user can think of, provided the design provides the proper mechanical and electrical requirements covered in the sections below.

The module shall be connectorized to allow a user to insert and remove as needed. This allows a user to swap out modules in the case of broken modules or PCBs and save the cost of rework or re-spin of a custom board. It also allows a user design to be compatible with different MoM modules, which may provide different MCU architectures, power output or other future features.

An alternative design strategy would be a solder-on or scalloped module, which is common in the hardware prototyping space. While reducing cost by removing the need for a connector, these modules also are permanently connected to a PCB, which means no upgradability nor ease of replacement in case of a damaged module or board.

### Daughterboard

In addition to the MoM-S1 module, a daughterboard shall be designed to provide the following functionality in conjunction with the module:

* All interface connector IOs pinned out to 0.1” headers
* 6-Pin Tag-Connect port for SWD programming and debug
* USB 2.0 port with power management and direction circuitry (VBUS, ID)
* ESD and EMI protection on all external connector data and IO pins
* User-configurable LEDs, buttons and switches

For more information regarding the technical specifications of the daughterboard, please see the *Microcontroller-on-Module Daughterboard v1 (MoM-D1) Board Architecture Specification*.

## Power Distribution

As power is a common component of all designs, the MoM-S1 module shall provide power output for user’s custom designs. The module will include the following common input and output voltages shown in Table 1 below:

Table - Voltage Rails on MoM-S1

|  |  |
| --- | --- |
| **Voltage Rails on MoM-S1** | |
| Input Voltage | 12V |
| Output Voltages | 5V, 3.3V |

The output voltage rails may be powered by either the MoM-S1 module or the user, depending on the application. Users shall also can turn off the output voltage rails on the MoM-S1 module to conserve power.

## Reconfigurable IO

The MoM-S1 shall provide access to all the IOs available on the microcontroller, either through the interface connector or test points onboard the module.

ST Microelectronics provides a flexible IO fabric for its STM32 microcontrollers that provides several available features (known as Alternate Functions) on each pin. This allows a user to configure the IOs to provide the functionality required for their design. For example, a user may decide to configure several pins to provide a SPI bus to talk to a sensor or dedicate two pins to a UART to send commands to a PC.

For a list of IOs and mapping of Alternate Functions, please see the *STM32F070CB Datasheet*.

# Detailed Implementation

## Mechanical

The following section describes the mechanical requirements of the MoM-S1 design. An overview of the mechanical features of the MoM-S1 is shown in Figure 2 below:

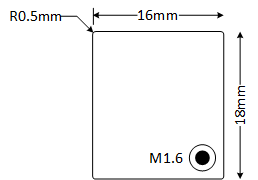


Figure - MoM-S1 Mechanical Dimensions

### Form Factor

The MoM-S1 measures **16mm x 18mm**, or almost a third of the size of an Arduino Nano. A scaled comparison of the two modules is shown in Figure 3 below:



Figure - MoM-S1 vs Arduino Footprint

The MoM-S1 module also includes 0.5mm radiused corners.

### Height and Clearance

The maximum component heights are as shown in the following Table 2 below:

Table - Maximum Component Height

|  |  |
| --- | --- |
| **Maximum Component Height** | |
| Top Side | 1.6mm |
| Bottom Side | 1.5mm – 4mm |

#### Mating Connector Height

The bottom side height requirement is driven by the chosen connector to mate with the interface connector on the MoM-S1 (**DF40C-60DP-0.4V(51)**). The mating connector has a mating height of **1.5mm**, but other variants can be chosen such that the mating height is up to **4mm**.

### Mounting Holes

The MoM-S1 module includes a single **M1.6** mounting hole in the bottom-right corner. This allows a user to secure the module to the mating board and provides mechanical stability when combined with the support from the mating connector.

### Enclosure

The MoM-S1 module was designed to be used in a variety of applications and thus the enclosure will vary by user application.

## Environmental

### Temperature

The MoM-S1 was designed to operate over a temperature range of **-20°C to 70°C**.

### Shock and Vibration

There is no specific shock and vibration requirement for the MoM-S1 module.

### Compliance

The MoM-S1 has not been designed to meet any specific UL, CE, FCC or other standards. Testing should be performed on the user’s specific application to confirm that the required standards are met.

### Reliability

There is no specific reliability requirement for the MoM-S1 module.

### Electromagnetic Interference (EMI)

To limit noise emissions and provide immunity for external noise sources, the MoM-S1 module has been designed to follow all recommended EMC requirements put forth in the specifications for individual components onboard the module. This includes safeguards such as additional filtering of power supply lines and sensitive signals and local decoupling of power supply pins to individual chips.

Additional EMI protection in the form of filtering or shielding may be required depending on the user’s application. These measures must be integrated into a user’s custom PCB design as they are not included in the MoM-S1 module.

## Power

The following sections describe the power architecture of the MoM-S1 module.

### Voltage Tree

Figure 4 below shows the voltage tree of the MoM-S1 module:

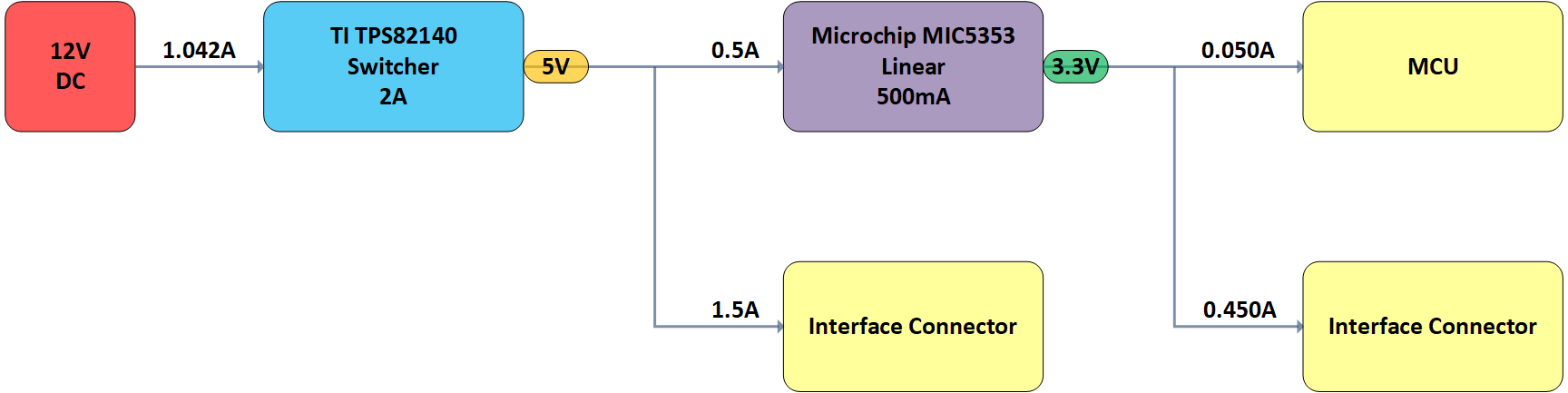


Figure - MoM-S1 Voltage Tree

The current values shown are based on the information provided for the microcontroller, which drove the values available at the interface connector. These are based on the maximum capacity of the power circuitry itself.

A summary of the components chosen can be found in Table 3 below:

Table - Voltage Regulators

|  |  |  |  |
| --- | --- | --- | --- |
| **Voltage Regulators** | | | |
| **Voltage Rail** | **Component** | **Designed Capacity** | **Interface Connector Capacity** |
| 5V | TI TPS82140 | 2A @ 5V | 1.5A @ 5V |
| 3.3V | Microchip MIC5353 | 500mA @ 3.3V | 450mA @ 3.3V |

The interface connector values given above assume worst case given the estimated microcontroller and 3.3V regulator power requirements shown in the figure above.

### Rating

The MoM-S1 module has been designed such that its rated input power requirement is **1.042A @ 12V** and provides the rated output power stated in the section above.

### Enables

Both voltage regulators have their enable (EN) signals pinned out to test points (see Table 6 below). This allows the user to turn off either voltage rail for power savings or when externally powering either voltage rail (see *Externally Powering Rails* below). **NOTE: Turning off either voltage rail without supplying external power to the rails will turn off the microcontroller and supporting circuitry!**

The enable signals are pulled up through a 10kΩ resistor to their appropriate voltage rails. **NOTE: These signals require open-drain signals when driven externally!**

### Externally Powering Rails

Both the 5V and 3.3V voltage rails may be powered externally through the appropriate pins on the Interface Connector or test points if desired. The MoM-S1 module includes back-power protection circuitry (see *Protection Circuitry* below) that prevents damage to the voltage regulators when externally powered.

If desired, the voltage rails onboard the MoM-S1 module may be disabled using the enable test points. See the *Enables* section above for more information.

### Protection Circuitry

The MoM-S1 module includes two layers of protection for the power circuitry on board.

The first measure is reverse voltage protection (RVP) on the 12V input rail implemented using a P-Channel MOSFET (**PMXB120EPE**). This prevents damage to the MoM-S1 module should the user reverse the 12V and ground signals into the board.

The second measure is back-power protection for both voltage regulators implemented using Schottky barrier diodes (**SDM2U30CSP-7**) on each regulator output. This prevents a large current from flowing back through the voltage regulator when either voltage rail is powered externally.

### Sequencing

There are no sequencing requirements for power-on or power-off of the MoM-S1 module.

## Processor

The MoM-S1 module is an STM32-based device (represented by the ‘S’ in the part number). MoM-S1 will use the **STM32F070CBT6** microcontroller (MCU). An overview of the MCU specifications are shown in Table 4 below:

Table - MCU Specification

|  |  |
| --- | --- |
| **MCU Specification** | |
| **Flash** | 128KB |
| **SRAM** | 16KB |
| **16-bit Timers** | 8 |
| **Communication Interfaces** | 2x SPI, 2x I2C, 4x UART, 1x USB |
| **ADC Channels** | 12 (10 external, 2 internal) |
| **GPIOs** | 37 |
| **Max CPU Frequency** | 48MHz |
| **Operating Voltage** | 2.4 - 3.6V |
| **Operating Temperature** | -40-85°C (ambient), -40-105°C (junction) |
| **Package** | LQFP48 |

## Configuration

The MoM-S module is programmed via the SWD interface on the MoM-D1 daughterboard or through a custom board created by the user. The MCU is programmed using the **ST-LINK/V2** programmer. The daughterboard utilizes the **ARM20-CTX** adapter and **TC2030-IDC-NL** cable from Tag-Connect for minimum footprint size. An image of the ST-LINK/V2 with the Tag-Connect adapter and cable are shown in Figure 5 below:



Figure - ST-LINK/V2 and Tag-Connect Hardware

Test points for the SWD pins (SWCLK/SWDIO) and reset (NRST) are provided if the user wishes to program the MoM-S1 module without additional boards.

## Clocking

The MoM-S1 module uses a 16MHz ceramic resonator with internal capacitors (**CSTCE16M0V53-R0**) to drive the MCU and its peripheral clocks.

## Interfaces

The following section describes the interfaces available on the MoM-S1 module.

### USB

The MCU on the MoM-S1 provides a single USB 2.0 full-speed device peripheral interface that is pinned out through the interface connector (See Interface Connector section below). The data lines (**D+/D-**) are impedance controlled to 90Ω differential as per USB 2.0 requirements.

There is no USB connector or additional hardware for other USB power management, ESD protection or other features (i.e. ID, VBUS) on the MoM-S1 module. That hardware is located on the MoM-D1 daughterboard and needs to be implemented on the user’s custom PCB if USB is to be used. Controlled impedance requirements should also be followed when implementing USB on a custom design.

### User IO

The MoM-S1 module provides **27 IOs** from the MCU to the interface connector. These may be used from any purpose. Some examples include serial interfaces (SPI, I2C, etc…), analog pins or generic IO.

An additional 2 IOs from MCU are available via test point only. See the Test Points section below for more information.

### LEDs

Two user-defined LEDs are provided on the MoM-S1 module. There is one blue LED (**USER\_LED0**) and one green LED (**USER\_LED1**) that can be controlled. Both are active-high (sending a high signal or ‘1’ from the MCU turns the LED on).

## Connectors

The following section describes the connectors available on the MoM-S1 module.

### Interface Connector

The interface connector provides the main connection between the MoM-S1 module and the custom PCB that it connects to. Table 5 below shows the pinout of the connector (provided as two sections) along with a key:

Table - Interface Connector Pinout and Key

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **2** | **4** | **6** | **8** | **10** | **12** | **14** | **16** | **18** | **20** | **22** | **24** | **26** | **28** | **30** |
| **12V** | **12V** | **GND** | **GND** | **5V** | **5V** | **GND** | **GND** | **GND** | **3V3** | **GND** | **NRST** | **GND** | **GND** | **D-** |
| **1** | **3** | **5** | **7** | **9** | **11** | **13** | **15** | **17** | **19** | **21** | **23** | **25** | **27** | **29** |
| **12V** | **12V** | **GND** | **GND** | **5V** | **5V** | **5V** | **GND** | **GND** | **3V3** | **GND** | **CLK** | **DIO** | **GND** | **D+** |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **32** | **34** | **36** | **38** | **40** | **42** | **44** | **46** | **48** | **50** | **52** | **54** | **56** | **58** | **60** |
| **GND** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **HW\_VER** |
| **31** | **33** | **35** | **37** | **39** | **41** | **43** | **45** | **47** | **49** | **51** | **53** | **55** | **57** | **59** |
| **GND** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** | **IO** |

|  |  |
| --- | --- |
| **GND** |  |
| **12V** |  |
| **5V** |  |
| **3V3** |  |
| **SWD** |  |
| **USB** |  |
| **MCU** |  |
| **HW\_VER** |  |

### Filtering and ESD Protection

Both filtering and ESD protection of IOs has been left off the MoM-S1 module. If required, these features should be located close to the connectors on the user’s custom PCB to off noise reduction and ESD protection prior to signals reaching the MoM-S1 module.

## Hardware Version

A single pin on the interface connector (HW\_VER) has been dedicated as a hardware version output of the MoM-S1 module. This signal provides a set voltage level to a user’s potential host system or co-processor to identify the hardware type and version of the MoM module connected to the system.

For the MoM-S1 module, the HW\_VER signal output shall be **GND (0V)** and is pulled down through a **10k** resistor.

## Debug

Debug options onboard the MoM-S1 module are limited to the test points provided (See *Test Points* section below), which includes the SWD programming interface. Additional debug methods, such as UART or USB, must be configured in the MCU and pinned out either on the MoM daughterboard or user’s custom PCB.

# Test Points

The following section explains the test points available onboard the MoM-S1 module.

Test points are provided for bring-up, programming and debugging potential issues. Table 6 below provides a list of signals and their associated test points on the MoM-S1 module:

Table - Test Points

|  |  |  |  |
| --- | --- | --- | --- |
| **Test Points** | | | |
| **Signal** | **Description** | **Designator(s)** |
| 12V0 | 12V Power Input | TP1 |
| 5V0 | 5V Power Output | TP3 |
| 3V3 | 3.3V Power Output | TP5 |
| GND | Ground | TP7, TP9, TP11 |
| MCU\_NRST | MCU Reset | TP2 |
| MCU\_SWCLK | SWD Clock | TP4 |
| MCU\_SWDIO | SWD Data | TP6 |
| MCU\_USB\_D\_P | USB Data (+) | TP8 |
| MCU\_USB\_D\_N | USB Data (-) | TP10 |
| MCU\_IO0 | User IO 0 | TP12 |
| MCU\_IO1 | User IO 1 | TP13 |
| MCU\_IO2 | User IO 2 | TP14 |
| MCU\_IO3 | User IO 3 | TP15 |
| MCU\_IO4 | User IO 4 | TP16 |
| MCU\_IO27 | User IO 27 | TP17 |
| MCU\_IO28 | User IO 28 | TP18 |
| 5V0\_EN | 5V Regulator Enable | TP19 |
| 3V3\_EN | 3.3V Regulator Enable | TP20 |

# Bring-up and Testing Procedures

TBD

# Future Revisions

TBD

# Appendix A: Glossary of Terms

Table - Glossary of Terms

|  |  |
| --- | --- |
| **Term** | **Explanation** |
| ADC | Analog-to-digital Converter |
| BAS | Board Architecture Specification |
| CE | Conformité Européenne (European certification mark) |
| CPU | Central Processing Unit |
| DC | Direct Current |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| EN | Enable Signal |
| ESD | Electrostatic Discharge |
| FCC | Federal Communications Commission |
| GND | Ground (0V) |
| GPIO | General Purpose Input Output |
| HW\_VER | Hardware Version Pin |
| IDE | Integrated Development Environment |
| I2C | Inter-integrated Circuit (serial interface) |
| IO | Input Output |
| LED | Light-Emitting Diode |
| MoM | Microcontroller-on-Module |
| MoM-D1 | Microcontroller-on-Module Daughterboard v1 |
| MoM-S1 | Microcontroller-on-Module STM32 Edition v1 |
| MOSFET | Metal Oxide Semiconductor Field-Effect Transistor |
| MCU | Microcontroller |
| PC | Personal Computer |
| PCB | Printed Circuit Board |
| RVP | Reverse Voltage Protection |
| SPI | Serial Peripheral Interface |
| SRAM | Static Random-Access Memory |
| STM32 | ST Microelectronics family of 32-bit Microcontrollers (used on MoM-S1) |
| SWD | Serial Wire Debug (2-wire programming port) |
| UART | Universal Asynchronous Receiver Transmitter |
| UL | Underwriter’s Laboratory |
| USB | Universal Serial Bus |