Wide Input Range CV Step Down Controller

General Description

The NT3876 is a synchronous-rectified Buck controller with integrated dual high/low side gate drivers, specifically designed for CLA applications where thermal is critical and ultra high efficiency is necessary. The NT3876 operates with a wide input voltage range from 8V to 40V delivers up to 6A output current with minimum external part count.

The NT3876 operates with constant frequency, externally-compensated voltage mode control, enabling flexible external component selection and yielding excellent line and load regulation. The NT3876 compensates voltage drop on cables due to load currents.

Other features include accurate over current protection (OCP), over voltage protection (OVP), under voltage protection (UVP) and over temperature protection (OTP). The NT3876 is available in PMSOP-10L package.

Ordering Information

Order Number	Package	Top Marking
NT3876ARUA	PMSOP-10L	NT3876A

Note: NT products are compatible with the current IPC/JEDEC J-STD-020 requirement. They are halogen-free, RoHS compliant and 100% matte tin (Sn) plating that are suitable for use in SnPb or Pb-free soldering processes.

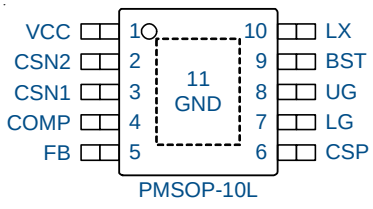
Features

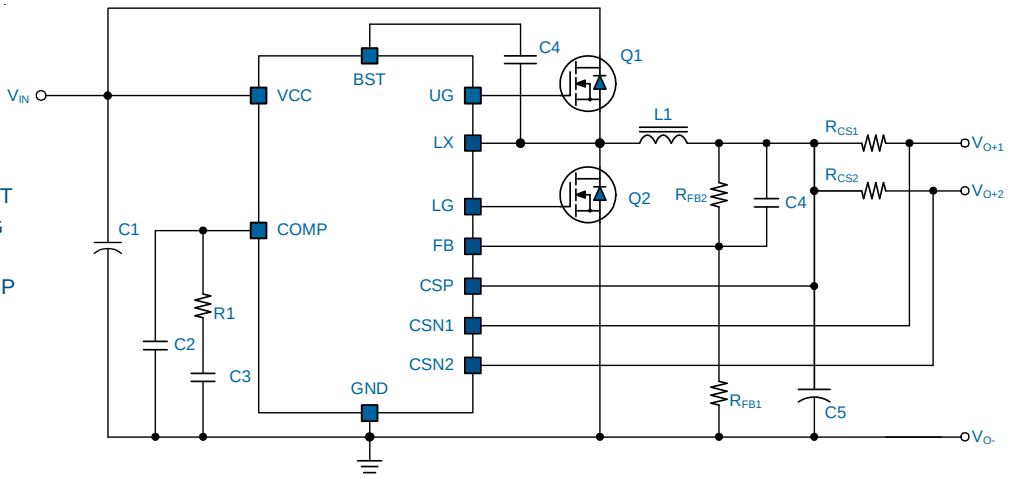
- 8V ~ 40V Supply Voltage Range
- Typical 7.5V UVLO Protection
- Accurate 1.2V ±1.0% V_{REF} Over Line Voltage
- Voltage Mode Control with External Compensation
- Fixed Frequency 120kHz
- Duty Cycle Range (0~90%)
- Cable Compensation
- Over Current Protection
- Output Over Voltage Protection (~120%)
- Output Under Voltage Protection (~70%)
- Over Temperature Protection
- Internal Soft Start ~15ms
- Single Pin for External Compensation and Shutdown Control
- PMSOP-10L Package

Applications

- Car Chargers
- Portable Charger Devices
- High-Brightness Lightings
- General-Purposed DC/DC Conerters

Pin Configuration & Typical Application Circuit

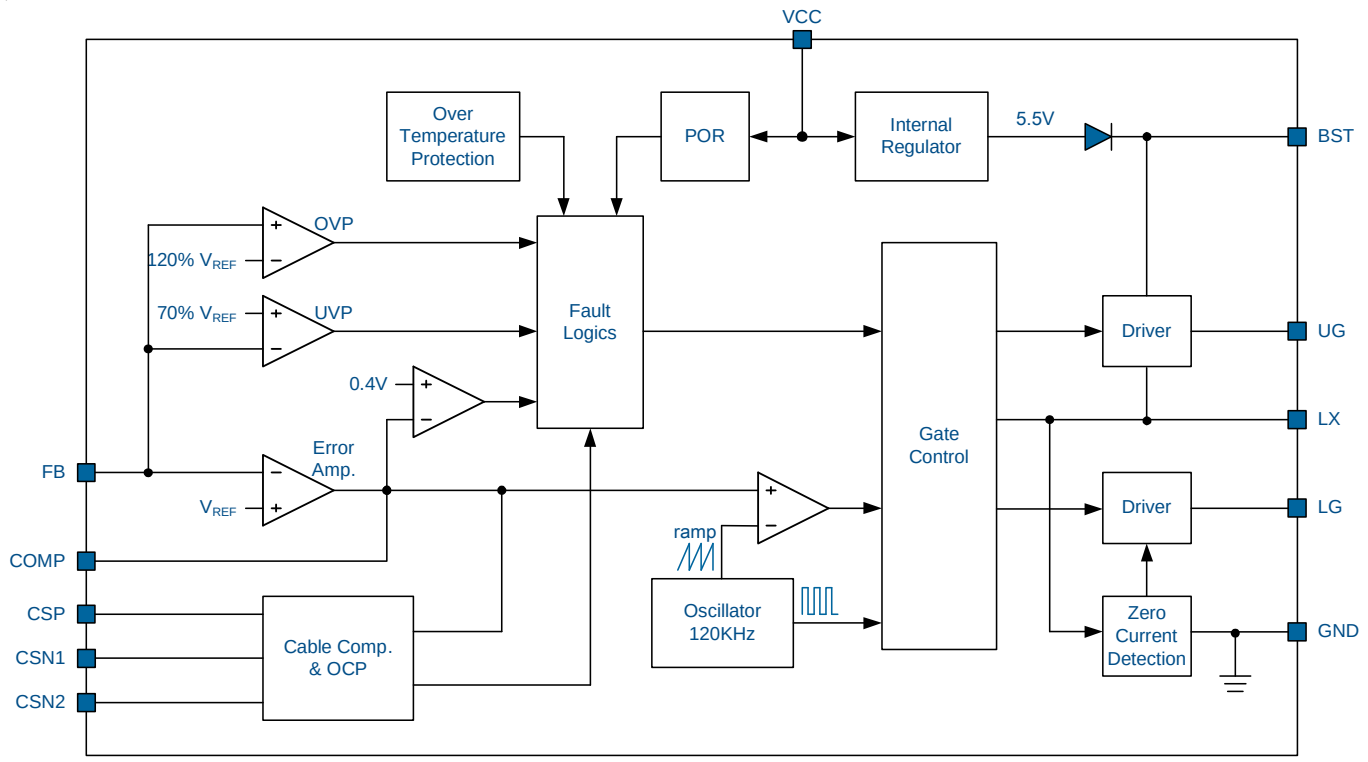




Functional Pin Description

No.	Pin Name	Pin Function
1	VCC	**Power Supply Input**. Bypass this pin with a 0.1uF ceramic capacitor to GND, placed as close to the IC as possible.
2	CSN2	**Current Sense Negative Input 2.** This pin senses channel 2 output current for cable compensation. When (V_{CSP} - V_{CSN2}) voltage is higher than 115mV, OCP function will enable.
3	CSN1	**Current Sense Negative Input 1.** This pin senses channel 1 output current for cable compensation. When (V_{CSP} - V_{CSN1}) voltage is higher than 115mV, OCP function will enable.
4	COMP	**Error Amplifier Output.** This is the output of the error amplifier (EA) and the non-inverting input of the PWM comparator. Use this pin in combination with the FB pin to compensate the voltage control feedback loop of the converter. Pulling COMP to a level below 0.4V nominal disables the controller.
5	FB	**Feedback Pin.** The voltage at this pin is regulated to 1.2V. Connect to the resistor divider between output and GND to set the output voltage.
6	CSP	**Current Sense Positive.** This pin senses channel output current for cable compensation.
7	LG	**Output to Low-side Gate Driver.**
8	UG	**Output to High-side Gate Driver.**
9	BST	**Bootstrap Pin.** This provides power to the internal higher MOSFET gate driver**.** Connect a 0.1uF capacitor from BST pin to LX pin.
10	LX	**Switching Node.** Connect this pin to drain terminal of lower MOSFET and source terminal of upper MOSFET.
11	GND	**Exposed Pad and Ground.** Connect this pin to a large PCB copper area for best heat dissipation. Return FB, and COMP to this GND and connect this GND to power GND at a single point for best noise immunity.

Functional Block Diagram



Functional Description

The NT3876 is a synchronous-rectified Buck controller with integrated dual high/low side gate drivers, specifically designed for up to 6A output current applications. It operates with a wide input voltage range from 8V to 40V.

Power On Reset

A power-on reset circuit monitors the input voltage. When the input voltage exceeds 7.5V, the converter will start operation. Once input voltage falls below 5.8V, the controller will shut down.

Chip Enable and Soft Start

The COMP pin is a multi-functional pin: voltage loop compensation and chip enable. Pulling the COMP pin lower than 0.4V keeps the NT3876 in shutdown mode. When released, the COMP pin is internally pulled to higher than 0.4V and initiates the soft start cycle.

The internal soft-start controls rising speed of the output voltage to minimized inrush current when the NT3876 is enabled. The rising time of output voltage is about 8ms.

Only when the soft start cycle completes, the NT3876 enables the output under voltage protection (UVP).

Output Voltage Setting

Use a voltage divider to set output voltage as shown in the *Typical Application Circuit*. The FB pin voltage V_{FB} is accurately regulated to internal 1.2V reference voltage. The output voltage is calculated as:

$$V_{OUT} = \frac{1.2V \times (R_{FB1} + R_{FB2})}{R_{FB1}}$$

Keep R_{FB1} around 10kΩ and select appropriate R_{FB2} accordingly.

Cable Compensation

The NT3876 compensates the cable voltage drop due to output currents. The output currents are sensed through CSN1 and CSN2 pins as shown in the *Typical Application Circuit*.

$$V_{CS1/2} = V_{CSP} - V_{CSN1/2} = I_{OUT1/2} \times R_{CS1/2}$$

The V_{FB} is compensated as:

$$V_{FB} = V_{REF} \times (1 + \frac{V_{CS1} + V_{CS2}}{105mV} \times 4\%)$$

Over Current Protection

The over current protection (OCP) is also implemented by the CS1 and CS2 pins. OCP is triggered and shuts down the NT3876 if (V_{CSP}-V_{CSN1}) or (V_{CSP}-V_{CSN1}) is higher than 115mV. OCP has a 4us debounce time.

When shut down by OCP, the NT3876 initiates the soft start cycle and rebuilds the output voltage again. The retry cycle is about 2.2 seconds.

Over Voltage Protection

Over voltage protection (OVP) is triggered and shuts down the NT3876 if V_{FB} voltage is higher than 1.44V. OVP has a 12us debounce time.

When shut down by OVP, the NT3876 initiates the soft start cycle and rebuilds the output voltage again. The retry cycle is about 2.2 seconds.

Under Voltage Protection

Under voltage protection (UVP) is triggered and shuts down the NT3876 if V_{FB} voltage is lower than 0.84V. UVP has a 5us debounce time. UVP is active only after the soft cycle completes.

When shut down by UVP, the NT3876 initiates the soft start cycle and rebuilds the output voltage again. The retry cycle is about 2.2 seconds.

FB Impedance Detection

The NT3876 features a smart FB impedance detection that protects the converter if the FB pin is short circuited (< 2kΩ low impedance) to ground by manufacturing errors. When FB short circuit is detected, the NT3876 disables both high/low side gate drivers. Eventually, UVP will be triggered after soft start cycle completes.

This function constrains applicable voltage divider range. R_{FB1} // R_{FB2} > 5kΩ is highly recommended.

Over Temperature Protection

The NT3876 provides over temperature protection. The OTP will shut down the converter when junction temperature exceeds 160°C. Once the junction temperature cools down by approximately 40°C, the converter will resume normal operation.

Absolute Maximum Rating

(Note1)

Supply Input Voltage, V_{CC} ---------- -0.3V to +45V

UG, BST to LX ---------- -0.3V to +7V

LX to GND, DC ---------- -1V to + V_{CC} + 1V

Other Pins to GND, DC ---------- -0.3V to +7V

Storage Temperature Range ---------- -65°C to +150°C

Junction Temperature ---------- -40°C to +150°C

Lead Temperature Range (Soldering 10sec) ---------- 260°C

ESD Rating (Note2)

MM (Machine Mode) ---------- 200V

HBM (Human Body Mode) ---------- 2kV

Thermal Information

Package Thermal Resistance (Note3)

PMSOP-10L θ_{JA} ---------- 60°C/W

PMSOP-10L θ_{JC} ---------- 10°C/W

Power Dissipation, P_D @ T_A = 25°C

PMSOP-10L ---------- 1.67W

Recommended Operating Conditions

Operating Junction Temperature Range (Note4) ---------- -40°C to +125°C

Operating Ambient Temperature Range ---------- -40°C to +85°C

Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Note 2. Devices are ESD sensitive. Handling precaution recommended.

Note 3. θ_{JA} is measured in the natural convection at T_A = 25°C on a high effective thermal conductivity test board of JEDEC 51-7 thermal measurement standard.

Note 4. The device is not guaranteed to function outside its operating conditions.

Electrical Characteristics

(V_{CC} = 12V, T_A = +25°C unless otherwise specified.)

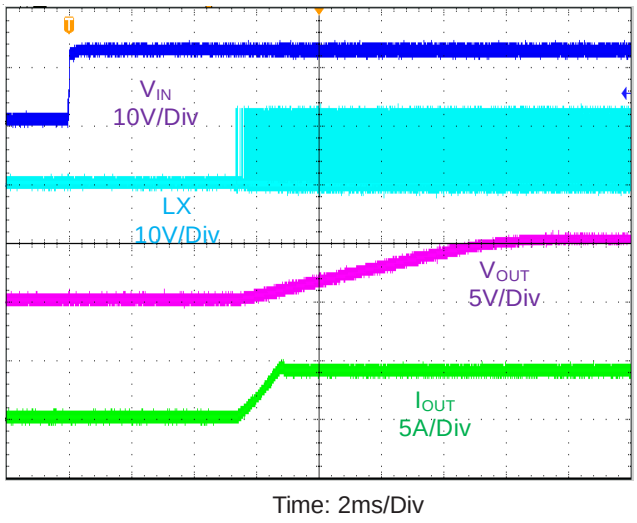
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Input						
Supply Voltage Range	V_{CC}		8	--	40	V
Supply Input Current	I_{CC-SD}	COMP = GND	--	1.0	1.5	mA
	I_{CC}	C_{LG}, C_{UG} = 10nF	--	3	5	mA
V_{CC} POR Threshold	V_{CC-RTH}	V_{CC} rising.	7.0	7.5	8.0	V
	V_{CC-FTH}	V_{CC} falling.	5.5	5.8	6.5	V
Oscillator						
Normal PWM Frequency	f_{OSC}		--	120	--	kHz
		T_A = -25°C to 85°C	102	--	138	kHz
Minimum On Time	t_{ON-MIN}		--	200	--	ns
Duty Cycle Range			0	--	90	%
Feedback Voltage						
Feedback Voltage	V_{FB}	V_{CSN1} = V_{CSN2} = V_{CSP}	--	1.2	--	V
Feedback Voltage Tolerance			-1	--	+1	%
V_{FB} Load Compensator		V_{CSN1} = V_{CSN2} = V_{CSP} - 105mV	--	8.0	--	%
FB Input Current	I_{FB}	V_{FB} = 1.2V	0.1	0	0.1	uA
PWM Error Amplifier						
COMP High Voltage	V_{COMP-H}	V_{FB} = 1V	--	5.5	--	V
COMP Low Voltage	V_{COMP-L}	V_{FB} = 1.3V	--	0.8	--	V
COMP Shutdown Threshold Voltage		V_{COMP} falling	--	0.4	--	V
COMP Source Current		V_{COMP} = 4.5V, V_{FB} = 1V	--	85	--	uA
COMP Sink Current		V_{COMP} = 1V, V_{FB} = 1.3V	--	85	--	uA
Gate Drivers						
UG High Voltage		V_{UG-LX}	--	5.5	--	V
LG High Voltage		V_{LG-GND}	--	5.5	--	V
UG Falling Time		V_{UG-LX} = 4.5V to 0.5V, C_{UG} = 1nF	--	20	--	ns
UG Rising Time		V_{UG-LX} = 0.5V to 4.5V, C_{UG} = 1nF	--	60	--	ns
LG Falling Time		V_{LG-GND} = 4.5V to 0.5V, C_{LG} = 1nF	--	20	--	ns
LG Rising Time		V_{LG-GND} = 0.5V to 4.5V, C_{LG} = 1nF	--	160	--	ns
Current Sense Amplifier						
OCP Threshold Level	V_{CS-OCP}	V_{CSP} = 4.8V	--	115	--	mV
OCP Debounce Time	t_{OCP}		--	4	--	us

Electrical Characteristics

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Protection						
FB Over Voltage Level	V_{OVP}	Percent of V_{REF}	--	120	--	%
OVP Debounce Time	t_{D-OVP}		--	12	--	us
FB Under Voltage Level	V_{UVP}	Percent of V_{REF}	--	70	--	%
UVP Debounce Time	t_{D-UVP}		--	5	--	us
Over Temperature Shutdown			--	160	--	^{O}C
Over Temperature Hysteresis			--	40	--	^{O}C
Soft Start						
Soft Start Time	t_{SS}		--	8	--	ms
Recycle Time			--	2.2	--	sec

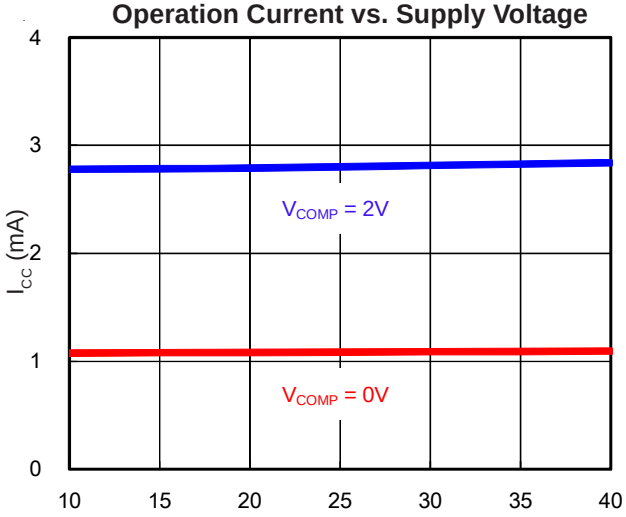
Typical Operation Characteristics

Power On Waveforms



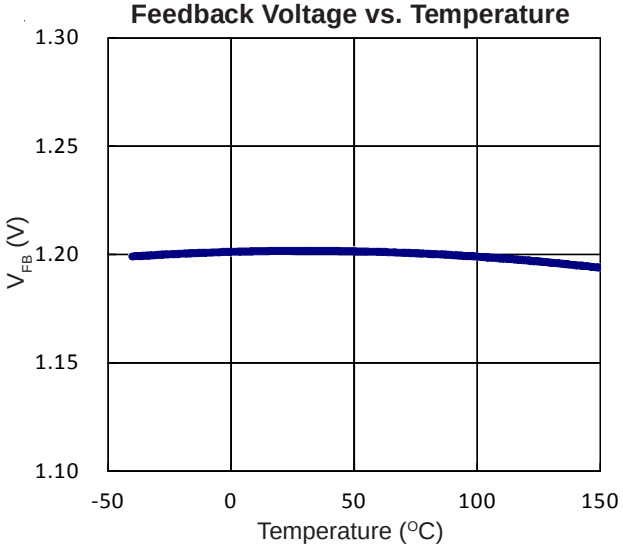
Time: 2ms/Div

Operation Current vs. Supply Voltage

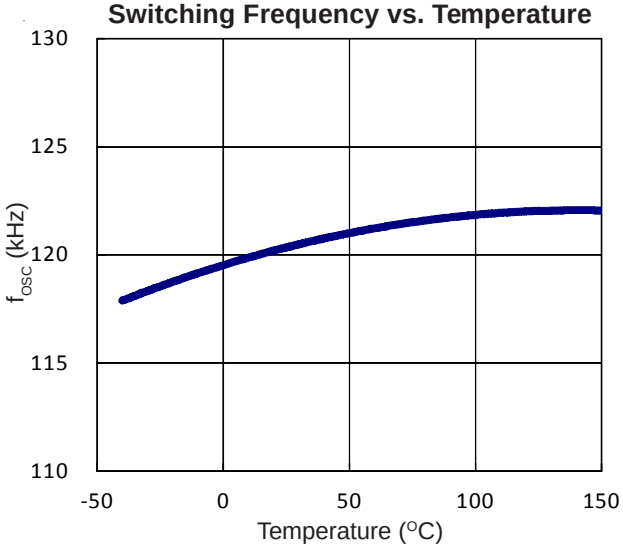


C_{LG} = 1nF, C_{UG} = 1nF

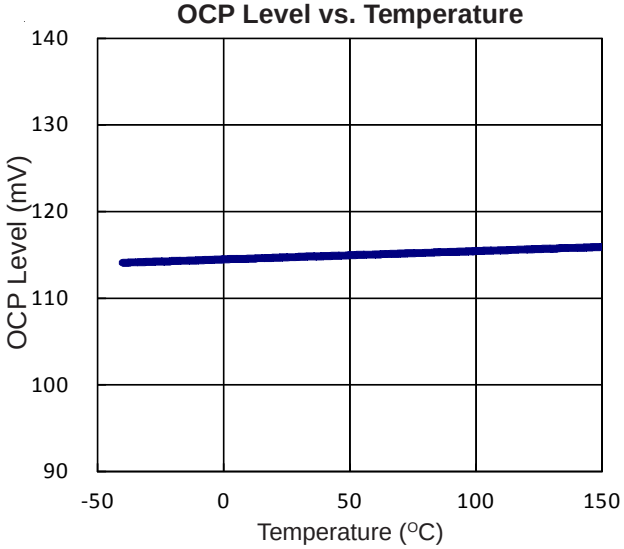
Feedback Voltage vs. Temperature



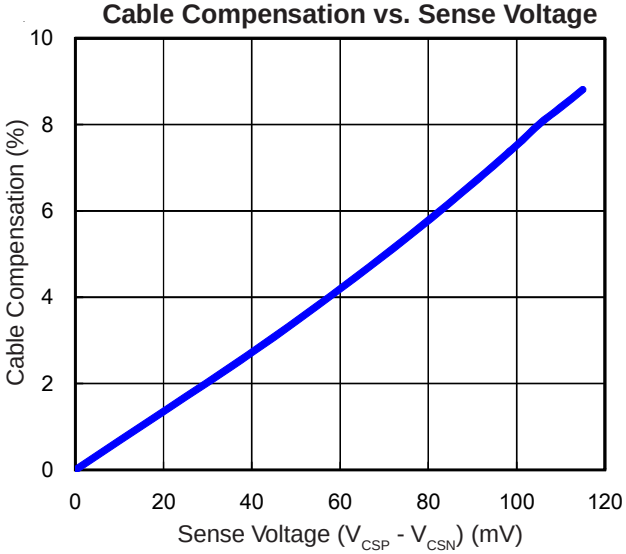
Switching Frequency vs. Temperature



OCP Level vs. Temperature



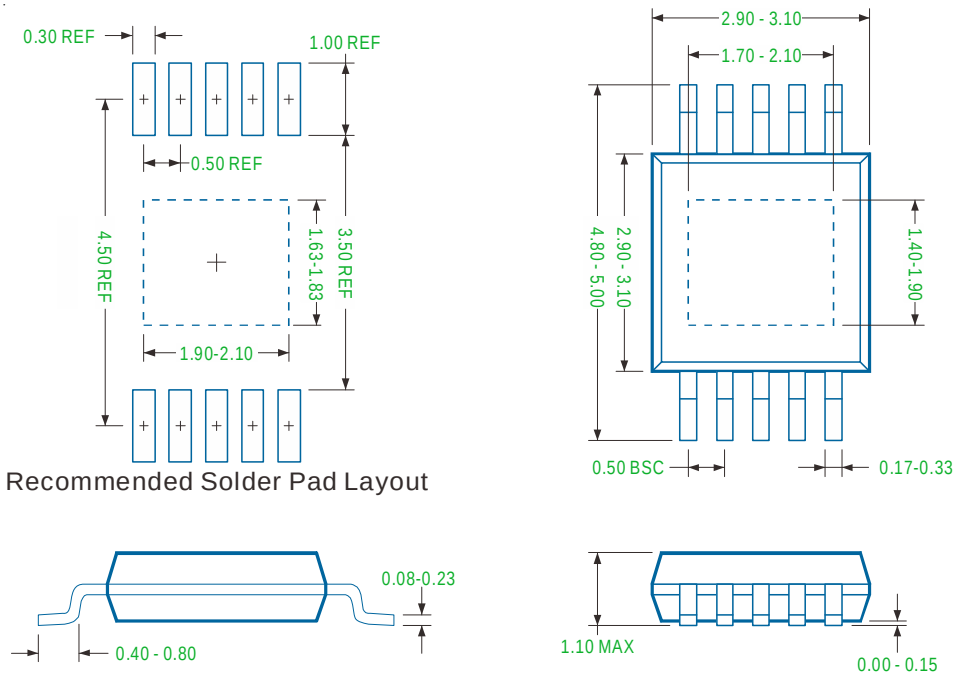
Cable Compensation vs. Sense Voltage



V_{CSN1} = V_{CSN2}

Package Information

PMSOP-10L



Note

1. Package Outline Unit Description:
   BSC: Basic. Represents theoretical exact dimension or dimension target
   MIN: Minimum dimension specified.
   MAX: Maximum dimension specified.
   REF: Reference. Represents dimension for reference use only. This value is not a device specification.
   TYP. Typical. Provided as a general value. This value is not a device specification.
2. Dimensions in Millimeters.
3. Drawing not to scale.
4. These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.