

# TWR-KE18F User's Guide

## 1. Introduction

The NXP Tower development platform is a set of software and hardware tools for evaluation and development. It is an ideal tool for the rapid prototyping of microcontroller-based applications.

The TWR-KE18F supports a power supply voltage range from 3.3 V to 5 V. It features a MKE18F16, a device featuring a maximum operating frequency of 168 MHz, up to 512 KB Flash size, and numerous analog and digital peripherals.

The TWR-KE18F includes the ARM® open standard embedded serial and debug adapter known as OpenSDA(CMSIS-DAP). This circuit offers the user several options for serial communications, flash programming, and run-control debugging.

The TWR-KE18F microcontroller module is designed to work either in standalone mode or as part of the NXP Tower System, a modular development platform that enables rapid prototyping and tool re-use through reconfigurable hardware.

There are many software development tool options available to the user. Choices include Kinetis Design Studio (KDS), IAR Embedded Workbench, and Keil MDK featuring the µVision IDE.

All of these features combine to give users the Tower needed to rapidly prototype many embedded designs: a powerful microcontroller built on a very low-power core and SOC platform, easy-access to I/O with a large

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ecosystem of compatible hardware, a flexible programming and debug interface, and a large ecosystem of software development environments.

## 2. Getting Started

Refer to the TWR-KE18F Quick Start Package for step-by-step instructions for getting started with the Tower board. See the “Jump Start Your Design” section at [nxp.com/TWR-KE18F](http://nxp.com/TWR-KE18F) for the Quick Start Package and software lab guides.

## 3. TWR-KE18F Features

The TWR-KE18F hardware is a NXP Tower development board assembled with the following features:

- MKE18F512VLL16 MCU (168 MHz core clock, 512 KB flash, 64 KB RAM, 100LQFP package)
- Tower-compatible processor board
- Onboard OpenSDA (CMSIS-DAP) circuit: K20DX128VFM5 with debug and virtual serial port
- Four user-controlled status LEDs and one RGB LED
- Two mechanical push buttons and one reset button
- I/O headers for easy access to MCU I/O pins
- Thermistors and potentiometer
- FXOS8700CQ 3D accelerometer + 3D magnetometer
- Board power select with 3.3 V or 5 V MCU operation
- Infrared port communication
- CAN transceiver
- Flex™ I/O header

The TWR-KE18F features two MCUs: The target MCU is the MKE18F512VLL16. The OpenSDA(CMSIS-DAP) MCU is the MK20DX128VFM5.

[Figure 1](#) shows the block diagram of the TWR-KE18F board. The primary components and their location on the hardware assembly are shown in [Figure 2](#) and [Figure 3](#).

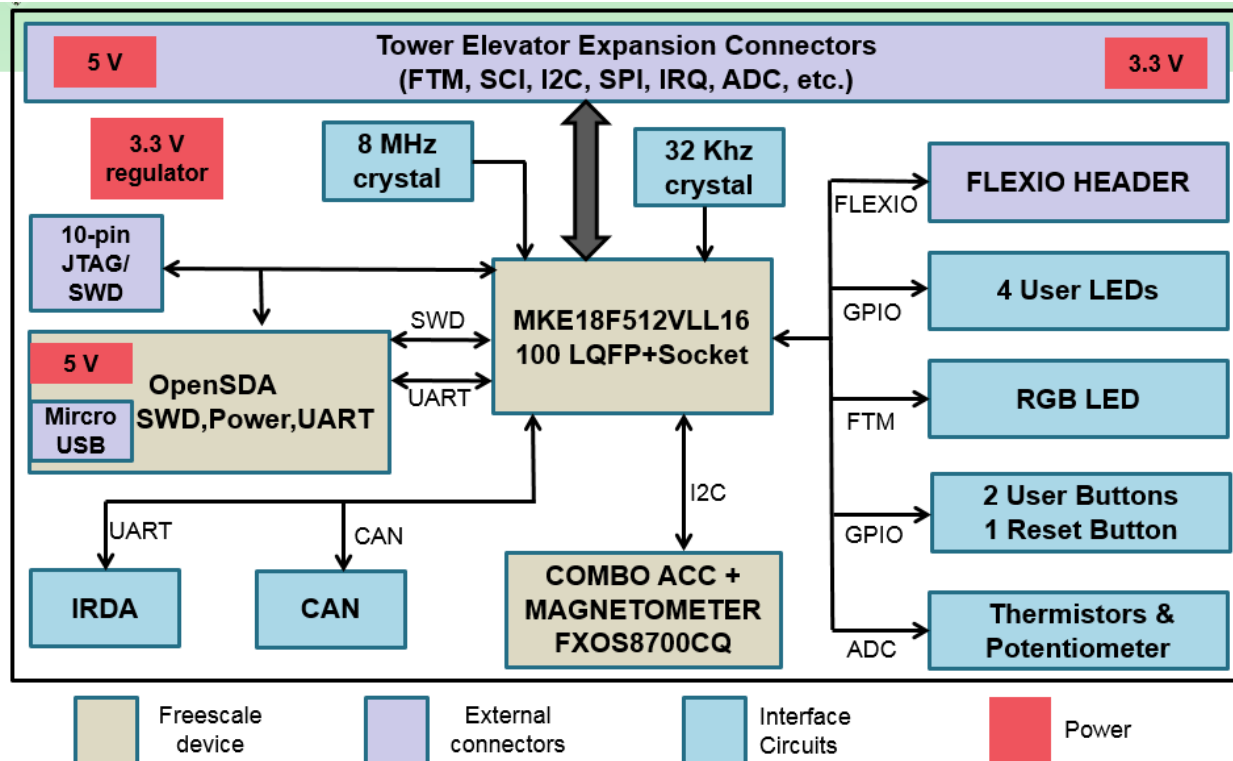


Figure 1. TWR-KE18F block diagram



Figure 2. Front Side of TWR-KE18F

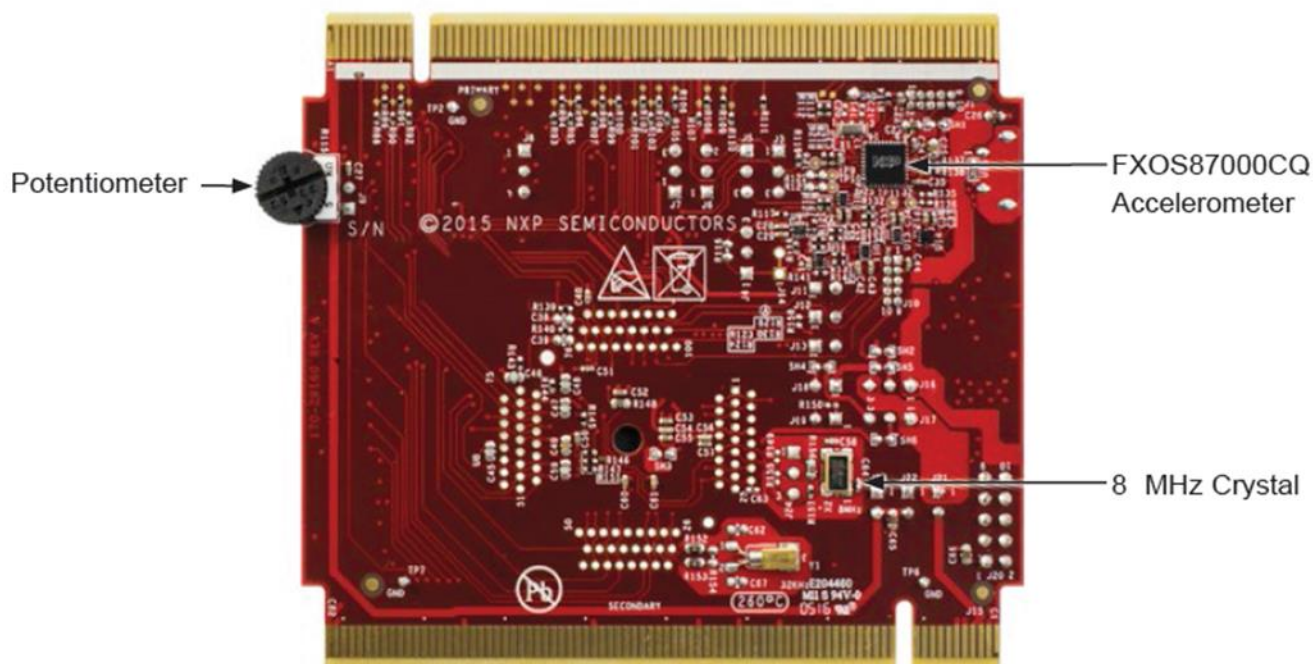


Figure 3. Back Side of TWR-KE18F

## 4. TWR-KE18F Hardware Description

### 4.1. Power supply

When TWR-KE18F is installed into the Tower System, the board power supply can be either from an on-board source (CMSIS-DAP USB connector) or from another source through Tower Elevator. By default, in stand-alone operation, the TWR-KE18F board power source is 5.0 V, which is derived from the CMSIS-DAP USB microB connector J2. One low-dropout regulator U6 provides 3.3 V supply from the 5.0 V input voltage. All of the user-selectable power options for peripherals can be configured by headers. Refer to the default headers setting table [section 5](#).

The following figure shows the schematic drawing for the power supply inputs and the on-board voltage regulator.

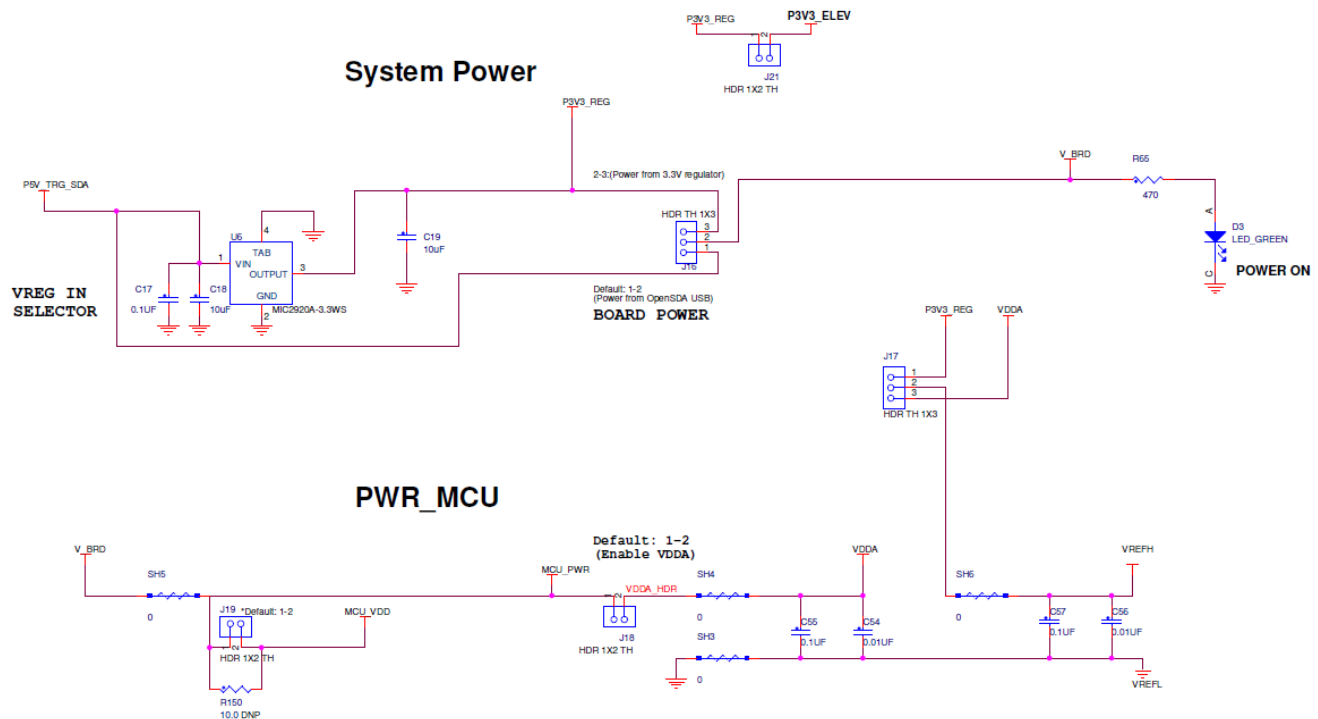


Figure 4. Power supply

The following table lists some power sources descriptions.

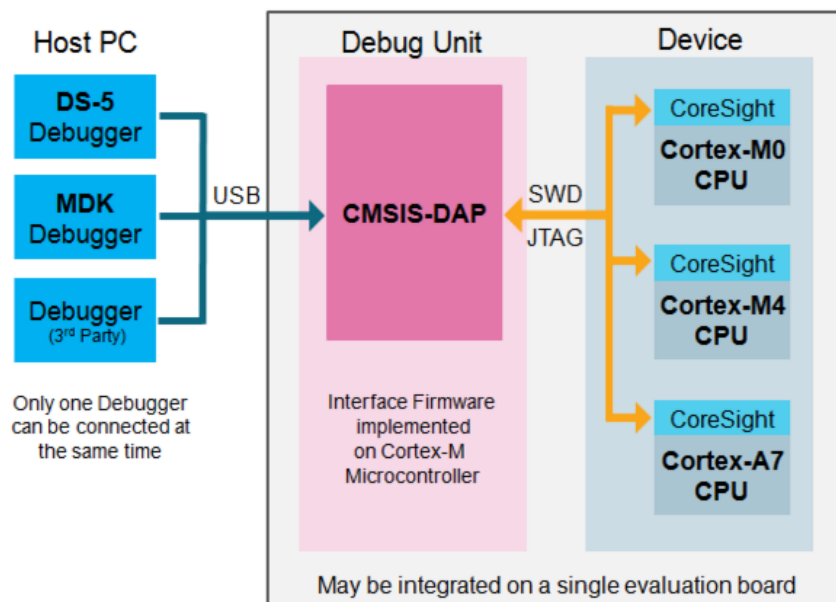
Table 1. TWR-KE18F power sources

Power Source Name	Description
P5V_TRG_SDA	Output of USB power switch controlled by the VTRG_EN signal from the OpenSDA and the ELE_PS_SENSE signal from the TWR elevator connectors. Goes to regulator input select header.
P5V_ELEV	Power to the elevator boards.
P3V3_REG	Output of 3.3 V regulator or from the Elevator connectors. May also be supplied externally by connecting to the board voltage select header.
V_BRD	Output of 3.3 V or 5 V regulators as selected by the board voltage select header. May also be supplied externally by connecting to the board voltage select header.
VREG_IN	Power into the on board voltage regulators.
MCU_PWR	MCU digital power. Filtered from V_BRD.
MCU_VDD	MCU digital power input after current measurement jumper.
VDDA	VDDA power for MCU and analog circuits. Filtered from MCU_PWR.
VREFH	Upper reference voltage for ADC on the MCU. Filtered from VDDA.

## 4.2. OpenSDA circuit (CMSIS-DAP)

The OpenSDA circuit (CMSIS–DAP) is an open-standard serial and debug adapter. It bridges serial and debug communications between a USB host and an embedded target processor as shown in [Figure 5](#). CMSIS-DAP features a mass storage device (MSD) bootloader, which provides a quick and easy mechanism for loading different CMSIS-DAP Applications such as flash programmers, run-control debug interfaces, serial-to-USB converters, and more. Two or more CMSIS-DAP applications can run simultaneously. For example, run-control debug application and serial-to-USB converter runs in parallel to provide a virtual COM communication interface while allowing code debugging via CMSIS-DAP

with just single USB connection. These two applications are provided in a single code package. Refer to the CMSIS-DAP User's Guide for more details.



**Figure 5. CMSIS-DAP block diagram**

CMSIS-DAP is managed by a Kinetis K20 MCU built on the ARM Cortex-M4 core. The CMSIS-DAP circuit includes a status LED (D1) and a RESET pushbutton (SW1). The pushbutton asserts the Reset signal to the KE18F target MCU. It can also be used to place the CMSIS-DAP circuit into bootloader mode by holding down the RESET pushbutton while plugging the USB cable to USB connector J2. Once the CMSIS-DAP enters bootloader mode, other CMSIS-DAP applications such as debug app can be programmed. SPI and GPIO signals provide an interface to the SWD debug port of the KE18F. Additionally, signal connections are available to implement a UART serial channel. The CMSIS-DAP circuit receives power when the USB connector is plugged into a USB host.

#### 4.2.1. Debug interface

Signals with SPI and GPIO capability are used to connect directly to the SWD of the KE18F. These signals are also brought out to a standard 10-pin Cortex Debug connector (J10) as shown in [Figure 6](#). The user could use J10 to debug and download code to KE18F with this SWD/JTAG interface.



# SWD/JTAG Connector

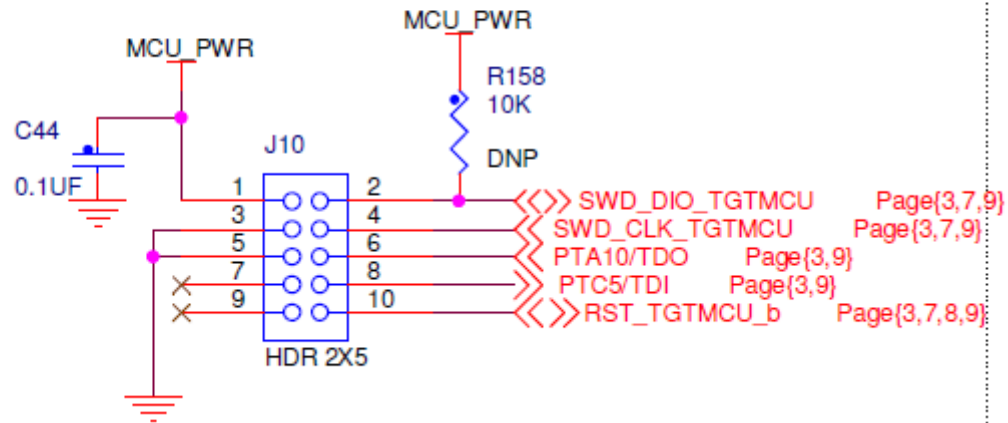


Figure 6. SWD/JTAG debug connector

## 4.2.2. Virtual serial port

A serial port connection is available between the CMSIS-DAP MCU and pins PTB1 and PTB0 of the KE18F. Several of the default CMSIS-DAP applications provided by NXP, including the MSD Flash Programmer and the CMSIS-DAP USB HID interface, provide a USB communications device class (CDC) interface that bridges serial communications between the USB host and this serial interface.

## 4.3. Microcontroller

MKE18F16 MCU is the high end series MCU in Kinetis E family, providing robust 5 V solution with the high performance ARM® Cortex®-M4 core clock running up to 168 MHz, flash size up to 512 KB. It offers multiple ADCs and Fleximers, a CAN 2.0B compliant FlexCAN module and rich suite of communication interfaces including UARTs, I2Cs, SPIs, and FlexIO which provide flexibility for serial communication emulation.

The following table lists the features of MKE18F512VLL16.

Table 2. Features of MKE18F512VLL16

Feature	Description
ARM Cortex-M4 core	<ul style="list-style-type: none"> <li>•32-bit MCU core from ARM's Cortex-M class adding DSP instructions and single-precision floating point unit based on ARMv7 architecture</li> </ul>
System	<ul style="list-style-type: none"> <li>•System integration module</li> <li>•Power management and mode controllers <ul style="list-style-type: none"> <li>○ Multiple power modes available based on high speed run, run, wait, stop, and power-down modes</li> </ul> </li> <li>•Miscellaneous control module</li> <li>•Crossbar switch</li> </ul>

**Table 2. Features of MKE18F512VLL16**

Feature	Description
	<ul style="list-style-type: none"> <li>•Memory protection unit</li> <li>•Peripheral bridge</li> <li>•Direct memory access (DMA) controller with multiplexer to increase available DMA requests. DMA can now handle transfers in VLPS mode</li> <li>•External watchdog monitor (EWM)</li> <li>•Watchdog (WDOG)</li> </ul>
Memories	<ul style="list-style-type: none"> <li>•Program flash memory</li> <li>•FlexMemory <ul style="list-style-type: none"> <li>◦ FlexNVM</li> <li>◦ FlexRAM</li> </ul> </li> <li>•SRAM</li> <li>•Boot ROM</li> </ul>
Clocks	<ul style="list-style-type: none"> <li>•Multiple clock generation options available from internally and externally generated clocks</li> <li>•System oscillator to provide clock source for the MCU</li> </ul>
Security	<ul style="list-style-type: none"> <li>•Cyclic Redundancy Check (CRC) module for error detection</li> <li>•Software watchdog (WDOG) with independent clock source</li> <li>•External watchdog monitor (EWM) module</li> <li>•Error-correcting code (ECC) on Flash memories</li> <li>•128-bit unique identification (ID) number</li> <li>•Memory Protection Unit (MPU) module</li> <li>•ADC self-test and calibration feature</li> </ul>
Analog	<ul style="list-style-type: none"> <li>•High speed analog-to-digital converter (ADC)</li> <li>•Comparator (CMP)</li> <li>•Digital-to-analog converter (DAC)</li> <li>•Bandgap voltage reference (1V reference voltage)</li> </ul>
Timers	<ul style="list-style-type: none"> <li>•Programmable delay block (PDB)</li> <li>•FlexTimers</li> <li>•Low-power periodic interrupt timer (LPIT)</li> <li>•Low power timer (LPTMR)</li> <li>•Independent real time clock (RTC)</li> </ul>
Communications	<ul style="list-style-type: none"> <li>•FlexCAN</li> <li>•Low-power Serial peripheral interface (LPSPI)</li> <li>•Low-power Inter-integrated circuit (LPI2C)</li> <li>•Low-power UART (LPUART)</li> <li>•FlexIO</li> </ul>

### 4.3.1. Clock source

The KE18F MCU starts up to the default reset clock for core/system clock, which is 48 MHz from FIRC. Software can enable the main external oscillator (EXTAL/XTAL), or slow frequency internal reference (SIRC) 2/8 MHz if desired as the core/system clock. There is one System PLL inside KE18F clock module, it enables the chip to run up to the maximum frequency of 168 Mhz.

The external oscillator/resonator can range from 32.768 KHz to 32 MHz. Its main usage is for RTC time base. An 8 MHz crystal is the default external source for the SCG oscillator inputs (XTAL/EXTAL). The clock source diagram is shown in the following figure.



## Clock

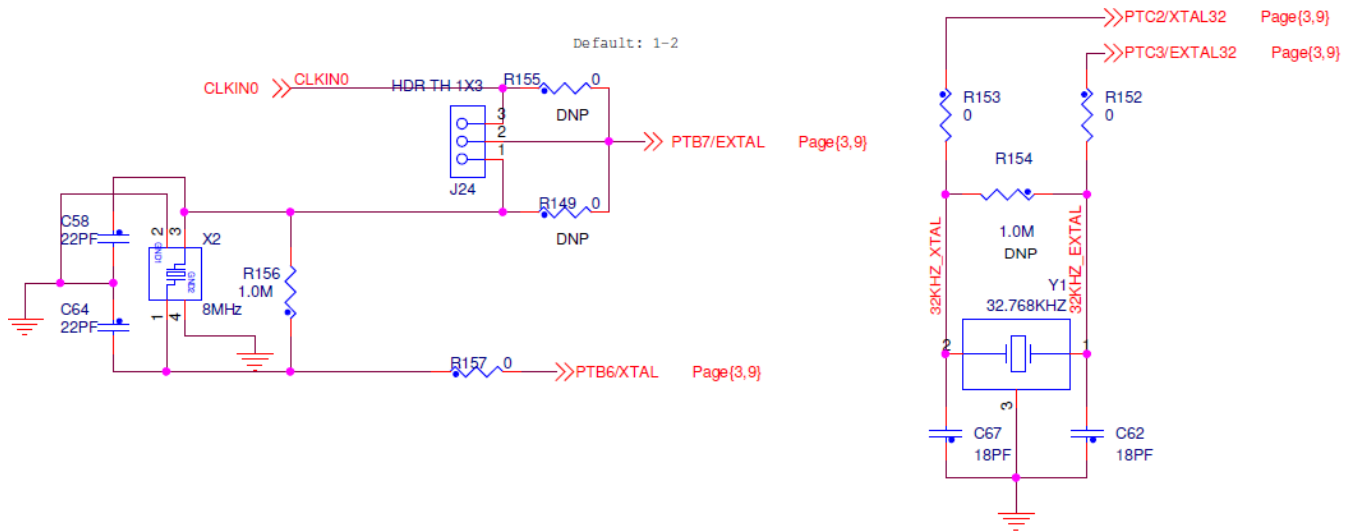


Figure 7. Clock source

### 4.3.2. Serial port

The primary serial port interface signals are PTB1 and PTB0. These signals are connected to both the CMSIS-DAP and to the J3/J5 TWR elevator connector.

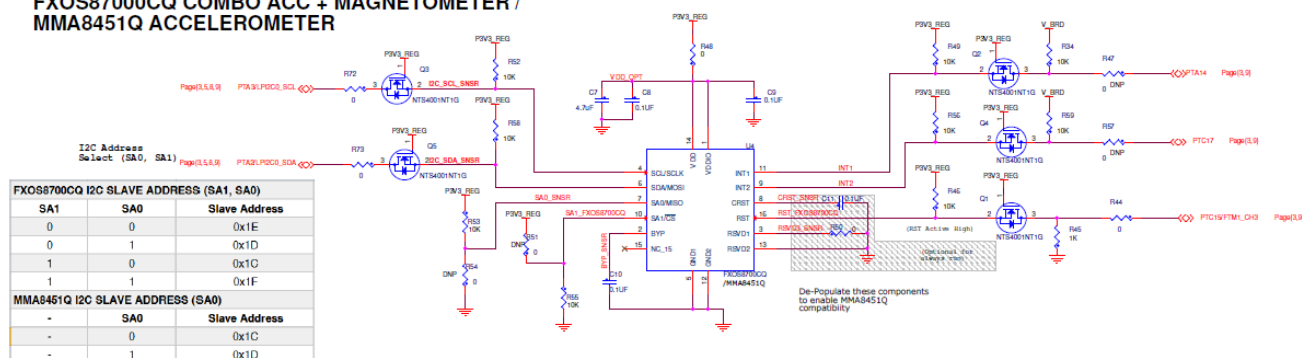
### 4.3.3. Reset

The PTA5/RESET signal on KE18F is connected externally to a pushbutton, SW1, and also to the CMSIS-DAP circuit. The reset button can be used to force an external reset event in the target MCU. The reset button can also be used to force the CMSIS-DAP circuit into bootloader mode.

## 4.4. Sensor

FXOS8700CQ is a small, low-power, 3-axis, linear accelerometer + magnetometer. The device features a selectable I2C or point-to-point SPI serial interface with 8-bit accelerometer and 14-bit magnetometer ADC resolution along with smart-embedded functions. It is interfaced through an I2C bus and three GPIO signals as shown in the following figure.

**FXOS87000CQ COMBO ACC + MAGNETOMETER / MMA8451Q ACCELEROMETER**



### Figure 8. FXOS8700CQ sensor

#### 4.5. Infrared port

An infrared transmit and receive interface is implemented on the board. The PTC7 pin directly drives an infrared diode. The receiver uses an infrared phototransistor connected to an on-chip analog comparator ACMP2\_IN3 through a low-pass filter. Then the output of the analog comparator ACMP2\_OUT is routed to a UART module externally for easier processing of the incoming data stream. The Infrared port schematic is shown in the following figure.

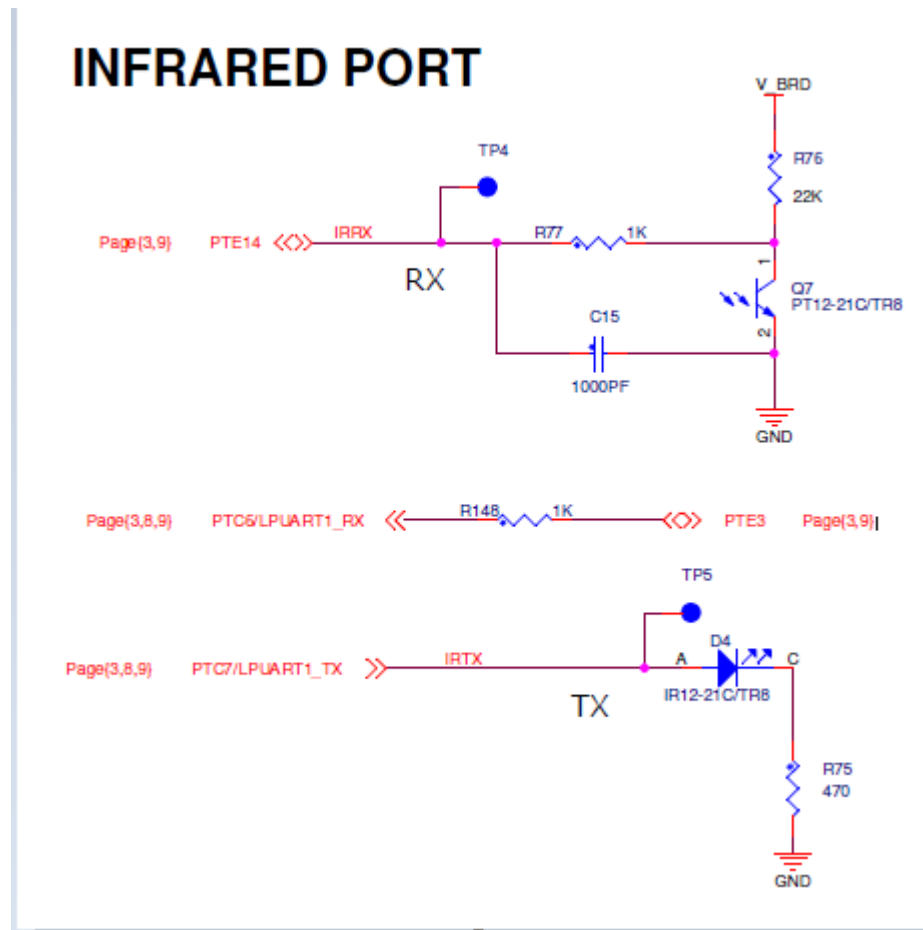


Figure 9. Infrared port

## 4.6. CAN transceiver

The TWR-KE18F features a Controller Area Network interface using a NXP MC33901WEF CAN transceiver. The signals from the transceiver are connected to two 3-pin headers with the FlexCAN module pin out of KE18F. They can also be routed to the CAN transceiver TJA1051T/3 on TWR SER board through the elevator. The CAN transceiver schematic is shown in the following figure.



### Figure 10. CAN receiver

## 4.7. Potentiometer, thermistor, pushbuttons, and LEDs

The TWR-KE18F features:

- A potentiometer connected to an ADC input channel (PTC14/ADC0\_SE12)
- A thermistor connected to two ADC input channels (PTA0/ADC0\_SE0 and PTA1/ADC0\_SE1)
- Two pushbutton switches (SW2 and SW3 connected to PTD3 and PTD6)
- User controllable LEDs connected to GPIO signals
  - Yellow LED D8 connected to PTC12
  - Red LED D6 connected to PTC10
  - Orange LED D9 connected to PTC13
  - GREEN LED D7 connected to PTC11
- A RGB LEDs connected to FTM signals
  - RED color connected to PTD16/FTM0\_CH1
  - GREEN color connected to PTD15/FTM0\_CH0
  - BLUE color connected to PTB5/FTM0\_CH5

#### 4.8. FlexIO header

KE18F has one on-chip FlexIO module, which is capable of supporting a wide range of protocols including: UART, I2C, SPI, I2S, and PWM generation. It is more efficient than integrating multiple peripherals for each desired protocol. There are eight FlexIO pins implemented in total and bonded out on J20, as shown in the following figure.

# FLEXIO HEADER

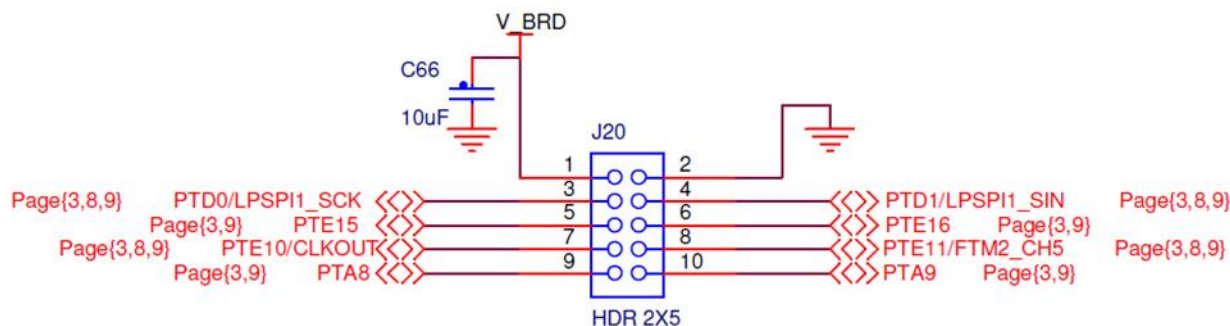


Figure 11. FlexIO header

## 5. Default Jumper Setting

There are several jumpers provided for isolation, configuration, and feature selection. The following table provides details.

Table 3. Default jumper settings

Jumper	Option	Setting	Description
J3	UART TX Selection	1-2	Connect to Elevator UART TX
		2-3	Connect to OpenSDA UART TX
J4	Reset Selection	1-2	Connect OpenSDA reset to MCU
		2-3	Connect pin reset to MCU directly, when OpenSDA is not powered
J5	UART RX Selection	1-2	Connect to Elevator UART RX
		2-3	Connect to OpenSDA UART RX
J6	CAN TX Selection	1-2	Connect CAN transceiver to MCU CAN0 TX pin directly
		2-3	Connect CAN transceiver to Elevator CAN TX
J7	CAN RX Selection	1-2	Connect CAN transceiver to MCU CAN0 RX pin directly
		2-3	Connect CAN transceiver to Elevator CAN RX
J8	CAN Transceiver connection	ON	Connection with external board
		OFF	No connection with external board
J9	POTENTIOMETER Enable	ON	Enable potentiometer
		OFF	Disable potentiometer
J11	OpenSDA SWD CLK connection	ON	Connect SWD_CLK to OpenSDA circuit
		OFF	Disconnect SWD_CLK to OpenSDA circuit
J12	OpenSDA SWD DIO connection	ON	Connect SWD_DIO to OpenSDA circuit
		OFF	Disconnect SWD_DIO to OpenSDA circuit

Table 3. Default jumper settings

Jumper	Option	Setting	Description
J13	Reset connection	ON	Connect reset signal to MCU pin
		OFF	Disconnect reset signal to MCU pin
J16	Board power supply selection	1-2	Board voltage V_BRD power from OpenSDA USB, 5V
		2-3	Board voltage V_BRD power from regulator, 3.3V
J17	Upper reference voltage V <sub>REFH</sub> selection	1-2	V <sub>REFH</sub> from 3.3V regulator
		2-3	V <sub>REFH</sub> from V <sub>DDA</sub>
J18	Analog circuits power V <sub>DDA</sub> connection	ON	Connect V <sub>DDA</sub> to board power V_BRD
		OFF	Disconnect V <sub>DDA</sub> to board power V_BRD
J19	MCU digital power connection	ON	Connect MCU_VDD to board power V_BRD
		OFF	Disconnect MCU_VDD to board power V_BRD
J21	Elevator 3.3V connection	ON	Connect 3.3V regulator output to TWR elevator
		OFF	Disconnect 3.3V regulator output to TWR elevator
J22	Elevator 5V connection	ON	Connect 5V USB power switch output to TWR elevator
		OFF	Disconnect 5V USB power switch output to TWR elevator
J23	Elevator 5V connection	ON	Connect 5V OpenSDA input to TWR elevator
		OFF	Disconnect 5V OpenSDA input to TWR elevator
J24	External clock selection	1-2	External 8Mhz crystal input
		2-3	External oscillator input to EXTAL pin directly

## 6. References

The reference documents for the TWR-KE18F hardware are shown below. All of these documents are available online at [www.nxp.com/TWR-KE18F](http://www.nxp.com/TWR-KE18F).

- TWR-KE18F Quick Start Guide: Quick Start Guide and supporting files for getting started with the TWR-KE18F.
- TWR-KE18F User's Guide: Document overview and detailed information for the TWR- KE18F hardware.
- TWR-KE18F Schematics PDF: Schematics for the TWR- KE18F hardware.
- KE18F Sub-Family Reference Manual: A reference manual for KE18F sub-family devices



## 7. Revision History

Table 4. Revision history

Revision number	Date	Substantive changes
0	09/2016	Initial release

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