1 Introduction

The Freescale three-phase power meter reference design is designed according to the China State Grid Corporation standard Q/GDW354-2012 *Functional Specification for Smart Electricity Meters* and standard Q/GDW 356-2012 *Type Specification for Smart Polyphase Electricity Meters*.

The reference design aims to reduce the time to market for power meter customers and partners, and tailor the design to the user’s unique needs in their powering system.

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The three-phase power meter reference design uses the Freescale ARM® Cortex®-M0+ core 144-PIN LQFP KM34Z256 SoC to realize all the metering and application functions.

**Figure 1. KM34Z256 block diagram**
The hardware design consists of the power board and the main board. The following figure shows the system diagram:

Figure 2. System block diagram
2 Demo board content

The following figure shows the demo board:

![Demo board content](image)

Figure 3. Power meter demo
The following figure shows the hardware connection method:

![Power meter demo without casing](image)

**Figure 4. Power meter demo without casing**

### 3 Demo board hardware features

The Freescale three-phase power meter includes the following hardware features:

- An ARM Cortex-M0+ core MKM34Z256VLQ7, a 144 LQFP, 75 MHz, 256 KB flash memory, and a 32 KB SRAM.
- 3 x 220/380 V voltage inputs generate two isolated 5 V DC outputs; one is for the system while the other one is for 485 communications.
- Current sampling: a 0.05% accuracy CT, a 25 ppm shunt, and a 24-bit SD ADC.
- Voltage sampling: a 25 ppm resistor divider, and a 16-bit SAR ADC.
Three-phase power meter demo board

- A KM34 internal ACMP module for zero cross point detection.
- 5 ppm accuracy RTC is achieved using an external 0.5 °C resolution temperature sensor, an external 32.768 kHz crystal and an internal RTC module.
- One isolated RS485 output in half-duplex mode, with an ISL3152EBZ.
- An infrared circuit with an AT205B as a transmitter and a TSOP4838 as receiver.
- An external 512 KB I2C EEPROM 24LC512 and 64 MB SPI flash MX25L6406EM2I-12G provide the memory extension.
- 3 x isolated electrical pulse output, 3 x light pulse output for meter calibration/indication/test.
- Tamper protection: A tamper input pin detects box opening and an I2C based magnetic sensor detects activity.
- Display: JIYA eight 32-segment LCD display modules with backlight control.

4 Three-phase power meter demo board

4.1. System power

The demo board is powered by 220 V AC. The power board transfers the grid AC voltage into two isolated linear 5 V DC outputs. One 5 V DC output for powering the MCU system while the other one is for isolated RS485 communication.

In power line off mode, the system has a 6 V lithium battery as backup power. One 3.6 V battery powers the RTC, this battery must not be changed in the meter’s lifespan.

As the MCU system has a 3.3 V DC input, it needs an LDO to transfer the 5 V input to 3.3 V output in the system. The LDO must have low quiescent current and low noise.

The following 2 figures illustrate the DC/DC and battery supply circuit.

The KM3x based metering system uses an internal ADC voltage reference; however to achieve higher accuracy the meter must have an external high accuracy voltage reference. See Figure 6.

Figure 5. DC power supply

Figure 6. Battery supply and RTC circuit
4.2 Clock

The KM34 system has an external Citizen +/-20 ppm 32.768 kHz crystal. RTC clock generation is also performed by the crystal, that requires a high consistency of performance level.

4.3 Debug interface

The KM34 system uses a SWD debug port, J-Link and Multilink tools can be used for code developing and debugging.
The software uses the IAR tool chain (version 7.3 or higher), which can be configured to use the selective hardware debugger.

4.4. Voltage sampling and frequency measuring

The power line voltage sampling is done by a 16-bit SAR ADC. 220 V AC is transformed to approximately 0.17 V AC by a resistor divider. The circuit adds a 0.6 V DC offset to this AC signal then sends it to the SAR ADC for sampling.

The 0.6 V DC offset is generated by the KM34 internal 1.2 V VREF output and external amplifier divider circuit by default.

There is an option to use an external 1.2 V VREF for the system. This requires a software switch configuration.
The following figure shows the voltage sampling circuit:

![Voltage Sampling Diagram](image_url)

**Figure 9. Voltage sampling circuit**

### 4.5. Current sampling

Current sampling is performed by an AFE 24-bit ΣΔ ADC module. The load current passes through the primary side of the CT (with 5/100 A current, 0.05% accuracy, and 2500 ratio). The secondary side current flows through the 3.9 R shunt resistor to generate a differential voltage to the ΣΔ ADC.

For some pads the voltage sampling function is multiplexed with the ACMP input, which means the frequency can be monitored by an ACMP module while the ADC module is sampling the voltage. The ACMP module has two inputs, the first input is the AC voltage after resistor divider and adding the offset. The second input is the ACMP input that is 0.6 V offset.
The following figure illustrates the current sampling circuit:

![Current Sampling Circuit](image)

**Figure 10. Current sampling circuit**

### 4.6. External memory

The system uses a 512 KB EEPROM (as shown in Figure 12) which is based on an I2C port and 64 MB SPI flash memory (as shown in Figure 11) for memory extension.

The choice of memory type and memory size are application-dependent. This memory is reserved for customer application usage. Only low-level read/write logic is implemented in the software.
4.7. Tamper protection

Tamper protection has three features. The tamper detection pin monitors whether the casing is open. The magnetic sensor detects activity.

In voltage missing mode the system enters into low-power mode, periodically sampling the current to prevent tampering.
The following figure shows the tamper detection circuit:

![Tamper Detection Diagram]

**Figure 13. Tamper input circuit**

![Magnetic Sensor Diagram]

**Figure 14. Magnetic Sensor**
4.8. Pulse output

The power meter has an isolated electrical output and a light pulse output for accuracy testing and calibration, RTC testing and calibration and status indication.

![Pulse Output Diagram]

**Figure 15. Pulse output circuit**

4.9. RS485 interface

The power meter system has one isolated RS485 port. This port is in half-duplex mode and has multiple purposes, for instance meter calibration and for billing purposes.
4.10. LCD display and backlight

The power meter system has the Chinese standard eight 32-segment LCD modules which display all of the metering information.

The LCD module has two 15 mA diodes as backlights. The system can switch these on or off according to the application.
4.11. Jumper table

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Option</th>
<th>Setting</th>
<th>Description</th>
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<tbody>
<tr>
<td>J3</td>
<td>System 3.3V power supply</td>
<td>1-2</td>
<td>System power supply on</td>
</tr>
<tr>
<td>J4</td>
<td>External VREF power supply</td>
<td>off</td>
<td>Internal VREF is used by default</td>
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</table>
5. Summary

This document describes the hardware design features of the three-phase power meter demo boards. For technical details about the board design and solution implementation see the Kinetis M Series MCUs documentation section of freescale.com.

6. References

1. Kinetis Series MCUs Taxonomy Page
   (http://www.freescale.com/webapp/sps/site/taxonomy.jsp?code=KINETIS_M_SERIES&cof=0&am=0)
2. Kinetis Series MCUs Product Summary Page
   (http://www.freescale.com/webapp/sps/site/prod_summary.jsp?code=KM3x)

7. Revision history

<table>
<thead>
<tr>
<th>Revision number</th>
<th>Date</th>
<th>Substantial changes</th>
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<tbody>
<tr>
<td>Rev.0</td>
<td>06/2015</td>
<td>Initial release</td>
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<tr>
<td>Rev.1</td>
<td>09/2015</td>
<td>Modifications to Figure 7, Figure 11, Figure 17, and Table 1</td>
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