



TWR-K20D50M Tower Module

User's Manual
TWR-K20D50M-UM
Rev. 1.1

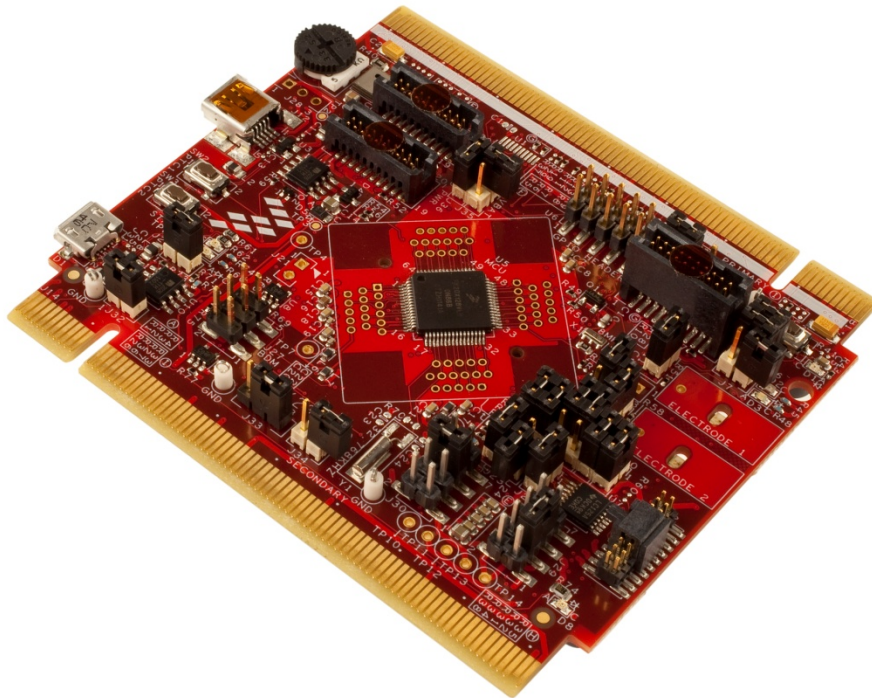


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1 TWR-K20D50M

The TWR-K20D50M 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-K20D50M specific information and updates visit www.freescale.com/TWR-K20D50M

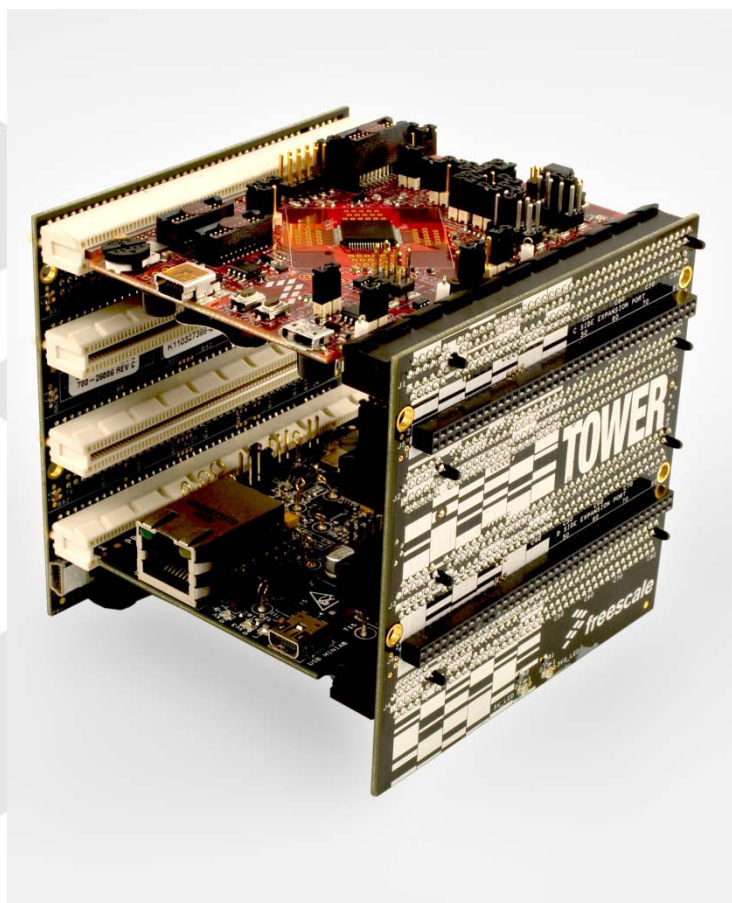


Figure 1 Freescale Tower System Overview

2 Contents

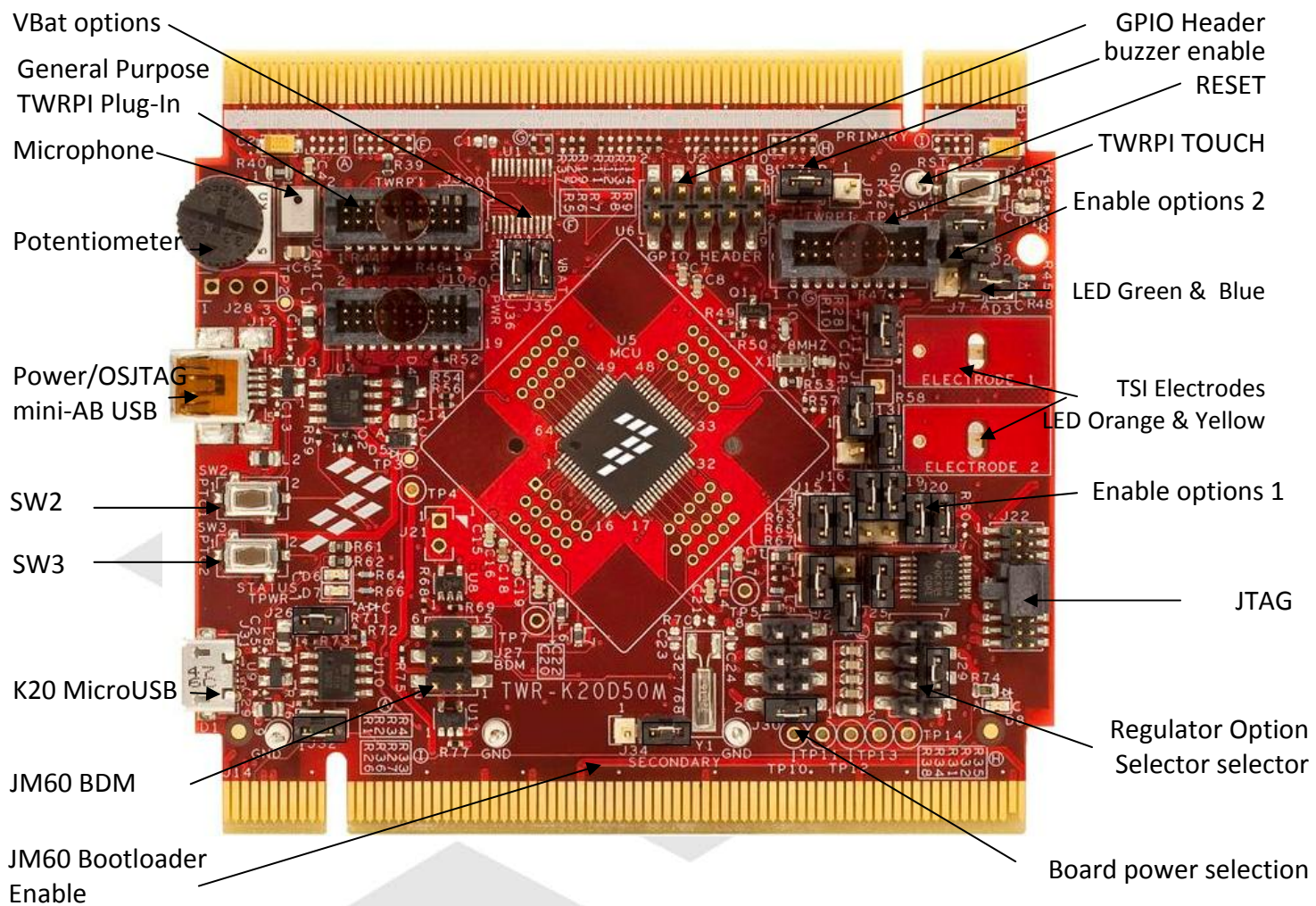
The TWR-K20D50M contents include:

- TWR-K20D50M board assembly
- 3ft A to mini-B USB cable for debug interface and power
- 3ft A to micro-B USB cable for MK20DX128VLH5 USB interface
- Micro-B to A adapter for MK20DX128VLH5 USB Host applications
- Quick Start Guide

3 TWR-K20D50M Features

- Tower compatible microcontroller module
- MK20DX128VLH5 MCU (50 MHz, 128KB Flash, 16 KB RAM, 32 KB FlexNVM, Low power, 64LQFP package)
- Dual role USB interface with Micro-AB USB connector
- Touch Tower Plug-in Socket
- 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) capacitive touch pads
- Two (2) user pushbutton switch
- Infrared transmit and receive
- Potentiometer
- Microphone (ADC)
- Buzzer
- Battery backup for RTC

4 Get to Know the TWR-K20D50M



**Figure 2 Front side of TWR-K20D50M module
(TWRPI devices not shown)**

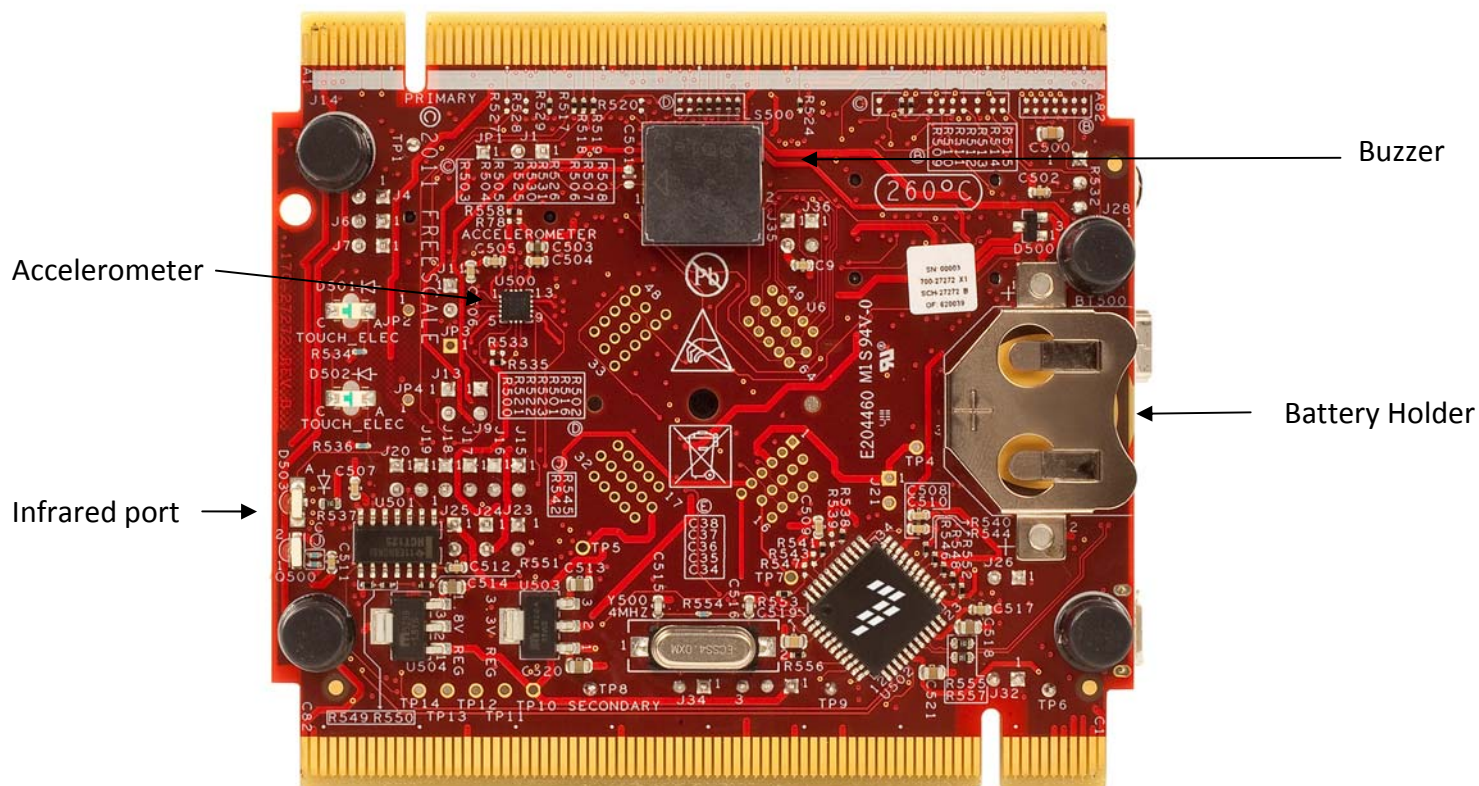


Figure 3 Back side of TWR-K20D50M

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-K20D50M> or <http://www.freescale.com/kinetis>

- TWRK20D50MQSG: Quick Start Guide
- TWR-K20D50M-SCH: Schematics
- TWR-K20D50M-PWA: Design Package
- K20P64M50SF0RM Reference Manual
- Tower Configuration Tool
- Tower Mechanical Drawing

6 Hardware description

The TWR-K20D50M is a Tower MCU Module featuring the MK20DX128VLH5—a Kinetis microcontroller with USB 2.0 full-speed OTG controllers in a 64 LQFP package. It is intended for use in the Freescale Tower System but can operate stand-alone. An on-board debug circuit, OSJTAG, provides a JTAG interface and a power supply input through a single USB mini-AB connector.

The block diagram of the TWR-K20D50M board is presented in the following figure:

6.1 Block Diagram

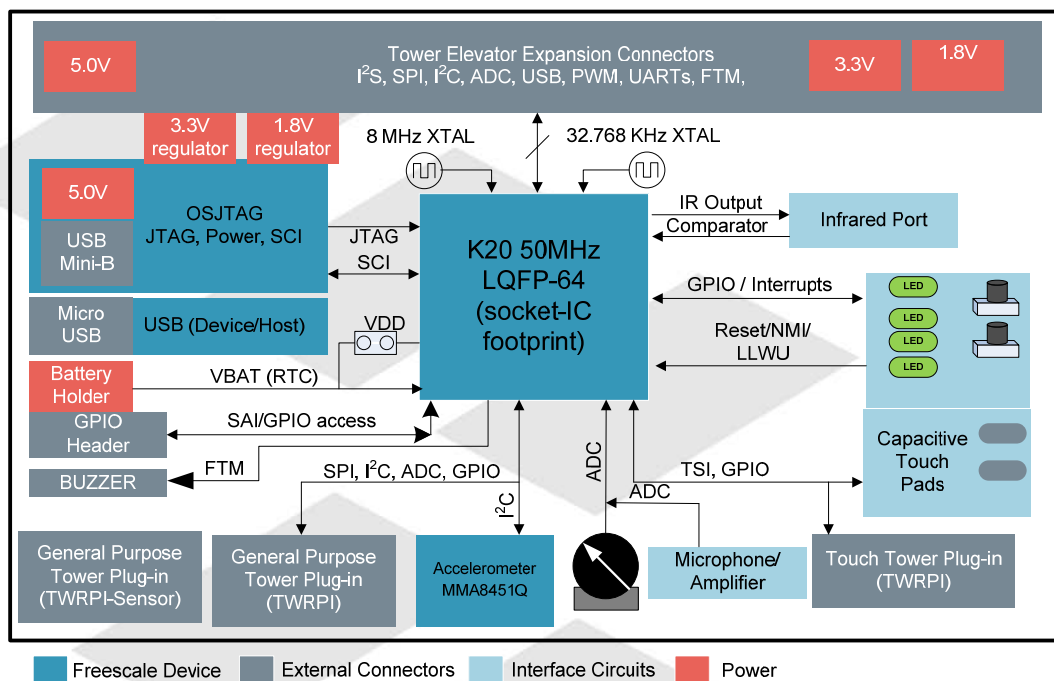


Figure 4 Block Diagram of TWR-K20D50M

6.2 Microcontroller

The TWR-K20D50M features the MK20DX128VLH5. This 50 MHz microcontroller is part of the Kinetis K20 family and is available in a 64 LQFP package. The following table notes the features of MK20DX128VLH5.

Table 1 Features of MK20DX128VLH5

Feature	Description
Ultra low power	<ul style="list-style-type: none"> -11 low-power modes with power and clock gating for optimal peripheral activity and recovery times. Stop currents of <190 nA (VLLS0), run currents of <280 uA/MHz, 4 μs wake-up from Stop mode -Full memory and analog operation down to 1.71V for extended battery life -Low-leakage wake-up unit with up to eight 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, SRAM and FlexMemory	<ul style="list-style-type: none"> -32 KB-128 KB flash featuring fast access times, high reliability, and four levels of security protection -16 KB of SRAM -2 KB of FlexMemory (user-segmentable byte write/erase EEPROM for data tables/system data) -EEPROM with over 10M cycles and flash with 70 μsec write time (brownouts without data loss or corruption) -No user or system intervention to complete programming and erase functions and full operation down to 1.71V -FlexNVM adds up 32 KB for extra program code, data or EEPROM backup
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 -Optional 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"> -50 MHz ARM Cortex-M4 core with DSP 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

<p>Timing and Control</p>	<ul style="list-style-type: none"> -Two FlexTimers with a total of 10 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
<p>Human-Machine Interface</p>	<ul style="list-style-type: none"> -Hardware touch-sensing interface (TSI) with up to 16 inputs -TSI operates in low power modes (minimum current added when enabled) -TSI hardware implementation avoids software polling methods -High sensitivity level allows use of overlay surfaces up to 5 mm thick.
<p>Connectivity and Communications</p>	<ul style="list-style-type: none"> -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 -Three UARTs (one UART supports RS232 with flow control, RS485, ISO7816 and IrDA while the other two UARTS support RS232 with flow control and RS485) -One Inter-IC Sound (I2S) serial interface for audio system interfacing -One DSPI module and one I2C module
<p>Reliability, Safety and Security</p>	<ul style="list-style-type: none"> -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 -Independent-clocked computer operating properly (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 -This product is 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 (EXTALO/XTALO) 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.

6.4 System Power

When installed into a Tower System, the TWR-K20D50M 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 (5.0V) for the TWR-K20D50M module is derived from either the OSJTAG USB mini-B connector (J12) or the K20DX128VLH5 USB micro-AB connector (J31). Two low-dropout regulators provide 3.3V and 1.8V supplies from the 5.0V input voltage. Additionally, the 3.3V regulator built into the K20DX128VLH5 can be selected to power the 3.3V bus. All the user selectable options can be configured using two headers, J29 and J30. Refer to sheet 5 of the TWR-K40X256 schematics for more details.

6.5 Real Time Clock (RTC)

The Real Time Clock (RTC) module on the K20 has two modes of operation, system power-up and system power-down. In system power-up mode, the RTC may be powered by either the MCU regulator or the backup power supply, VBAT. During system power-down, the RTC is only powered from the backup power supply, VBAT. The TWR-K20D50M provides a battery holder for a coin cell battery that can be used as the VBAT supply. The holder can accept common 20mm diameter 3V 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.

6.6.1 OSJTAG

An on-board MC9S08JM60 based Open Source JTAG (OSJTAG) circuit provides a JTAG debug interface to the K20DX128. A standard USB A male to mini-B male cable (provided) can be used for debugging via the USB connector, J12. 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>.

6.6.2 Cortex Debug +ETM Connector

The Cortex Debug +ETM connector is a standard 2x10-pin (0.05") connector providing an external debugger cable with access to the SWD, JTAG, cJTAG, and EzPort interfaces of the K20DX128VLH5. Alternatively, the on-board OSJTAG debug interface can be used to access the debug interface of the K20DX128VLH5. The pinout of the debug connector, J22, is shown in following table.

Table 2 Cortex Debug connector

Pin	Function	TWR-K20D50M Connection
1	VTref	3.3V MCU supply (MCU_PWR)
2	TMS / SWDIO	PTA3/SCIO_RTS_b/FTM0_CH0/JTAG_MS/SWD_DIO
3	GND	GND
4	TCK / SWCLK	PTA0/SCIO_CTS_b/FTM0_CH5/JTAG_CLK/SWD_CLK/EZP_CLK
5	GND	GND
6	TDO / SWO	PTA2/SCIO_TX/FTM0_CH7/JTAG_DO/TRACE_SWO/EZP_DO
7	Key	—
8	TDI	PTA1/SCIO_RX/FTM0_CH6/JTAG_DI/EZP_DI
9	GNDDetect	PTA4/FTM0_CH1/MS/NMI_b/EZP_CS_b
10	nRESET	RESET_b
11	Target Power	5V supply (via J15)
12	TRACECLK	PTA6/FTM0_CH3/FB_CLKOUT/TRACE_CLKOUT
13	Target Power	5V supply (via J15)
14		
15	GND	GND
16		
17	GND	GND
18		
19	GND	GND
20		

Note: K20 50MHz family do not have trace port

6.7 Infrared Port

An infrared transmit and receive interface is implemented as shown in Figure 5. The CMT_IRO pin directly drives an infrared diode. The receiver uses an infrared phototransistor connected to an on-chip analog comparator through a low-pass filter. Internal to the K20D50M device, the output of the analog comparator can be routed to a UART module for easier processing of the incoming data stream.

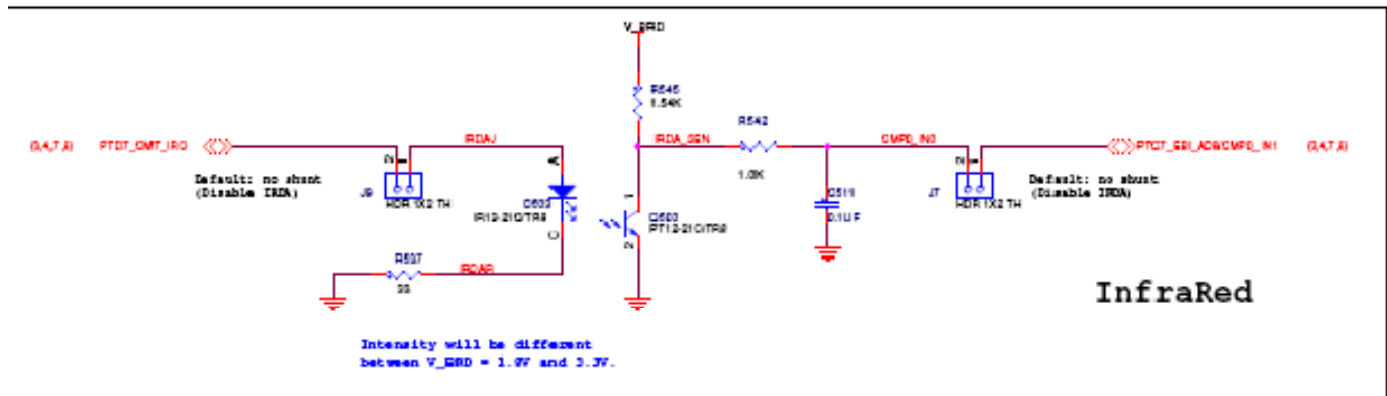


Figure 5 Infrared circuit

6.8 Accelerometer

An MMA8451Q digital accelerometer is connected to the K20DX128MCU through I2C module, I2C0, and GPIO/IRQ signals, PTB0 and PTB1. The MMA8451Q is a smart low-power, three-axis capacitive micromachined accelerometer with 14 bits of resolution. The device can be configured to generate inertial wake-up interrupt signals from any combination of the configurable embedded functions allowing the MMA8451Q to monitor events and remain in a low-power mode during periods of inactivity. For more information on the MMA8451Q, please visit the [MMA8451Q Product Summary Page](#).

6.9 Microphone

A microphone circuit is provided to allow sampling of audio data. A single-ended ADC signal (ADC0_DP3) is used to sample the value on the microphone IC output. Jumper, J16, is provided to isolate the ADC signal from the microphone so that it can be used for other purposes

6.10 General Purpose Tower Plug-in (TWRPI) Socket

The TWR-K20D50M features a socket (J3 and J10) that can accept a variety of different Tower Plug-in modules featuring sensors, RF transceivers, and more. 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 Table 1Table 3

Table 3 General Purpose TWRPI socket pinout

J10		J3	
Pin	Description	Pin	Description
1	5V VCC	1	GND
2	3.3 V VCC	2	GND
3	GND	3	I2C: SCL
4	3.3V 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	GPIO: GPIO2
18	ADC: TWRPI ID 1	18	GPIO: GPIO3
19	GND	19	GPIO: GPIO4/Timer
20	Reset	20	GPIO: GPIO5/Timer

6.11 Potentiometer, Pushbuttons, LEDs

The TWR-K20D50M features two pushbutton switches connected to GPIO/interrupt signals, one pushbutton connected to the master reset signal, two capacitive touch pad electrodes, four user-controllable LEDs, and a

potentiometer connected to an ADC input signal. Refer to Table 5 “I/O Connectors and Pin Usage Table” for information about which port pins are connected to these features.

6.12 Touch Interface

The touch sensing input (TSI) module of the K20DX128VLH5 MCUs provides capacitive touch sensing detection with high sensitivity and enhanced robustness. Each TSI pin implements the capacitive measurement of an electrode.

The TWR-K20D50M provides two methods for evaluating the TSI module. There are two electrodes on-board. Additionally, 12 TSI signals are connected to a Touch Tower Plug-in (TWRPI) socket (J5) that can accept Touch TWRPI daughter cards that may feature keypads, rotary dials, sliders, etc.

Table 4 Touch TWRPI socket pinout

Pin	Description
1	P5V_TRG_USB
2	3.3 V VCC *V_BRD
3	Electrode 0
4	3.3V VDDA
5	Electrode 1
6	VSS (Analog GND)
7	Electrode 2
8	Electrode 3
9	Electrode 4
10	Electrode 5
11	Electrode 6
12	Electrode 7
13	Electrode 8
14	Electrode 9
15	Electrode 10
16	Electrode 11
17	ADC: TWRPI ID 0
18	ADC: TWRPI ID 1
19	GND
20	Reset

6.13 USB

The K20DX128VLH5 features a full-speed/low-speed USB module with OTG/Host/Device capability and built-in transceiver. The TWR-K20D50M routes the USB D+ and D- signals from the K20DX128 MCU directly to the on-board USB connector (J31)

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 K20DX128 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 port pins can be isolated with jumpers J32 and J26 if needed.

7 TWR-K20D50M Jumper options

The following is a list of all the jumper options. The default installed jumper settings are shown in bold.

Note: Default Configuration, Board powered by OSJTAG USB, RTC powered by PWR_MCU

Jumper	Jumper designator	Signal	Jumper Option
V_BRD	J25	V_BRD	DEF: 1-2 VBRD to MCU_PWR
	J23	VDDA_HDR	DEF: 1-2 VDDA to MCU_PWR
VBAT	J35	VBATD Enable VBAT	DEF: 1-2
	J36	VBATD Enable MCU_PWR	DEF: 1-2
P5V_TRG_USB	J24	P5V_TRG_USB	DEF: open Disconnect target power of JTAG connector
JM60 Bootloader	J34	JM60 BOOTLOAD EN	open OSJTAG mode 1-2 JM60 bootloader mode
VREG IN SELECTOR	J30	VREG IN SELECTOR	DEF: 1-2 Regulator powered by OSJTAG USB 5-6 K20 USB power the K20 Regulator 8-6 TWR-USB power up the K20 Regulator

BOARD POWER SELECTION	J29	BOARD POWER SELECTION	DEF: 3-5 P3.3V_REG powers VBRD(MCU_PWR) 7-5 1.8V powers VBRD(MCU & Interface circuit input power) 1-2 K20 3.3 Regulator Output powers VBRD(MCU_PWR)
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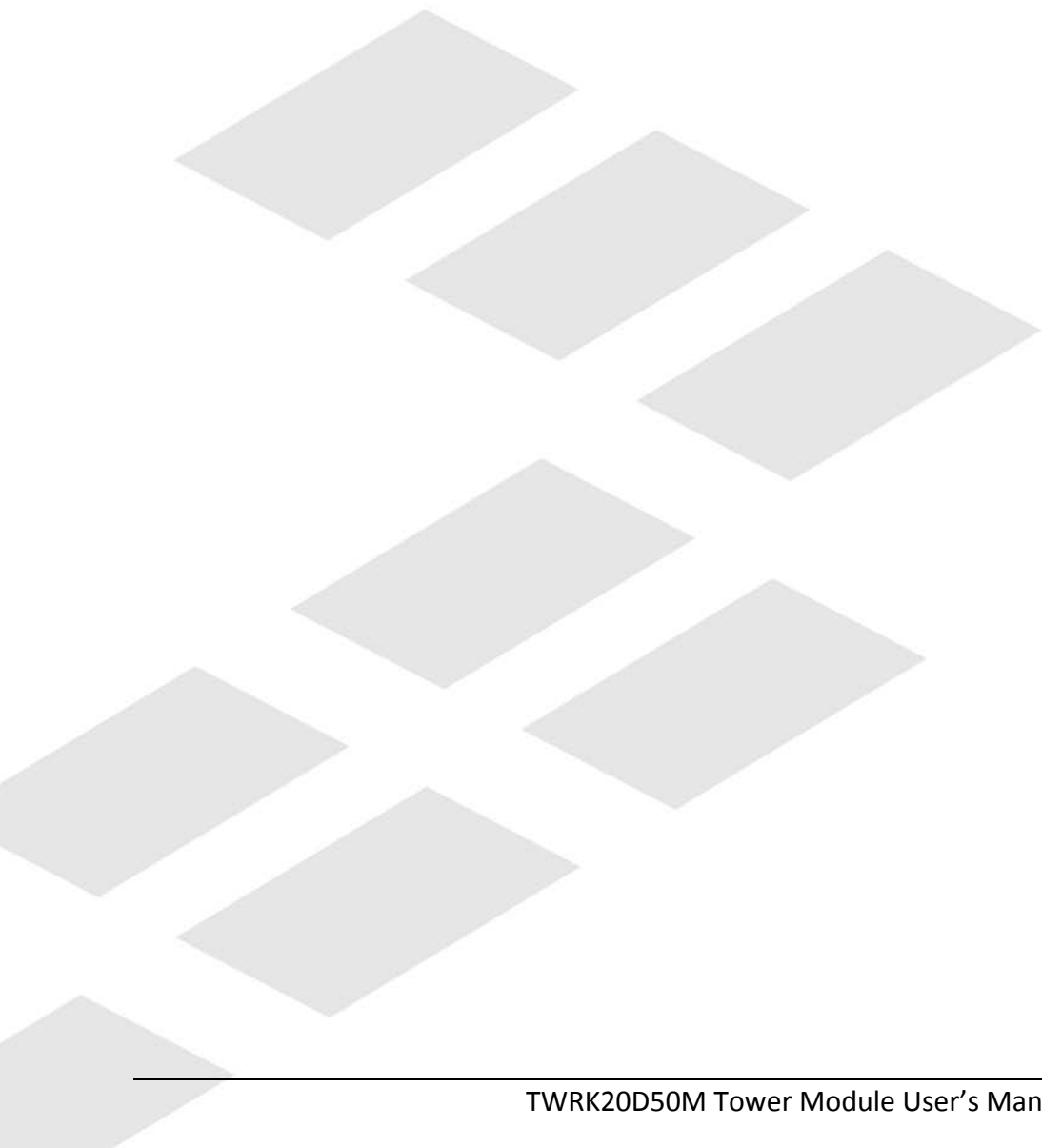


Table 5 Connectors and Pin Usage

Module	Jumper Designator	name	Options	Signal
USB	J26	K20 USN ENA	DEF: 1-2	PTC9_EBI_AD6
	J32	K20 USB FLGA	DEF: 1-2	PTC8_EBI_AD7/SSI0_CLK
IRDA	J9	IRDAJ	open	PTD7_CMT_IRO
	J7	CMPO_IN0	open	PTC7_EBI_AD8/CMPO_IN1
Microphone	J16	Microphone Enable	DEF: 1-2	ADC0_DP3
Potentiometer	J15	Potentiometer Enable	DEF: 1-2	ADC0_DM3
Buzzer	J1	Buzzer Enable	DEF: 1-2	PTC4
Accelerometer	J19	SDA Accelerometer Enable	DEF: 1-2	PTB3_I2C0_SDA/ADC0_SE13/TSI0_CH8
	J20	SCL Accelerometer Enable	DEF: 1-2	PTB2_I2C0_SCL/ADC0_SE12/TSI0_CH7
	J18	ACCELEROMETER INT1	DEF: OPEN	PTB0/ADC0_SE8/TSI0_CH0
	J17	ACCELEROMETER INT2	DEF: OPEN	PTB1/ADC0_SE9/TSI0_CH6
GPIO Header	J2-1	SAI0_RX_FS	PTC10_EBI_AD5/SSI0_RX_FS	
	J2-2	SAI0_TX_FS	PTB19/SSI0_TX_FS/TSI0_CH12	
	J2-3	SAI0_RXD0	PTC5	
	J2-4	SAI0_TXD0	PTC1/UART_RTS/FTM0_CHO/TSI0_CH14	
	J2-5	SAI0_RXD1	PTC11_LLWU_SSI0_RXD1	
	J2-6	SAI0_TXD1	PTC0/SSI0_TXD/TSI0_CH13	
	J2-7	SAI0_RX_BCLK	PTC6	
	J2-8	SAI0_TX_BCLK	PTB18/SSI0_TX_BCLK/TSI0_CH11	
	J2-9	SAI0_MCLK	PTC8_EBI_AD7/SSI0_CLK	
	J2-10	GND	GND	
LEDs	J13	LED orange Enable	DEF: 1-2	PTC10
	J11	LED Yellow Enable	DEF: 1-2	PTC9

Module	Jumper Designator	name	Options	Signal
	J4	LED Green Enable	DEF: 1-2	PTC7
	J6	LED Blue	DEF: 1-2	PTC8
PTA12 - Header	J28	PTA12	1 MCU_PWR 2 PTA12 3 GND	This header can be used to power up an external circuit/sensor
Push Buttons	SW2	Pushbutton1	PTC1	PTC1/UART_RTS/FTM0_CH0/TSIO_CH14
	SW3	Pushbutton0	PTC2	PTC2/UART_CTS/FTM0_CH1/TSIO_CH15
TSI Electrodes	Elec1	Electrode1	TSIO_CH0	PTB0/ADC0_SE8/TSIO_CH0
	Elec2	Electrode2	TSIO_CH6	PTB1/ADC0_SE9/TSIO_CH6

8 Useful links

- ▶ <http://www.freescale.com/twr-k20d50M>
- ▶ www.freescale.com
- ▶ www.iar.com/freescale
- ▶ www.pemicro.com
 - <http://www.pemicro.com/osbdm>
 - [OSBDM/OSJTAG Virtual Serial Toolkit](#)
- ▶ www.freescale.com/codewarrior
 - CodeWarrior MCUv10.x
- ▶ www.segger.com
 - <http://www.segger.com/jlink-flash-download.html>

Revision History

Revision	Date	Description
1.0	Jan, 2012	Initial release for PWA 700-27272 A draft
1.1	Feb, 2012	Initial release for PWA 700-27272 A