TWR-K21F120M Tower Module

User's Manual

Rev. 1.0

Table of Contents

1 TWR-K21F120M

The TWR-K21F120M microcontroller module is designed to work either in standalone mode or as part of the Freescale Tower System, a modular development platform that enables rapid prototyping and tool re-use through reconfigurable hardware. Take your design to the next level and begin constructing your Tower System today by visiting www.freescale.com/tower for additional Tower System microcontroller modules and compatible peripherals. For TWR-K21F120M specific information and updates visit www.freescale.com/TWR-K21F120M

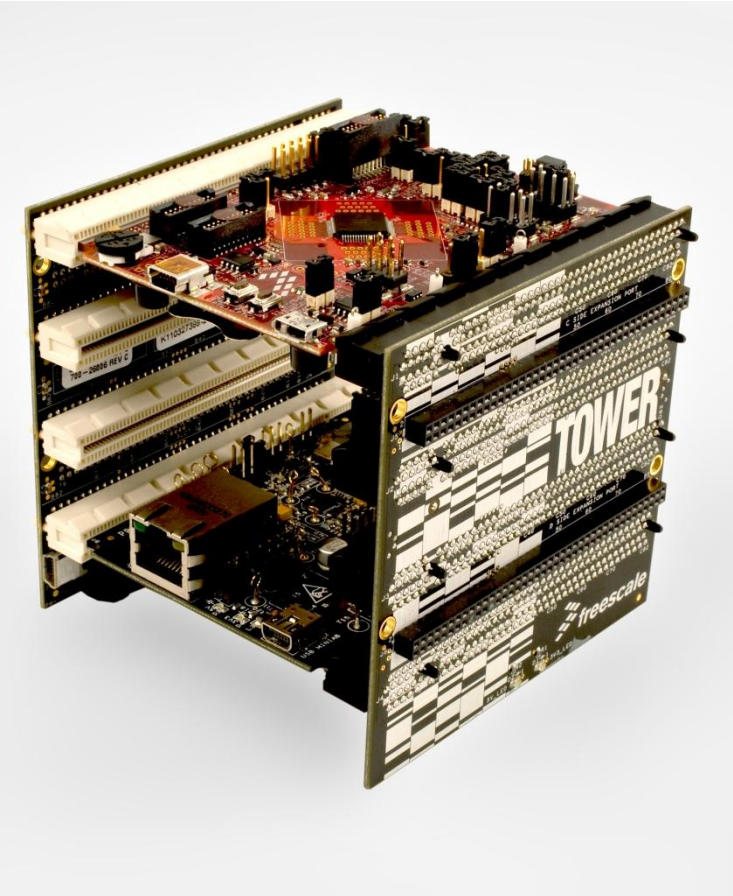

Figure 1 Freescale Tower System Overview

2 Contents

The TWR-K21F120M contents include:

- TWR-K21F120M board assembly
- 3 ft A to micro-B USB cable for debug interface and power or MK21FN1M0VMC12 USB interface
- CR2025 coin cell battery for VBAT power supply
- Quick Start Guide

3 TWR-K21F120M Features

- Tower-compatible microcontroller module
- MK21FN1M0VMC12 MCU (120 MHz, 1 MB Flash, 128 KB RAM, low power, 121 MAPBGA package)
- Dual-role USB interface with Micro-AB USB connector
- General-purpose Tower Plug-in (TWRPI) socket
- On-board debug circuit: MC9S08JM60 open source JTAG (OSJTAG) with virtual serial port
- Three-axis accelerometer (MMA8451Q)
- Four (4) user-controllable LEDs
- Two (2) user pushbutton switches for GPIO interrupts
- One (1) user pushbutton switch for MCU reset
- Potentiometer
- Independent, battery-operated power supply for Real Time Clock (RTC) and tamper detection modules
- SD Card slot

4 Get to Know the TWR-K21F120M

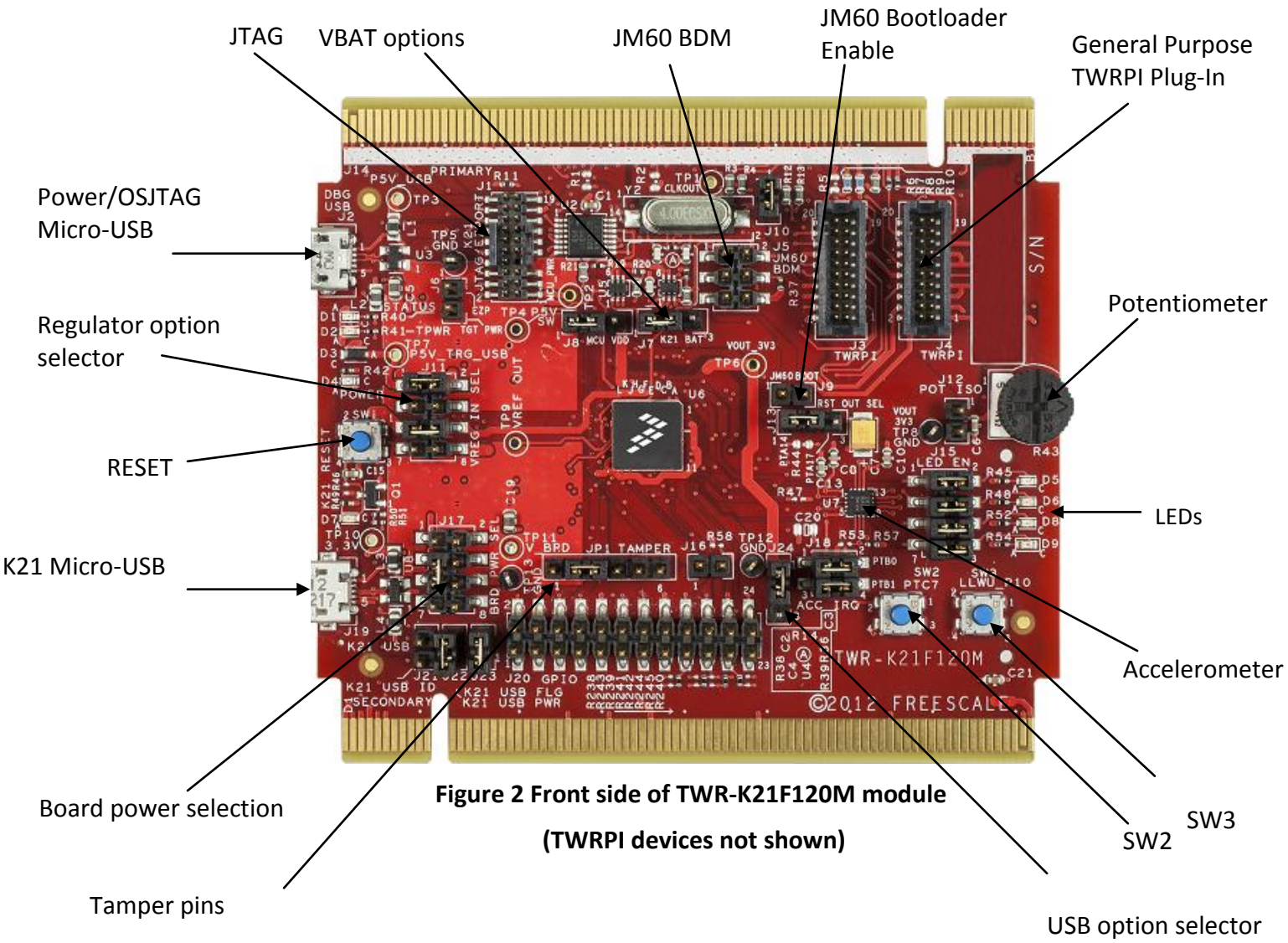

Figure 2 Front side of TWR-K21F120M module

(TWRPI devices not shown)

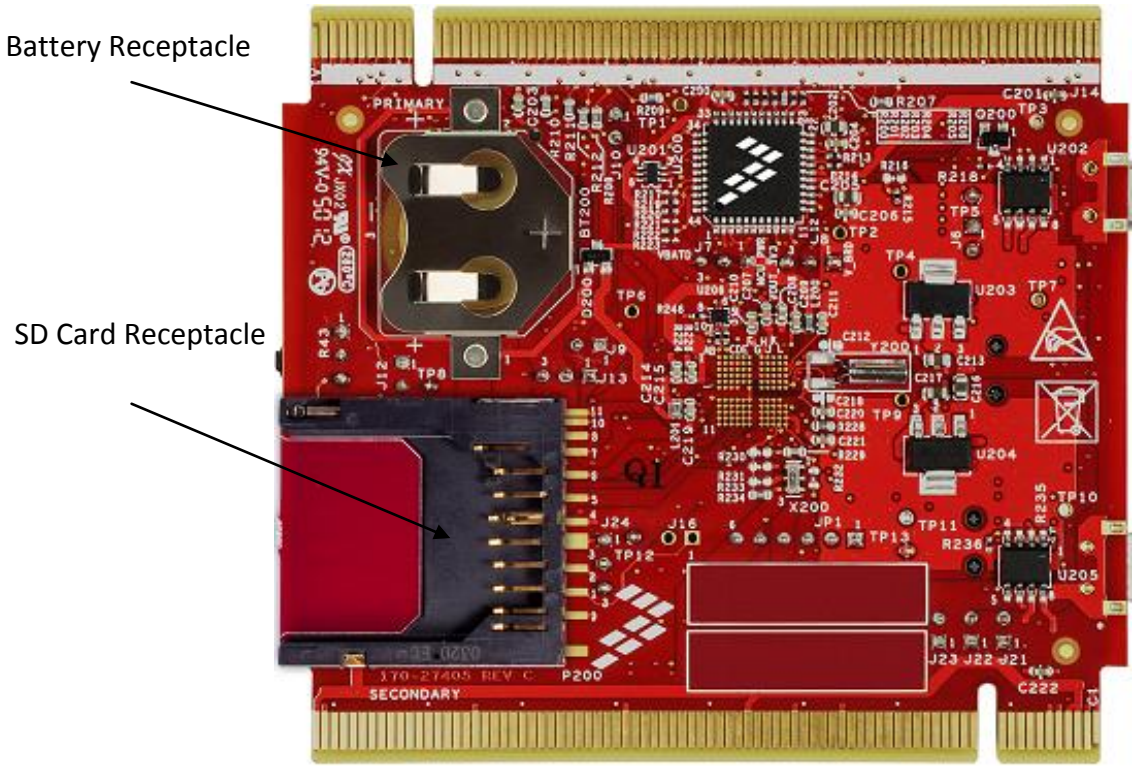

Figure 3 Back side of TWR-K21F120M

5 Reference Documents

The documents listed below should be referenced for more information on the Kinetis family, Tower System, and MCU Modules. These can be found in the documentation section of http://www.freescale.com/TWR-K21F120M or http://www.freescale.com/kinetis

- TWR-K21F120M-SCH: Schematics
- TWR-K21F120M-PWA: Design Package
- K21P121M120SF5RM: Reference Manual
- Tower Configuration Tool
- Tower Mechanical Drawing

6 Hardware description

The TWR-K21F120M is a Tower MCU Module featuring the MK21FN1M0VMC12 a Kinetis microcontroller in a 121 MAPBGA package with USB 2.0 full-speed on-the-go (OTG) controllers and system security and tamper detection with a secure real-time clock with independent battery supply. It is intended for use in the Freescale Tower System but can also operate stand-alone. An on-board OSJTAG debug circuit provides a JTAG interface and a power supply input through a single micro-USB connector.

The block diagram of the TWR-K21F120M board is presented in the following figure:

6.1 Block Diagram

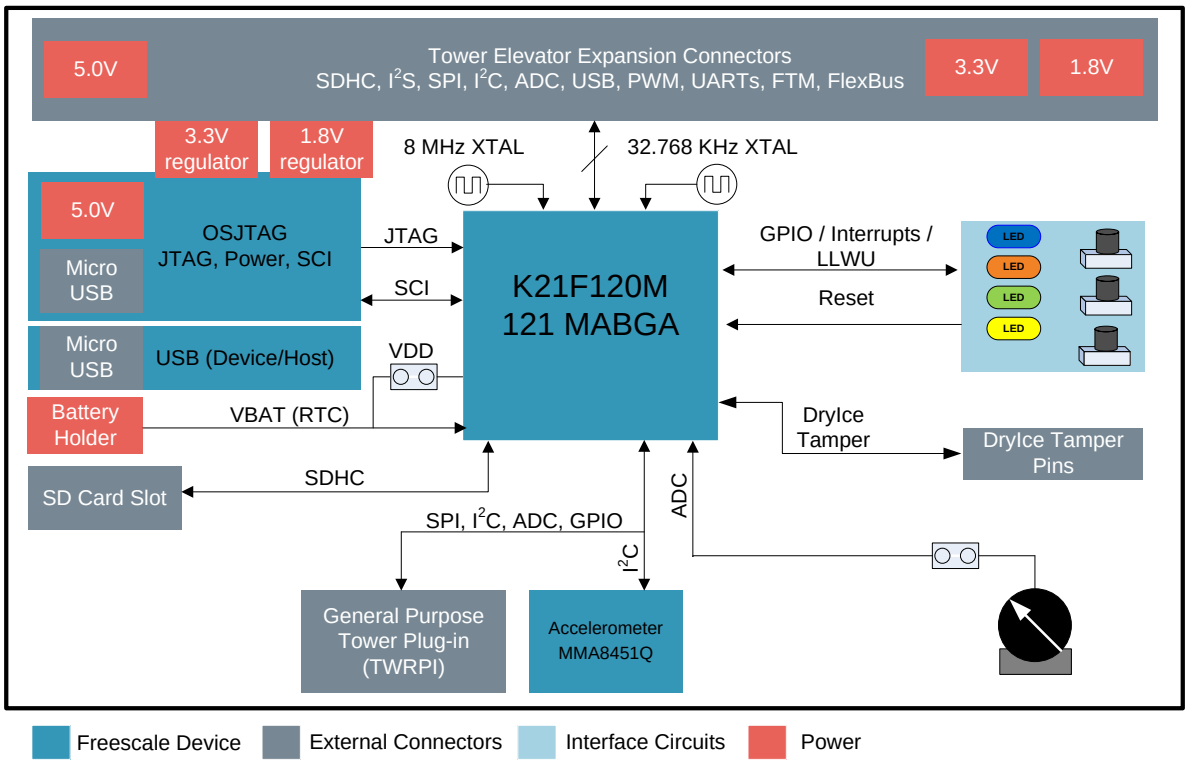

Figure 4 Block Diagram of TWR-K21F120M

6.2 Microcontroller

The TWR-K21F120M features the MK21FN1M0VMC12 MCU. This 120 MHz microcontroller is part of the Kinetis K2x family and is implemented in a 121 MAPBGA package. The following table notes some of the features of the MK21FN1M0VMC12 MCU.

Table 1 Features of MK21FN1M0VMC12

Feature	Description
Ultra low power	– 11 low-power modes with power and clock gating for optimal peripheral activity and recovery times. – Full memory and analog operation down to 1.71 V for extended battery life – Low-leakage wake-up unit with up to six internal modules and sixteen pins as wake-up sources in low-leakage stop (LLS)/very low-leakage stop (VLLS) modes – Low-power timer for continual system operation in reduced power states
Flash and SRAM	– 1-MB flash featuring fast access times, high reliability, and four levels of security protection – 128 KB of SRAM – No user or system intervention to complete programming and erase functions and full operation down to 1.71 V
Mixed-signal capability	– Two high-speed 16-bit SAR ADCs with configurable resolution – Single or differential output modes for improved noise rejection – 500-ns conversion time achievable with programmable delay block triggering – Three high-speed comparators providing fast and accurate motor over-current protection by driving PWMs to a safe state – Optional analog voltage reference provides an accurate reference to analog blocks and replaces external voltage references to reduce system cost – Two 12-bit DACs
Performance	– 120 MHz ARM Cortex-M4 core with DSP and FPU instruction set, single cycle MAC, and single instruction multiple data (SIMD) extensions – Up to four channel DMA for peripheral and memory servicing with reduced CPU loading and faster system throughput – Cross bar switch enables concurrent multi-master bus accesses, increasing bus bandwidth – Independent flash banks allowing concurrent code execution and firmware updating with no performance degradation or complex coding routines

Timing and Control	– Three FlexTimers with a total of 12 channels – Hardware dead-time insertion and quadrature decoding for motor control – Carrier modulator timer for infrared waveform generation in remote control applications – Four-channel 32-bit periodic interrupt timer provides time base for RTOS task scheduler or trigger source for ADC conversion and programmable delay block
Connectivity and Communications	– Full-Speed USB Device/Host/On-The-Go with device charge detect capability – Optimized charging current/time for portable USB devices, enabling longer battery life – USB low-voltage regulator supplies up to 120 mA off chip at 3.3 volts to power external components from 5-volt input – Six UARTs: o one UART supports RS232 with flow control, RS485, ISO7816, IrDA, and CEA709.1-B (LON) o five UARTs support RS232 with flow control and RS485 – One Inter-IC Sound (I2S) serial interface for audio system interfacing – Two DSPI modules and two I2C modules – Secured digital host controller (SDHC) – A multi-function external bus interface called the FlexBus interface controller capable of interfacing to slave-only devices.
Reliability, Safety and Security	– Hardware Encryption co-processor for secure data transfer and storage. Faster than software implementations and with minimal CPU loading. Supports a wide variety of algorithms - DES, 3DES, AES, MD5, SHA-1, SHA-256 – System security and tamper detection with secure real-time clock (RTC) and independent battery supply. Secure key storage with internal/external tamper detection for unsecured flash, temperature, clock, and supply voltage variations and physical attack detection – Memory protection unit provides memory protection for all masters on the cross bar switch, increasing software reliability – Cyclic redundancy check (CRC) engine validates memory contents and communication data, increasing system reliability – Independently-clocked COP guards against clock skew or code runaway for fail-safe applications such as the IEC 60730 safety standard for household appliances – External watchdog monitor drives output pin to safe state for external components in the event that a watchdog timeout occurs – Included in Freescale's product longevity program, with assured supply for a minimum of 10 years after launch

6.3 Clocking

The Kinetis MCUs start up from an internal digitally controlled oscillator (DCO). Software can enable the main external oscillator (EXTAL0/XTAL0) if desired. The external oscillator/resonator can range from 32.768 KHz up to a 32 MHz. An 8 MHz crystal is the default external source for the MCG oscillator inputs (XTAL/EXTAL).
A 32.768 KHz crystal is connected to the RTC oscillator inputs by default.

By populating isolation resistors, other external clock sources for the MK21FN1M0VMC12 include the CLKIN0 signal that can be provided through the TWR-ELEV or pin 20 of TWRPI connector J3.

6.4 System Power

When installed into a Tower System, the TWR-K21F120M can be powered from either an on-board source or from another source in the assembled Tower System.

In stand-alone operation, the main power source (5.0 V) for the TWR-K21F120M module is derived from either the OSJTAG USB mini-B connector (J2) or the MK21FN1M0VMC12 USB micro-AB connector (J19). Two low-dropout regulators provide 3.3 V and 1.8 V supplies from the 5.0 V input voltage. Additionally, the 3.3 V regulator built into the MK21FN1M0VMC12 MCU can be selected to power the 3.3 V bus. All the user selectable options can be configured using two headers, J11 and J17. Refer to sheet 5 of the TWR-K21F120M schematics for more details.

6.5 DryIce and RTC VBAT

The DryIce tamper detection module and the Real Time Clock (RTC) module on the MK21FN1M0VMC12 have two modes of operation: system power-up and system power-down. During system power-down, the tamper detection module and the RTC are powered from the backup power supply (VBAT) and electrically isolated from the rest of the MCU. The TWR-K21F120M provides a battery receptacle for a coin cell battery that can be used as the VBAT supply. The receptacle can accept common 20-mm diameter 3 V lithium coin cell batteries.

6.6 Debug Interface

There are two debug interface options provided: the on-board OSJTAG circuit and an external ARM JTAG connector. The ARM-JTAG connector (J1) is a standard 2x10-pin connector providing an external debugger cable with access to the JTAG interface of the MK21FN1M0VMC12. Alternatively, the on-board OSJTAG debug interface can be used to access the debug interface of the MK21FN1M0VMC12.

6.7 OSJTAG

An on-board MC9S08JM60 based Open Source JTAG (OSJTAG) circuit provides a JTAG debug interface to the MK21FN1M0VMC12. A standard USB A male to micro-B male cable (provided) can be used for debugging via the USB connector (J2). The OSJTAG interface also provides a USB to serial bridge. Drivers for the OSJTAG interface are provided in the P&E Micro OSBDM/OSJTAG Tower Toolkit. These drivers and more utilities can be found online at http://www.pemicro.com/osbdm.

6.8 Cortex Debug Connector

The Cortex Debug connector is a 20-pin (0.05") connector providing access to the SWD, JTAG, cJTAG, EzPort signals available on the K21 device. The pinout and K21 pin connections to the debug connector (J1) are shown in Table 2.

Table 2 Cortex Debug connector

Pin	Function	TWR-K21F120M Connection
1	VTref	3.3 V MCU supply (MCU_PWR)
2	TMS / SWDIO	PTA3/SCI0_RTS_b/FTM0_CH0/**JTAG_MS**/**SWD_DIO**
3	GND	GND
4	TCK / SWCLK	PTA0/SCI0_CTS_b/FTM0_CH5/**JTAG_CLK**/**SWD_CLK**/EZP_CLK
5	GND	GND
6	TDO / SWO	PTA2/SCI0_TX/FTM0_CH7/**JTAG_DO**/**TRACE_SWO**/EZP_DO
7	Key	—
8	TDI	PTA1/SCI0_RX/FTM0_CH6/**JTAG_DI**/EZP_DI
9	GND Detect	PTA4/FTM0_CH1/MS/NMI_b/EZP_CS_b
10	nRESET	RESET_b
11	Target Power	5 V supply (via J6)
12	TRACECLK	PTE0/mADC0_SE10/SPI1_PCS1/UART1_TX/**TRACE_CLKOUT**/I2C1_SDA/RTC_CLKOUT
13	Target Power	5 V supply (via J6)
14	TRACEDATA[0]	PTE4/LLWU_P2/SPI1_PCS0/UART3_TX/**TRACE_D0**
15	GND	GND
16	TRACEDATA[1]	PTE3/ADC0_DM2/mADC0_DM1/SPI1_SIN/UART1_RTS/**TRACE_D1**/SPI1_SOUT
17	GND	GND
18	TRACEDATA[2]	PTE2/LLWU_P1/ADC0_DP2/mADC0_DP1/SPI1_SCK/UART1_CTS/**TRACE_D2**
19	GND	GND
20	TRACEDATA[3]	PTE1/LLWU_P0/mADC0_SE11/SPI1_SOUT/UART1_RX/**TRACE_D3**/I2C1_SCL/SPI1_SIN

6.9 Accelerometer

An MMA8451Q digital accelerometer is connected to the MK21FN1M0VMC12 MCU through an I2C interface (I2C1) and GPIO/IRQ signals (PTB0 and PTB1).

6.10 Potentiometer, Pushbuttons, LEDs

The TWR-K21F120M also features:

- a potentiometer connected to an ADC input signal (ADC0_SE12).
- two pushbutton switches (SW2 and SW3 connected to PTC7 and PTC6, respectively)
- four user-controllable LEDs connected to GPIO signals (optionally isolated using jumpers):
    - Green LED (D5) to PTD4
    - Yellow LED (D6) to PTD5
    - Orange LED (D8) to PTD6
    - Blue LED (D9) to PTD7

6.11 General Purpose Tower Plug-in (TWRPI) Socket

The TWR-K21F120M features a socket (J3 and J4) that can accept a variety of different Tower Plug-in modules featuring sensors, RF transceivers, and other peripherals. The General Purpose TWRPI socket provides access to I2C, SPI, IRQs, GPIOs, timers, analog conversion signals, TWRPI ID signals, reset, and voltage supplies. The pinout for the TWRPI Socket is defined in Table 3.

Table 3 General Purpose TWRPI socket pinout

J4	
Pin	Description
1	5 V VCC
2	3.3 V VCC
3	GND
4	3.3 V VDDA
5	VSS (Analog GND)
6	VSS (Analog GND)
7	VSS (Analog GND)
8	ADC: Analog 0
9	ADC: Analog 1
10	VSS (Analog GND)
11	VSS (Analog GND)
12	ADC: Analog 2
13	VSS (Analog GND)
14	VSS (Analog GND)
15	GND
16	GND
17	ADC: TWRPI ID 0
18	ADC: TWRPI ID 1
19	GND
20	Reset

J3	
Pin	Description
1	GND
2	GND
3	I2C: SCL
4	I2C: SDA
5	GND
6	GND
7	GND
8	GND
9	SPI: MISO
10	SPI: MOSI
11	SPI: SS
12	SPI: CLK
13	GND
14	GND
15	GPIO: GPIO0/IRQ
16	GPIO: GPIO1/IRQ
17	UART: UART_RX or GPIO: GPIO2
18	UART: UART_TX or GPIO: GPIO3
19	UART: UART_CTS or GPIO: GPIO4/Timer
20	UART: UART_RTS or GPIO: GPIO5/Timer

6.12 USB

The MK21FN1M0VMC12 features a full-speed/low-speed USB module with OTG/Host/Device capability and built-in transceiver. The TWR-K21F120M routes the USB D+ and D- signals from the MCU via J24 jumper either to the on-board micro-AB USB connector (J19) or to the mini-AB USB connector (J14) on the TWR-SERIAL tower board.

A power supply switch with an enable input signal and over-current flag output signal is used to supply power to the USB connector when the MK21FN1M0VMC12 is operating in host mode. Port pin PTC8 is connected to the flag output signal and port pin PTC9 is used to drive the enable signal. Both PTC8 and PTC9 port pins can be isolated with jumpers (J23 and J22, respectively) if needed.

6.13 Secure Digital Card Slot

A Secure Digital (SD) card slot is available on the TWR-K21F120M connected to the SD Host Controller (SDHC) signals of the MCU. This slot will accept SD memory cards. Refer to the Table 4 “SD Card Socket Connection Table” for the SDHC signal connection details.

Table 4 SD Card Socket Connection

Pin	Function	TWR-K21F120M Connection
1	SDHC0_D3	PTE4/LLWU_P2/SPI1_PCS0/UART3_TX/SDHC0_D3/TRACE_D0
2	SDHC0_CMD	PTE3/ADC0_DM2/ADC1_SE7A/SPI1_SIN/UART1_RTS/SDHC0_CMD/TRACE_D1/SPI1_SOUT
3	VSS1	GND
4	VDD	3.3 V board supply (V_BRD)
5	SDHC0_DCL	PTE2/LLWU_P1/ADC0_DP2/ADC1_SE6A/SPI1_SCK/UART1_CTS/SDHC0_DCLK/TRACE_D2
6	VSS2	GND
7	SDHC0_D0	PTE1/LLWU_P0/ADC1_SE5A/SPI1_SOUT/UART1_RX/SDHC0_D0/TRACE_D3/I2C1_SCL/SPI1_SIN
8	SDHC0_D1	PTE0/ADC1_SE4A/SPI1_PCS1/UART1_TX/SDHC0_D1/TRACE_CLKOUT/I2C1_SDA/RTC_CLKOUT
9	SDHC0_D2	PTE5/SPI1_PCS2/UART3_RX/SDHC0_D2/FTM3_CH0
10	SD_CARD_DETECT	PTC18/UART3_RTS/FB_TBST/FB_CS2/FB_BE15_8_BLS23_16
11	CD_WP_COMMON	GND
12	SD_CARD_WP	PTC19/UART3_CTS/FB_CS3/FB_BE7_0_BLS31_24/FB_TA

6.14 External Bus Interface - FlexBus

The device features a multi-function external bus interface called the FlexBus interface controller capable of interfacing to slave-only devices. The FlexBus interface is not used directly on the TWR-K21F120M. Instead, a subset of the FlexBus is connected to the Primary Connector so that the external bus can access devices on Tower peripheral modules. Refer to the sheet 8 of the TWR-K21F120M schematic for more details.

7 TWR-K21F120M Jumper Options and Headers

The following is a list of all the jumper options on the TWR-K21F120M. The default installed jumper settings are indicated by white text on a black background.

Table 5 TWR-K21F120M Jumper Options and Headers

Option	Jumper	Setting	Description
MCU power connection	J8	**1-2**	Connect on-board 3.3 V or 1.8 V supply (V_BRD) to MCU VDD
		2-3	Connect K21 USB regulator output to MCU VDD
VBAT power source	J7	**1-2**	Connect VBAT to on-board 3.3 V or 1.8 V supply
		2-3	Connect VBAT to the higher voltage between MCU supply (MCU_PWR) or coin cell supply (VBATD)
JTAG board power selection	J6	ON	Connect OSJTAG 5V output (P5V_TRG_USB) to JTAG port (supports powering board from JTAG pod supporting 5V supply output)
		OFF	Disconnect OSJTAG 5V output (P5V_TRG_USB) from JTAG port
OSJTAG bootloader selection	J9	ON	OSJTAG bootloader mode (OSJTAG firmware reprogramming)
		OFF	Debugger mode
V_BRD power source (Board Power Selector)	J17	1-2	Connect K21 USB regulator output (VOUT_3V3) to on-board supply (V_BRD)
		3-5	Connect 3.3 V on-board regulator output (P3V3) to on-board supply (V_BRD)
		5-7	Connect 1.8 V on-board regulator output (P1V8) to on-board supply (V_BRD)
VREG IN selector	J11	**1-2**	OSJTAG 5V output (P5V_TRG_USB) connected to on-board regulator input (VREG_IN)
		5-6	VBUS signal on micro-USB connector J19 connects to K21_VREGIN to allow stand-alone USB operation
		6-8	VBUS signal from Tower Elevator connector connects to K21_VREGIN to allow USB operation with complete Tower System

SDHC card	J16	**OFF**	10K pulldown resistor is disconnected from CD/DATA3 line
		ON	10K pulldown resistor is connected to CD/DATA3 line to allow card detection
USB ID connection	J21	ON	Connect PTD7 to USB ID pin
		OFF	Disconnect PTD7 from USB ID pin
USB power enable	J22	**ON**	Connect PTC9 to USB power enable on power switch MIC2026
		OFF	Disconnect PTC9 from USB power enable on power switch MIC2026
USB over-current flag	J23	**ON**	Connect PTC8 to over-current flag on power switch MIC2026
		OFF	Disconnect PTC8 from over-current flag on power switch MIC2026
USB option selector	J24	**1-2**	USB micro J19
		2-3	USB mini J14 on TWR-SER
General Purpose TWRPI V_BRD power enable	J10	**ON**	Connect on-board 1.8 V or 3.3 V supply (V_BRD) to TWRPI 3-V power (GPT_VBRD)
		OFF	Disconnect from-board 1.8 V or 3.3 V supply (V_BRD) to TWRPI 3-V power (GPT_VBRD)
Accelerometer IRQ connection	J18	**1-2**	Connect PTB0 to INT1 pin of accelerometer
		3-4	Connect PTB1to INT2 pin of accelerometer
		OFF	Disconnect PTB0 and/or PTB1 from INT1 and/or INT2 of accelerometer
Potentiometer connection	J12	**ON**	Connect potentiometer to ADC0_SE12
		OFF	Disconnect potentiometer from ADC0_SE12
GPIO RESET_OUT_B Connection	J13	**1-2**	Connect PTA14 to RESET_OUT_B signal
		2-3	Connect PTA17 to RESET_OUT_B signal
		OFF	Leave RESET_OUT_B signal disconnected
LED connections	J15	**1-2**	Connect PTD4 to green LED (D5)
		3-4	Connect PTD5 to yellow LED (D6)
		5-6	Connect PTD6 to red LED (D8)
		7-8	Connect PTD7 to blue LED (D9)
		OFF	Disconnect PTD[4:7] from associated LED

8 Useful links

- www.freescale.com
  - www.freescale.com/Kinetis
  - www.freescale.com/TWR-K21F120M
  - www.freescale.com/codewarrior
- www.iar.com/freescale
- www.pemicro.com
  - http://www.pemicro.com/osbdm
  - OSBDM/OSJTAG Virtual Serial Toolkit
- www.segger.com
  - http://www.segger.com/jlink-flash-download.html

Revision History

Revision	Date	Description
1.0	July, 2013	Initial Release

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TWR-K21F120M-UM
Rev. 1.0
07/2013