Maxim IO-Link Live Seminar

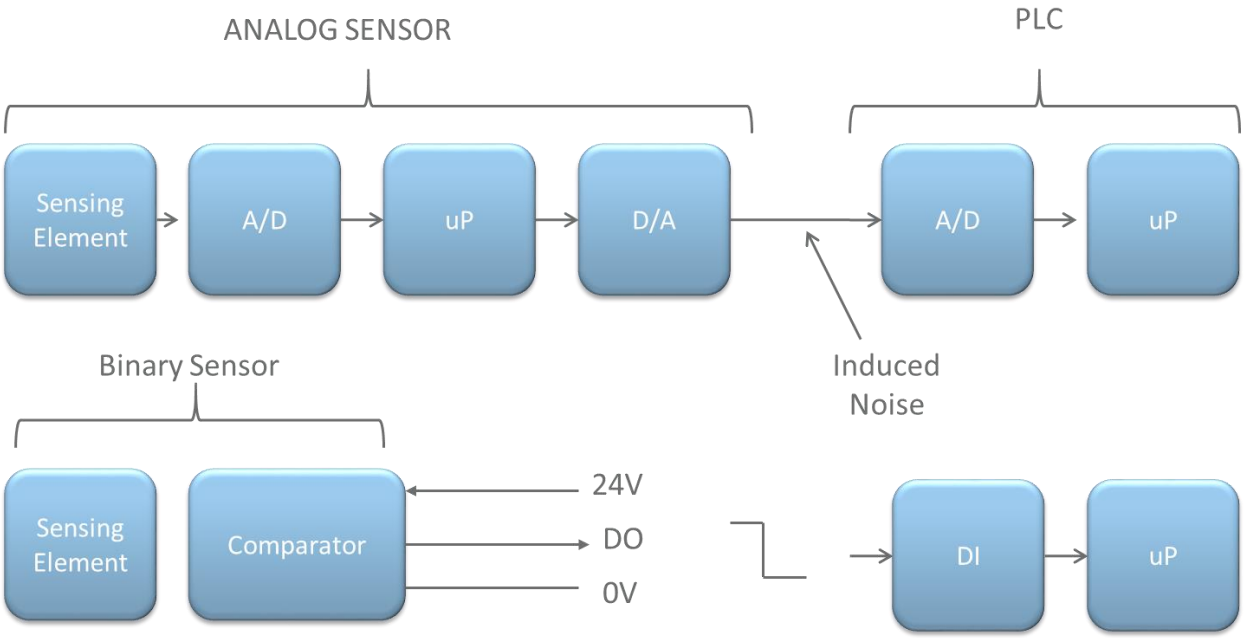
Ning Jia, Training and Technical Service

Agenda

1	IO-Link Technology
2	IO-Link Master
3	IO-Link Device (Slave)
4	IO-Link Protection (both Master and Device)
5	Summary

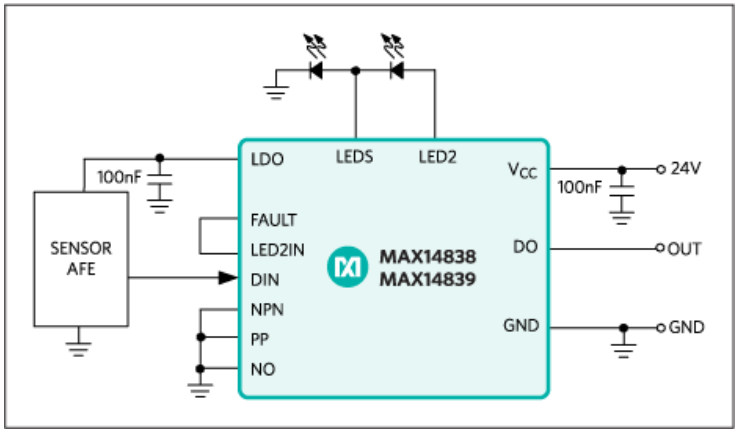
The “Old School” Sensor

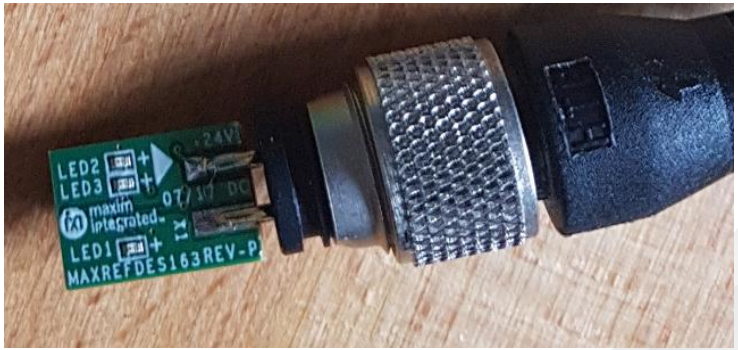
How to adjust, configure and diagnose?



Tiny Binary Sensor Drivers

- Pin-Selectable High-Side (PNP), Low-Side (NPN), or Push-Pull Driver
- The MAX14838 features an onboard 5V linear regulator, while the MAX14839 features a 3.3V linear regulator
- Dual Integrated 2mA LED Drivers
- Integrated Protection Provides Robust Sensor Solutions
  - > Reverse-Polarity Protection on DO, VCC, and GND
  - > 4.75V to 34V Supply Range (MAX14839)
  - > VCC Hot Plug Protection
  - > Thermal Shutdown Protection
  - > ±8kV IEC 61000-4-2 Air Gap ESD Protection
  - > -40°C to +105°C Temperature Range



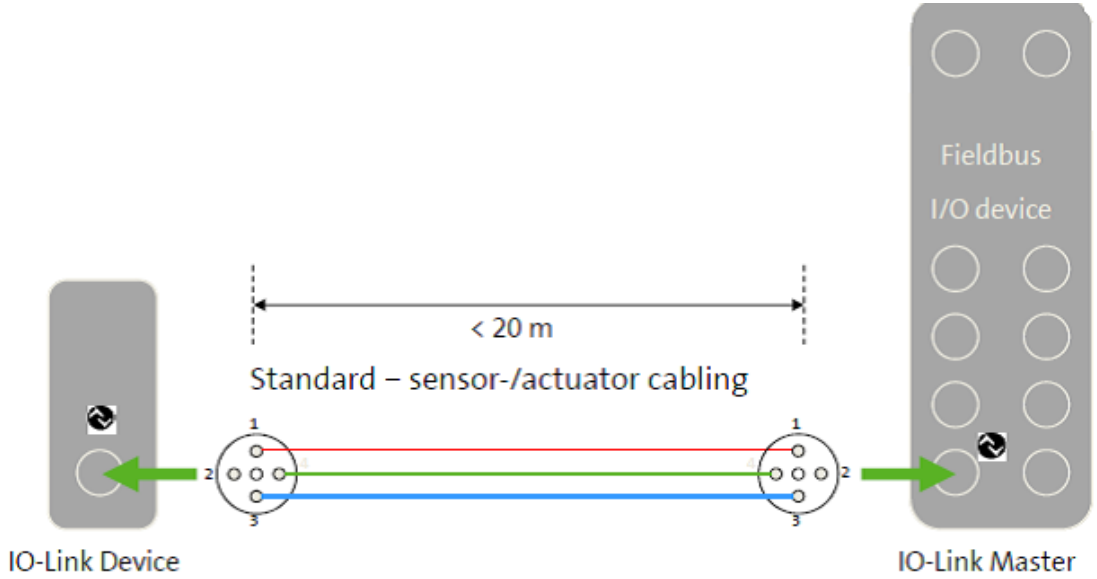


WLP
1.6x2=3mm^2

maxim integrated™

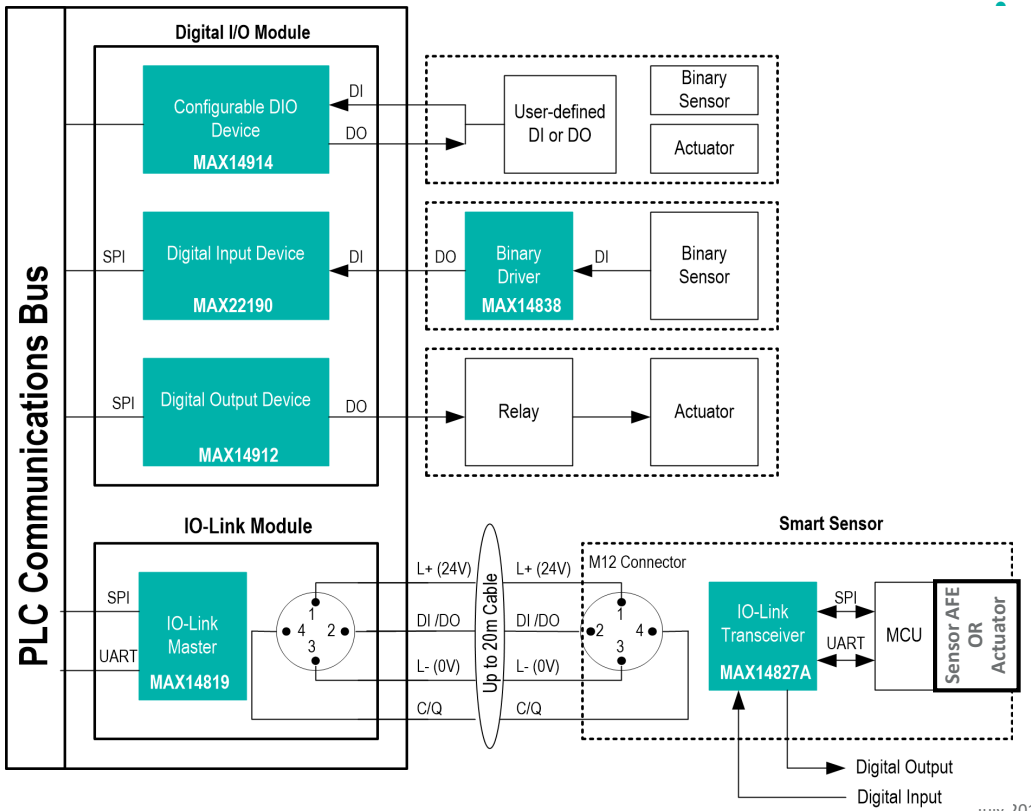
IO-Link: An Open, Low Cost Sensor Interface

- 1st standardized IO technology worldwide (IEC 61131-9) for communication with sensors and actuators
- Powerful point-to-point communication based on 3-wire sensor and actuator connection w/out additional requirements regarding cable material



maxim integrated™

Maxim's IO-Link Ecosystem



- Global Standard to Enable Smart Sensors

Reduce Maintenance and Increased Uptime

> Parameter settings can be downloaded from microcontroller (no longer manual)

> Easy parameterization without down time associated with machine changeover

> Continuous diagnostics and monitoring → improved data logging and error detection

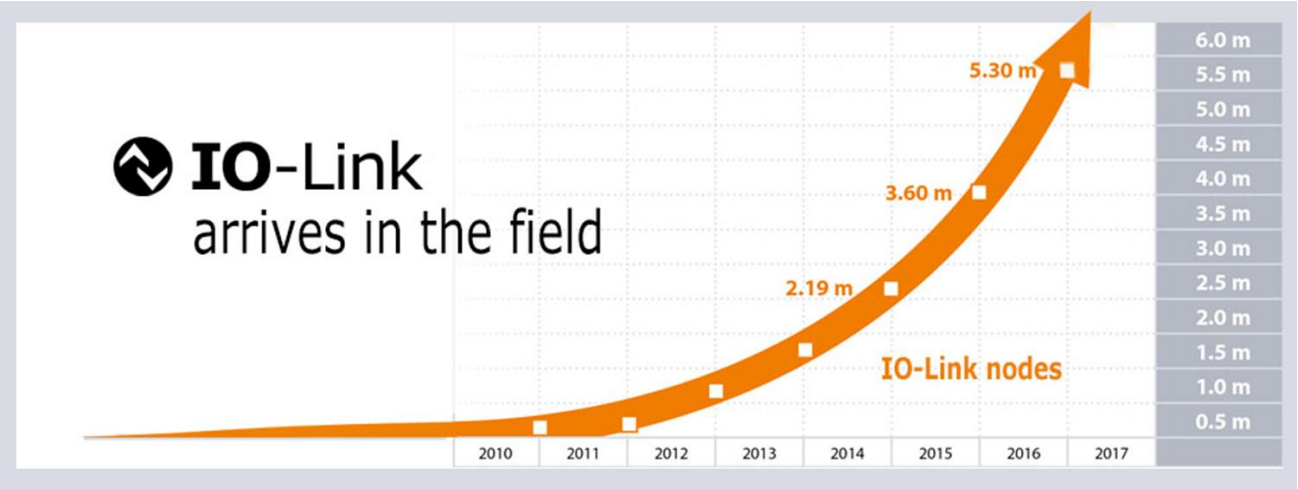
Reduce Costs

> Easy installation with standard sensor connector allows direct binary sensor upgrades

> Reduce SKU's with PNP,NPN, Push-Pull configurability

> Reduce cabling

IO-Link Nodes

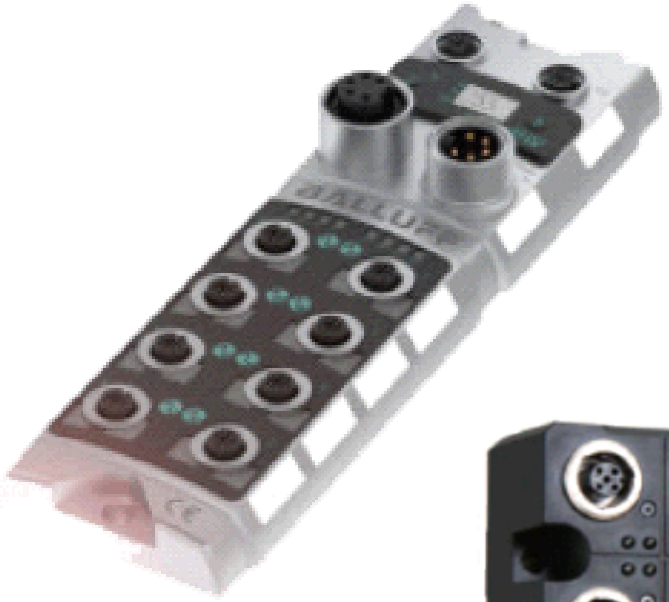


*Data from IO-Link.com

Agenda

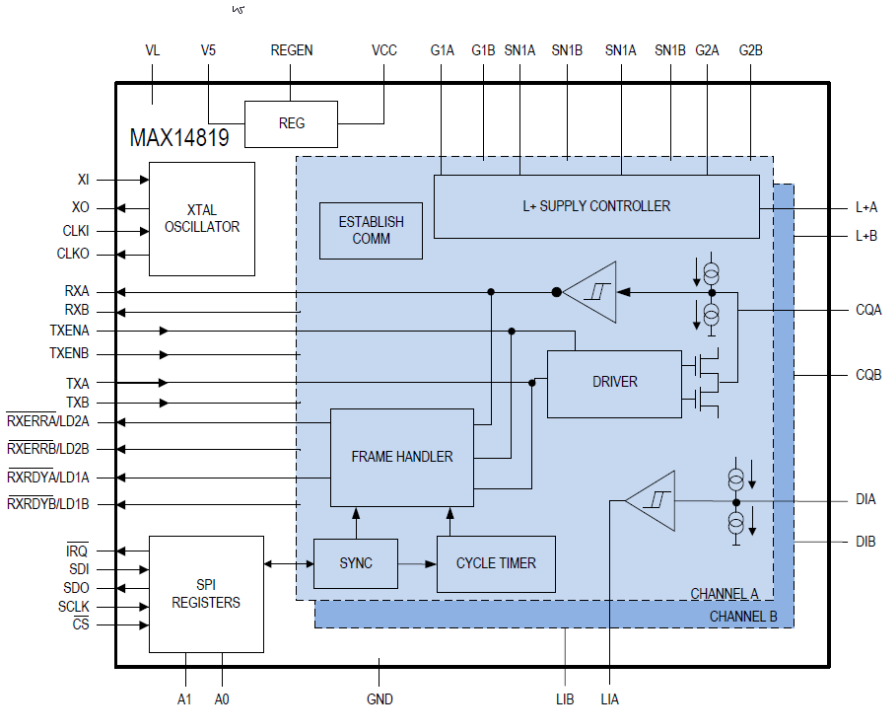
1	IO-Link Technology
2	IO-Link Master
3	IO-Link Device (Slave)
4	IO-Link Protection (both Master and Device)
5	Summary

MAX14819 Applications



maxim integrated™

MAX14819 Dual IO-Link Master



- Dual Channel Master with two DI
- Low Power Architecture
  - > 1Ω (typ) Driver On-Resistance
  - > 1.9mA (typ) Total Supply Current for 2 Channels
- Integrated IO-Link Framer Eliminates Need for External UARTs
- Two Auxiliary Type1/Type 3 Digital Inputs
- Integrated Protection Enables Robust Systems
  - > C/Q and DI Fully Compliant with IEC 61131-2
  - > C/Q Compliant with IO-Link 1.1.2
  - > Reverse Current Blocking on L+

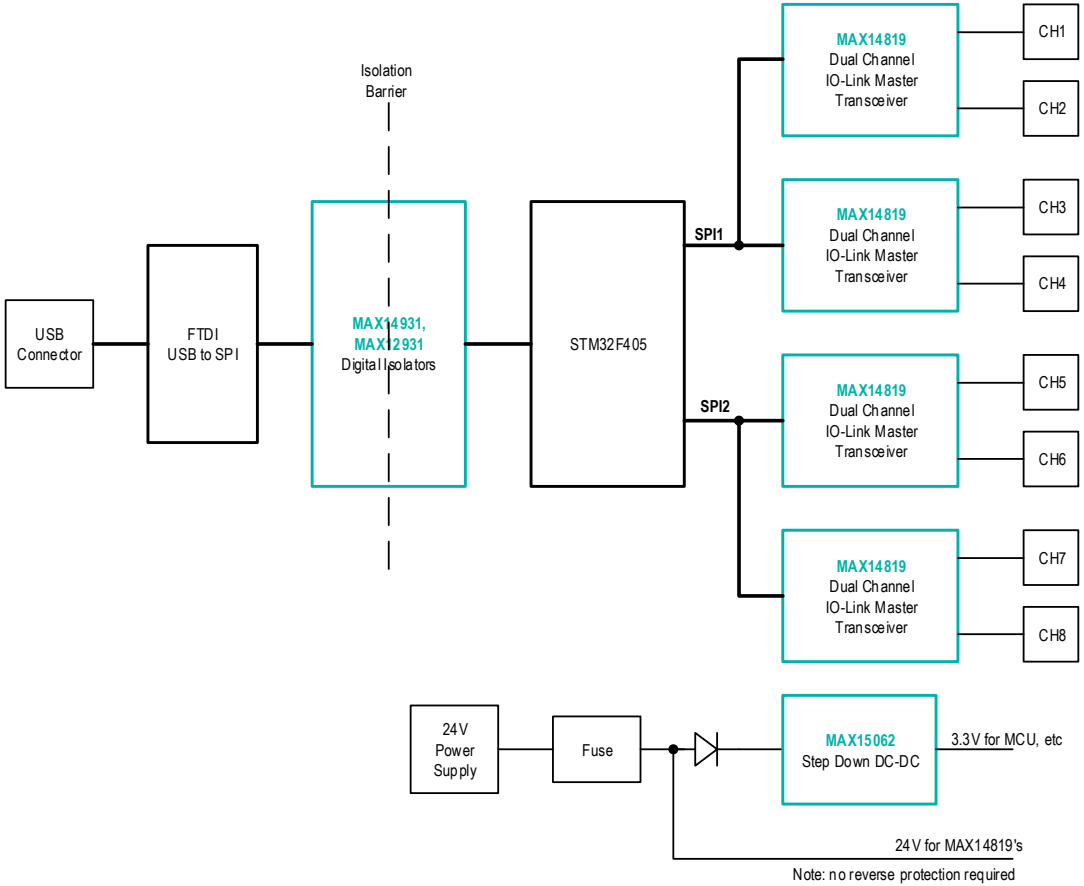
maxim integrated™

MAXREFDES145# 8-Port Master Design Features

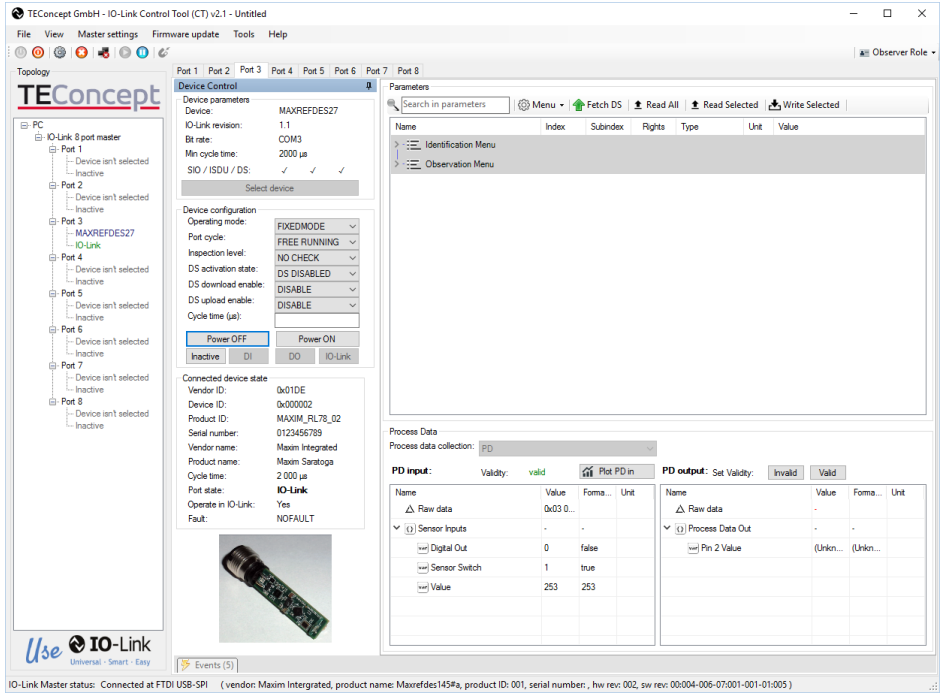
- Fully IO-Link version 1.1 compliant (downloadable test report)
- TEConcept IO-Link Master Stack
- Easy-to-Use TEConcept TC tool
- 8 IO-Link Master Ports
- Power and status LEDs
- Ships with all cables needed

maxim integrated™

Description of Hardware



IO-Link Software



- 8-port IO-Link master using TEConcept's IO-Link master stack
- Software runs on STM32F405 ARM Cortex M3 microcontroller
- MAXREFDES145# ships with master stack preprogrammed hardware with an indefinite time license

maxim integrated™

MAXREFDES165# 4-Port Master Design Features

- Fully IO-Link version 1.1 compliant (downloadable test report)
- TMG IO-Link Master Stack
- Easy-to-Use TMG IO-Link Device Too
- 4 IO-Link Master Ports
- Power and status LEDs
- Ships with all cables needed

maxim integrated™

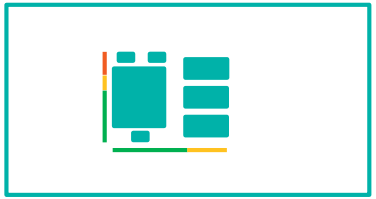
Agenda

1	IO-Link Technology
2	IO-Link Master
3	IO-Link Device (Slave)
4	IO-Link Protection (both Master and Device)
5	Summary

Why Do Customers Choose Maxim for Sensor Interface? Maxim Solutions are 60% Smaller!

- ✓ Maxim solutions are small and getting smaller
  - ✓ Transceivers available in TQFN and WLP packages
- ✓ Robust transceivers require smaller external protection
  - ✓ Higher Abs Max allows for smaller external protective diodes

Non-Maxim Solution



- Single Channel
- 3 External Diodes Req'd

Older Maxim Solution

- Dual Channel
- 2 External Diodes Req'd

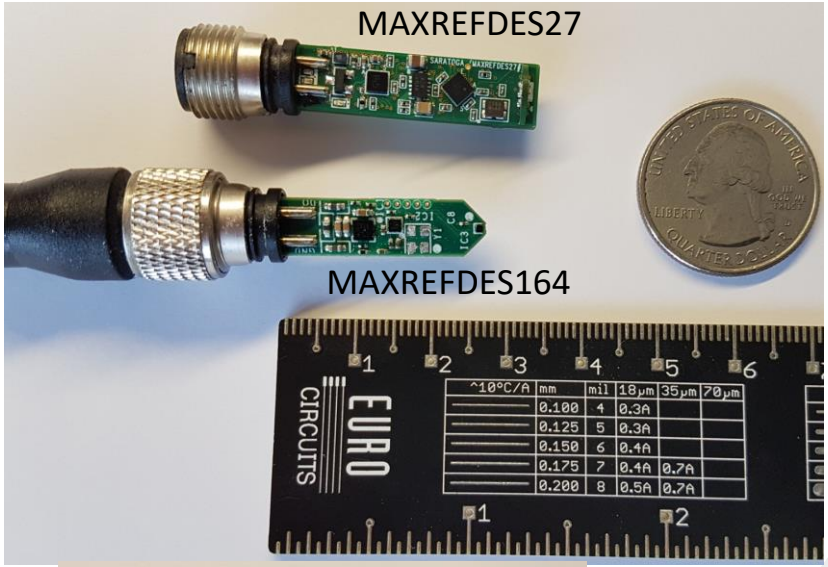
MAX14827A Solution

- Dual Channel
- WLP lowers footprint by 60%
- Dissipates 50% less power

maxim integrated™

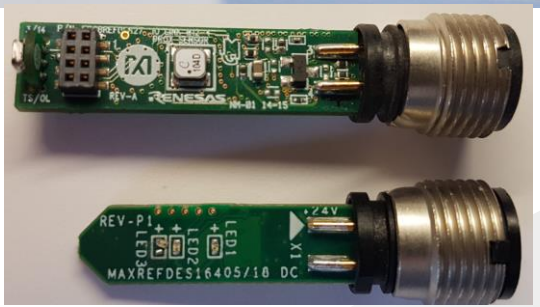
IO Link Smart Sensor Design Features

- Tiny industrial sensor form factor
- Ultra low power: ~150mW
- Low cost
- IEC 61131-9
- IO-Link version 1.1 and 1.0 compliant
- Field bus agnostic
- Transient voltage suppression
- Reverse polarity and short-circuit protected



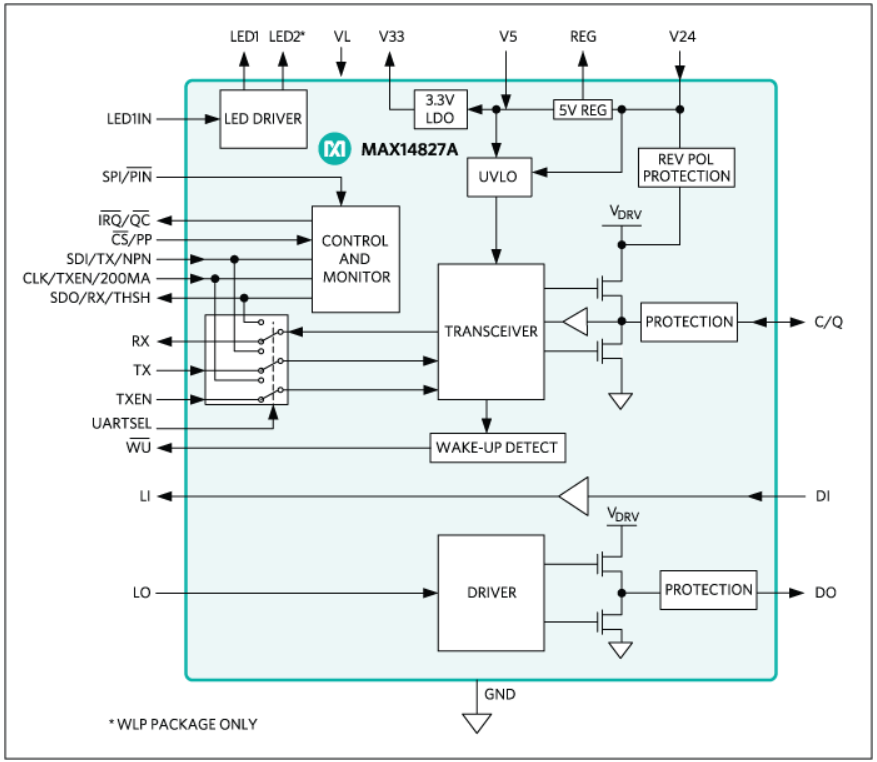
MAXREFDES27

MAXREFDES164



maxim integrated™

MAX14827A – Dual 250mA IO-Link Transceiver



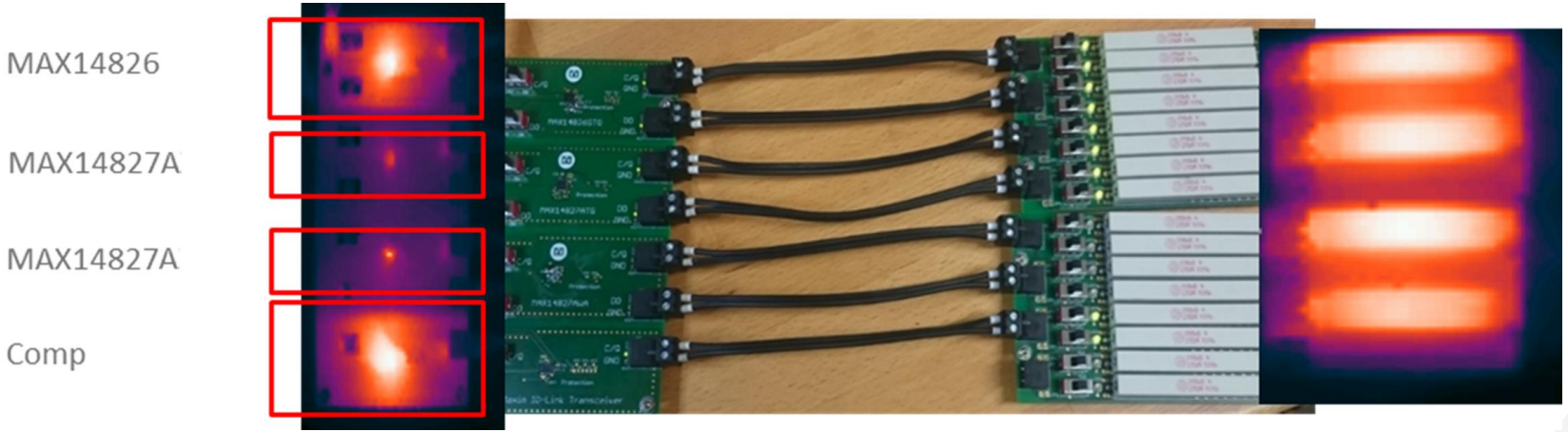
- Lowest Power and Smallest IO-Link Transceiver
  - > WLP 2.5mm x 2.5mm
  - > TQFN 4mmx4mm
- Low 2.3Ω (typ) Ron reduces power consumption
- Robust: 65V Abs Max allows for smaller external protection & Reverse Polarity/Short Circuit Protection
- Supports all 3 COM_ data rates (4.8kbps, 38.4kbps and 230.4kbps)

  Very few competitor transceivers can do this!
- MAX14828 – Single channel variant of MAX14827A

maxim integrated™

MAX14827A runs 64% cooler than the competition

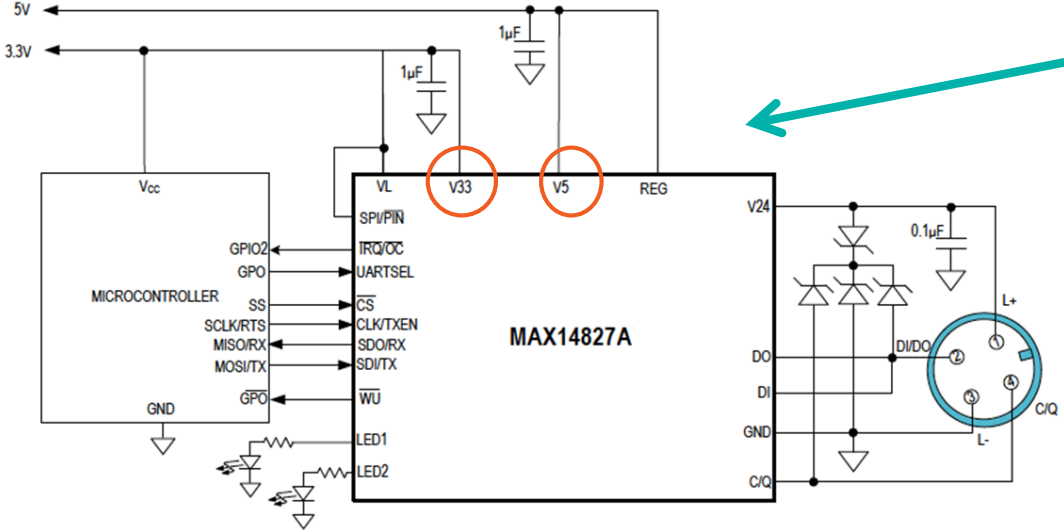
Power Dissipation in single channel 180mW(Maxim) vs. 500mW (Comp)

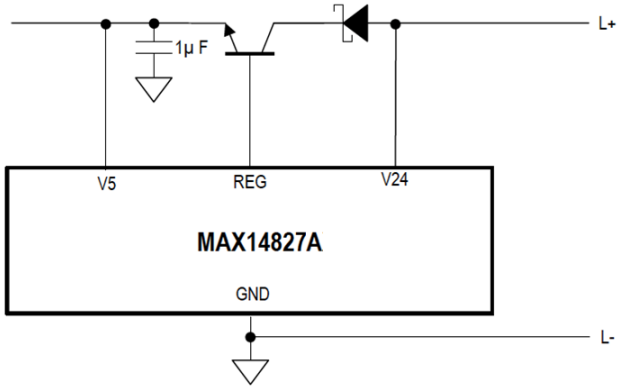


maxim integrated™

MAX14827A with 2 Internal Linear Regulators

5V up to 30mA & 3.3V up to 40mA

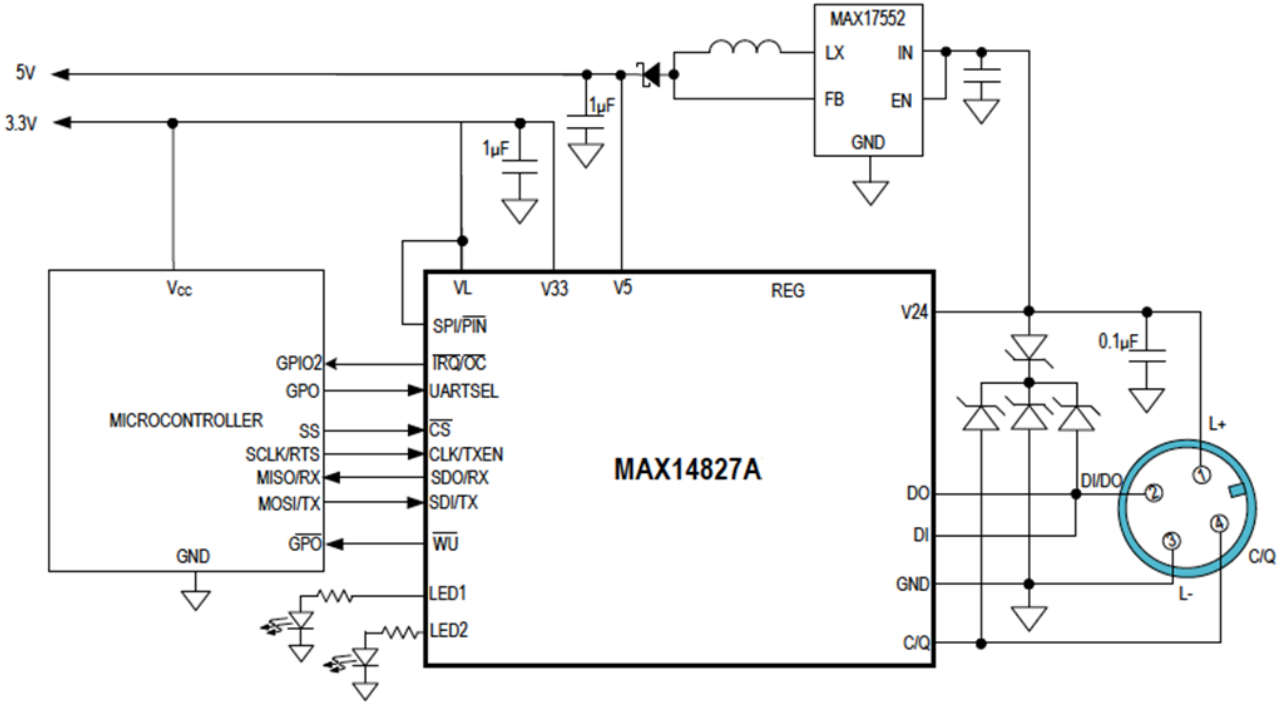




* To achieve larger load currents or to shunt the power dissipation away from the MAX14827A, an external NPN transistor can be connected as shown in

maxim integrated™

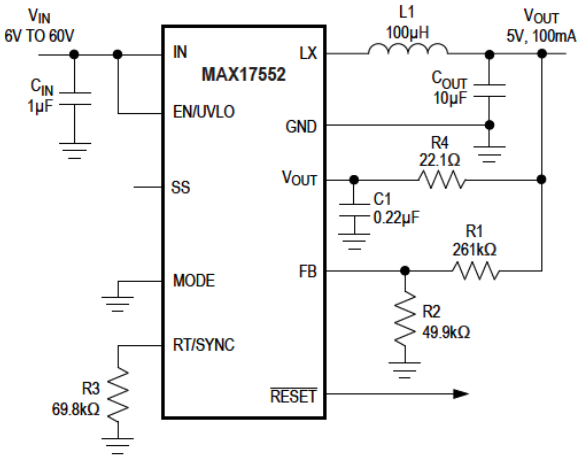
Usage of external DC/DC



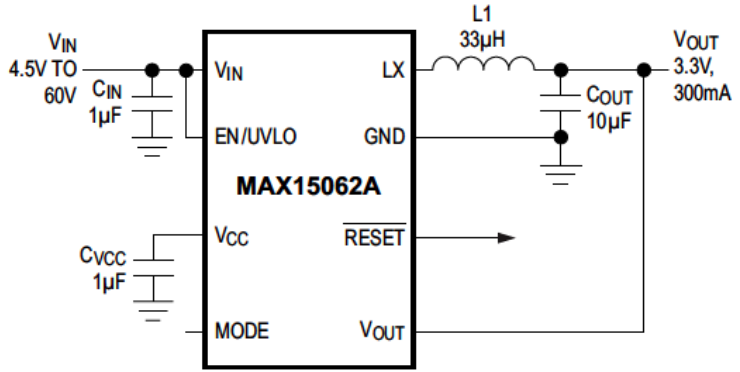
Suitable DC/DC

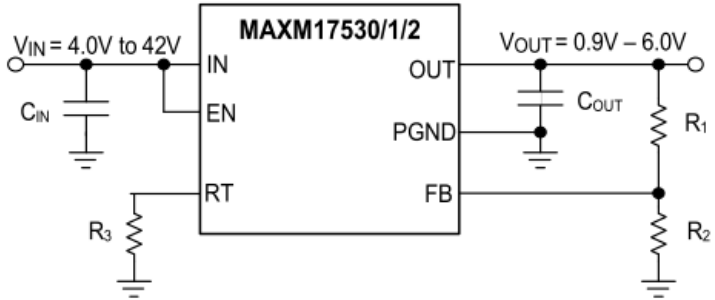
MAXIM´s 60V Synchronous DC/DC solutions are available from 25mA up to 6 A

100mA

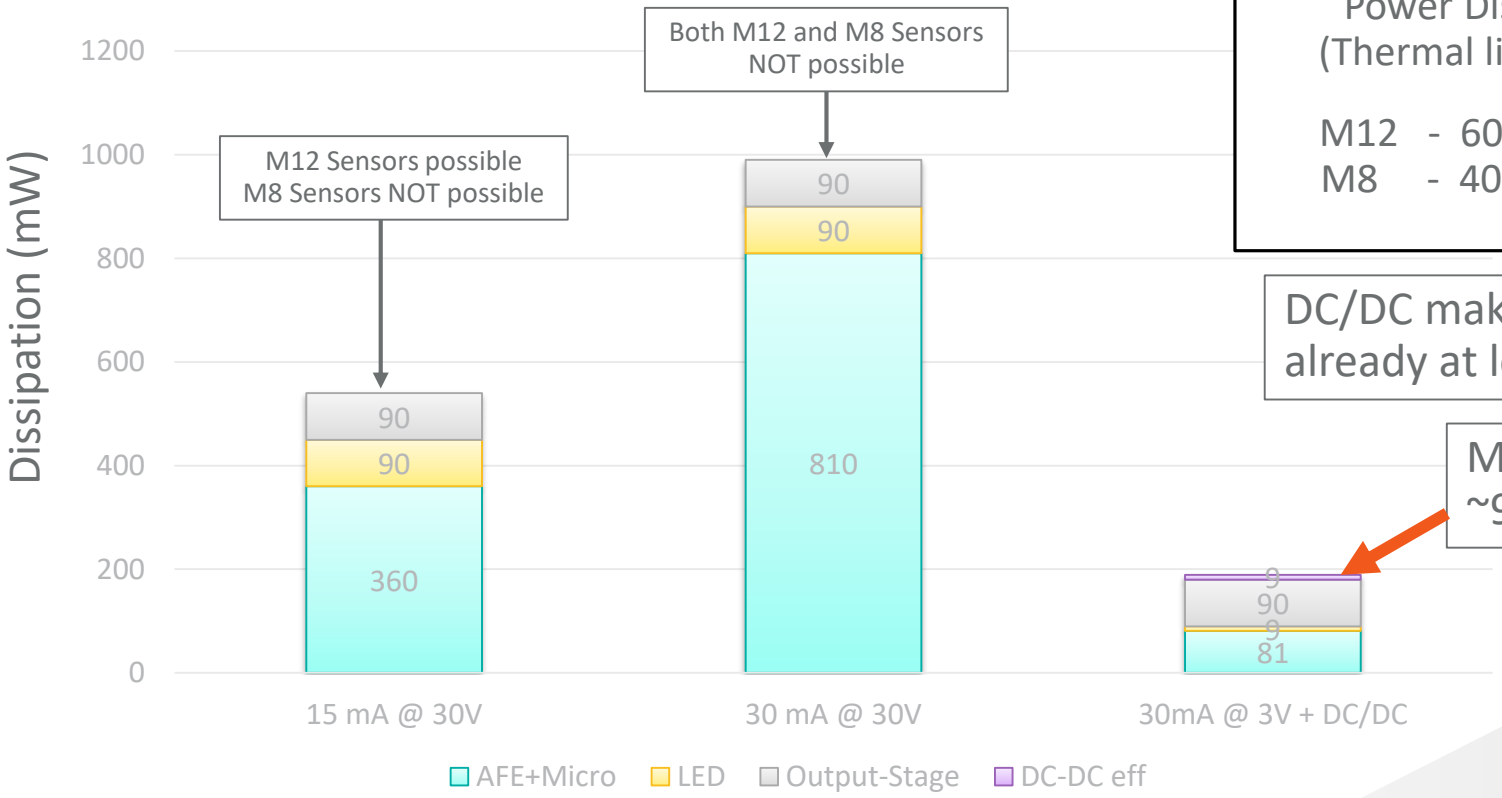


300mA





HEAT the biggest issue for your design



Typical Sensor MAX allowed Power Dissipation (Thermal limitations)

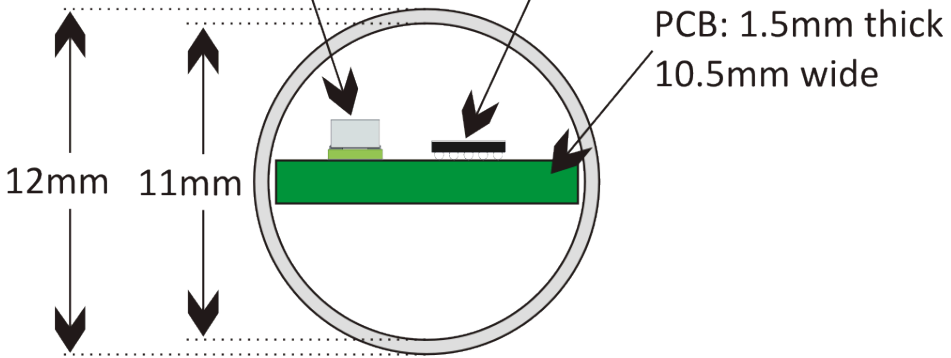
M12 - 600mW max
M8 - 400mW max

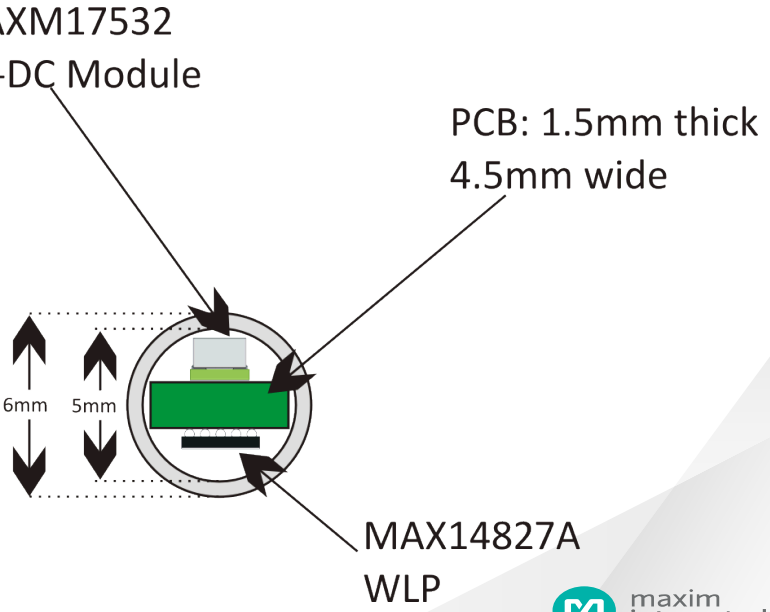
DC/DC makes sense already at low current !

MAXM17530
~90% @30mA

maxim integrated™

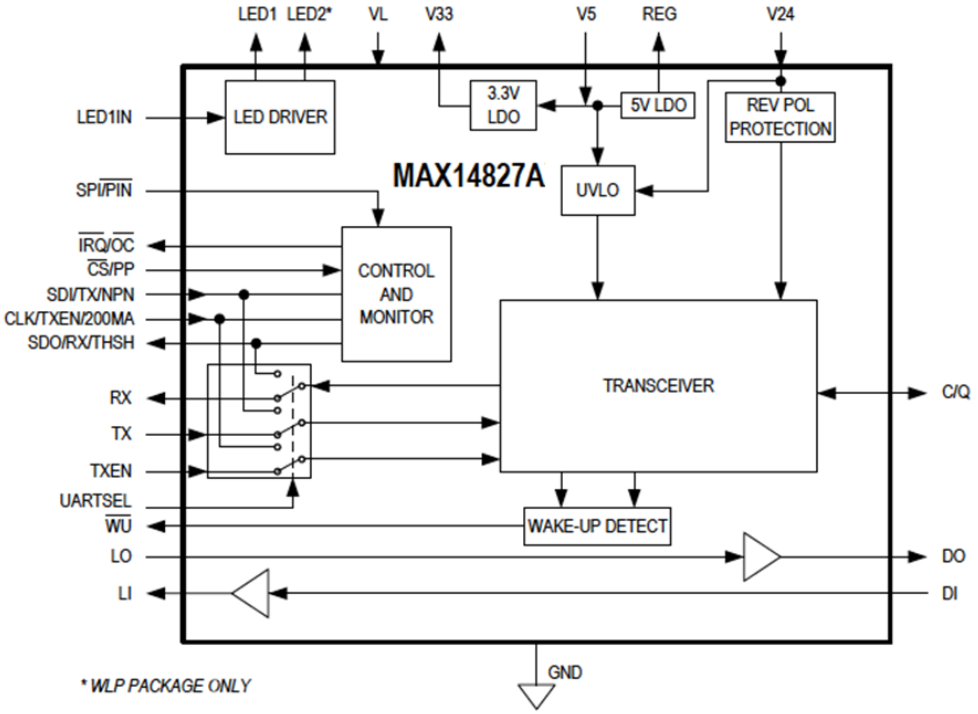
SIZE another big issue for your design

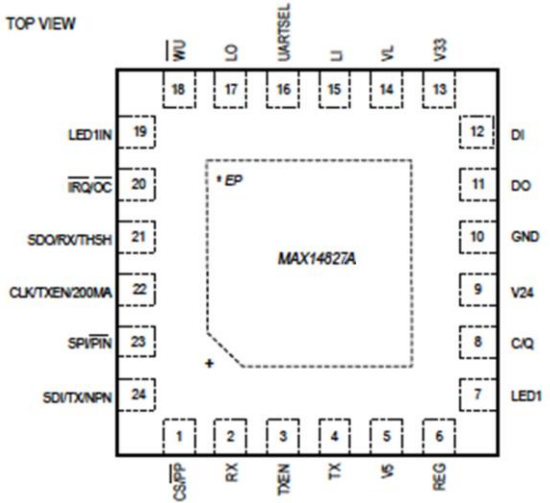




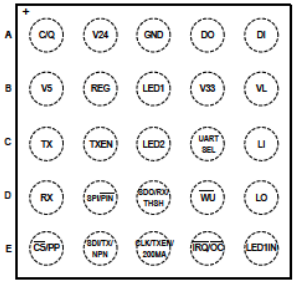
maxim integrated™

Blockdiagram and Package





TQFN
4mm x 4mm



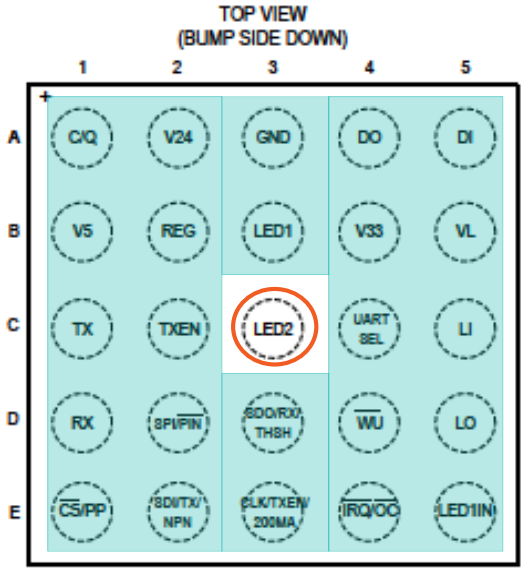
WLP
2.5mm x 2.5mm

maxim integrated™

WLP pinout designed for LOW COST PCB

We are using 0.5mm PITCH which allows to use lowest cost PCB processes as long as just the two outer rows are used.

At MAX14827A just the LED2 connection is in ROW#3



WLP
2.5mm x 2.5mm

maxim integrated™

MAX22513 Dual IO-Link + Protection + DC-DC

Industry's smallest IO-Link solution

Benefits

- Integration reduces footprint by 3X
- Integrated surge + reverse polarity
- 4X lower power dissipation
- I^2C reduces 2 interface pins

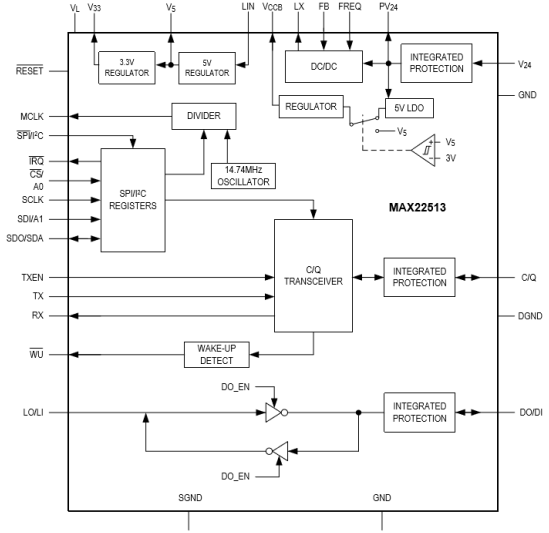
Features

- C/Q, DI/DO
- WLP 2.148 x 4.157mm/3.5x5.5 TQFN
- 8-36V supply range with surge protection ±1kV/500Ω
- 2Ω (typ) driver R_{ON}
- +85% efficiency 300mA DC-DC
- Hot plug/reverse pol./short circuit protection

Applications

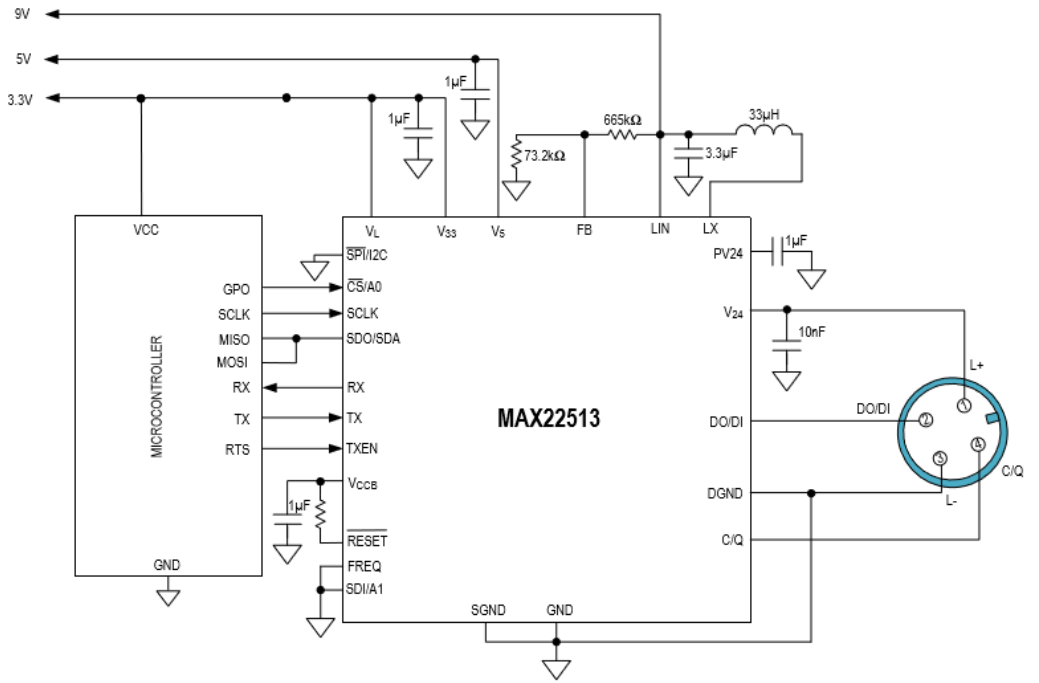
- Industrial binary sensors
- Proximity switches
- Capacitive and inductive sensors

2.1 x 4.1mm WLP



EvKit	MAX22513EVKIT#

MAX22513 Half Duplex SPI Application Circuit



How the MAX22513 Addresses Common Design Challenges

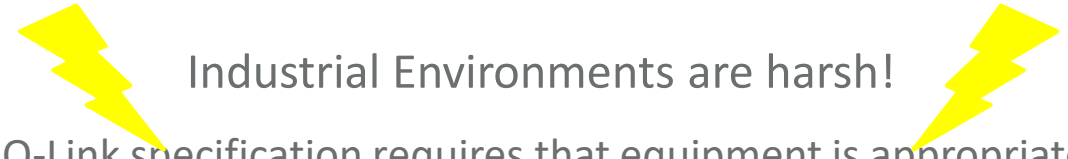
Key challenges – size and heat

- Sensors are shrinking
  - > 3X Smaller with the highest integration (Dual IO-Link + Protection + DC-DC)
- Sensors are fanless and need lower power dissipation to ensure robustness over temperature
  - > 4X Lower heat from low Ron Drivers, Integrated DC-DC, and lowest supply current

Agenda

1	IO-Link Technology
2	IO-Link Master
3	IO-Link Device (Slave)
4	IO-Link Protection (both Master and Device)
5	Summary

Physical Layer: EMC Requirements Standardized



Industrial Environments are harsh!

The IO-Link specification requires that equipment is appropriately protected for robust operation:

- ESD: ±8kV for air discharge
- ESD: ±4kV for contact discharge (based on the IEC 61000-4-2 standard)
- Surge: Not required when the cable length is limited to 20m
  - Otherwise: Protection levels of ranging from ±500V to ± 2kV
- Burst: ±1kV or ±2kV

While transceivers are increasingly robust, external protection will be necessary.

- ESD Protection for the End Product
- Surge and Burst Protection (TVS Diodes)
- Optimized Layout

EMC Test Levels

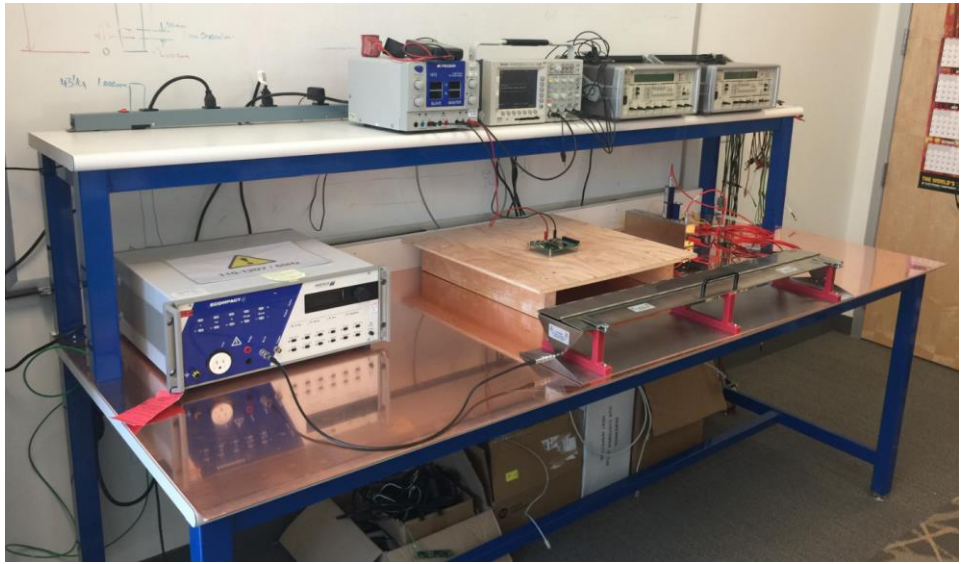
Table G.2 – EMC test levels

Phenomena	Test Level	Performance Criterion	Constraints
Electrostatic discharges (ESD) IEC 61000-4-2	Air discharge: ± 8 kV Contact discharge: ± 4 kV	B	See G.1.4, a)
Radio-frequency electromagnetic field. Amplitude modulated IEC 61000-4-3	80 MHz – 1 000 MHz 10 V/m 1 400 MHz – 2 000 MHz 3 V/m 2 000 MHz – 2 700 MHz 1 V/m	A	See G.1.4, a) and G.1.4, b)
Fast transients (Burst) IEC 61000-4-4	± 1 kV	A	5 kHz only. The number of M-sequences in Table G.1 shall be increased by a factor of 20 due to the burst/cycle ratio 15 ms/300 ms. See G.1.4, c)
	± 2 kV	B	
Surge IEC 61000-4-5	Not required for an SDCI link (SDCI link is limited to 20 m)		-
Radio-frequency common mode IEC 61000-4-6	0,15 MHz – 80 MHz 10 VEMF	A	See G.1.4, b) and G.1.4, d)
Voltage dips and interruptions IEC 61000-4-11	Not required for an SDCI link		

* From IO-Link Standard Version 1.1.2

Immunity Testing

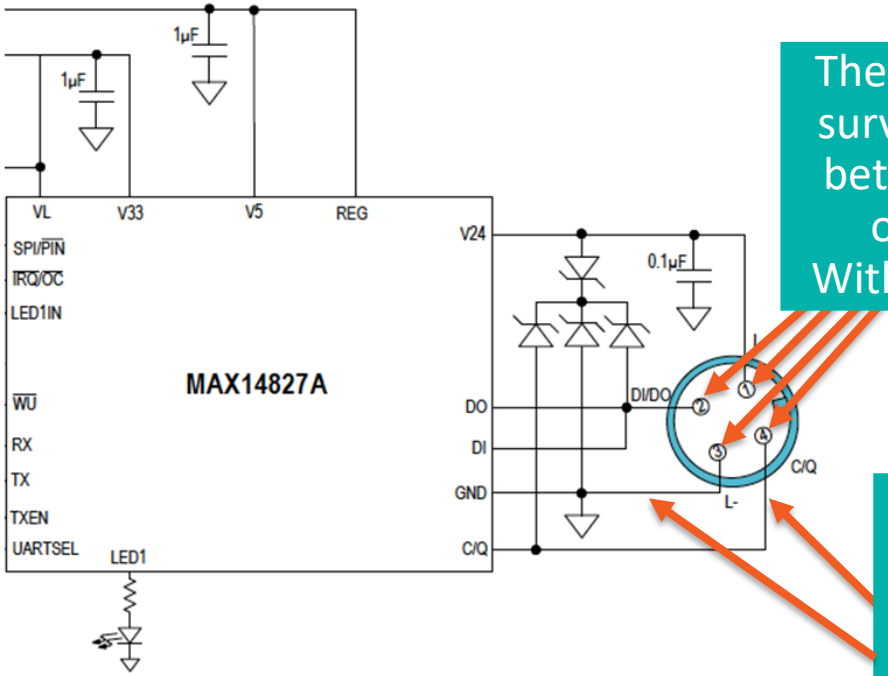
EFT Burst & Surge Testing



ESD Testing

TVS protection circuit

How does 70V Abs-Max (vs 40V) help on protection



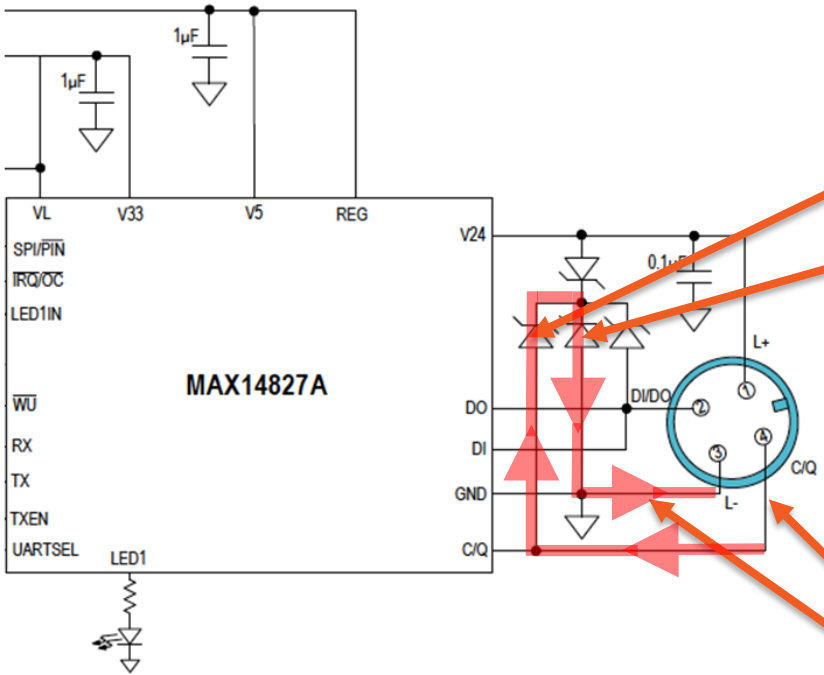
The Sensor needs to survive surge pulses between any 2 pins out of these 4. With both polarities.

Let‘s take one example: 1kV @ 24A between C/Q and L- (GND).

maxim integrated™

TVS protection circuit

How does 70V Abs-Max (vs 40V) help on protection



This diode opens. Regular forward voltage: ~0.5V-1V

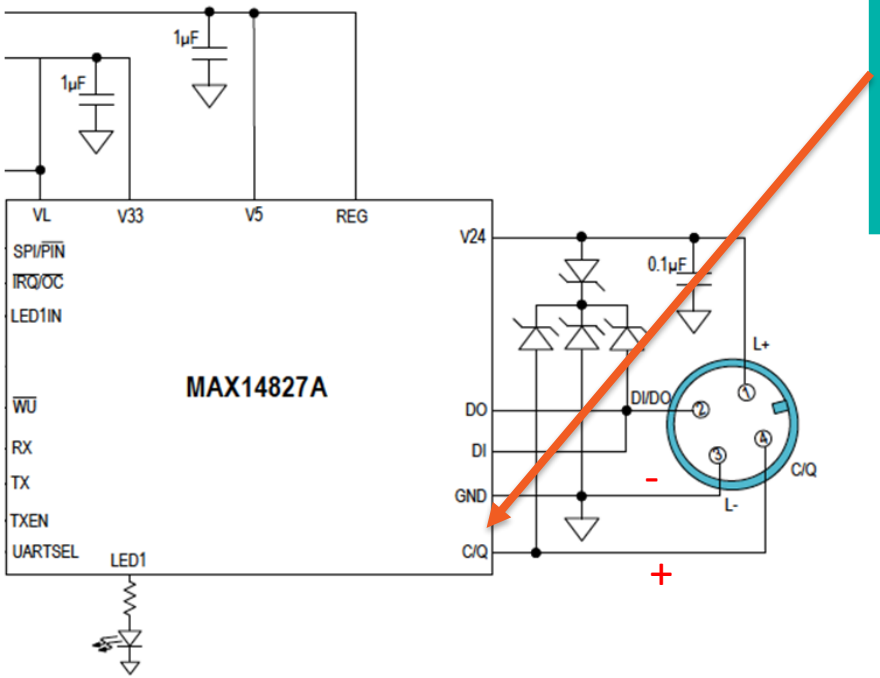
This diode will clamp to clamping voltage. (similar to zener-diode)

Let‘s take one example: 1kV @ 24A between C/Q and L- (GND).

maxim integrated™

TVS protection circuit

How does 70V Abs-Max (vs 40V) help on protection



Voltage between C/Q and GND will be:
TVS clamp voltage + TVS forward voltage
Assuming TVS clamp voltage is 60V@24A,
TVS forward voltage is 1V@24A.
-> Voltage between C/Q and GND = 61V
-> MAX14827 will survive

Absolute Maximum Ratings

(All voltages referenced to GND, unless otherwise noted.)

V24 .....-70V to +65V

REG.....-0.3V to (V_5 + 16V)

V5, VL.....-0.3V to +6V

V33 .....-0.3V to (V_5 + 0.3V)

C/Q, DO, DI..... MIN: Larger of -70V and (V_{24} - 70V) to MAX: the lower of +70V and (V_{24} + 70V)

TVS protection circuit

How does 70V Abs-Max (vs 40V) help on protection

Order code	I_{RM} max@V_{RM}			V_{BR} @I_R (1)			V_{CL} @I_{PP} 10/1000 µs		R_D (2) 10/1000 µs	V_{CL} @I_{PP} 8/20 µs		R_D (2) 8/20 µs	αT (3)
	25 °C	85 °C		min	typ		max			max			max
	µA		V	V		mA	V	A(4)	Ω	V	A(4)	Ω	10-4/° C
SMAJ24A/CA	0.2	1	24	26.7	28.1	1	38.9	10.3	0.912	50	46	0.446	9.6
SMAJ26A/CA	0.2	1	26	28.9	30.4	1	42.1	9.5	1.07	53.5	43	0.502	9.7
SMAJ28A/CA	0.2	1	28	31.1	32.7	1	45.4	8.8	1.26	59	39	0.632	9.8
SMAJ30A/CA	0.2	1	30	33.3	35.1	1	48.4	8.3	1.39	64.3	36	0.762	9.9
SMAJ33A/CA	0.2	1	33	36.7	38.6	1	53.3	7.5	1.70	69.7	33	0.884	10
SMAJ40A/CA	0.2	1	40	44.4	46.7	1	64.5	6.2	2.49	84	27	1.30	10.1
SMAJ43A/CA	0.2	1	43	47.8	50.3	1	69.4	5.7	2.91	91	25	1.53	10.2
SMAJ48A/CA	0.2	1	48	53.3	56.1	1	77.4	5.2	3.56	100	23	1.79	10.3

2. To calculate maximum clamping voltage at other surge level,use the following formula: $V_{CLmax} = V_{CL} - R_D \times (I_{PP} - I_{PPappli})$ where $I_{PPappli}$ is the surge current in the application

Unidirectional

SMA

2.9mm x 5.25mm

SMAJ33A: 69,7V – 0.884Ω x (33A – 24A) = 61,7V

-> MAX14827A will survive, but ICs with abs-max < 65V won‘t survive !!

maxim integrated™

TVS protection circuit

How does 70V Abs-Max (vs 40V) help on protection

Order code	I_{RM} max@V_{RM}			V_{BR} @I_R (1)			V_{CL} @I_{PP} 10/1000 µs		R_D (2) 10/1000 µs	V_{CL} @I_{PP} 8/20 µs		R_D (2) 8/20 µs	αT (3)
	25 °C	85 °C		min	typ		max			max			max
	µA		V	V		mA	V	A(4)	Ω	V	A(4)	Ω	10-4/ °C
SMBJ30A/CA	0.2	1	30	33.3	35.1	1	48.4	13	0.888	64.3	62	0.443	9.9
SMBJ33A/CA	0.2	1	33	36.7	38.6	1	53.3	11.8	1.08	69.7	57	0.512	10.0
SMBJ36A/CA	0.2	1	36	40.0	42.1	1	58.1	10.3	1.35	76	52	0.611	10.0
SMBJ40A/CA	0.2	1	40	44.4	46.7	1	64.5	9.7	1.59	84	48	0.728	10.1
SMBJ48A/CA	0.2	1	48	53.3	56.1	1	77.4	8.1	2.28	100	40	1.03	10.3

2. To calculate maximum clamping voltage at other surge level,use the following formula: $V_{CLmax} = V_{CL} - R_D \times (I_{PP} - I_{PPappli})$ where $I_{PPappli}$ is the surge current in the application

Unidirectional

SMB

3.95mm x 5.6mm

SMBJ33A: 69,7V – 0.512Ω x (57A – 24A) = 52,8V

-> MAX14827A will survive, but ICs with abs-max < ~55V won't survive !!

maxim integrated™

TVS protection circuit

How does 70V Abs-Max (vs 40V) help on protection

Order code	I_{RM} max@V_{RM}			V_{BR} @I_R (1)			V_{CL} @I_{PP} 10/1000 µs		R_D (2) 10/1000 µs	V_{CL} @I_{PP} 8/20 µs		R_D (2) 8/20 µs	αT (3)
	25 °C	85 °C		min	typ		max			max			max
	µA		V	V		mA	V	A(4)	Ω	V	A(4)	mΩ	10-4/ °C
SMCJ30A/CA	0.2	1	30	33.3	35.1	1	48.4	32	0.361	64.3	156	176	9.9
SMCJ33A/CA	0.2	1	33	36.7	38.6	1	53.3	29	0.440	69.7	143	204	10.0
SMCJ40A/CA	0.2	1	40	44.4	46.7	1	64.5	24	0.644	84	119	294	10.1
SMCJ48A/CA	0.2	1	48	53.3	56.1	1	77.4	20	0.925	100	100	411	10.3

2. To calculate maximum clamping voltage at other surge level,use the following formula: $V_{CLmax} = V_{CL} - R_D \times (I_{PP} - I_{PPappli})$ where $I_{PPappli}$ is the surge current in the application

Unidirectional

SMC

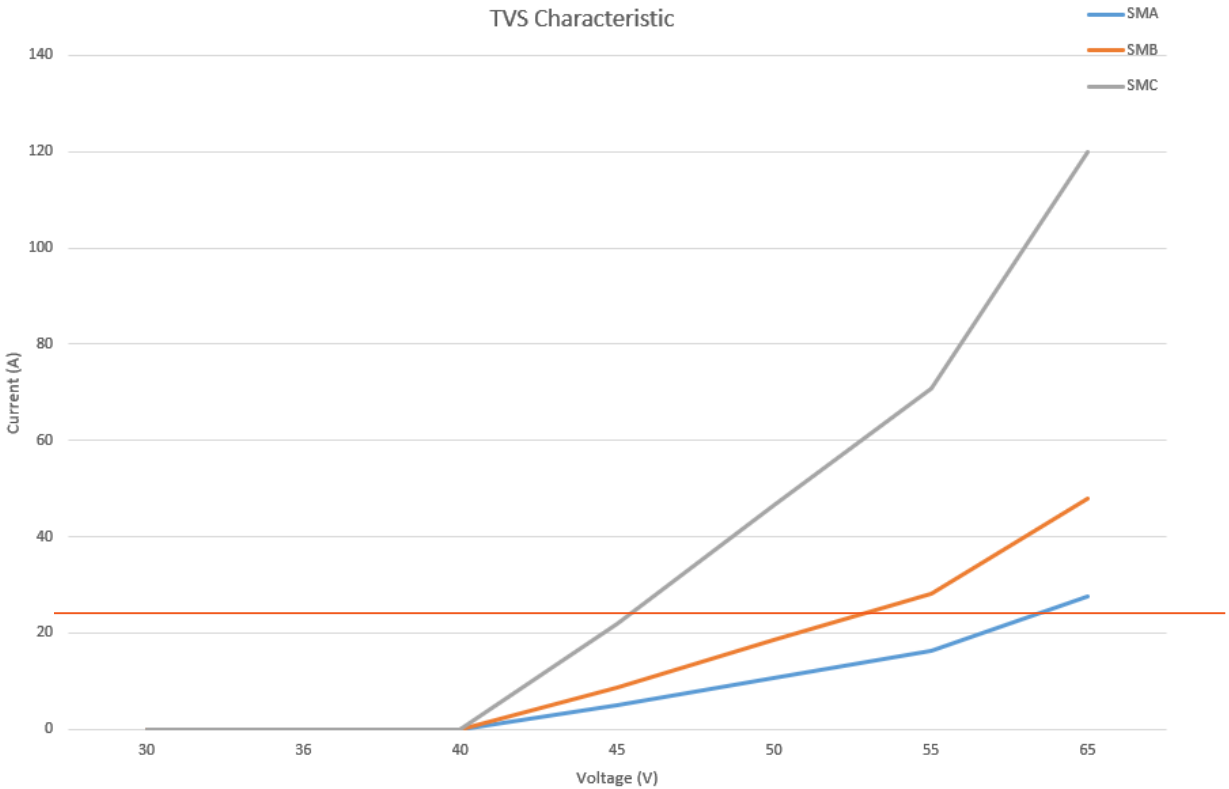
6.25mm x 8.15mm

SMCJ33A: 69,7V – 0.204Ω x (143A – 24A) = 45,4V

-> MAX14827A will survive, but ICs with abs-max < ~47V won‘t survive !!

maxim integrated™

Comparing Characteristics of 3 different TVS diodes



Unidirectional

SMA

2.9mm x 5.25mm

Unidirectional

SMB

3.95mm x 5.6mm

Unidirectional

SMC

6.25mm x 8.15mm

maxim integrated™

Advantages of 65V AbsMax on IO-Link Interfaces

Protection Solution: 5x Smaller and up to 40% Lower Cost

		MAX14827A	Competitor
Standard Surge ±1KV/2A Smallest Solution	Smallest TVS	uClamp3603	SPT01
	Max Clamp Voltage	65V	46V
	Total PCB Area	**1.7mm²**	9mm²
Standard Surge ±1KV/2A Lowest Cost	Cheapest Solution	AVX Varistor	SPT01
	Max Clamp Voltage	60V	46V
	Price (1k)	**$0.30**	$0.74
High Level Surge ±1KV/24A	Smallest TVS	SMAJ33	SMCJ33
	Max Clamp Voltage	62V	45V
	Total PCB Area	**40.5mm²**	144mm²

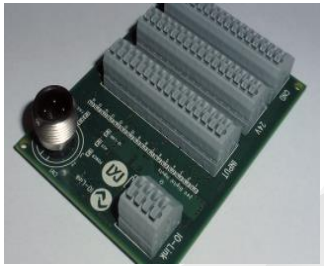
maxim integrated™

Agenda

1	IO-Link Technology
2	IO-Link Master
3	IO-Link Device (Slave)
4	IO-Link Protection (both Master and Device)
5	Summary

Entire ECO-System Reference Designs for Faster Time to Market

Reference Design	Description
IO-Link Sensor	
MAXREFDES27	IO-Link Optical Proximity Sensor
MAXREFDES36	16 Channel Digital Input IO-Link Hub
MAXREFDES37	IO-Link Quad Servo Driver
MAXREFDES42	IO-Link RTD Temp Sensor
MAXREFDES164	IO-Link Local Temp Sensor
MAXREFDES171	IO-Link Distance Sensor
IO-Link Master	
MAXREFDES79	4-Port IO-Link Master
MAXREFDES145	8-Port IO-Link Master



maxim integrated™

Why Maxim for IO-Link Transceivers?

- ✓ Industry's lowest power dissipation transceivers
- ✓ Smallest packages meets shrinking sensor trends.
- ✓ Maxim's long term dedication and commitment to IO-Link
- ✓ Industry's most complete IO-Link and binary sensor portfolio (Sensor and Master side)
- ✓ In depth IO-link knowledge and IO-Link consortium membership since 2009
- ✓ Complete ecosystem reference designs, customer support

Product Selection Guide

Part Number	Interface	Description
IO-Link Master Transceivers		
MAX14819	IO-Link	Low-power dual-channel IO-Link master transceiver + supply controllers + UART/Framer + DI
MAX14824	IO-Link	Single-channel IO-Link transceiver
IO-Link Device Transceivers		
MAX14827A	IO-Link	Tiny low-power dual IO-Link device transceiver
MAX14828	IO-Link	Tiny low-power single IO-Link device transceiver
MAX22513	IO-Link	Tiny low-power dual IO-Link device transceiver + protection + Dc-Dc
IO-Link Sensor Drivers		
MAX14838/ MAX14839	Binary	24V/100mA pin-configurable industrial sensor output driver + protection
MAX14832	Binary	24V/100mA one-time-programmable (OTP) industrial sensor output driver + protection

maxim integrated™

maxim integrated™