

# TWR-KV10Z32 Tower Module User's Guide

## 1 Overview

The KV10 is the entry-level member of Kinetis V series, a Kinetis-based Microcontroller family. On a single chip, it combines the processing power of up to a 75MHz ARM M0+ CPU with up to 32KB Flash, 8KB RAM, a motor control timer and an ADC with the capability to capture two inputs simultaneously (for example, two current phase measurements), within a period of 800nS to 1uS at 12-bit resolution. It has a full set of programmable peripherals including a 6-channel PWM timer to drive a 3-phase complimentary inverter stage, 2x 16 bit ADCs with 2 capture & hold circuits, 2 UART, 1 SPI, I2C, CRC block, analog comparators w/DAC, on-chip/off-chip clock sources, and a 12b DAC. Also included is a Programmable Delay Block module for precise ADC sampling points timing. Each peripheral can be shut down independently to save power. It can work with a power supply voltage range from 1.71V to 3.6V.

The KV10 is targeted for low dynamic variable speed sensorless motor control used in industrial pumps, compressors, and fans, power conversion as well as other general purpose applications.

### Contents

1. Overview .....	1
2. Hardware description .....	2
2.1. Block diagram .....	2
2.2. Microcontroller .....	3
2.3. Clocking .....	3
2.4. System power .....	4
2.5. Debug interface .....	5
2.6. Accelerometer .....	8
2.7. User interfaces .....	9
2.8. Interface connectors .....	13
3. Jumper settings .....	15
4. Reference documents .....	17
5. Revision history .....	17

The KV10 Tower MCU Module part number is TWR-KV10Z32 and has a 48-LQFP chip soldered directly on the PCB. The module works under -40~ +105 degrees celsius.

The following list summarizes the features of the KV10 Tower MCU Module TWR- KV10Z32:

- 48-LQFP KV10 Microcontroller
- On board OpenSDA with USB connection used to debug code without external debug interface
- Header for standard mini Cortex SWD connector used to debug code on either OpenSDA or KV10 with external debug interface
- Power indication LED
- 10MHz crystal on board for the microcontroller
- MMA8451Q Accelerometer connected to I2C channel
- 8 LEDs connected with buffers to PWM channels for dimming.
- 2 Push buttons for user input or interrupts to the microcontroller
- 4 Thermistors for single ended or differential analog inputs
- Reset push button for KV10
- Elevator signal supporting TWR-MC-LV3PH
- Header to connect to APMOTOR56F800E motor board
- Can be powered by external supply such as APMOTOR56F800E motor board and TWR-MC-LV3PH
- Headers to connect SCI0 and SCI1 signals to either OpenSDA or elevator board
- 2-pin jumper for current measurement

## 2 Hardware description

This section provides specification details for the KV10 MCU Module board TWR- KV10Z32.

### 2.1 Block diagram

A block diagram for the TWR- KV10Z32 is shown in the figure below.

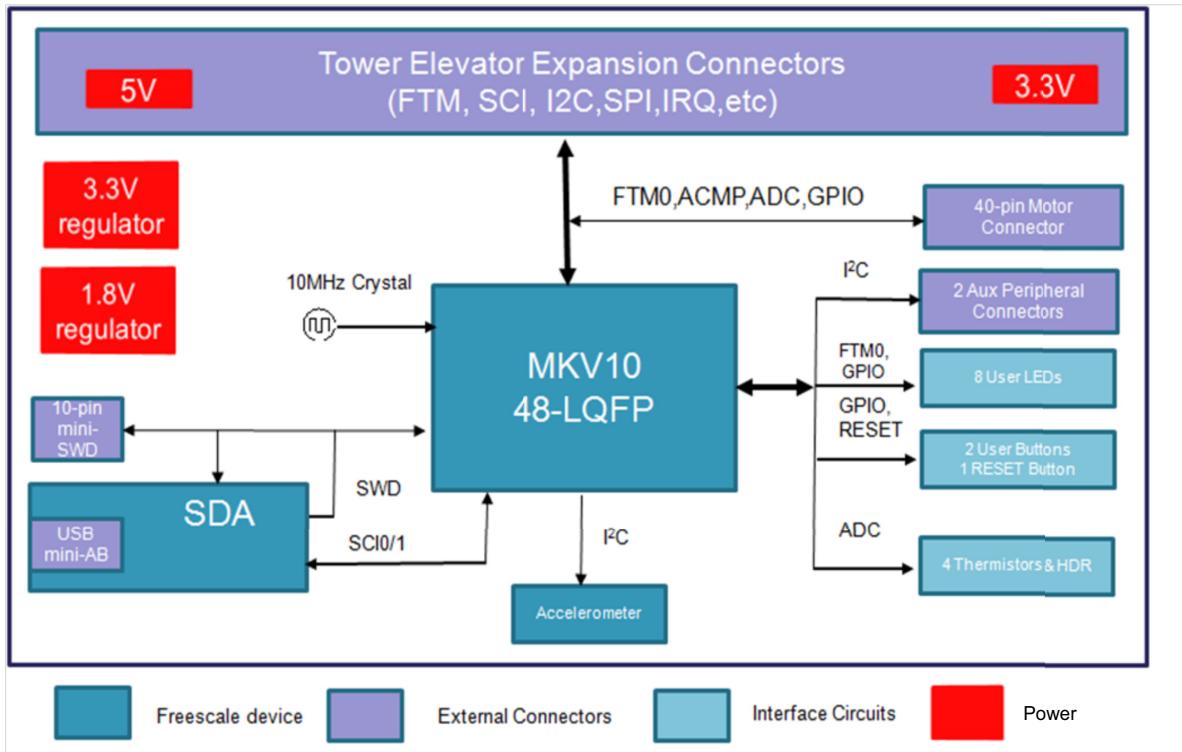


Figure 1. KV10 MCU tower module block diagram

## 2.2 Microcontroller

The KV10 package used on the board is 48-LQFP. The MC part number for KV10 is MKV10Z32VLF7.

## 2.3 Clocking

A 10M Hz external crystal which can work under -40C~ +105C, is used for the external clock source of the KV10. The clock signal can be isolated when the EXTAL and XTAL pin are used for the other purpose (GPIO, IIC) via J4 and/or J5.

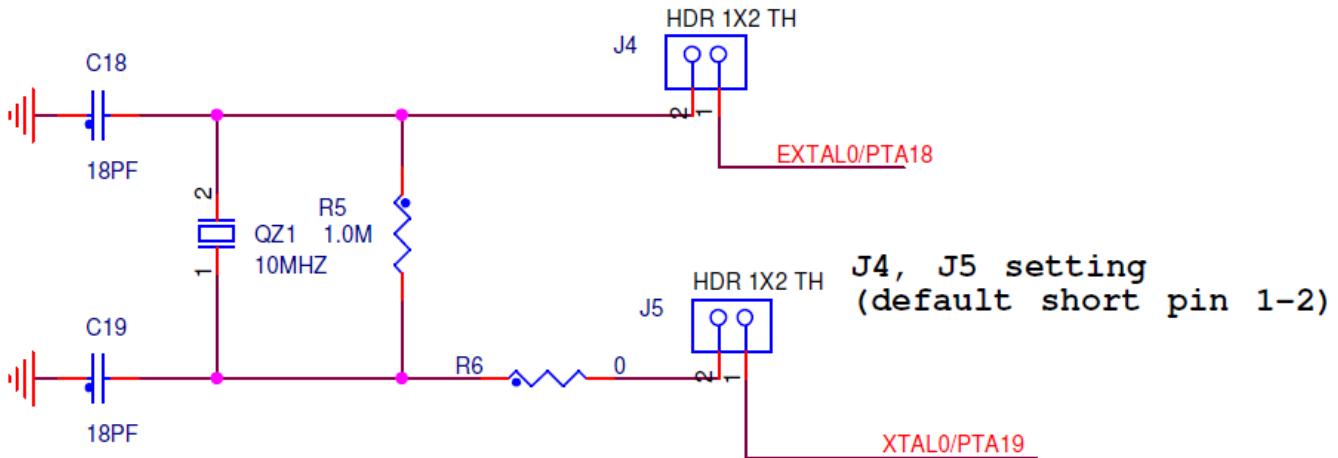


Figure 2. Clock circuit

## 2.4 System power

The KV10 MCU module can be powered by the OpenSDA circuit (via the Mini-AB USB connector), the Tower Elevator power connections, or the motor connection. The KV10 can work with 3.3V power supply or 1.8V power supply selectable via J1 header. The 3.3V power supply can be from the tower system, 3.3V regulator from 5V power rail coming from USB port, or it can be directly from other tower modules through tower elevators. It can also be directly from the Motor Connector.

The power supply source selection from either the 3.3V regulator or the tower elevator is done automatically. The power supply source selection from the tower system and the Motor Connector is also done automatically.

The LED indicators for power, reset, target power, and status are present: D11 indicates the 5V power is on from USB port rail and enabled by OpenSDA; D18 indicates the 3.3V power supply is on.

VDDA, VREFH and VSSA, VREFL are the analog power supply pins for the microcontroller. These voltage sources supply power to the ADC module. A 0.1uF ceramic bypass capacitor is located as close to the microcontroller power pins to suppress high-frequency noise.

A jumper J2 is provided between the system power supply and the power rail to the MCU to allow for current measurements. It also allows external power supply directly to the microcontroller.

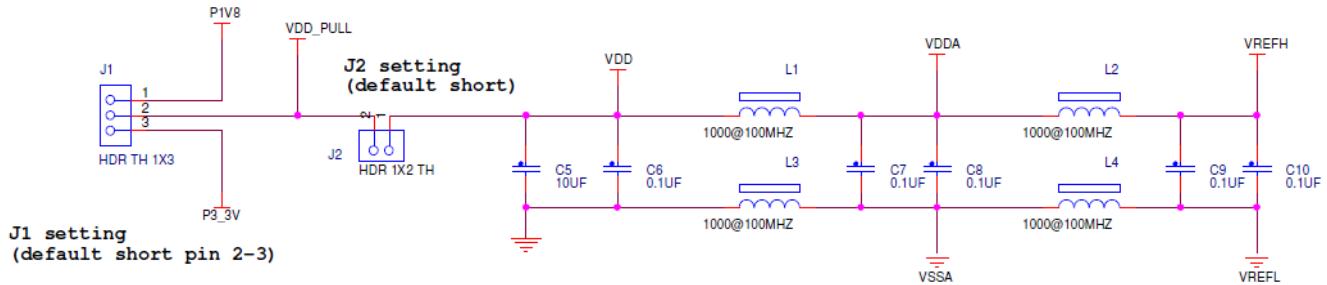


Figure 3. MCU power

## 2.5 Debug interface

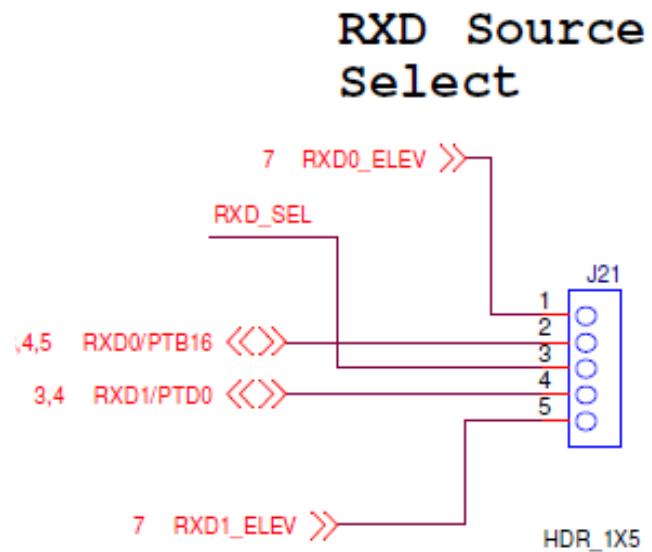
There are two debug interface options provided: the on-board Open Source SDA (OpenSDA) circuit and an external ARM JTAG mini connector (2x5 pins). The KV10 can be debugged with OpenSDA, or the external ARM JTAG mini connector.

### 2.5.1 OpenSDA

The OpenSDA circuit is MK20 based and provides SWD debug interface to the KV10. A standard USB or a male to mini-B male cable can be used for debugging via the USB connection.

This interface also supports the USB virtual serial port. This port can be selected to connect to the SCI0 or SCI1 with option jumpers J21 and J22. SCI0 pins used here are PTB16/RXD0, PTB17/TXD0. SCI1 pins used here are PTD0/RXD1, PTD1/TXD1. Default setting is that J21 pin 2-3 has a shunt installed, and J22 pin2-3 has a shunt installed, see figures below. This ensures that SCI0 RXD0/PTB16 and TXD0/PTB17 are used for OpenSDA COM port interface.

The OpenSDA firmware is preprogrammed to support KV10 debugging.



**J21 setting**  
(default short pin 2-3)

Figure 4. OpenSDA RXD source select

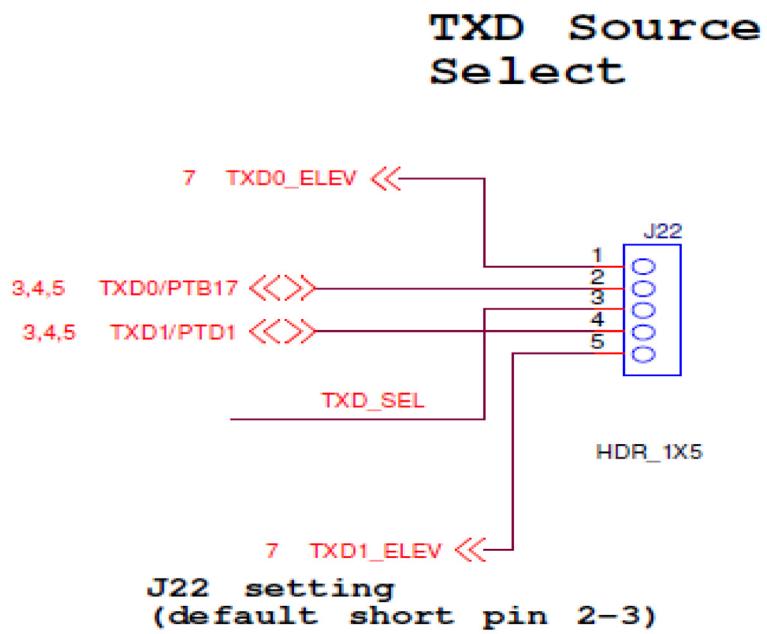


Figure 5. OpenSDA TXD source select

## 2.5.2 ARM JTAG/SWD mini connector

The Cortex-M Debug SWD connector J17 is a standard 2x5-pin (0.05") connector providing an external debugger cable with access to either the SWD interface of the KV10 or the OpenSDA microcontroller MK20.

Three headers (J18 to J20) are used to select which microcontroller will be interfaced. By default pin 2-3 are short on these headers, this ensures that the SWD interface connects to KV10. Furthermore J29 is VDD select for J17 pin1, the default pin 1-2 of J29 is short.

**Table 1. ARM JTAG/SWD mini connector J17 description**

Pin	Function	Connection to KV10	Connection to OpenSDA K20
1	VTref	Target MCU power supply	Target MCU power supply
2	SWDIO/TMS	PTA3/SWD_DIO	JTAG_TMS
3	GND	GND	GND
4	SWDCLK/TCK	PTA0/SWD_CLK	JTAG_TCLK
5	GND	GND	GND
6	SWO/TDO	NC	JTAG_TDO
7	NC	NC	NC
8	TDI	NC	JTAG_TDI
9	NC	NC	NC
10	RESET	PTA20/RESET_b	K20_RESET

**Table 2. J18 connector description**

Pin	Usage	Description
1	K20 JTAG_TCK_SI	Pin 1-2 short: debugger interface to K20; Pin 2-3 short: debugger interface to KV10 (default setting)
2	SWDCLK	—
3	KV10 SWD_CLK	—

**Table 3. J19 connector description**

Pin	Usage	Description
1	K20 JTAG_TMS_SI	Pin 1-2 short: debugger interface to K20; Pin 2-3 short: debugger interface to KV10 (default setting)
2	SWDIO	—
3	KV10 SWD_IO	—

**Table 4. J20 connector description**

Pin	Usage	Description
1	K20 RESET	Pin 1-2 short: debugger interface to K20; Pin 2-3 short: debugger interface to KV10 (default setting)
2	/RESET	—
3	KV10 RESET	—

**Table 5. J29 connector description**

Pin	Usage	Description
1	KV10 VDD_PULL	Pin 1-2 short: debugger interface to K20; Pin 2-3 short: debugger interface to KV10 (default setting)
2	VDD_JTAG(SWD)	—
3	K20 VDD(+3.3V)	—

## 2.6 Accelerometer

An MMA8451Q digital accelerometer is featured on-board. This accelerometer is connected to KV10 via I<sup>2</sup>C interface 0 with headers for isolation: J7 to J10.

**Table 6. MMA8451Q connection description**

Pin	Connection to KV10
SCL	SCL0/PTC6, with header
SDA	SDA0/PTC7, with header
INT1	PTB3, with header
INT2	PTA2, with header
SA0	HIGH

**Table 7. J7 connector description**

Pin	Usage	Description
1	Accelerometer SDA	Pin 1-2 short: KV10 SDA0 to accelerometer (default setting); Pin 2-3 short: KV10 SDA0 to other places
2	KV10 SDA0/PTC7	—
3	SDA0/PTC7 to other places than the accelerometer	—

**Table 8. J8 connector description**

Pin	Usage	Description
1	Accelerometer INT1	Pin 1-2 short: KV10 PTB3 to accelerometer (default setting); Pin 2-3 short: KV10 PTB3 to other places
2	KV10 PTB3	—
3	PTB3 to other places than the accelerometer	—

**Table 9. J9 connector description**

Pin	Usage	Description
1	Accelerometer SCL	Pin 1-2 short: KV10 SCL0 to accelerometer (default setting); Pin 2-3 short: KV10 SCL0 to other places
2	KV10 SCL0/PTC6	—
3	SCL0/PTC6 to other places than the accelerometer	—

**Table 10. J10 connector description**

Pin	Usage	Description
1	Accelerometer INT2	Pin 1-2 short: KV10 PTA2 to accelerometer (default setting); Pin 2-3 short: KV10 PTA2 to other places
2	KV10 PTA2	—
3	PTA2 to other places than the accelerometer	—

## 2.7 User interfaces

### 2.7.1 Push button

Two push buttons (SW1 and SW2) are connected to GND and GPIO with LLWU pin interrupt signals (PTA4 and PTB0) to support waking KV10 up from LLS mode via LLWU pin interrupt. One push button switch (SW3) is connected to GND and KV10 /RESET\_b pin. When there is a reset, D16 LED will be lit.

### 2.7.2 User LEDs

There are 8 LEDs driven directly by FTM0 and GPIO pins of the MCU via buffers. The connection of LEDs to MCU pins are shown below:

**Table 11. LED connection description**

<b>LED #</b>	<b>KV10 pin</b>	<b>Description</b>
LED0	PWM0/PTC1	Yellow/green
LED1	PWM1/PTE25	Yellow
LED2	PWM2/PTC3	Yellow/green
LED3	PWM3/PTC4	Yellow
LED4	PWM4/PTD4	Yellow/green
LED5	PWM5/PTD5	Yellow
LED6	ENC_PHASE_B/PTD6	Orange
LED7	ENC_PHASE_C/PTD7	Red

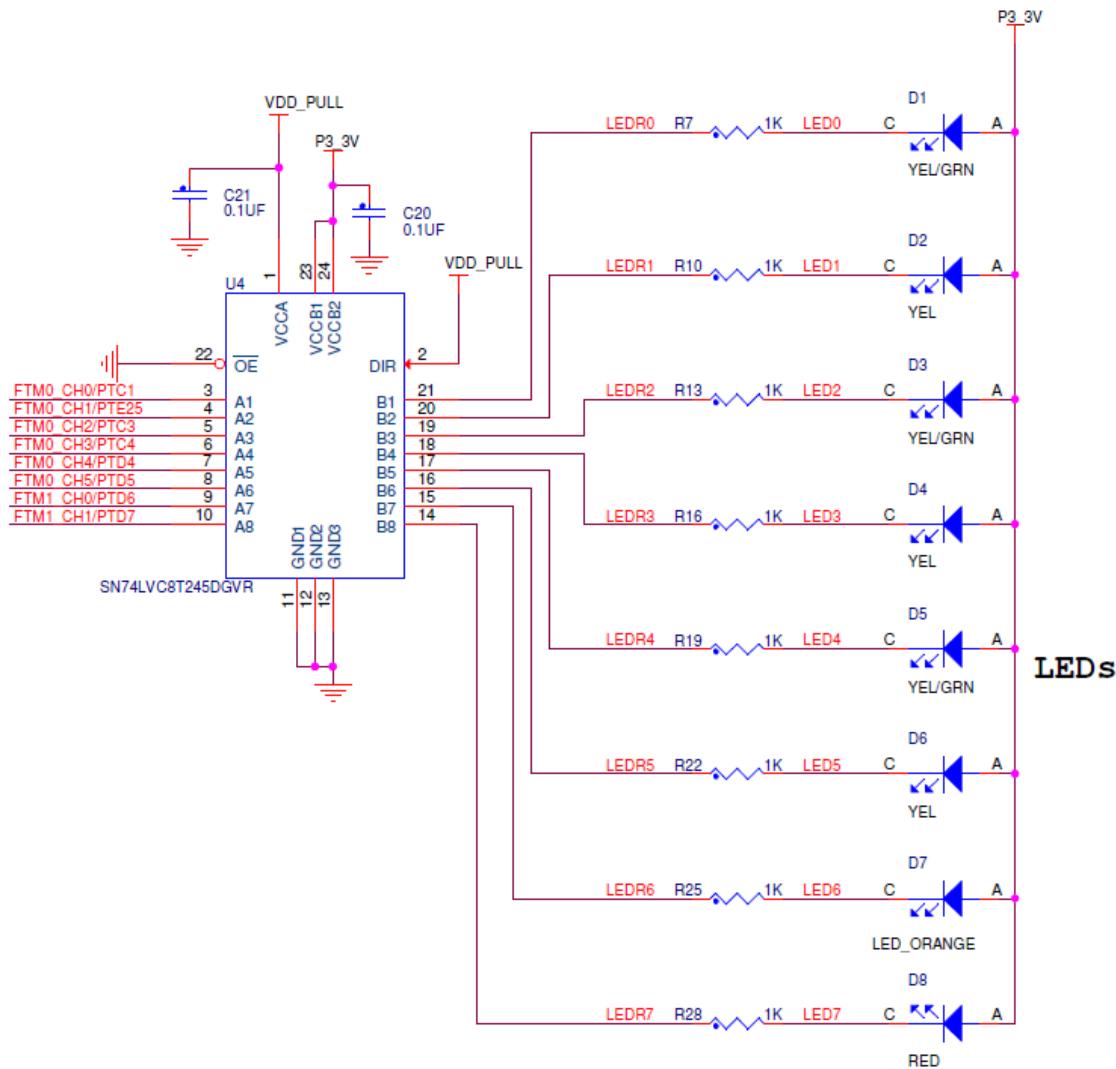


Figure 6. LED connection

## 2.7.3 Thermistor

There are four thermistors (RT1-4) near the corners of the board that can be used as single ended or differential analog inputs to the KV10. In addition to each thermistor there is a resistor between the thermistor and 3.3V system power supply and another resistor between the thermistor and ground. The thermistors are all 10K ohm parts but the associated divider chain uses different resistors. This makes the voltage across the thermistor larger or smaller and provides the ability to try the different gain settings on the analog channels. All four thermistor circuits are designed to provide usable differential inputs over the temperature range of 90°C to -20°C. RT2 and RT4 both give a differential voltage of ~1.65V at 25°C. RT1 gives a differential voltage of ~0.10V and RT3 gives a differential voltage of ~0.28V at 25°C. In addition to the thermistor voltage divider chain each thermistor has a 0.1 uF capacitor in parallel. Each thermistor circuit also has a header (J11 to J14, default settings: pin 1-2 short, pin3-4 short on these headers) that

## Hardware description

allows the thermistor to be disconnected from the analog inputs to the KV10. If a user wishes to apply an external analog value these headers may be removed and the external analog signal attached to the KV10 side of the headers. Finally, each analog input to the KV10 has a 100 ohm series resistor and a capacitor as a low pass filter. This helps protect the KV10 from electrostatic discharges and lowers the impedance of the analog signal so that it can be sampled with less noise.

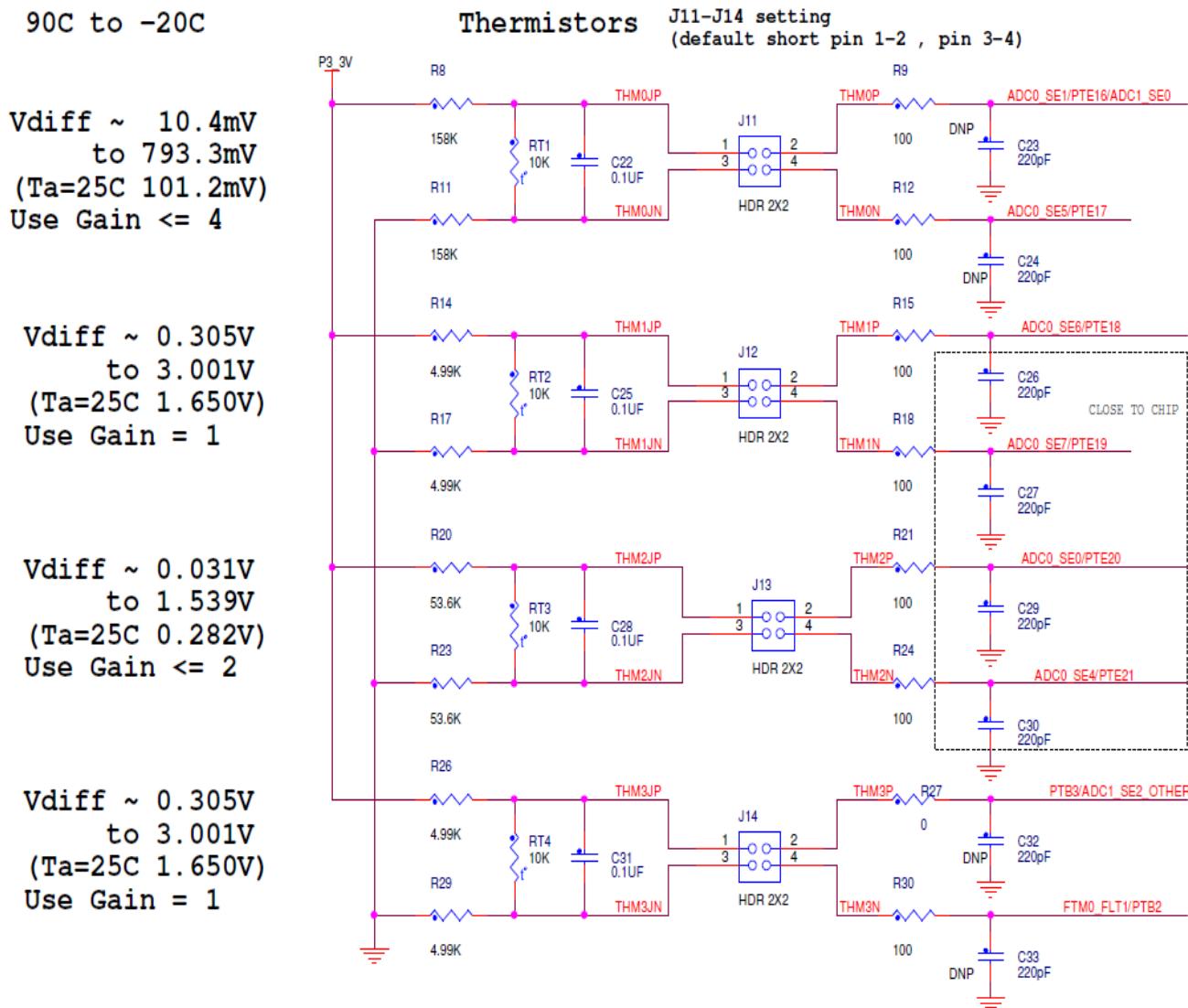


Figure 7. Thermistor inputs

## 2.8 Interface connectors

### 2.8.1 Motor connector

The KV10 board can be connected to a motor control board such as the AP MOTOR56F8000E. The motor control connector (female) is on the bottom of the board to provide a convenient connection to the motor control board.

Some of the KV10 pins are connected to the motor control connector. Those pins associated with analog inputs have 100 ohm resistors in series to provide some ESD protection for the analog inputs of the KV10. Those pins providing analog signals from the motor control board have 220 pF caps with the resistors to provide a low pass filter. The connector pin out is shown in the following table.

**Table 12. 40-Pin motor connector J15 description**

Pin#	Signal Connection	Function	Pin#	Signal Connection	Function
1	+3.3V power supply from motor board	External Power supply	2	PTE16/ADC0_SE1/ADC1_SE0	ADC
3	GND	GND	4	RESET_b/PTA20	RESET
5	TXD0/PTB17	TXD	6	PTC0/ADC1_SE11	ADC
7	RXD0/PTB16	RXD	8	GND	GND
9	FTM0_CH0/PTC1	PWM0	10	ADC0_SE5/PTE17	ANA0, DC Bus voltage
11	FTM0_CH1/PTE25	PWM1	12	ADC0_SE4/PTE21	ANA1, DC Bus current
13	FTM1_CH0/PTD6	T0, Phase A Zero crossing/ Hall effect	14	PTA4/NMI	GPIO, LED6 on motor board, GREEN
15	FTM1_CH1/PTD7	T1, Phase B Zero crossing/ Hall effect	16	GND	GND
17	FTM2_CH0/PTA1	T3	18	ADC0_SE6/PTE18	ANB0, Phase A BEMF
19	FTM2_CH1/PTA2	T2, Phase C Zero crossing/ Hall effect	20	ADC0_SE9/PTB1	ANB1, Phase B BEMF
21	PTC7/SDA0	GPIO	22	ADC0_SE7/PTE19	ANB2, Phase C BEMF
23	PTC6/SCL0	GPIO	24	GND	—

**Table 12. 40-Pin motor connector J15 description**

25	SWD_DIO/PTA3	TDI/GPIO	26	PTE24	GPIO, LED3, YELLOW on motor board
27	SWD_DIO/PTA3	TDO/GPIO	28	PTE30	GPIO, LED2, RED on motor board
29	SWD_CLK/PTA0	TCK/GPIO	30	FTM0_CH2/PTC3	PWM2
31	PTC5	GPIO	32	FTM0_CH3/PTC4	PWM3
33	PTC0/ PDB0_EXTRG	GPIO,LED5,RED on motor board	34	FTM0_CH4/PTD4	PWM4
35	PTE20/ ADC0_SE0	ADC	36	FTM0_CH5/PTD5	PWM5
37	PTB2/ADC0_SE1	ADC	38	PTB0/ ADC0_SE8	ADC
39	PTB3/ADC0_SE10	ADC	40	PTD1/ADC0_SE2	ADC

## 2.8.2 Aux peripheral connector

Aux peripheral connector 1 is designed to facilitate the evaluation of digital functions.

**Table 13. Aux peripheral connector1 J6 description**

Pin#	Signal Connection	Pin#	Signal Connection
2	VDD	1	VSS
4	PTA1	3	PTA0
6	PTA3	5	PTA2
8	VSS	7	PTA4
10	PTB17	9	PTB16
12	PTB3	11	PTB2
14	PTE25	13	PTE24
16	PTC3	15	PTC2
18	PTC5	17	PTC4
20	PTC7	19	PTC6
22	PTD1	21	PTD0
24	PTD3	23	PTD2
26	PTD5	25	PTD4
28	PTD7	27	PTD6

Aux peripheral connector 2 is designed to facilitate the evaluation of analog functions.

**Table 14. Aux peripheral connector2 J16 description**

Pin#	Signal Connection	Pin#	Signal Connection
2	VDDA	1	VSSA
4	VREFH	3	VREFL
6	PTE17/ADC0_SE5/ADC1_SE5	5	PTE16/ADC0_SE1
8	PTE19/ADC0_SE7/ADC1_SE7	7	PTE18/ADC0_SE6
10	PTE21/ADC0_SE4	9	PTE20/ADC0_SE0
12	PTE29/ CMP0_IN5/CMP1_IN5	11	PTE30/ADC1_SE4
14	PTC1/ADC1_SE3	13	PTC0/ ADC1_SE11
16	PTC3/CMP1_IN1	15	PTC2/ADC0_SE11
18	PTB1/ ADC1_SE9	17	PTB0/ ADC0_SE8
20	PTB3/ADC1_SE2	19	PTB2/ADC0_SE10

### 3 Jumper settings

The following table provides the jumper options. The default installed jumper settings are presented in the shaded boxes.

**Table 15. Jumper table (default settings highlighted)**

Jumper	Option	Setting	Description
J1	KV10 power supply select	1-2	+1.8V power supply
		2-3	+3.3V power supply
J2	KV10 power connection	ON	Connect power supply to KV10
		OFF	Isolate KV10 from power (connect an ammeter to measure current)
J3	PTB0 select	1-2	Connect PTB0 to elevator
		2-3	Connect PTB0 to SW2
J4	PTA18 select	ON	Connect one terminal of crystal to KV10 EXTAL0/PTB18 pin
		OFF	Isolate one of terminal of crystal to KV10
J5	PTA19 select	ON	Connect the other terminal of crystal to KV10 XTAL0/PTA19
		OFF	Isolate the other terminal of crystal to KV10
J7	I2C0 SDA0(PTC7) selection	1-2	Connect SDA0 to elevator J24 A8 pin and J6
		2-3	Connect this pin to accelerometer(U6)

## Jumper settings

**Table 15. Jumper table (default settings highlighted)**

J8	PTB3 selection	1-2	Connect PTB3 to MMA8451Q Accelerometer
		2-3	Connect PTB3 to elevator J24 and auxiliary connector J6
J9	I2C0 SCL0(PTC6) selection	1-2	Connect SCL0 to elevator J24 A7 pin and J6
		2-3	Connect this pin to accelerometer(U6)
J10	PTA2 selection	1-2	Connect PTA2 to MMA8451Q Accelerometer
		2-3	Connect PTA2 to elevator J24 and auxiliary connector J6
J11	RT1 connection with KV10 PTE16 RT1 connection with KV10 PTE17	1-2	Connect one terminal of RT1 to KV10 PTE16 pin
		Open	Isolate one terminal of RT1 to KV10 PTE16 pin
		3-4	Connect one terminal of RT1 to KV10 PTE17 pin
		Open	Isolate one terminal of RT1 to KV10 PTE17 pin
J12	RT2 connection with KV10 PTE18 RT2 connection with KV10 PTE19	1-2	Connect one terminal of RT2 to KV10 PTE18 pin
		Open	Isolate one terminal of RT2 to KV10 PTE18 pin
		3-4	Connect one terminal of RT2 to KV10 PTE19 pin
		Open	Isolate one terminal of RT2 to KV10 PTE19 pin
J13	RT3 connection with KV10 PTE20	1-2	Connect one terminal of RT3 to KV10 PTE20 pin
		Open	Isolate one terminal of RT3 to KV10 PTE20 pin
	RT3 connection with KV10 PTE21	3-4	Connect one terminal of RT3 to KV10 PTE21 pin
		Open	Isolate one terminal of RT3 to KV10 PTE21 pin
J14	RT4 connection with KV10 PTB3	1-2	Connect one terminal of RT4 to KV10 PTB3 pin
		Open	Connect one terminal of RT3 to KV10 PTB3 pin
	RT4 connection with KV10 PTB2	3-4	Connect one terminal of RT3 to KV10 PTB2 pin
		Open	Connect one terminal of RT3 to KV10 PTB2 pin
J18	JTAG SWDCLK select	1-2	Connect to OpenSDA
		2-3	Connect to KV10
J19	JTAG SWDIO select	1-2	Connect to OpenSDA
		2-3	Connect to KV10
J20	JTAG SWD reset	1-2	Connect to OpenSDA
		2-3	Connect to KV10

**Table 15. Jumper table (default settings highlighted)**

J21	RXD source selection	1-2	Connect KV10 PTB16 pin to elevator J24 A41 pin
		2-3	Connect KV10 PTB16 pin to OpenSDA RXD
		3-4	Connect KV10 PTD0 pin to OpenSDA RXD
		4-5	Connect KV10 PTD0 pin to elevator J24 A43 pin
J22	TXD source selection	1-2	Connect KV10 PTB17 pin to elevator J24 A42 pin
		2-3	Connect KV10 PTB17 pin to OpenSDA TXD
		3-4	Connect KV10 PTD1 pin to OpenSDA TXD
		4-5	Connect KV10 PTD1 pin to elevator J24 A44 pin
J25	PTC3 select	ON	Connect PTC3 Connect PTC3 to J24 A38 and B47pin
		OFF	Connect PTC3 to J24 B47pin only
J26	OpenSDA reset signal to KV10	ON	Connect OpenSDA reset signal to KV10
		OFF	Isolate OpenSDA reset signal to KV10 when test KV10 IDD current
J27	OpenSDA SWDCLK signal to KV10	ON	Connect OpenSDA SWDCLK signal to KV10
		OFF	Isolate OpenSDA SWDCLK signal to KV10 when test KV10 IDD current
J28	OpenSDA SWDIO signal to KV10	ON	Connect OpenSDA SWDIO signal to KV10
		OFF	Isolate OpenSDA SWDIO signal to KV10 when test KV10 IDD current
J29	JTAG VDD signal select	1-2	Connect KV10 power supply to JTAG pin1 and pull-up voltage of pin2
		2-3	Connect OpenSDA +3.3V provided by K20 to JTAG pin1 and pull-up voltage of pin2

## 4 Reference documents

The OpenSDA User's Guide, available on freescale.com, is a guide for users of the OpenSDA embedded circuit.

## 5 Revision history

Revision number	Date	Substantial changes
0	01/2014	Initial release

**How to Reach Us:**

**Home Page:**  
[freescale.com](http://freescale.com)

**Web Support:**  
[freescale.com/support](http://freescale.com/support)

Information in this document is provided solely to enable system and software implementers to use Freescale products. There are no express or implied copyright licenses granted hereunder to design or fabricate any integrated circuits based on the information in this document.

Freescale reserves the right to make changes without further notice to any products herein. Freescale makes no warranty, representation, or guarantee regarding the suitability of its products for any particular purpose, nor does Freescale assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. "Typical" parameters that may be provided in Freescale data sheets and/or specifications can and do vary in different applications, and actual performance may vary over time. All operating parameters, including "typicals," must be validated for each customer application by customer's technical experts. Freescale does not convey any license under its patent rights nor the rights of others. Freescale sells products pursuant to standard terms and conditions of sale, which can be found at the following address: [freescale.com/SalesTermsandConditions](http://freescale.com/SalesTermsandConditions).

Freescale, the Freescale logo, and Kinetis are trademarks of Freescale Semiconductor, Inc., Reg. U.S. Pat. & Tm. Off. Tower is a trademark of Freescale Semiconductor, Inc. All other product or service names are the property of their respective owners. ARM and Cortex are registered trademarks of ARM Limited (or its subsidiaries) in the EU and/or elsewhere. All rights reserved.

© 2014 Freescale Semiconductor, Inc.



Document Number: TWRKV10Z32UG  
Rev. 0  
01/2014

