ENHANCE PERFORMANCE AND FLEXIBILITY WHILE PROVIDING ADDITIONAL I/O'S AND FASTER SPEEDS WITH OUR NEWEST I2C/I3C DEVICES

New Product Update

Rosemary Sanchez
- Product Marketing Engineer
Tyler Townsend
- Applications Engineer

Agenda

- TI I2C/I3C hero and new devices overview
- TCAL Agile I/O Expander overview and applications
- TCA39416 (I2C/I3C translator) I2C vs I3C enhancements and low voltage applications

TI | I2C portfolio overview

Level shifters, Buffers & Hubs

Overview

- Strengthen your I2C bus signal and resolve voltage mismatch
- Buffering translators
- Translators
- FM, FM+ support

Hero Products

- PCA9306/Q1
- TCA9511A
- TCA4307
- TCA9517A/Q1
- TCA9617A

Applications

- Servers, Enterprise SSD
- Routers (Telecom Switching Equipment)
- I2C, SMBus, PMBus, MDIO, UART, low-speed SDIO, GPIO, and other two-signal interfaces
- Factory Automation
- Automotive – HUD, Clusters, ADAS


IO Expanders

Overview

- Increase the number of available I2C I/O pins
- 4-, 8-, 16-, 24-bit
- Level translating expanders
- Open drain, push-pull I/Os
- I2C based key pad scanners and LED drivers

Hero Products

- TCA9555
- TCA6408A/Q1
- TCA9539/Q1
- TCA6507
- TCA6416A

Applications

- Servers, Enterprise SSD
- Routers (Telecom Switching Equipment)
- PC & Notebooks
- Mobile Phones
- Factory Automation
- Automotive – Infotainment / BCM


Switches & Muxes

Overview

- Expand the capability of your control system by switching between I2C buses.
- 1:2, 1:4, 1:8
- Level translating switches
- Cascaded interrupts

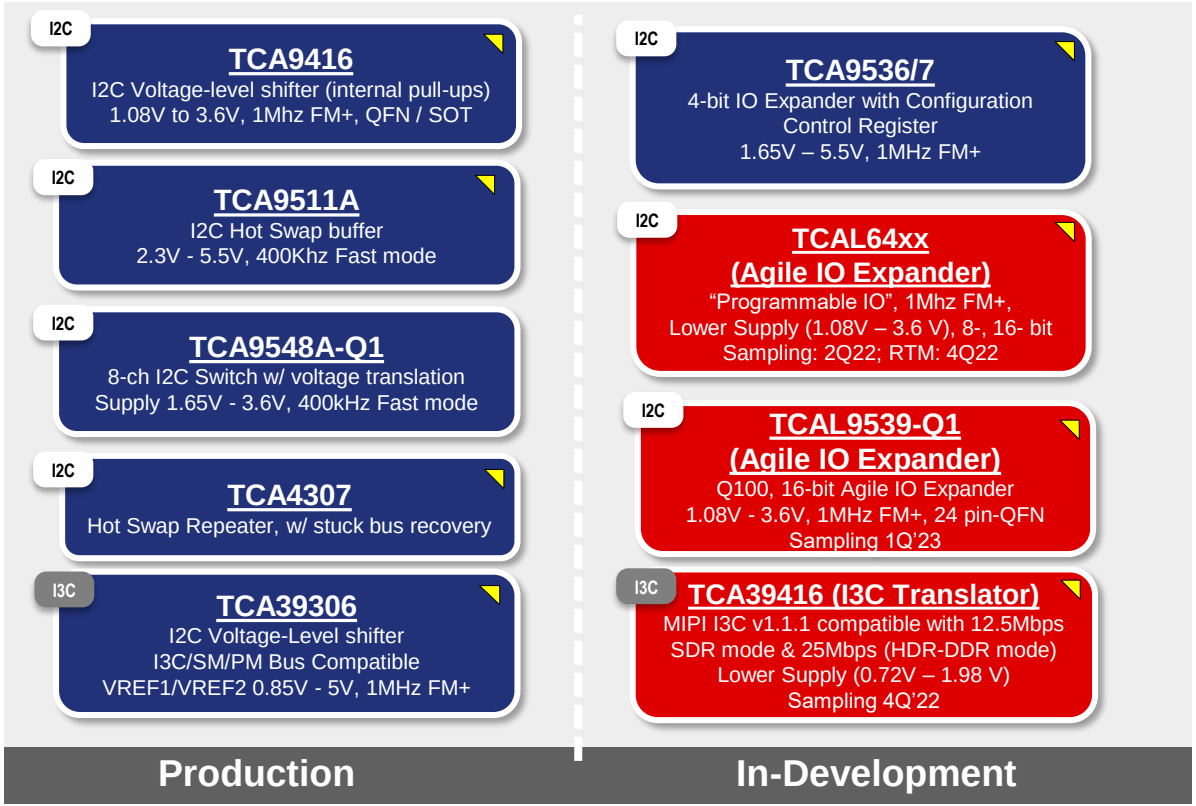
Hero Products

- TCA9546A
- TCA9548A/Q1
- TCA9543A
- TCA9545A

Applications

- Servers, Enterprise SSD
- Routers (Telecom Switching Equipment)
- Factory Automation
- Products With I2C Slave Address Conflicts (Ex: Multiple Sensors))
- Automotive – Infotainment / BCM


Interface | IxC roadmap



I3C I2C

Production

Sampling

Target Operating Temp: -40˚C to 125˚C

TCAL64xx/TCAL95xx

Ultra Low Voltage Agile I/O Expander Family

Sampling

Features

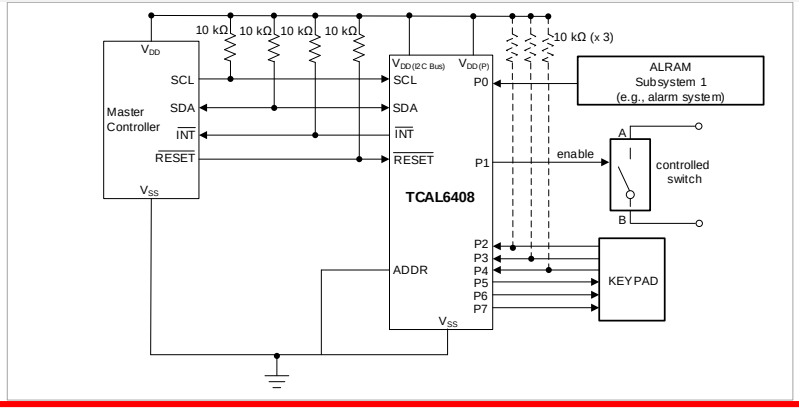
- 8/16-bit I2C bus GPIO expanders
- Low supply voltage range of **1.08 V to 3.6 V**
  - 64xx family supports level translation, 95xx is single supply
- Fast-Mode plus **(FM+)** I2C Interface (1000 kHz)
- **Small 16 pin QFN package** (1.6 x 1.6 x 0.35mm height)
- Highly configurable IO interface
  - Selectable pull-up and pull-down resistors
  - Configurable push-pull or open-drain outputs
- Low typical standby current **<1 µA** (1.8 V typ)
- Operating temperature: -40°C to 125°C
- ESD protection:
  - 2000-V Human-body model (A114-A)
  - 1000-V Charged-Device model (C101)

Applications

- Wearables
- System monitoring:
  - LED driving
  - Button input
- Industrial automation, Factory automation, Building automation, Protection relay
- Telecom baseband
- Computing segments

Benefits

- Low voltage support for next generation processors
- Reduced BoM and board space providing reduced costs
- Higher data rates allowing increased data throughput
- Reduced current consumption for power critical systems
- System adaptability for easy prototyping
- Agile I/O Features:
  - Programmable output drive strength
  - Latchable inputs
  - Mask Interrupt & Interrupt status register
  - Programmable output configuration
  - Selectable input pull-up/pull down registers



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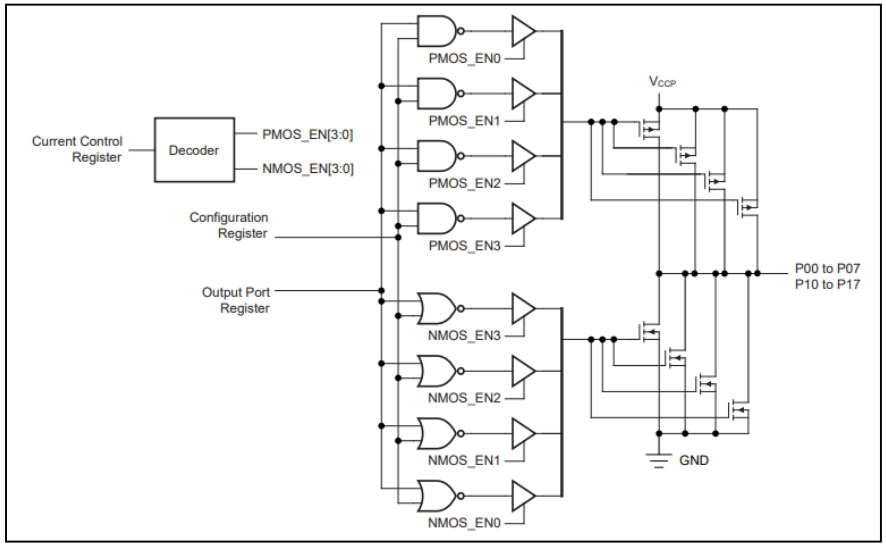
Agile I/O | Features

TCAL64xx/95xx Ultra Low Voltage Agile I/O Expander Family improves the I/O by increasing flexibility and allowing the user to optimize their design for power consumption, speed, and EMI at lower cost

Agile I/O Features	Benefit
Programmable output drive strength	• Helps conserve battery power • Reduces EMI issues and system noise
Latchable inputs	• Locks in any changes on input pins until the input port register is read • Eliminates external hardware • Simplifies software
Mask Interrupt	• Selects which inputs can cause an interrupt event on the output pin simplifying Interrupt service software • Masks abnormal interrupts from meddling with software performance
Interrupt status register	• Simplifies interrupt service routine software by specifying which input caused an event on the pin • Improves software performance
Programmable output configuration	• Customizable output configurations (open-drain or push-pull outputs) • Increases flexibility and simplifies software
Selectable input pull-up/pull down registers	• Reduces BOM cost by eliminating need for external resistors

Programmable output drive strength



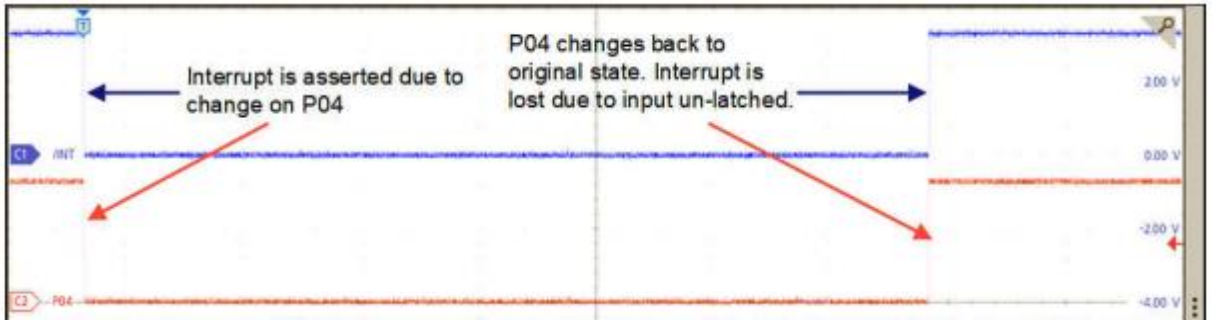
- Weaker outputs reduce ringing effects
- Can vary drive strength for different loading conditions
- Reduces overall power consumption

Table 2-2. Two-Bit Combination for Adjusting Output Drive Strength on P-Port

CC – XX	Output Strength
00	0.25x
01	0.5x
10	0.75x
11	1.00x

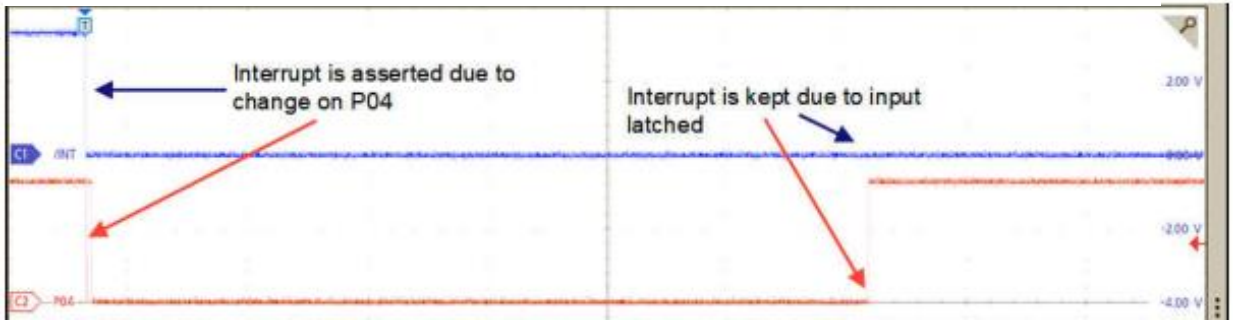
Latchable inputs

Case 1



Interrupt is asserted and lost due to the input changing back to its original state

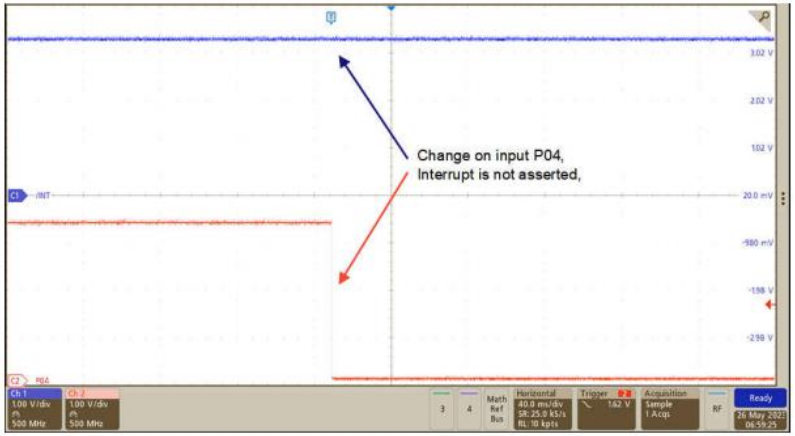
Case 2



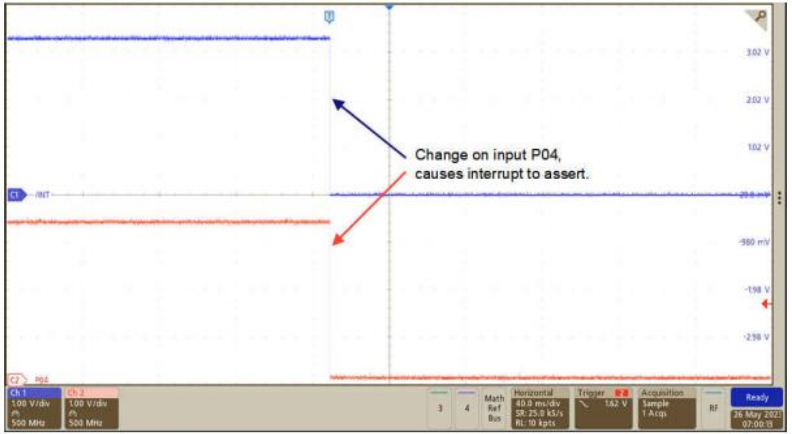
Interrupt is kept even when input changes back to its original state

This is the main difference between our **TCA** and **TCAL** IO expanders.

Maskable interrupts



“Interrupt is Masked”



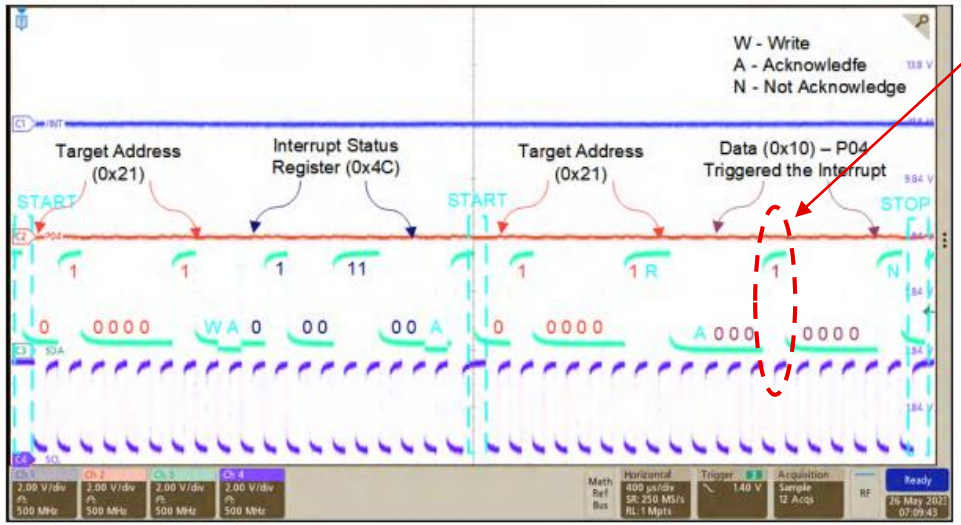
“Interrupt is Un-Masked”

***Maskable interrupts are useful for priority switching. When one task is more important the another, the designer can choose to mask an interrupt to push the GPIO’s task lower in the priority list.

Interrupt status register

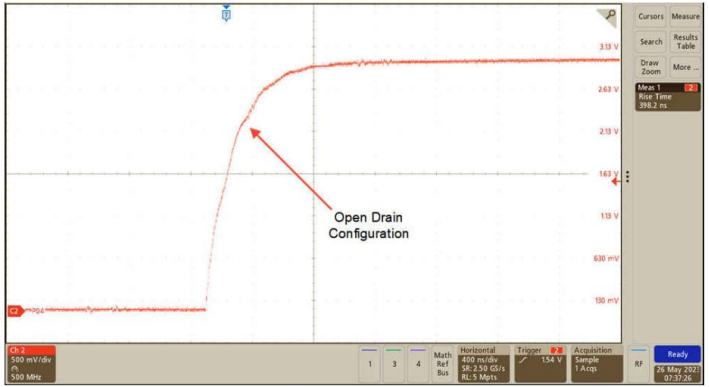
P04

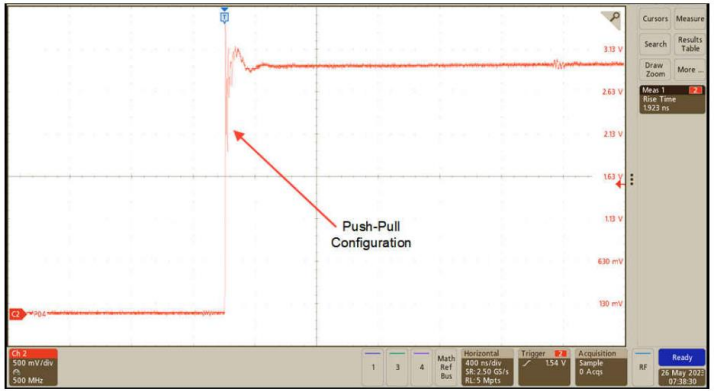
BIT	S-07	S-06	S-05	S-04	S-03	S-02	S-01	S-00
Default	0	0	0	0	0	0	0	0
BIT	S-17	S-16	S-15	S-14	S-13	S-12	S-11	S-10
Default	0	0	0	0	0	0	0	0

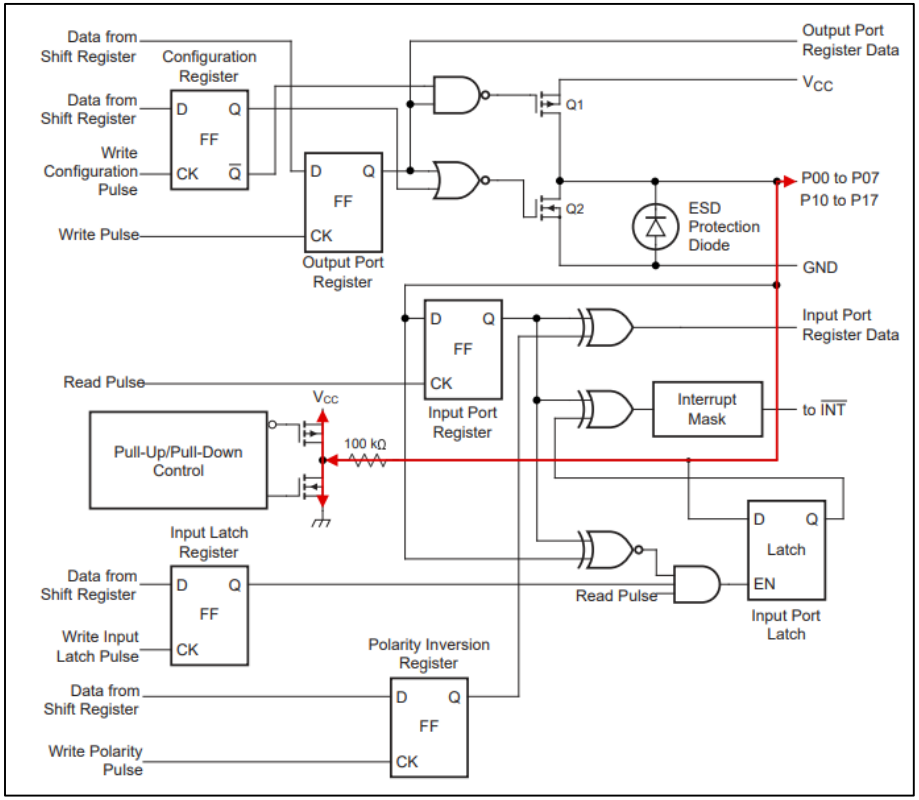


- Interrupt status register flags which p-port was responsible for triggering the interrupt
  - (Benefit) Instead of polling through each IO port, a single register can be read to determine source of interrupt

Programmable output configuration and Pull-Up/Pull-down resistors







TCAL9539-Q1

Ultra Low Voltage 16-Bit I2C and SMBus Agile I/O Expander

Sampling

Features

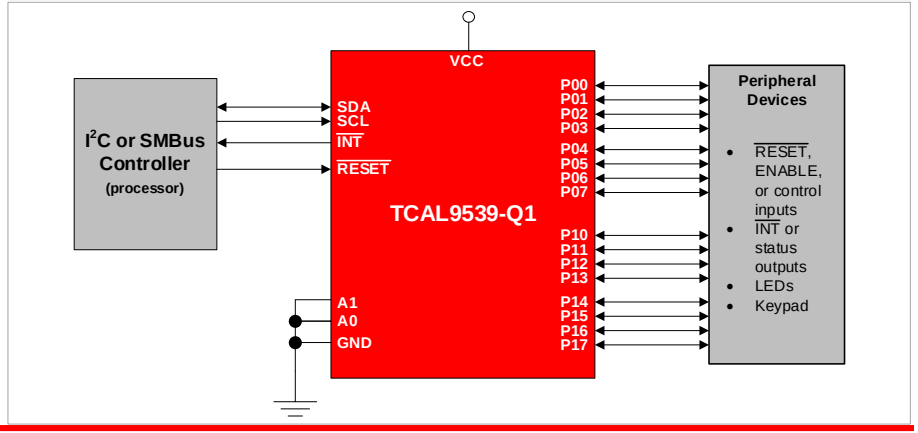
- 16-bit I2C bus GPIO expander
- Low supply voltage range of **1.08 V to 3.6 V**
- Fast-Mode plus **(FM+)** I2C Interface (1000 kHz)
- Highly configurable IO interface:
  - Selectable pull-up and pull-down resistors
  - Configurable push-pull or open-drain outputs
- Low typical standby current **<1 µA** (1.8 V typ)
- Operating temperature: -40°C to 125°C
- ESD protection:
  - 2000-V Human-body model (A114-A)
  - 1000-V Charged-Device model (C101)
- Packaging:
  - 24 pin WQFN package (4 mm x 4 mm)
- AEC-Q100 qualified for automotive applications

Applications

- Automotive Infotainment
- Advanced Drive Assistance Systems (ADAS)
- Automotive Body Electronics
- HEV, EV, and Power train
- System monitoring:
  - LED driving
  - Button input
- Industrial automation, Factory automation, Building automation

Benefits

- Low voltage support for next generation processors
- Reduced BoM and board space providing reduced costs
- Higher data rates allowing increased data throughput
- Reduced current consumption for power critical systems
- System adaptability for easy prototyping
- Agile I/O Features:
  - Programmable output drive strength
  - Latchable inputs
  - Mask Interrupt & Interrupt status register
  - Programmable output configuration
  - Selectable input pull-up/pull down registers



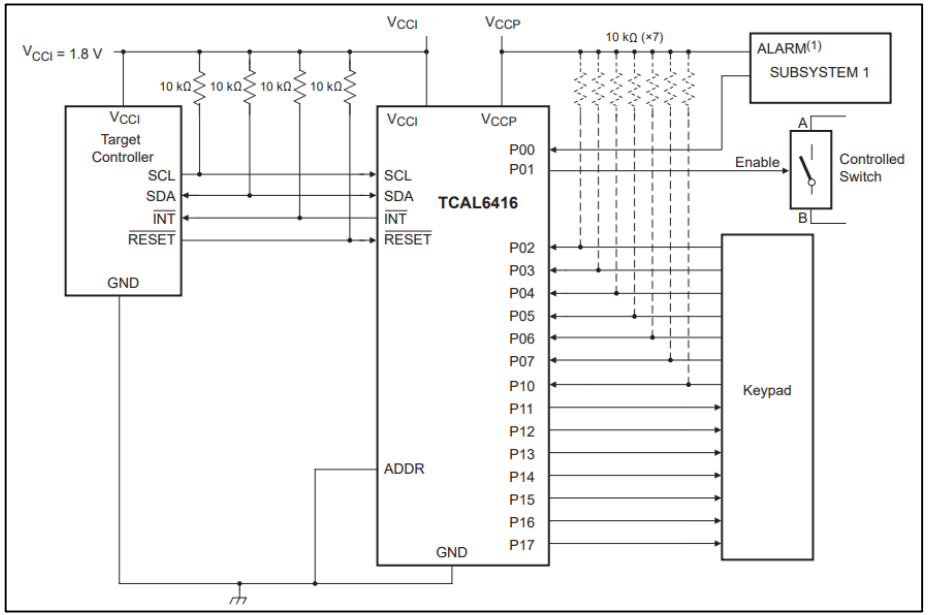
TCA6408 | performance benchmark

	TCAL6408	TCA6408A
VCC support	1.08 – 3.6V	1.65 – 5.5V
Data rate	1MHz	400kHz
Temperature range	-40°C – 125°C	-40°C – 85°C
Agile IO features	Yes	No
Standby current (max)	1.5µA	7µA
Small QFN Package (<0.4mm height)	Yes	No
Packages Offered	TSSOP, UQFN, X2QFN	TSSOP, VQFN, UQFN
Current sinking capability	25mA	25mA
ESD HBM	2kV	2kV

TCA6416 | performance benchmark

	TCAL6416	TCA6416A
VCC support	1.08 – 3.6V	1.65 – 5.5V
Data rate	1MHz	400kHz
Temperature range	-40°C – 125°C	-40°C – 85°C
Agile IO features	Yes	No
Standby current (max)	3µA	5µA
Packages offered	TSSOP, WQFN	TSSOP, WQFN
Current sinking capability	25mA	25mA
ESD HBM	2kV	2kV

TCAL Agile I/O| applications



Target Sectors:

- Wearables
- System monitoring:
  - LED driving
  - Button input
- Industrial automation, Factory automation, Building automation, Protection relay
- Telecom baseband
- Computing segments

Key care-about:

1. Additional configurable I/O's, 8/16-bit translating/non-level translating options
2. Low-voltage support, 1.08 V to 3.6 V
3. Reduce BOM and board space, X2QFN package
4. Faster data rates, 1MHz I2C speeds

TCAL6408 in temperature sensor interface for PLC's

I2C

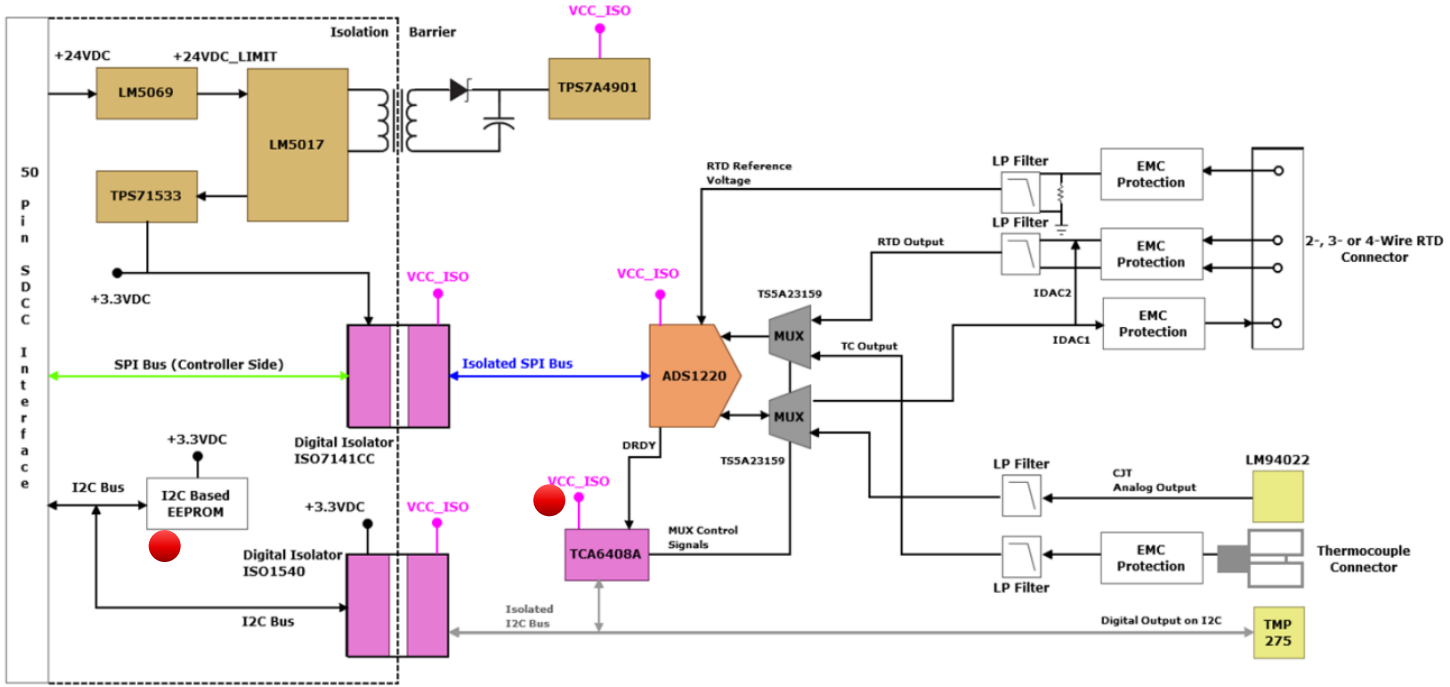


Figure 1. Block Diagram of Temperature Sensor Interface Module for PLC

Specifications: I2C vs I3C

Features	I2C	I3C
Frequency	400KHz	SDR up to 12.5MHz
Typology	Open Drain only	Open Drain & Push-Pull
Multi-Host	1 Host	Multi-Host/ 1 Host at a time
Operation Modes (SDR, HDR-DDR)	High Speed Mode	HDR mode
Capacitive Load per bus line	400 pF for FM; 550 pF for FM+	50 pF
Dynamic Addressing	Static	Dynamic (plug and play)
Voltage Levels	1.8, 3.3, 5.0V	1.2, 1.8, 3.3 V
In band Interrupt (reduce pin#)	Host initiate Alert pin	Target request control
Hot Join	Not supported	Supported

**Images from MIPI Alliance*

**Specs from MIPI I3C-Basic specification*

TCA39416

Sampling

Ultra-low voltage I3C and I2C translator with rise time accelerators

Features

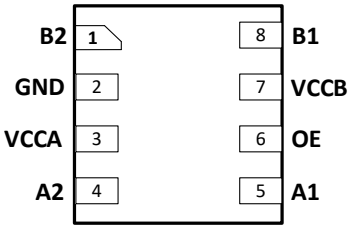
- VCCA and VCCB supply range of 0.72 V to 1.98 V
- Integrated rise and fall time accelerators to redrive signal
- **Compatible with MIPI I3C** supporting speeds up to **12.5 MHz**
- Standard mode, Fast mode and Fast-mode plus I^2C support
- 0.72 V to 1.98 V on both A and B ports; $V_{CCA} \leq V_{CCB}$
- No power-supply sequencing required: either VCCA
- or VCCB can be ramped first
- Low ICC current
- Powered-off high impedance for all pins
- Temperature Range: -40˚C to +125˚C
- ESD protection: 2000-V Human-body model (A114-A)
- Packages:
  - 8-pin SOT-23 package (DDF, 1.6mm x 2.9mm)
  - 8-pin X2SON package (DTW, 1.35mm x 1.00mm)

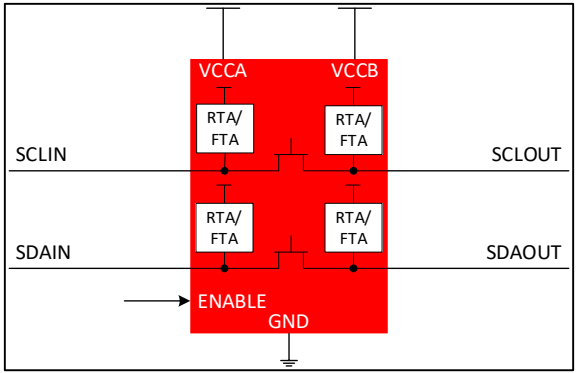
Applications

- Enterprise Servers
- PC & Notebooks
- Industrial Servers
- Wearables

Benefits

- Rise and fall time accelerators speed up the rise and fall times
- Redrive signal with integrated edge rate accelerators (RTA/FTA)
- Symmetrical power supply support allows for low voltage buffering in addition to translation
- I3C (data rates up to 12.5 Mbps in SDR mode, 25 Mbps in HDR-DDR mode)



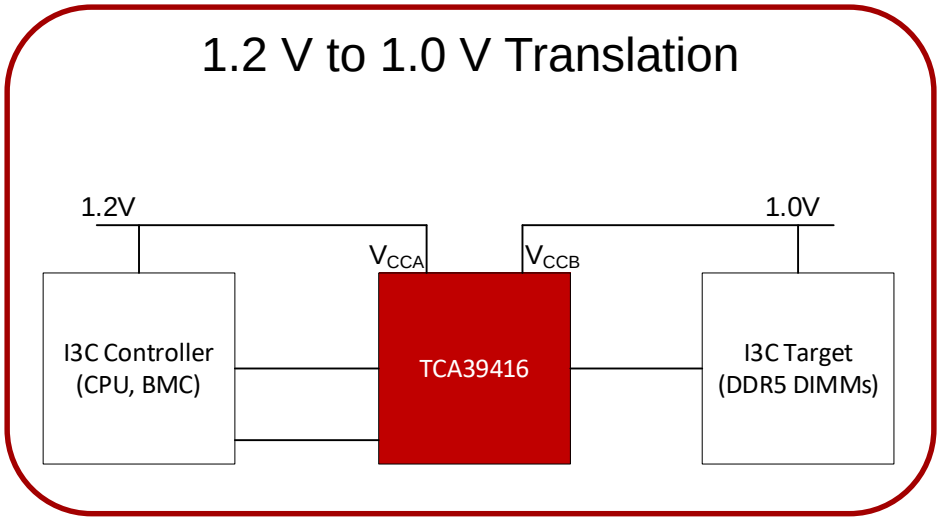


Texas Instruments

TCA39416 | performance benchmark

	TCA39306	TCA39416
Supply voltage (V)	.72 V to 1.98 V	.72 V to 1.98 V
V_{CCA} vs V_{CCB} dependencies	$V_{CCA} \leq V_{CCB}$	$V_{CCA} \leq V_{CCB}$
Data rate @ 12.5MHz	12.5 Mbps	25 Mbps with HDR-DDR
Temperature (°C)	-40 to 125	-40 to 125
Supply current EN LOW @ 1.98V V_{cc}	< 1 µA	< 40 µA
ESD protection	HBM: 2kV CDM: 1kV	HBM: 4kV CDM: 1.5kV
Package	8-pin X2SON (DTM) 8-pin SOT-23 (DDF) 8-pin VSSOP (DCU)	8-pin SOT-23 (DDF) 8-pin X2SON
Additional features		Rise and fall time accelerators

I3C level translator | applications



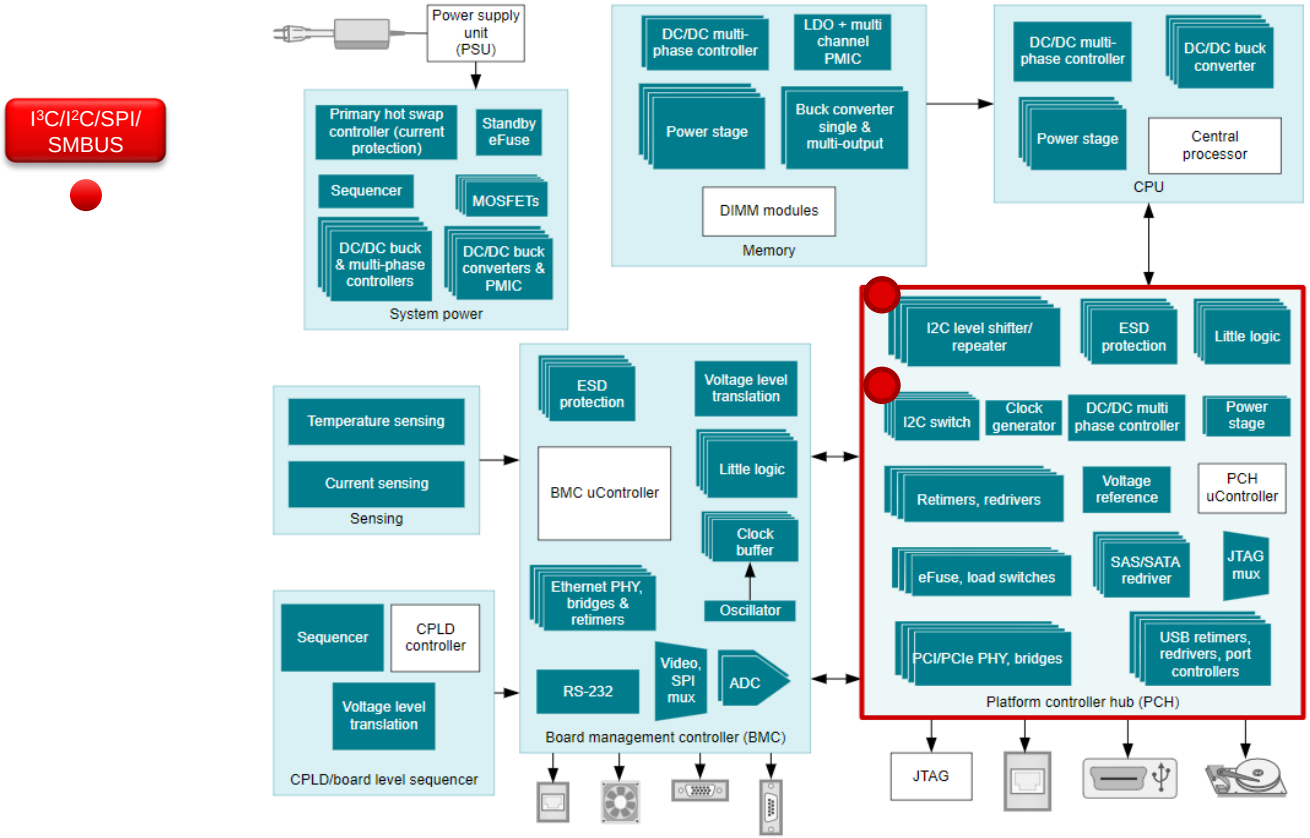
Target Sectors:

- DDR5 DIMM modules
- Enterprise Servers
- PC & Notebooks
- Wearables

Key care-about:

1. 1.2 V or 1.8V to 1.0 V translation
2. Support 12.5 MHz (I3C) speed
3. I3C HDR support >25Mbps

I3C in rack servers



Getting started

You can start evaluating this device leveraging the following:

Content type	TCAL64XX/95XX	TCA39416
Product folder	TCAL6408, TCAL6416, TCAL9538, TCAL9539, TCAL9539-Q1	TCA39416
Customer training series or webinar session	I2C Technology Training	I3C Technology Training
Technical blog content or white paper	Features of TCAL Agile I/O Expanders	I3C – Next Generation Serial Communication Interface
Development tool or evaluation kit	I/O Expander EVM	TCA39416 EVM

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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265