AN14903

Implementation of Window Comparator using MCX A34x

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Document information

Information	Content
Keywords	AN14903, MCX, MCXA, MCX A34x, Low-Power Comparator (LPCMP), AOI, window comparator
Abstract	This application note describes the implementation of window comparator using MCX A34x MCUs.

1 Introduction

This application note describes the implementation of window comparator on the NXP MCX A34x MCU. It also applies to MCX A17x, A18x, A25x, A26x, A35x, and A36x MCU series.

This document also introduces the hardware platform, MCU features, peripheral settings, and demo setup. The NXP Freedom board FRDM-MCXA346 is used as a hardware platform.

The MCX A34x MCUs use a single Arm Cortex-M33 core, which operates up to 180 MHz. It offers multiple high-speed connectivity options and features serial peripherals like timers, analog, and programming logic units.

The demo includes one FRDM-MCXA346 board. The MCX A34x MCU gets voltage input and connects to an internal LPCMP. The trigger output signal of the Comparator (CMP) is routed to the AND/OR INVERT module (AOI), which manifests the comparison result.

2 Window comparator overview

A window comparator is an electronic circuit, which determines whether an input voltage falls within a specific range (or window) defined by two threshold voltages. If the input signal is within the window, the output typically goes high (or low, depending on design). If the input is outside the window, the output changes the state accordingly.

The circuit is implemented using two CMPs and some logic gates. Window comparators are widely used in voltage monitoring, Battery Management Systems (BMS), sensor signal validation, industrial control systems, and protection against overcurrent or temperature conditions.

3 Hardware platform

The FRDM-MCXA346 board is a design and evaluation platform based on the NXP MCX A Microcontroller Unit (MCU). The board is compatible with Arduino UNO boards. It can be used with a wide range of development tools, including NXP MCUXpresso IDE, IAR Embedded Workbench, and Arm Keil MDK. The board is lead-free and RoHS-compliant.

For debugging the MCX A34x MCU, the FRDM-MCXA34x board uses an onboard MCU-Link Debugger, which is based on another MCU.

Figure 1 presents the system structure block diagram of the window comparator demo.

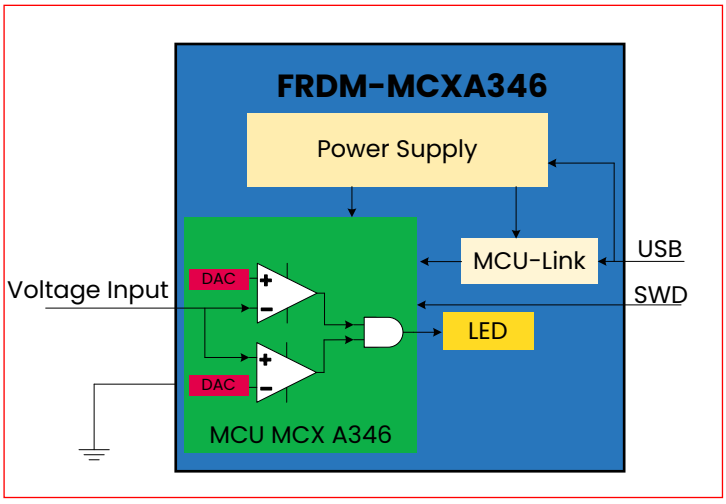

Figure 1. System structure block diagram

4 MCU features and peripheral settings

The MCX A34x MCUs provide a rich set of features and peripherals that support the implementation of the window comparator. These include SCG, LPCMP, AOI logic module, and INPUTMUX.

4.1 MCU Peripheral settings

The subsections that follow describe the MCU peripheral configurations of the demo.

4.1.1 System clock Generator (SCG)

The SCG generates and controls the clocks of various modules in the design. This module uses the available clock sources to generate the clock roots.

The clock source used in the window comparator application is the FRO180M (FIRC), which can boot up to 180 MHz at most. The clock frequency for the Arm core and CMP is 180 MHz.

Table 1 shows the clock source configuration.

Table 1. Clock source configuration for motor control peripherals

Module on MCU	Clock source	Divided frequency
main_clock	180 MHz	fro_hf
Core clock	180 MHz	fro_hf
CMP	180 MHz	fro_hf

4.1.2 Low-Power Comparator (LPCMP)

MCX A346 includes three instances of the CMP module: CMP0, CMP1, and CMP2. The LPCMP module provides a circuit to compare analog input voltage. It includes a LPCMP, a Digital-to-Analog Converter (DAC), an Analog Multiplexer (ANMUX).

The LPCMP operates across the full supply voltage range, known as rail-to-rail operation. The DAC is a 256-tap resistor ladder network that provides a selectable voltage reference for applications requiring a voltage reference.

The DAC divides the supply reference Vin into 256 voltage levels. An 8-bit digital signal input selects the output voltage level, which varies from Vin to Vin/256.

ANMUX allows selection of an analog input signal from eight channel options. One channel option is the DAC output,while other chip resources are connected to the other channels. ANMUX operates across the full supply voltage range.

In the demo, CMP0 and CMP1 use the following configurations:

CMP0 configuration:

- The DAC internal voltage reference source is selected as a resistor ladder network supply reference
- DAC low power mode is disabled
- High-speed power mode is enabled
- Analog CMP hysteresis is set to 30 mV
- Positive channel using internal DAC output as an upper limit voltage reference
- Negative Channel using CMP0_IN1N as an external voltage input

CMP1 configuration:

- The DAC internal voltage reference source is selected as a resistor ladder network supply reference

- DAC low power mode is disabled
- High-speed power mode is enabled
- Analog CMP hysteresis is set to 30 mV
- Positive Channel using CMP1_IN2P as an external voltage input
- Negative Channel using internal DAC output as a lower limit voltage reference

4.1.3 AND/OR INVERT (AOI)

MCX A346 includes two instances of the AOI module: AOI0 and AOI1.

The AOI controller is a target peripheral module that connects event input indicators from various modules and generates event output signals routed to other peripherals. Users can access its programming model through the standard IPS target interface and configure AOI to implement different Boolean functions.

The AOI module supports the generation of a configurable number of EVENT signals. Each output EVENTn is a configurable AOI function of four associated AOI inputs: An, Bn, Cn, and Dn, where *n* represents the channel number. AOI supports four event outputs, each representing a programmable, combinational Boolean function.

The window CMP demo configures the AOI module as a single AND gate. If the input voltage falls outside the defined range, AOI outputs a negative signal; if the input voltage is within the range, AOI outputs a positive signal.

The truth table for this configuration is shown in Table 2:

Table 2. Truth table

Input voltage	CMP0 Output AOI Input A1 A	CMP1 Output AOI Input B1 B	AOI Output Event Y
Higher than defined range	Low	High	Low
Within a defined range	High	High	High
Lower than defined range	High	Low	Low

4.1.4 Input Multiplexing (INPUTMUX)

The INPUTMUX provides signal routing options for internal peripherals. Some peripheral inputs are multiplexed to multiple input sources. The sources include external pins, interrupts, output signals of other peripherals, or other internal signals.

In this demo, INPUTMUX routes CMP output signals to the AOI module as follows:

• CMP0_OUT_TRIG is selected as trigger input for AOI0_TRIGSEL0.

• CMP1_OUT_TRIG is selected as trigger input for AOI0_TRIGSEL1.

5 Demo setup

This section demonstrates the operation and performance of the demos. The board FRDM-MCXA346 is used in demos. The board user guide is described in *FRDM-MCXA346 Board User Manual* (document UM12348).

5.1 Demo connection

On the FRDM-MCXA346 board, connect J2_17 (CMP0_IN1N) and J2_19 (CMP1_IN2P) together as an external voltage input, which connects to the DC power supply.

Use a USB-Type C cable to connect to the FRDM board connector (J15) marked as MCU-Link. After compiling the project, download the code using the debug button in the toolbar. Select CMSIS-DAP or J-Link in the Debug as label, depending on the firmware installed on the onboard debugger.

Figure 2 shows the connection of this demo.

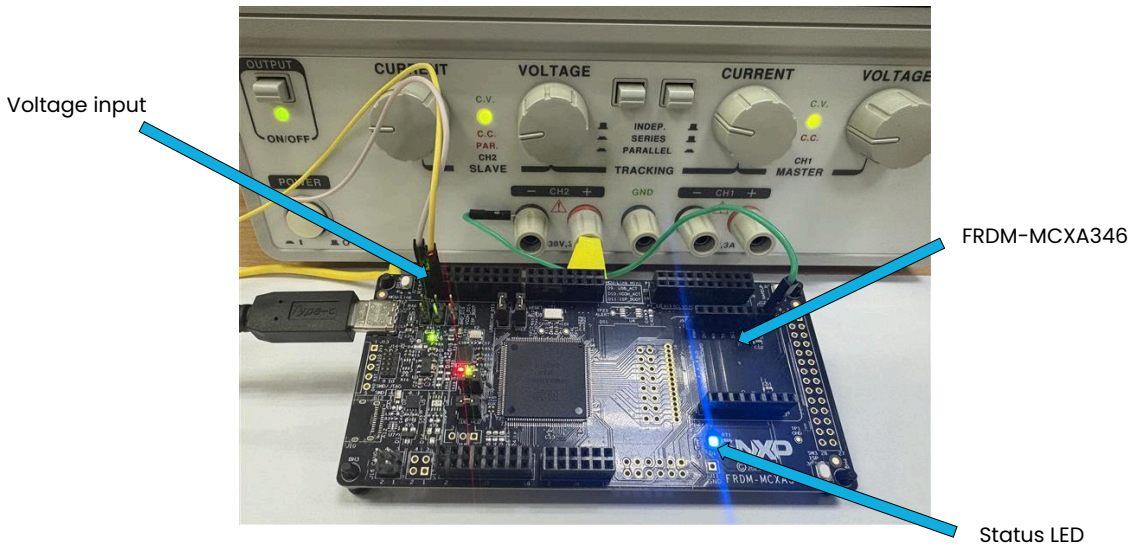

Figure 2. Demo connection

5.2 Project setup in MCUXpresso IDE

To clone the demo code from Application Code Hub directly in MCUXpresso IDE, follow the steps below:

1. Open MCUXpresso IDE, and in the *Quick Start Panel*, select *Import*.
2. In the Import window, select *From Application Code Hub* to open the list of online NXP demo projects.
3. Search for the required demo by entering its name or by selecting relevant tags. Open the demo project, click the *GitHub link*, and then select *Next*.
4. Select the *main* branch of the repository and click *Next*.
5. In the *Destination -> Directory* field, choose the local folder where you want to store the cloned repository. MCUXpresso IDE clones the repository into the selected location. After the cloning process completes, select *Next*.
6. In the Project Import Wizard, select *Import existing Eclipse projects*, and then click *Next*.
7. Select the project in the repository (only one project in this repo) and click *Finish* to complete the import.

5.3 Run the demo

Figure 3 shows the result of the running demo. An oscillate scope measures the DC power supply output voltage and the AOI trigger output (P3_21). The voltage upper limit is set to 3.0 V (8-bit DAC value is 0xE8), and the lower limit is set to 1.0 V (8-bit DAC value is 0x4D).

The yellow line represents the input voltage, and the blue line represents the comparison result. When the input voltage falls within the defined range, the system output goes high; otherwise, it goes low.

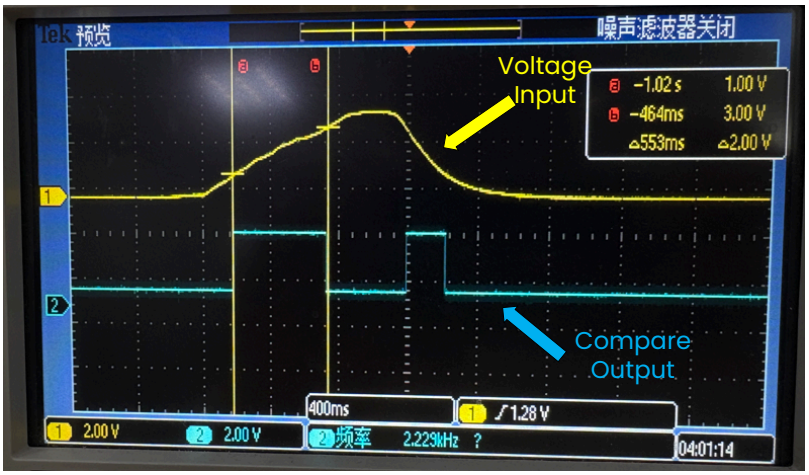

Figure 3. Test result

Figure 4 and Figure 5 show the transfer delay of the demo when setting LPCMP in high-speed power mode with hysteresis level 3. When the input voltage rises above the comparison window, the output goes high. The transfer delay measures 27 ns, as shown in Figure 4.

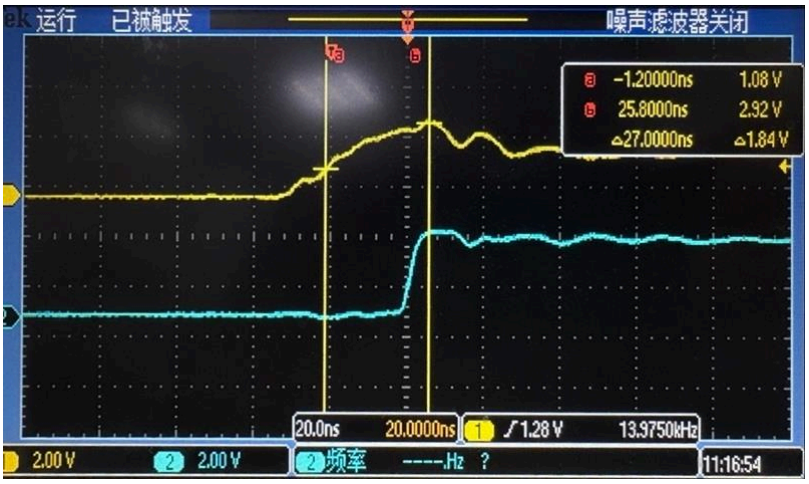

Figure 4. Transfer delay on rising edge

When the input voltage falls below the comparison window, the output goes low. The transfer delay is also 27 ns, as shown in Figure 5.

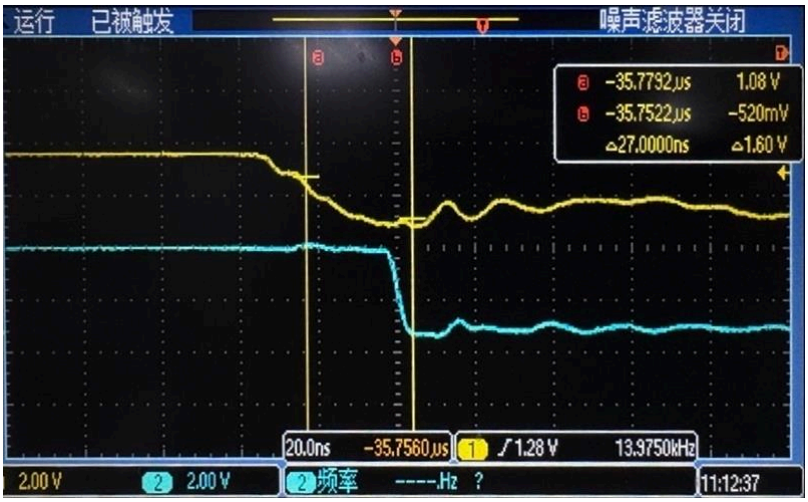

Figure 5. Transfer delay on falling edge

6 Acronyms

Table 3 lists the acronyms used in this document along with their description.

Table 3. Acronyms

Term	Description
AOI	AND/OR INVERT module
ANMUX	Analog Multiplexer
BMS	Battery Management Systems
CMP	Comparator
DAC	Digital-to-Analog Converter
INPUTMUX	Input Multiplexing
LPCMP	Low-Power Comparator
MCU	Microcontroller Unit
SCG	System Clock Generator

7 Related documentation

lists the references used to supplement this document.

Table 4. Related documentation/resources

Document	Link/how to access
MCX A345 and MCX A346 Reference Manual (document MCXAP144M240F60RM)	MCXAP144M240F60RM
MCXA345/346/355/356/365/366 Data Sheet (document MCXAP144M240F60)	MCXAP144M240F60
FRDM-MCXA346 Board User Manual (document UM12348)	UM12348

8 Revision history

Table 5 summarizes the revisions to this document.

Table 5. Revision history

Document ID	Release date	Description
AN14903 v.1.0	24 December 2025	Initial public release

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