How to create your own peripheral modules for use with the ARC EMSK and embARC

Overview

embARC is an open software platform designed to help accelerate the development and production of embedded systems based on DesignWare® ARC® processors.

The ARC EM Starter Kit (EMSK) is a low-cost, versatile solution enabling rapid software development, code porting, software debugging and profiling for the ARC EM Family of processors, including the EM4/6/5D/7D/9D/11D cores (depending on EMSK version).

Together, the EMSK and embARC open software platform provide developers with a powerful platform with six (6) unified connectors that can be used to extend the system's capabilities through various peripheral devices. These connectors comply with Pmod Interface Specification by Digilent Inc.

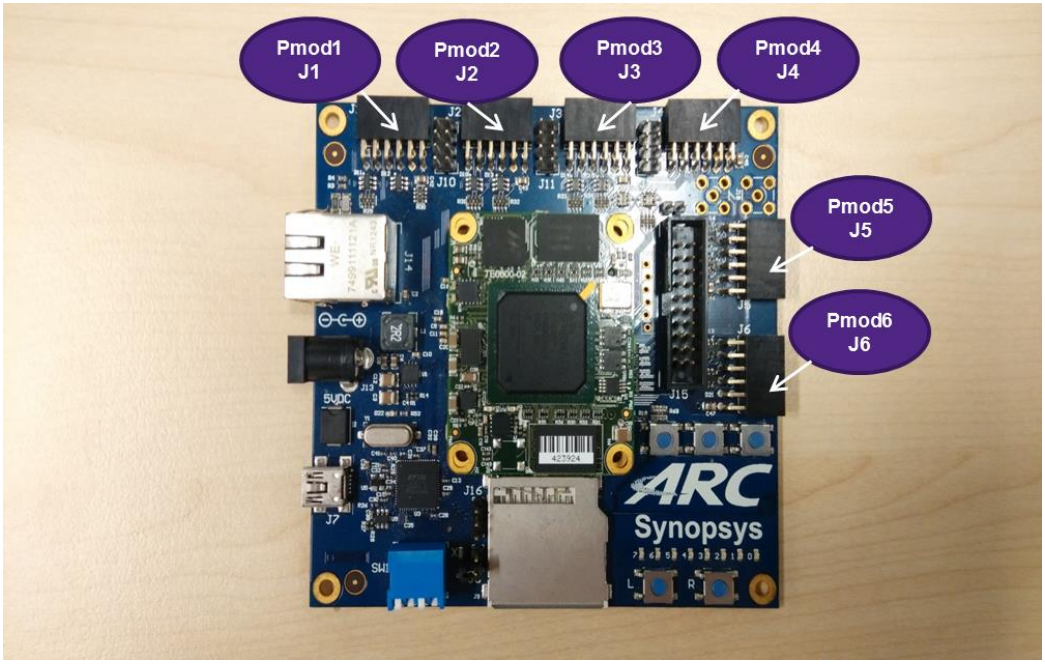
This article provides instructions on how to create your own module to be connected to the Pmod interface for use with the EMSK and embARC.

NOTE: This article assumes the reader is already familiar with embARC. If this is your first project with embARC, please start by first reading our "Quick start" article.

Please visit https://www.embarc.org/index.html for more information on embARC.

EMSK

Four versions of the EMSK are supported in embARC: v1.1, v2.0, v2.1 and v2.2. The EMSK board is based on a Xilinx Spartan®-6 FPGA. It supports hardware extensions using six unified 2x6 connectors allowing users to extend capabilities by connecting peripheral modules such as sensors, actuators, displays, buttons, switches and communication devices. These connectors comply with the Digilent Pmod Interface Specification.



The core configurations in EMSK v1.1 and v2.x are shown below. The EM4 processor is a subset of EM5D and EM6 is a subset of EM7D, so software may be built for EM4 or EM6 and also run on EM5D or EM7D respectively.

EMSK 1.1 Predefined ARC Configuration				
Parameters	ARC_EM4	ARC_EM4_16CR	ARC_EM6	ARC_EM6_GP
ICCM	128 KB	128 KB	32 KB	32 KB
DCCM	64 KB	64 KB	-	-
Instruction Cache	-	-	32 KB, 4-way, Line Length 128	16 KB, 2-way, Line Length 32
Data Cache	-	-	32 KB, 4-way, Line Length 128	16 KB, 2-way, Line Length 32
Timer	2	1	2	1
Core Register	32	16	32	32
Address Width	32	24	32	32

EMSK 2.1 Predefined ARC Configuration			
Parameters	ARC_EM5D	ARC_EM7D	ARC_EM7DFPU
ICCM	128 KB	32 KB	32 KB
DCCM	256 KB	32 KB	32 KB
Instruction Cache	-	16 KB	16 KB
Data Cache	-	16 KB	16 KB
Timer	2	2	2
Core Register	32	32	32
Address Width	32	32	32

NOTE: Please refer to EMSK User Guide for Configuration information if using EMSK version other than the ones listed in above tables.

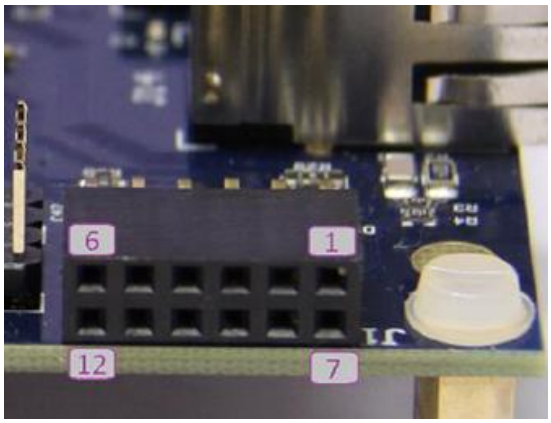
The EMSK hardware board integrates many peripheral devices such as SPI master, SPI slave, I^2C, UART and GPIO. Pmod pins are configured by the Pin Mux Controller using the PMOD_MUX_CTRL register. The peripheral connections for EMSK boards are shown below. Please note that the SPI slave is not available for the ARC_EM6 and ARC_EM6_GP configurations in EMSK 1.1. The EMSK 2.2 peripheral connections are compatible with EMSK 2.1 and 2.0.

EMSK 1.1 Peripheral Device Connection to Pmods			
Pmod	Connector	MUX option0	MUX option 1
Pmod1	J1	GPIOs	External SPI master + UART
Pmod2	J2	GPIOs	ARC EM control/status signals + I2C
Pmod3	J3	GPIOs	GPIO + I2C
Pmod4	J4	GPIOs	GPIO + I2C
Pmod5	J5	GPIOs	External SPI slave 1 and 2
Pmod6	J6	GPIOs	External SPI slave 0 and CS outputs for all other SPI slaves + ARC EM control/status signals

EMSK 2.x Peripheral Device Connection to Pmods			
Pmod	Connector	MUX option0	MUX option 1
Pmod1	J1	GPIOs	External SPI master + UART0
Pmod2	J2	GPIOs	ARC EM control/status signals + I2C_0
Pmod3	J3	GPIOs	GPIO + I2C_0
Pmod4	J4	GPIOs	GPIO + I2C_1
Pmod5	J5	GPIOs	External SPI slave 1 + UART2
Pmod6	J6	GPIOs	External SPI slave 0 and CS outputs for all other SPI slaves + ARC EM control/status signals

Pmod Interface

The EMSK Pmod interface is used to connect low frequency, low I/O pin count peripheral modules. The twelve-pin version Pmod on the EMSK hardware board provides eight I/O signal pins, two power pins and two ground pins. The image below shows the Pmod pins location on the board connectors. Pmod bits [5] and [11] are shorted together and connected to ground (GND). Pmod bits [6] and [12] are shorted together and connected to a 3.3 V power supply. Pmod bits [4:1] and [10:7] are functional pins.



Electrical specifications

The I/O pins on the EMSK hardware board have symmetrical 24 mA source/sink capability. For most Pmod peripheral modules, a 3.3 V logic power supply is required and the signals conform to LVCMOS 3.3 V or LVTTL 3.3 V logic conventions. The pins driver should be able to source or sink at least 5 mA of current at whatever the operating speed of the interface on Pmod is expected to be. The amount of power that a peripheral module is allowed to draw from the host is not specified, but should not be assumed to be more than approximately 100 mA.

Physical connection standard

Pmod connections are made using standard 100 mil spaced, 25 mil square, pin-header style connectors. There are multiple connectors placed side-by-side along board edge on the EMSK board. The connectors are spaced 0.9 inch, center-to-center. This allows for 0.8 inch wide modules to be plugged side-by-side into the EMSK board without interference. Peripheral modules with multiple connectors must also have them spaced on 0.9 inch centers for direct connection to the EMSK board.

In the following sections, peripheral modules complying with Digilent Pmod Interface Specification are introduced for I^2C, SPI and UART interfaces. A flexible method is provided to make peripheral modules compatible with Pmod Interface Specification for your own modules.

Various Pmod peripheral modules can be bought from Digilent. Please visit http://www.digilentinc.com/Products/Catalog.cfm?NavPath=2,401&Cat=9 for Pmod peripheral modules and visit http://www.digilentinc.com/Pmods/Digilent-Pmod_%20Interface_Specification.pdf for the Digilent Pmod Interface Specification.

Creating your own modules

Pre-requisites

- Small, blank PCB board
- 2x4 pin header/2x6 pin header
- Soldering iron and wire, experience with small electronics soldering
- 2x40 pin double-row curved header
- 40-pin single-row header



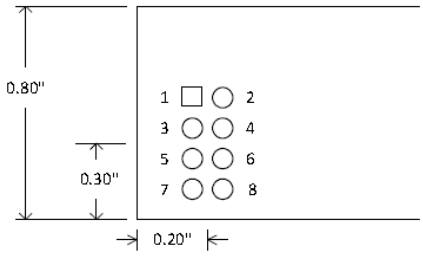
These components can be bought from Amazon and / or Taobao (China).

I²C interface

I²C pin assignment

The peripheral module with I²C interface generally uses a 2x4 pin header connector to provide two sets of I²C signals, power and ground. So the I²C bus can be formed by daisy chaining modules and system boards. The following image and table show basic PCB dimensions, physical connector placement and pin numbering conventions for the module circuit boards intended for direct connection to the EMSK board. OLED module with I²C interface is introduced as an example.

Pin	Signal
1,2	SCL
3,4	SDA



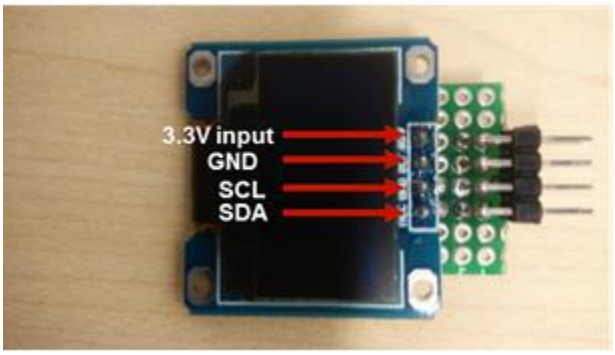
5,6	GND
7,8	VCC

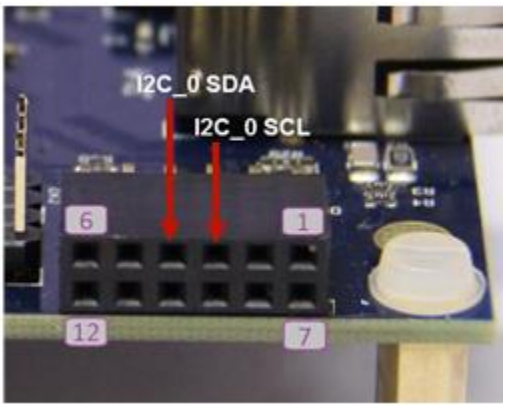
OLED module

SSD1306 is a 128 x 64 dot matrix OLED/PLED segment/common driver with controller. It can be connected with the I^2C interface. The SSD1306 pin description is shown below.

Pin	Signal
1	VCC
2	GND
3	SCL
4	SDA

Assemble the SSD1306 OLED module on a blank PCB and use wires to connect module pins to the 2x4 pins header connector according to the above I^2C pin assignment. Then SSD1306 OLED module can be connected to the EMSK board as shown below.





SSD1306 OLED modules can be bought from Amazon and Taobao by searching keyword “OLED module”.

SPI interface

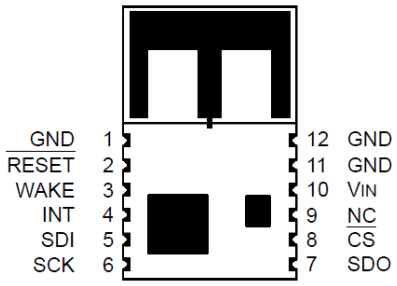
SPI pin assignment

Pin	Signal	Direction	Description
1	SS	Out	Slave select, active low to enable slave device
2	MOSI	Out	Master out slave in, data from master to slave
3	MISO	In	Master in slave out, data from slave to master
4	SCK	Out	Serial clock
5	GND	--	
6	VCC	--	
7	INT	In	Interrupt signal from slave to master
8	RESET	Out	Reset signal for master to reset slave
9	N/S	--	Not-specified, depending on the module
10	N/S	--	Not-specified, depending on the module
11	GND	--	
12	VCC	--	

The peripheral module with SPI interface conforms to the pin assignment above. This provides a SPI interface plus additional control signals. The additional control and status signals can provide additional functions between master and slave devices. Please note that INT and RESET are implemented with EMSK GPIO signals when the EMSK board acts as a SPI master device.

RF2 module

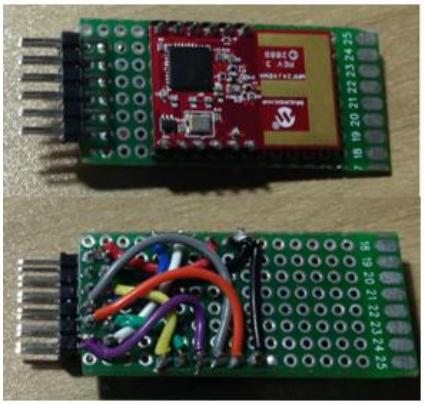
MRF24J40MA is a SPI-based RF2 module and its pin description is shown below.

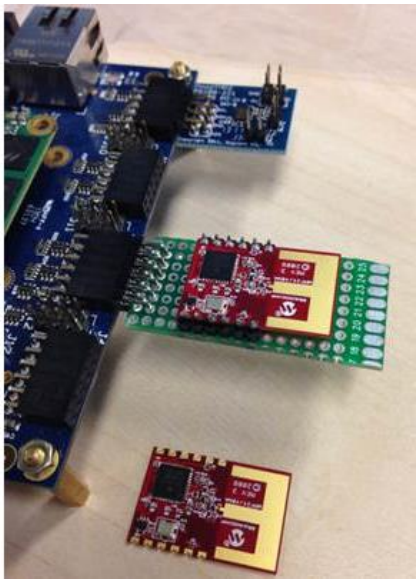


Pin	Signal	Direction	Description
1	GND		Ground
2	RESET	In	Global hardware reset pin, active low
3	WAKE	In	External wake-up trigger
4	INT	Out	Interrupt pin to microcontroller
5	SDI	In	Serial interface data input
6	SCK	In	Serial interface clock
7	SDO	Out	Serial interface data output from MRF24J40
8	CS	In	Serial interface enable, active low
9	NC		No connection (allow pin to float)
10	Vin		Power supply
11	GND		Ground

12	GND		Ground

Assemble the MRF24J40MA module on the blank PCB and use wires to connect module pins to the 2x6 pins header connector according to the above SPI pin assignment. WAKE signal (pin 3) is not defined in the SPI pin assignment and can be connected to EMSK Pmod connector pin 9. A GPIO signal acts as WAKE signal. The MRF24J40MA module can be connected to the EMSK board as shown below.

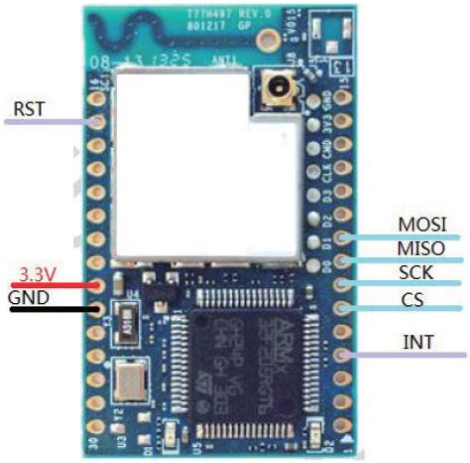




MRF24J40MA RF2 modules can be bought from Amazon and Taobao by searching keyword "MRF24J40MA".

WiFi module

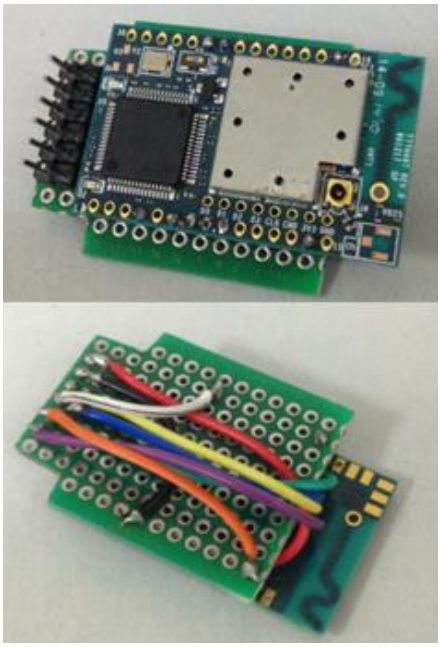
RW 009 is a SPI-based WiFi module and its pin description is shown below.

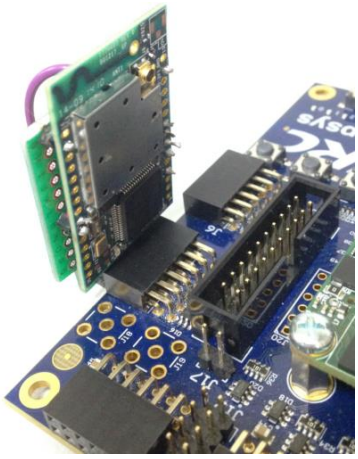


No.	Signal	Direction	Description

1	VCC		3.3 V power supply
2	MOSI	In	Serial interface data input
3	MISO	Out	Serial interface data output
4	SCK	In	Serial interface clock
5	CS	In	Serial interface enable
6	RST	In/Out	Global hardware reset pin
7	INT	Out	Interrupt pin
8	GND		Ground

Assemble the RW 009 module on the blank PCB and use wires to connect module pins to 2x6 pins header connector according to the above SPI pin assignment. CS signal is connected to EMSK Pmod connector pin 9. A GPIO signal acts as CS signal. The RW 009 module can be connected to the EMSK board as shown below.





UART interface

UART pin assignment

Pin	Signal	Direction	Description
1	CTS	In	Device will only transmit when this signal is asserted
2	TXD	Out	Data from host to peripheral
3	RXD	In	Data from peripheral to host
4	RTS	Out	Device is ready to receive data
5	GND		
6	VCC		
7	INT	In	Interrupt signal from peripheral to host

8	RESET	Out	Reset signal for host to reset peripheral
9	N/S		Not-specified, depending on the module
10	N/S		Not-specified, depending on the module
11	GND		
12	VCC		

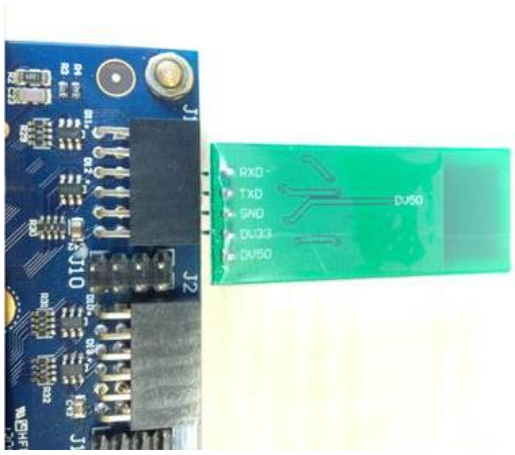
The peripheral module with UART interface conforms to the above pin assignment. The hardware flow control and additional control signals are optional. EMSK UART signals CTS, TXD, RXD and RTS are programmable and can be configured to be any order on Pmod1 pins 1, 2, 3 and 4. Please note that INT and RESET are implemented with EMSK GPIO signals.

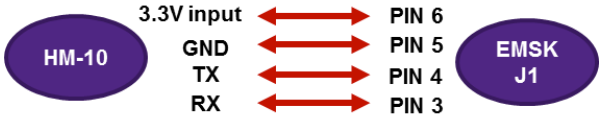
BLE module

The HM-10 is an UART-based BLE (Bluetooth Low Energy) module and its pin description is shown below.

The HM-10 BLE module has two power supply pins, DV33 and DV50. If DV33 is connected to a 3.3V power supply, the TX/RX are 3.3V signals and DV50 should be kept floating. If DV50 is connected to a 5.0V power supply, the TX/RX are 5V signals and DV33 should be kept floating.

Since the EMSK provides a 3.3V power supply from Pmod connector pins 6 & 12, the DV50 pin of HM-10 BLE module can simply be removed/clipped. The module can be connected to the EMSK board as below. EMSK Pmod1 pin 3 and pin4 are configured as RXD and TXD.





HM-10 BLE modules can be bought from Amazon and Taobo by searching keyword “HM-10 BLE module”.

IMPORTANT NOTE:

When making your own peripheral module connected to the EMSK board Pmod interface, the interface should be based on UART/SPI/I^2C/IO. The power supply & signals of the module are 3.3 V since the EMSK board only provides 3.3 V power supply. When completing your own Pmod module, please check VCC and GND signals (Pin 6, 12, 5 and 11) and make sure that VCC signal is not connected to GND signal by mistake to avoid damaging the EMSK board.