

TWR-K24F120M Tower Module User's Guide

1 TWR-K24F120M

The TWR-K24F120M 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 freescale.com/tower for additional Tower System microcontroller modules and compatible peripherals.

2 Contents

The TWR-K24F120M contents include:

- TWR-K24F120M board assembly
- Two A to micro-B USB cables — one for debug interface/power and one for the processor's USB port
- Quick start guide

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TWR-K24F120M features

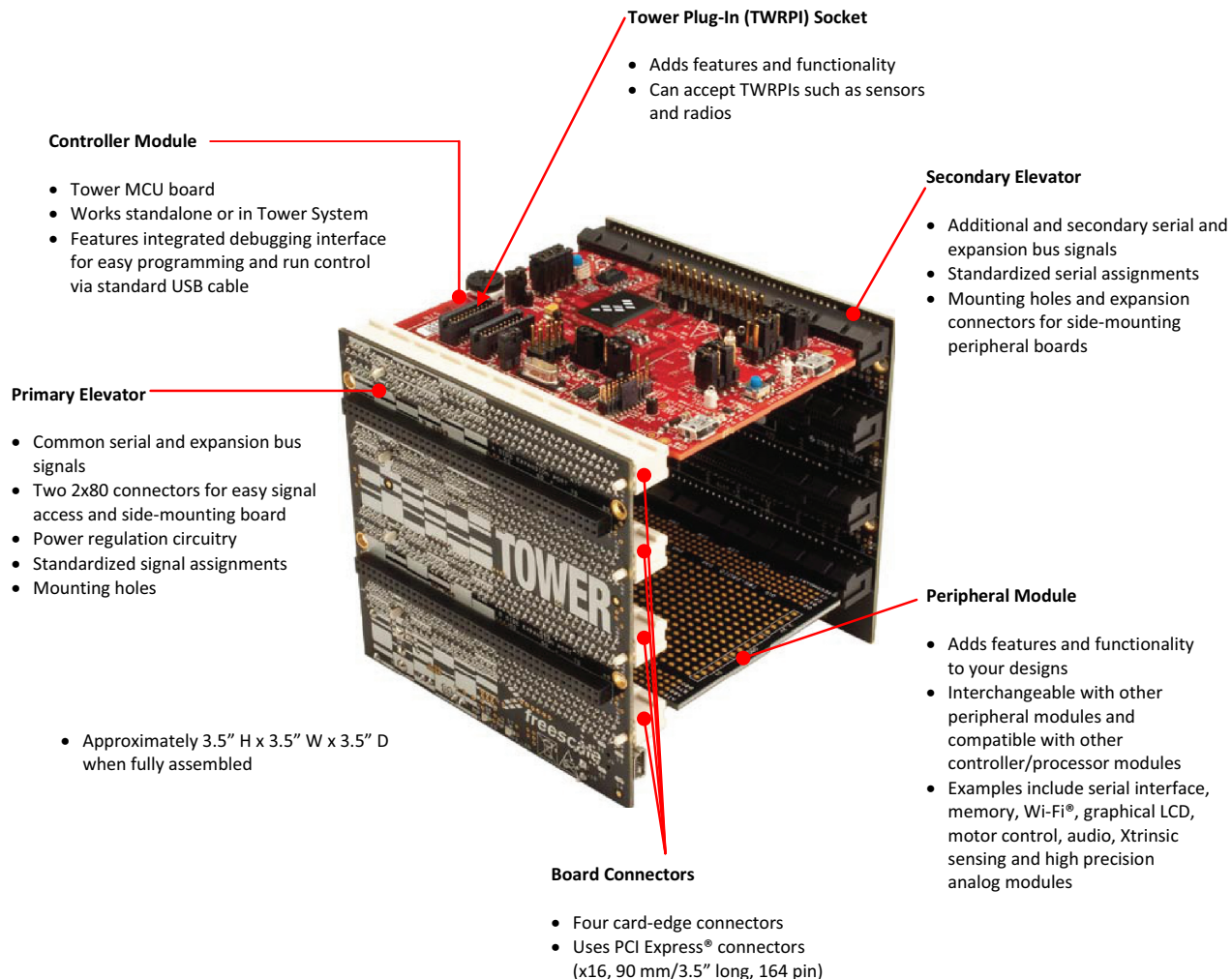


Figure 1. Freescale Tower system overview

3 TWR-K24F120M features

- Tower-compatible microcontroller module
- K24FN256VDC12 MCU (120 MHz, 256 KB flash memory, 256 KB RAM, low power, 121 MAPBGA thin-profile package)
- Dual-role USB interface with micro-AB USB connector
- General-purpose Tower Plug-in (TWRPI) socket
- Onboard debug circuit: K20DX128VFM5 OpenSDA with virtual serial port
- Three-axis combination accelerometer and magnetometer (FXOS8700CQ)
- On-board Freescale SGTL5000 audio codec
- 16 Mbit SPI serial flash memory
- Li-Ion battery charging circuit (battery not included)
- Four (4) user-controllable LEDs plus RGB LED

- Two (2) user push button switches for GPIO interrupts
- One (1) user push button switch for MCU reset
- Potentiometer
- Independent, battery-operated power supply for real-time clock (RTC) module

4 Get to know the TWR-K24F120M

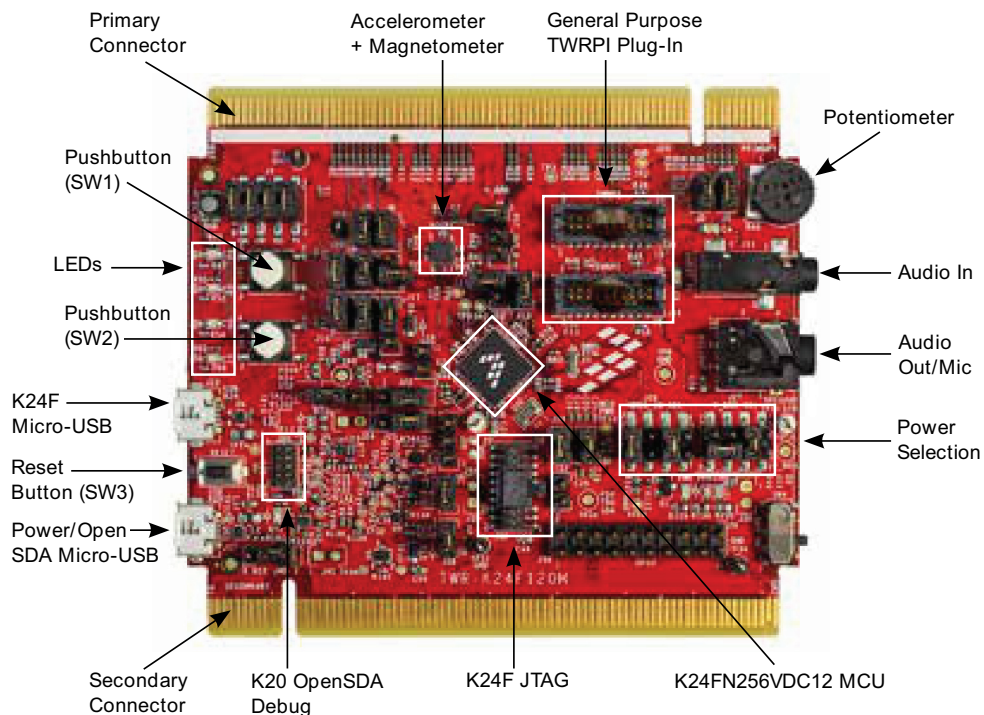


Figure 2. Front side of TWR-K24F120M module (TWRPI devices not shown)

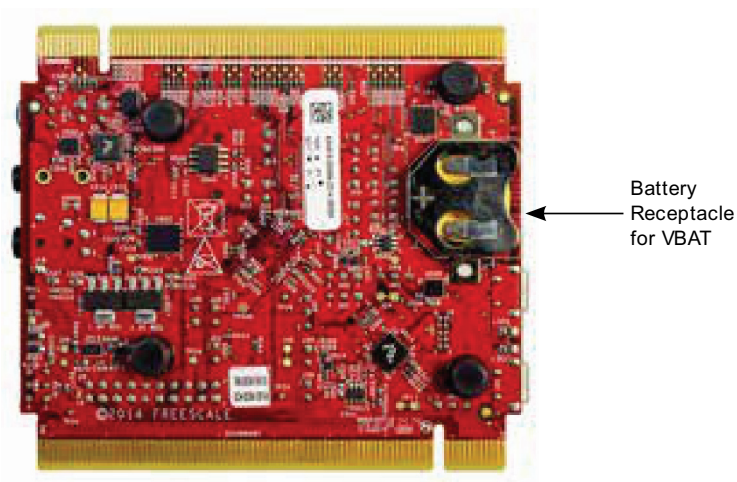


Figure 3. Back side of TWR-K24F120M

5 Reference documents

The documents listed below should be referenced for more information on the Kinetis K series, Tower system, and MCU modules. These can be found in the documentation section of freescale.com/kinetis.

- TWR-K24F120M-SCH: Schematics
- K24P121M120SF5RM: Reference Manual
- Tower Mechanical Drawing (TWR-MECHDRW.pdf)

6 Hardware description

The TWR-K24F120M is a Tower MCU Module featuring the K24FN256VDC12 — a Kinetis K series microcontroller in a thin profile 121 MAPBGA package with a USB 2.0 full-speed on-the-go (OTG) controller, and a real-time clock with an independent battery supply. It is intended for use in the Freescale Tower System but can also operate stand-alone. An on-board OpenSDA debug circuit provides a Serial Wire Debug (SWD) interface and a power supply input through a single micro-USB connector.

6.1 Block diagram

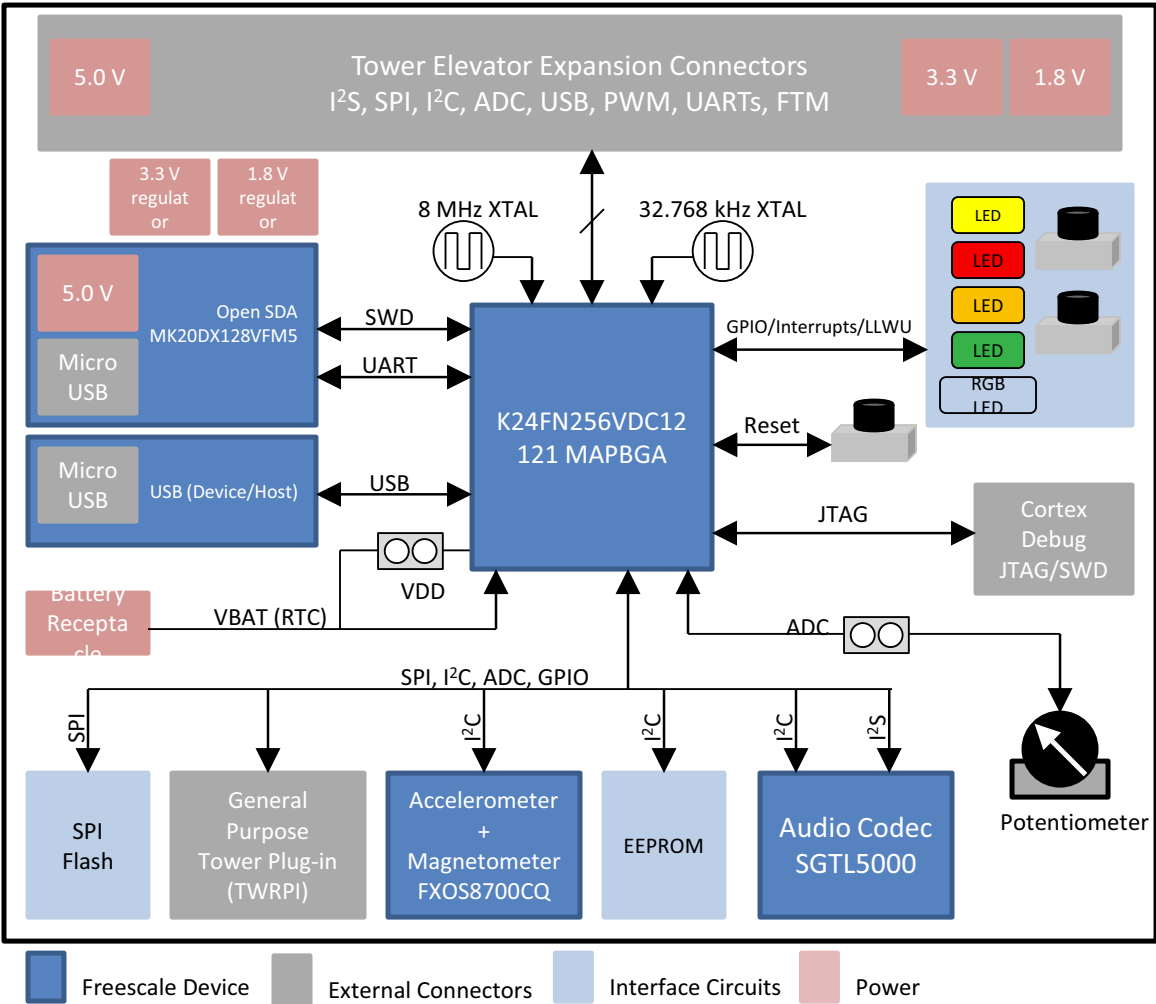


Figure 4. Block diagram of TWR-K24F120M

6.2 Microcontroller

The TWR-K24F120M features the K24FN256VDC12 MCU. This 120 MHz microcontroller is part of the Kinetis K2x family and is implemented in a thin profile 121 MAPBGA package. [Table 1](#) notes some of the features of the K24FN256VDC12 MCU.

Table 1. Features of MK24FN256VDC12

| Feature | Description |
|----------------------------------|---|
| Ultra-low-power | <ul style="list-style-type: none"> • 10 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 three internal modules and 16 pins as wake-up sources in low-leakage stop (LLS) and very low-leakage stop (VLLS) modes • Low-power timer for continual system operation in reduced power states |
| Flash and SRAM | <ul style="list-style-type: none"> • 256 KB of flash memory featuring fast access times, high reliability, and four levels of security protection • 256 KB of SRAM • No user or system intervention to complete programming and erase functions, and full operation down to 1.71 V • Pre-programmed Kinetis flash loader for one-time, in-system factory programming¹ |
| Mixed-signal capability | <ul style="list-style-type: none"> • High-speed 16-bit ADC with configurable resolution • Single or differential output modes for improved noise rejection • 500 ns conversion time achievable with programmable delay block triggering • Two high-speed comparators providing fast and accurate motor over-current protection by driving PWMs to a safe state • Analog voltage reference provides an accurate reference to analog blocks and replaces external voltage references to reduce system cost |
| Performance | <ul style="list-style-type: none"> • 120-MHz ARM® Cortex®-M4F core with DSP and FPU instruction set, single cycle MAC, and single instruction multiple data (SIMD) extensions • Up to 16 channel DMA for peripheral and memory servicing with reduced CPU loading and faster system throughput • Crossbar switch enables concurrent multi-master bus accesses, increasing bus bandwidth |
| Timing and control | <ul style="list-style-type: none"> • Up to four FlexTimers (FTM) with a total of 20 channels • Hardware dead-time insertion and quadrature decoding for motor control • Four-channel 32-bit periodic interrupt timer (PIT) provides time base for RTOS task scheduler, or trigger source for ADC conversion and programmable delay block |
| Connectivity and communications | <ul style="list-style-type: none"> • Full-speed USB device/Host/On-The-Go • USB low-voltage regulator that supplies up to 120 mA off chip at 3.3 V to power external components from 5 V input • Four UARTs: <ul style="list-style-type: none"> – one UART that supports RS-232 with flow control, RS-485, and ISO-7816 – two UARTs that support RS-232 with flow control and RS-485 – one low-power UART (LPUART) • One inter-IC sound (I²S) serial interface for audio system interfacing • Two DSPI modules and two I²C modules |
| Reliability, safety and security | <ul style="list-style-type: none"> • 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 time-out occurs |

¹ The MCU populated on the TWR-K24F120M comes pre-programmed with an out-of-box demo, so the flash loader is not present. To find out more information about the flash loader and how to restore it, visit freescale.com/kboot.

6.3 Clocking

Kinetis K Series 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 32 MHz. An 8 MHz crystal is the default external source for the MCGoscillator 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 K24FN256VDC12 include the CLKIN0 signal, which can be provided through the TWR-ELEV module or pin 20 of TWRPI connector J4.

6.4 System power

When installed into a Tower System, the TWR-K24F120M can be powered from either an on-board source or from another source in the assembled Tower System.

In standalone operation, the main power source (5.0 V or 4.2 V) for the TWR-K24F120M module is derived from one of three sources:

- OpenSDA USB micro-B connector (J37)
- K22FN512VDC12 USB micro-AB connector (J32)
- Li-ion battery (J36) — not installed by default

Two low-dropout regulators provide 3.3 V and 1.8 V supplies from the 5.0 V or 4.2 V input voltage. Additionally, the 3.3 V USB 120 mA regulator built into the K22FN512VDC12 MCU can be selected to power the 3.3 V bus. All of the user-selectable options can be configured using two headers, J28 and J27. Refer to sheet 4 of the TWR-K24F120M schematics and [Section 7, “TWR-K24F120M jumper options”](#) for more details.

6.5 RTC VBAT

The Real Time Clock (RTC) module on the K24FN256VDC12 has two modes of operation: system power-up and system power-down. During system power-down, the RTC are powered from the backup power supply (VBAT) and electrically isolated from the rest of the MCU. The TWR-K24F120M provides a battery receptacle for a coin cell battery that can be used as the VBAT supply. This receptacle can accept common 3 V lithium coin cell batteries that are 20 mm in diameter.

6.6 Debug interface

There are two debug interface options provided: the on-board OpenSDA circuit and an external ARM Cortex JTAG connector. The ARM Cortex JTAG connector (J32) is a standard 2 × 10-pin connector that provides an external debugger cable access to the JTAG interface of the K24FN256VDC12. Alternatively, the on-board OpenSDA debug interface can be used to access the debug interface of the K24FN256VDC12.

6.6.1 OpenSDAv2

An on-board K20DX128VFM5-based OpenSDAv2 circuit provides an SWD debug interface to the K24FN256VDC12. A standard USB A male to micro-B male cable (provided) can be used for debugging via the USB connector (J37).

The OpenSDA circuit on the TWR-K24F120M board is programmed with the OpenSDAv2.1 bootloader. The bootloader can be used to program the OpenSDA circuit with different debugging applications. By default the board is programmed with the OpenLINK application, which includes a CMSIS-DAP debugging interface, an mbed serial port, and drag-and-drop programming capability. Drivers for USB to serial bridge functionality are provided by mbed. Installation directions and a link to the latest driver can be found at mbed.org/handbook/Windows-serial-configuration.

6.6.2 Cortex debug connector

The Cortex debug connector is a 20-pin (0.05") connector providing access to the SWD, JTAG, cJTAG, and EzPort signals available on the K24 device. The pinout and K24 pin connections to the debug connector (J32) are shown in [Table 2](#).

Table 2. Cortex debug connector

| Pin | Function | TWR-K24F120M connection |
|-----|--------------|--|
| 1 | VTref | 3.3 V MCU supply (MCU_PWR) |
| 2 | TMS / SWDIO | PTA3/UART0_RTS_b/FTM0_CH0/JTAG_TMS/SWD_DIO |
| 3 | GND | GND |
| 4 | TCK / SWCLK | PTA0/UART0_CTS_b/FTM0_CH5/JTAG_CLK/SWD_CLK/EZP_CLK |
| 5 | GND | GND |
| 6 | TDO / SWO | PTA2/UART0_TX/FTM0_CH7/JTAG_TDO/TRACE_SWO/EZP_DO |
| 7 | Key | — |
| 8 | TDI | PTA1/UART0_RX/FTM0_CH6/JTAG_TDI/EZP_DI |
| 9 | GNDDetect | PTA4/LLWU_P3/FTM0_CH1/NMI_b/EZP_CS_b (via R567 - not populated by default) |
| 10 | nRESET | RESET_b |
| 11 | Target Power | 5 V supply (via jumper J6) |
| 12 | — | NC |
| 13 | Target Power | 5 V supply (via jumper J6) |
| 14 | — | NC |
| 15 | GND | GND |
| 16 | — | NC |
| 17 | GND | GND |
| 18 | — | NC |

Table 2. Cortex debug connector (continued)

| Pin | Function | TWR-K24F120M connection |
|-----|----------|-------------------------|
| 19 | GND | GND |
| 20 | — | NC |

6.7 Accelerometer and magnetometer

An FXOS8700CQ digital accelerometer and magnetometer is connected to the K24FN256VDC12 MCU through an I²C interface (I²C0) and GPIO/IRQ signals (PTE24 and PTE25).

6.8 Audio codec

A Freescale SGTL5000 audio codec is connected to the K24FN256VDC12 MCU. The I²C0 signals are used as the configuration channel (PTE24 and PTE25). I²S0 is used as for the audio data interface (PTC5, PTC1, PTB19, PTB18, and PTC8).

NOTE

The audio codec requires 3.3 V for proper operation. If the board is using a 1.8 V supply for V_BRD, then you should not attempt to use the audio codec. J2 should be removed so that the codec will not be powered by an out of spec voltage when V_BRD is 1.8 V.

6.9 SPI flash memory

The TWR-K24F120M includes a 16 Mbit AT45DB161E SPI flash memory. The memory is connected to the K24FN256VDC12 MCU using SPI1 with SPI_CS0 as the chip select. The signals used are PTB16, PTB11, PTB10, and PTB17.

6.10 Potentiometer, push buttons, LEDs

The TWR-K24F120M also features:

- A potentiometer connected to an ADC input signal (ADC0_SE12)
- Two push button switches (SW1 and SW2 connected to PTC7 and PTC6/LLWU_P10 respectively)
- Four user-controllable LEDs connected to GPIO signals (optionally isolated using jumpers):
 - Yellow LED (D7) to PTD4
 - Red LED (D4) to PTD5
 - Orange LED (D3) to PTD6
 - Yellow/Green LED (D2) to PTD7
- RGB LED (R60, R50, and R44 should be populated to use the RGB LED)

6.11 General Purpose Tower plug-in (TWRPI) socket

The TWR-K22F120M features sockets (J5 and J6) 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

| J14 | | J4 | |
|-----|----------------------|-----|-------------------------------------|
| Pin | Description | Pin | Description |
| 1 | 5 V VCC | 1 | GND |
| 2 | V_BRD (3.3V or 1.8V) | 2 | GND |
| 3 | GND | 3 | I2C: SCL |
| 4 | 3.3 V VDDA | 4 | I2C: SDA |
| 5 | VSS (Analog GND) | 5 | GND |
| 6 | VSS (Analog GND) | 6 | GND |
| 7 | VSS (Analog GND) | 7 | GND |
| 8 | ADC: Analog 0 | 8 | GND |
| 9 | ADC: Analog 1 | 9 | SPI: MISO |
| 10 | VSS (Analog GND) | 10 | SPI: MOSI |
| 11 | VSS (Analog GND) | 11 | SPI: SS |
| 12 | ADC: Analog 2 | 12 | SPI: CLK |
| 13 | VSS (Analog GND) | 13 | GND |
| 14 | VSS (Analog GND) | 14 | GND |
| 15 | GND | 15 | GPIO: GPIO0/IRQ |
| 16 | GND | 16 | GPIO: GPIO1/IRQ |
| 17 | ADC: TWRPI ID 0 | 17 | UART: UART_RX or GPIO: GPIO2 |
| 18 | ADC: TWRPI ID 1 | 18 | UART: UART_TX or GPIO: GPIO3 |
| 19 | GND | 19 | UART: UART_CTS or GPIO: GPIO4/Timer |
| 20 | Reset | 20 | UART: UART_RTS or GPIO: GPIO5/Timer |

6.12 USB

The K24FN256VDC12 features a full-speed/low-speed USB module with OTG/Host/Device capability and built-in transceiver. The TWR-K24F120M routes the USB D+ and D– signals from the K24FN256VDC12 MCU to a switch that can be used to route the signals to the on-board micro-USB connector (J23) or to the Tower primary elevator connector (J20A).

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 K24FN256VDC12 is operating in host mode. PTB22 is connected

to the flag output signal and PTB23 is used to drive the enable signal. Both PTB22 and PTB23 port pins can be isolated with jumpers (J16 and J15, respectively) if needed.

7 TWR-K24F120M jumper options

The following is a list of all of the jumper options on the TWR-K24F120M. The default installed jumper settings are indicated by in [Figure 5](#), and in gray text on a black background in [Table 4](#) below.

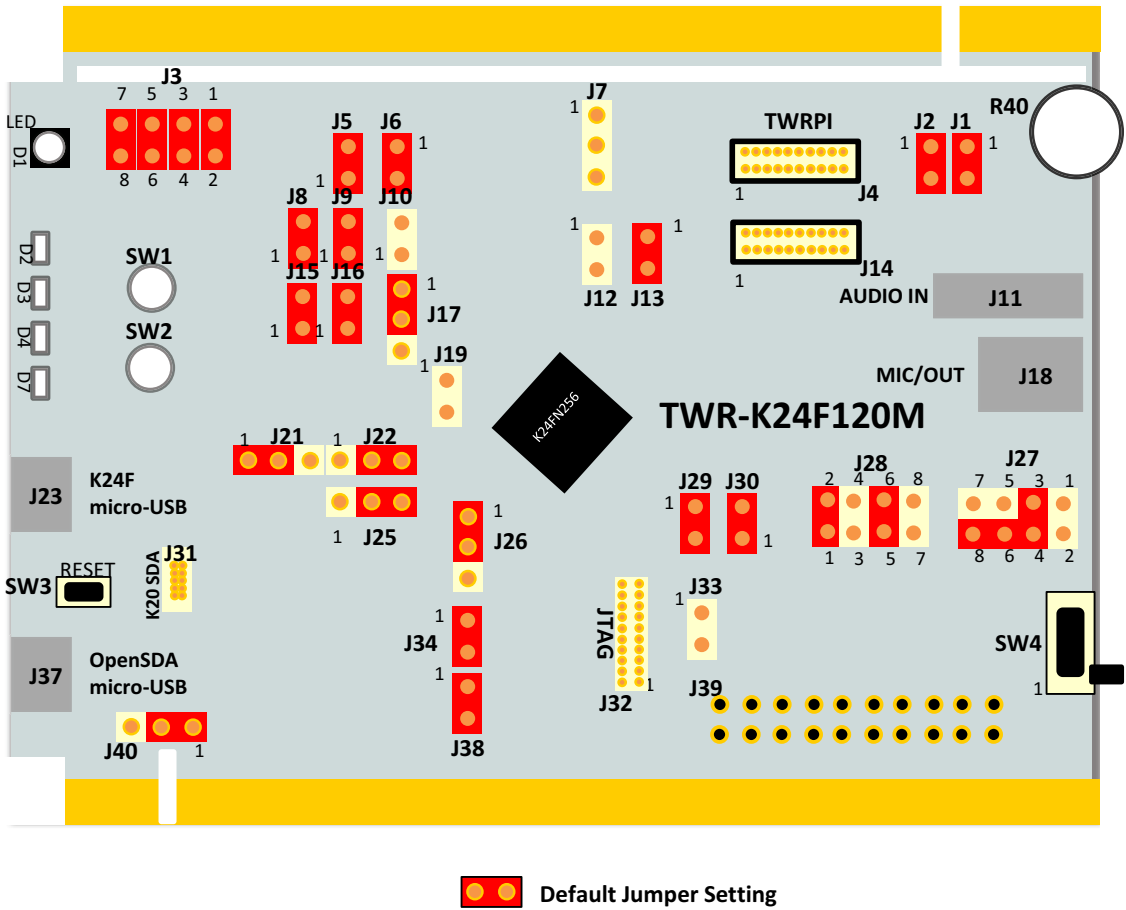


Figure 5. TWR-K24F120M jumper locations

Table 4. TWR-K24F120M jumper options

| Option | Jumper | Setting | Description |
|--------------------|--------|---------|--|
| Debug Target Power | J33 | ON | Connect P5V_SDA to target power |
| | | OFF | Disconnect P5V_SDA from target power |
| Enable USB Power | J15 | ON | Connect PTB23 to USB power enable on power switch MIC2026 |
| | | OFF | Disconnect PTB23 from USB power enable on power switch MIC2026 |

Table 4. TWR-K24F120M jumper options (continued)

| Option | Jumper | Setting | Description |
|--------------------------------|--------|-----------|--|
| USB ID Connection | J19 | ON | Connect PTD7 to USB ID pin |
| | | OFF | Disconnect PTD7 from USB ID pin |
| USB over-current flag | J16 | ON | Connect PTB22 to over-current flag on power switch MIC2026 |
| | | OFF | Disconnect PTB22 from over-current flag on power switch MIC2026 |
| USB switch | J21 | 1-2 | Connect MCU USB0_DP and USB0_DM pins to micro-USB connector (J23) |
| | | 2-3 | Connect MCU USB0_DP and USB0_DM pins to Tower Elevator |
| VREGIN input to processor | J26 | 1-2 | Connect P5V0_VREGIN_K24 to MCU VREGIN pin |
| | | 2-3 | Connect on-board regulator output P3V3_REG to MCU VREGIN pin |
| P5V0_VREGIN_K24 selection | J28 | 5-6 | 5 V MCU input from on-board USB connector (J23) |
| | | 6-8 | 5 V MCU input from tower USB VBUS |
| | | 4-6 & 1-3 | 5 V from OpenSDA USB/TWR 5 V (P5V_TRG_SDA) |
| 3.3V regulator input selection | J28 | 1-2 | 5 V from OpenSDA USB/TWR 5 V (P5V_TRG_SDA) |
| | | 3-5 & 2-4 | 5 V power from on-board USB connector (J23) |
| MCU power selection | J27 | 3-4 | 3.3 V from regulator |
| | | 1-3 | VOUT_3V3 (from MCU) |
| | | 3-5 | 1.8 V from regulator |
| Rechargeable battery selection | J27 | 6-8 | Rechargeable battery powers input to 3.3 V regulator |
| | | 4-6 | Rechargeable battery powers input to 1.8 V regulator |
| MCU VDD current measurement | J30 | ON | Connect V_BRD to MCU_PWR |
| | | OFF | Allow current measurement on MCU VDD |
| VDDA and VREFH Power | J29 | ON | Connect V_BRD to VDDA and VREFH |
| | | OFF | Disconnect V_BRD from VDDA and VREF |
| VBAT Power | J17 | 1-2 | Connect VBAT to MCU_PWR |
| | | 2-3 | Connect VBAT to the higher voltage between MCU_PWR and coin-cell battery (P3V0_COINCELL) |

Table 4. TWR-K24F120M jumper options (continued)

| Option | Jumper | Setting | Description |
|---|--------|---------|---|
| LED Connections | J3 | 1-2 | Connect PTD4 to Yellow LED D7 |
| | | 3-4 | Connect PTD5 to Red LED D4 |
| | | 5-6 | Connect PTD6 Orange LED D3 |
| | | 7-8 | Connect PTD7 Yellow/Green LED D2 |
| TWRPI Current Measurement | J13 | ON | Connect V_BRD to TWRPI 3 V power (GPT_VBRD) |
| | | OFF | Disconnect V_BRD from TWRPI 3 V power (GPT_VBRD) |
| Accelerometer/Magnetometer I ² C SCL Connection | J5 | ON | Connect PTE24 to I2C_SCL_SNSR |
| | | OFF | Disconnect PTE24 from I2C_SCL_SNSR |
| Accelerometer/Magnetometer I ² C SDA Connection | J6 | ON | Connect PTE25 to I2C_SDA_SNSR |
| | | OFF | Disconnect PTE25 from I2C_SDA_SNSR |
| Accelerometer/Magnetometer I ² C Slave Address SA0 | J9 | ON | Pull accelerometer/magnetometer SA0 low |
| | | OFF | Pull accelerometer/magnetometer SA0 high |
| Magnetometer Slave Address SA1 | J8 | ON | Pull magnetometer SA1 high |
| | | OFF | Pull magnetometer SA1 low (also used for accelerometer GND) |
| Accelerometer/Magnetometer I ² C Interrupt 1 | J12 | ON | Connect PTB0 to INT1 |
| | | OFF | Disconnect PTB0 from INT1 |
| Accelerometer/Magnetometer I ² C Interrupt 2 | J10 | ON | Connect PTB1 to INT2 |
| | | OFF | Disconnect PTB1 from INT2 |
| Potentiometer Enable | J1 | ON | Connect PTB2 to POT_5K |
| | | OFF | Disconnect PTB2 from POT_5K |
| Reset push button | J40 | 1-2 | Connect SW3 to SDA_RST_TGTMCU_J_B |
| | | 2-3 | Connect SW3 to RST_TGTMCU_B |
| SWD_DIO Isolation | J38 | ON | Connect SWD_DIO_TGTMCU_BUF to SWD_DIO_TGTMCU |
| | | OFF | Disconnect SWD_DIO_TGTMCU_BUF from SWD_DIO_TGTMCU |

Table 4. TWR-K24F120M jumper options (continued)

| Option | Jumper | Setting | Description |
|-----------------------|--------|---------|---|
| SWD_CLK Isolation | J34 | ON | Connect SWD_CLK_TGTMCU_BUF to SWD_CLK_TGTMCU |
| | | OFF | Disconnect SWD_CLK_TGTMCU_BUF from SWD_CLK_TGTMCU |
| UART RX Selection | J25 | 1-2 | Connect UART1_RX_TGTMCU to UART1_RX_ELEV_BUF (Tower Elevator) |
| | | 2-3 | Connect UART1_RX_TGTMCU to UART1_RX_TGTMCU_BUF (OpenSDA) |
| UART TX Selection | J22 | 1-2 | Connect UART1_TX_TGTMCU to UART1_TX_ELEV_BUF (Tower Elevator) |
| | | 2-3 | Connect UART1_TX_TGTMCU to UART1_TX_TGTMCU_BUF (OpenSDA) |
| RESET_OUT_B Selection | J7 | 1-2 | Connect Tower Elevator RESET_OUT_B to PTA14 |
| | | 2-3 | Connect Tower Elevator RESET_OUT_B to PTA17 |

8 Useful links

- freescale.com
 - freescale.com/Kinetis
 - freescale.com/ksdk (Kinetis Software Development Kit)
 - freescale.com/mqx (MQX RTOS)
 - freescale.com/kds (Kinetis Design Studio IDE)
 - freescale.com/kboot (Kinetis Flash loader)
- iar.com/freescale
- mbed.org
 - mbed.org/handbook/Windows-serial-configuration
- segger.com
 - segger.com/jlink-flash-download.html

9 Revision history

Table 5. Document revision history

| Revision | Date | Description |
|----------|-----------|------------------|
| 1.0 | Sept 2014 | Initial release. |

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