

Wide Input Range CV/CC/CP Step-Down Converter for Quick Charge 3.0™

General Description

The NT3885A is a synchronous-rectified step-down converter capable of delivering 3A output current and 3.6V~12V output voltage, dedicatedly designed for CLA applications. Integrated 30mW MOSFETs enables high efficiency and minimizes thermal loading. The NT3885 is designed to work with a wide supply voltage range from 9V to 30V.

The NT3885 integrates smart DP/DM interface that complies with Qualcomm® Quick Charge™ 3.0 specification. The output voltage is adjustable through Quick Charge™ 3.0 protocol. It also features constant current operation ($V_{OUT} < 7V$ typ.) and constant power operation ($V_{OUT} > 7V$ typ.), fulfilling power profile requirement of Qualcomm® Quick Charge™ 3.0. The external compensation makes feedback control have good line and load regulation with flexible external design.

The NT3885 features input over voltage, output over voltage, output under voltage and over temperature protections. It is available in WDFN5x6-14L package.

Applications

- Car Chargers
- Portable Charging Devices
- High-Brightness Lightings
- General-Purposed DC/DC Converters with Current Limit

Ordering Information

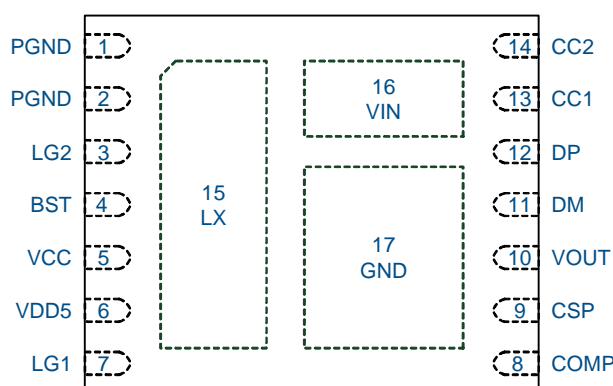
Order Number	Package	Top Marking
NT3885ADEC	WDFN5x6-14L	NT3885A

Note: EOSMEM 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.

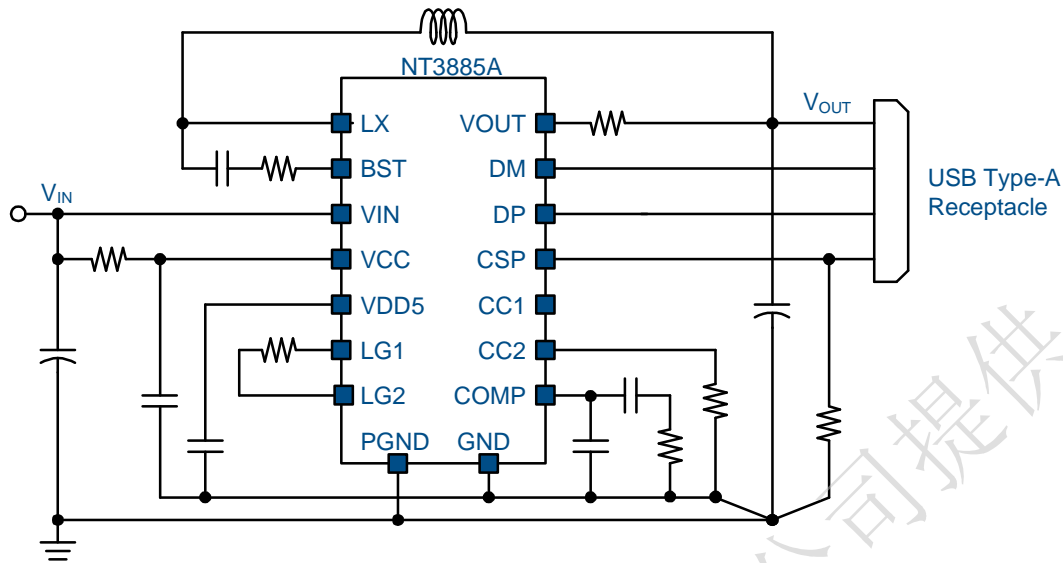
Features

- High Efficiency Power Conversion
 - n Integrate 30mW Switches
 - n Capable of Delivering 3A Output Current
 - n 125kHz Fixed Frequency Operation
 - n 0%~95% Duty Cycle
 - n 1% Output Voltage Accuracy Over Line
 - n 5% Constant Current Accuracy
 - n 3.6V~12.0V Adjustable Output Voltage
 - n Cable Compensation
- Smart USB Charger Identification Circuit
 - n Compliant with Quick Charge 2.0/3.0 Class A
 - n Support Apple 2.4A Applications
 - n Support BC1.2 & YD/T 1591 Battery Charging Specifications
- CC/CP Power Profile
- Comprehensive Protections
 - n Input Over Voltage Protection
 - n Output Over Voltage Protection
 - n Output Under Voltage Protection
 - n Over Temperature Protection
 - n Output Voltage Discharge Function
- DFN5x6-14L Package
- RoHS Compliant and Halogen-Free

Pin Configuration



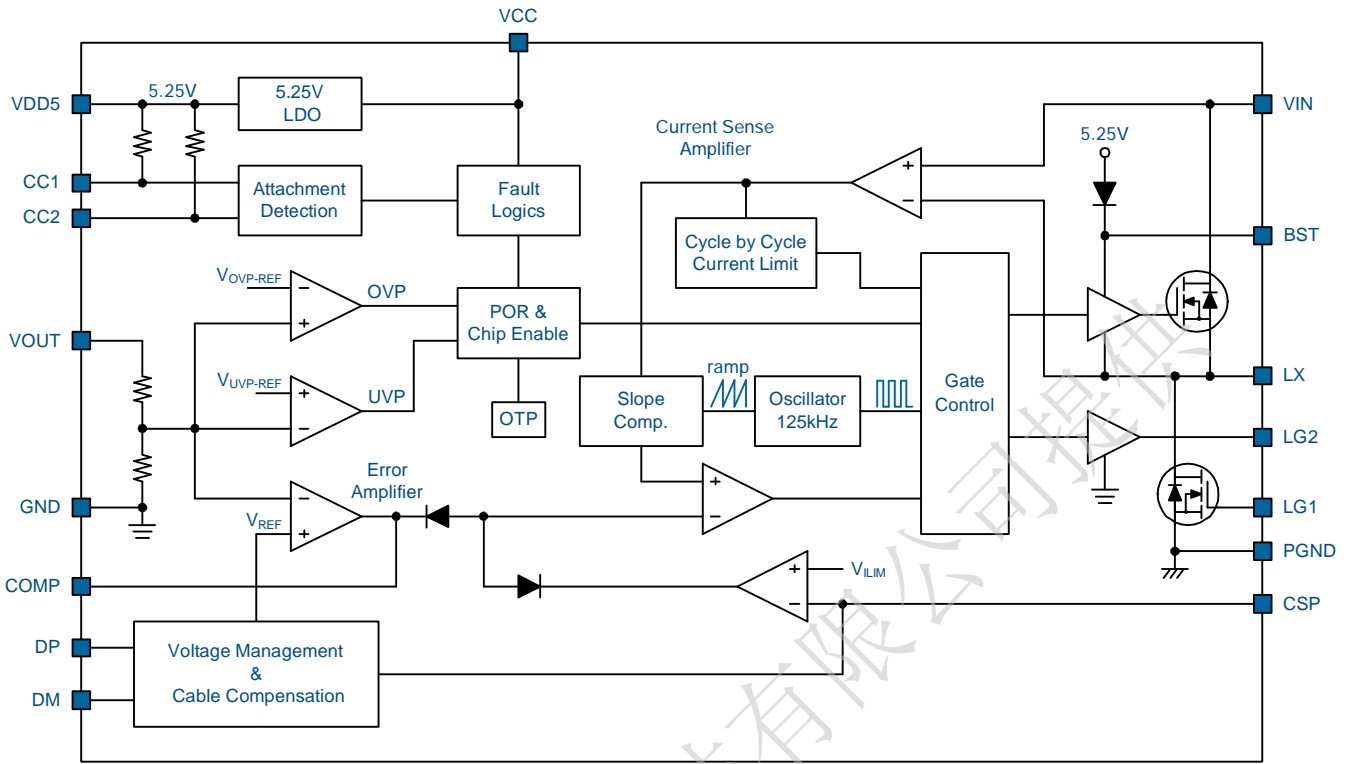
Typical Application Circuit



Functional Pin Description

Pin No.	Pin Name	Pin Function
1, 2	PGND	Power Ground
3	LG2	Gate of Lower MOSFET
4	BST	Bootstrap Pin. This pin provides power to the internal higher MOSFET gate driver. Connect a 470nF capacitor from BST pin to LX pin.
5	VCC	Power Supply Input. Bypass this pin with a 1uF ceramic capacitor to GND, placed as close to the IC as possible.
6	VDD5	Output Pin for the Internal 5V LDO. Bypass the VDD5 with a 1uF ceramic capacitor physically near the IC.
7	LG1	Low Side Gate Driver Output.
8	COMP	Error Amplifier Output. This is the output of the error amplifier (EA) and the non-inverting input of the PWM comparator.
9	CSP	Current Sensing Input.
10	VOUT	Output Voltage Sensing.
11	DM	Negative Data Line for USB.
12	DP	Positive Data Line for USB.
13	CC1	Configuration Channel 1 for USB Type-C receptacle. This pin is internally pulled high to VDD5 with a 10kΩ resistor.
14	CC2	Configuration Channel 2 for USB Type-C receptacle. This pin is internally pulled high to VDD5 with a 10kΩ resistor.
15	LX	Power Switching Output to External Inductor.
16	VIN	Exposed Pad. The exposed is connected to drain of the internal high-side MOSFET. Large PCB area is required for thermal dissipation.
17	GND	Ground.

Functional Block Diagram



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Functional Description

Power On Reset

A power-on reset circuit monitors the input voltage at VCC pin. When the input voltage exceeds 8V, the converter will start operation. Once input voltage falls below 7V, the converter shuts down.

Input Over Voltage Protection

If the VCC pin voltage is higher than 32V (typical), the input OVP is triggered. The NT3885 turns off the switches and shuts down. The NT3885 resets itself and waits for another attachment after 1 second time delay when input OVP occurs.

Waiting for Attachment

Before power on reset, the CC1/CC2 are kept high impedance. After power on reset, the NT3885 connects CC1/CC2 to VDD5 by 10kΩ resistors and waits for attachment of an UFP. If and only if one of CC1/CC2 voltage is between 0.8V and 2.2V for 100ms, the NT3885 asserts attachment and initiates the soft start cycle. This will advertise the NT3885, as a DFP, can provide 3A output current.

Soft Start

When attached, the NT3885 initiates the soft-start cycle if the output voltage is lower than 0.45V (typical). The softstart function ramps up the output voltage from 0V to 5.2V within about 5ms. This effectively reduces the inrush current to charge the output capacitor. After softstart completes, the NT3885 enables output under voltage protection (UVP) which turns off the converter if output voltage is lower than 3.0V. The NT3885 resets itself and waits for another attachment after 1 second time delay when UVP occurs.

Detachment Detection

The NT3885 continuously monitors CC1/CC2 voltage for detachment detection during normal operation. The NT3885 asserts detachment of UFP and turns off the step-down converter if both CC1/CC2 voltages are higher than 2.7V for 15ms. An internal discharge circuit is turned on for 500ms to discharge the output voltage to a safe level, vSafe0V, within specified period. After the discharge expires, the NT3885 resets its interface configuration and resumes looking for a new UFP attachment.

DM/DP Configuration

The DM/DP have three configurations, mode 1 ~ mode 3, as shown in Figure 1 ~ Figure 3. The NT3885 automatically selects configurations according to the DP/DM status and pre-defined timing so that the attached portable devices can be quickly charged.

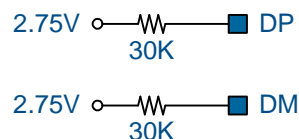


Figure 1. Mode 1 Configuration.

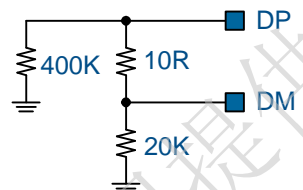


Figure 3. Mode 2 Configuration.

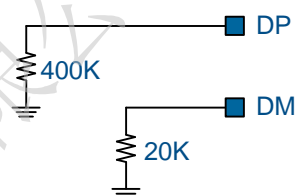


Figure 4. Mode 3 Configuration.

Mode 1 Configuration

Mode 1 is the default configuration when output voltage is higher than 4.0V. The NT3885 leaves mode 1 and enters mode 2 if one of the three conditions is true: 1.) $V_{DP-0} < V_{DP}$ for 2ms; 2.) $V_{DM} < V_{DM-1}$ for 15ms or 3.) $V_{DP} < V_{DP-1}$ for 15ms.

When entering mode 2, the NT3885 resets the internal 2-second counter.

Mode 2 Configuration

The NT3885 leaves mode 2 under two conditions:

- 1.) enters mode 3 if $V_{DP-2} < V_{DP} < V_{DP-1}$ for 1.2 seconds.
- 2.) otherwise enters mode 1 when the 2-second counter expires.

Mode 3 Configuration

The NT3885 leaves mode 3 and enters mode 1 if $V_{DP-2} > V_{DP}$ for 40ms.

At mode 3, the NT3885 keeps monitoring DM voltage. Once $V_{DM} < V_{DM-2}$ for longer than 40ms, the NT3885 recognizes a Quick Charge supporting device is attached and adjusts the output voltage according to DP/DM voltage as illustrated in Table 1.

Functional Description

The NT3885 features a soft transition function when adjusting the output voltage. The output voltage slew rate is limited to 3.5V/ms. This effectively reduces the inrush current to charge the output capacitors.

Table 1. V_{OUT} vs. DP/DM voltages relationship

V_{DP}	V_{DM}	V_{OUT}
$V_{DP} < V_{DP-2}$	X	Enter mode 1
$V_{DP-2} < V_{DP}$	$V_{DM} < V_{DM-1}$	5.2V
$V_{DP-2} < V_{DP} < V_{DP-1}$	$V_{DM-2} < V_{DM} < V_{DM-1}$	12.0V
$V_{DP-2} < V_{DP} < V_{DP-1}$	$V_{DM} > V_{DM-1}$	Continuous mode
$V_{DP} > V_{DP-1}$	$V_{DM-2} < V_{DM} < V_{DM-1}$	9.0V
$V_{DP} > V_{DP-1}$	$V_{DM} > V_{DM-1}$	Keep last state

Incremental Output Voltage

When $V_{DP-2} < V_{DP} < V_{DP-1}$ and $V_{DM} > V_{DM-1}$, the NT3885 enters continuous mode. Upon each DP positive pulse with 150us delay time, the NT3885 increases output voltage by 200mV as shown in Figure 5. Pulsewidth (both t_L and t_H) shorter than 150us will be skipped. The maximum output voltage is limited at 12.0V.

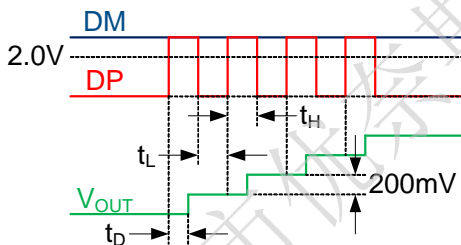


Figure 5. Incremental Output Voltage.

Decremental Output Voltage

Upon each DM negative pulse with 150us delay time, the NT3885 decreases output voltage by 200mV as shown in Figure 6. Pulsewidth (both t_L and t_H) shorter than 150us will be skipped. The minimum output voltage is 3.6V.

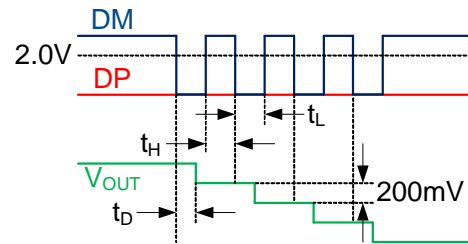


Figure 6. Decremental Output Voltage.

CV/CC/CP mode control

The NT3885 provides CV/CC/CP function to meet power profile requirement of Quick Charge™ 3.0. In the CV mode, the output voltage is controlled within $\pm 1\%$. In the CC mode, the output current variation is less than $\pm 5\%$ of the nominal value which can be set up to 3A by the current sensing resistor as:

$$I_{OUT-N} = \frac{V_{ILIM}}{R_{CS}} = \frac{66mV}{R_{CS}}$$

The NT3885 enters CP mode (constant power) when output voltage is higher than 7.0V as shown Figure 7. The current limit is linearly decreased as output voltage increases and roughly keeps the output power constant.

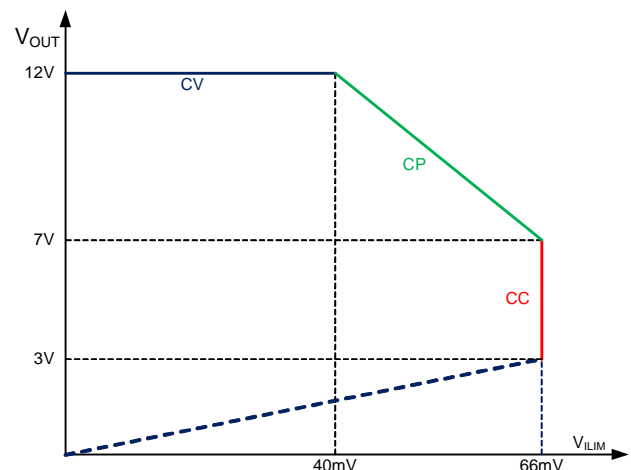


Figure 7. Power Profile.

Cycle-by-Cycle Current Limit

The NT3885 uses on-state resistance of the internal power MOSFET as a current sense element. Once the peak switch current through the power MOSFET is higher than current-limit threshold, the NT3885 turns off the power MOSFET immediately to limit the inductor current. The NT3885

resumes normal operation at next PWM clock.

Under Voltage Protection

When the load demands more current than CC level or cycle-by-cycle current limit level (CC mode operation or output short circuit), the output voltage will decrease. Once the output voltage is lower than 3.0V, the under voltage protection (UVP) will be triggered to shut down the converter.

The NT3885 resets itself and resumes normal operation with 1 second time delay.

Over Voltage Protection

The over voltage protection (OVP) is triggered when the output voltage is 15% higher than its target level. When OVP, the step-down converter stops switching immediately. The converter resumes normal operation when OVP disappears.

Over Temperature Protection

The over temperature protection (OTP) is triggered and shuts down the NT3885 when its junction temperature exceeds 160°C. Once the junction temperature cools down by approximately 40°C, the converter will resume normal operation.

Cable Compensation

In charger applications, the load current will cause considerable voltage drop along the output cable and current sensing resistor R_{CS} . The NT3885 automatically compensates the voltage drop so that the terminal voltage is kept constant over entire loading current range. The real output voltage is adjusted according to the current sensing voltage as:

$$V_{OUT} = V_{OUT-N} + 3 \cdot V_{CS}$$

where V_{OUT-N} is the target output voltage level set by DP/DM.

Output Voltage Discharge

The NT3885 turns on the internally discharge circuit for 500ms under the following conditions:

- 1.) UFP detachment is detected.
- 2.) Discrete output voltage decreasing command is received.

This will sink a 50mA current (at $V_{OUT} = 5.2V$) to discharge the output voltage to a safe level within the specified requirement.

Absolute Maximum Rating

(Note1)

Supply Input Voltage, V_{IN} -----	-0.3V to +40V
BST to LX -----	+0.3V to +7V
LX to GND -----	-1V to $V_{IN}+1V$
Other Pins -----	-0.3V to +7V
Storage Temperature Range -----	-65°C to +150°C
Operation Temperature Range -----	-40°C to +150°C
Lead Temperature Range (Soldering 10sec) -----	260°C

ESD Rating (Note2)

MM (Machine Mode) -----	200V
MM (Machine Mode), DP/DM Pins -----	800V
HBM (Human Body Mode) -----	2kV
HBM (Human Body Mode), DP/DM Pins -----	8kV

Thermal Information

Package Thermal Resistance (Note3)

WDFN5x6-14L q_{JA} -----	50°C/W
WDFN5x6-14L q_{JC} -----	5°C/W

Power Dissipation, P_D @ $T_A = 25^\circ\text{C}$

WDFN5x6-14L -----	2W
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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. q_{JA} is measured in the natural convection at $T_A = 25^\circ\text{C}$ on a high effective thermal conductivity test board of JEDEC 51-7 thermal measurement standard.

Electrical Characteristics

 ($V_{IN} = 14V$, $T_A = +25^{\circ}C$ unless otherwise specified.)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Supply Input						
Supply Voltage Range	V_{IN}		9	--	30	V
Supply Input Current	I_{IN-SD}	CC1, CC2 open.	--	0.6	1.2	mA
	I_{IN-Q}	No load.	--	1.5	3.0	
VDD5 Output Voltage	V_{DD5}	$V_{IN} = 9V \sim 30V$	5.1	5.25	5.4	V
Power On Reset						
V_{IN} POR Threshold	V_{IN-POR}	V_{IN} rising,	7.5	8.0	8.5	V
V_{IN} POR Hysteresis	V_{IN-HYS}	V_{IN} Falling	--	1.0	--	V
V_{IN} Over Voltage Protection	V_{IN-OVP}		30	32	34	V
Oscillator						
Normal PWM Frequency	f_{OSC}		--	125	--	kHz
		$T_A = -25^{\circ}C$ to $125^{\circ}C$	110	--	140	
Minimum On-Time	t_{ON-MIN}		--	500	--	ns
Maximum Duty Cycle	D_{MAX}		95	--	--	%
Output Voltage						
Output Voltage	V_{OUT}	Default	5.15	5.20	5.25	V
		9V mode	8.6	9.0	9.4	
		12V mode	11.4	12.0	12.6	
Incremental/Decremental Step			150	200	250	mV
V_{OUT} Load Compensator		$V_{CS} = 60mV$	160	180	200	mV
PWM Error Amplifier						
Error Amplifier Transconductance	GM		--	500	--	$\mu A/V$
COMP Source Current		$V_{COMP} = 4V$	--	36	--	μA
COMP Sink Current		$V_{COMP} = 1V$	--	36	--	μA
Current Sense Amplifier						
Current Limit Level	V_{ILIM}	$V_{OUT} = 4.5 \sim 6.5V$	62	66	70	mV
		$V_{OUT} = 12V$	36	40	44	
Current Limit Breaking Point			--	7.0	--	V
Protection						
Over Voltage Protection Level	V_{OVP}	Percentage of target level.	112	115	118	%
Over Voltage Protection Hysteresis		V_{OUT} falling.	--	5	--	%
Under Voltage Protection Level	V_{UVP}	V_{OUT} falling.	2.9	3.0	3.1	V
Current Limit	I_{LIM}		4.0	5.0	6.0	A
Over Temperature Shutdown			--	160	--	$^{\circ}C$
Over Temperature Hysteresis			--	40	--	$^{\circ}C$

Electrical Characteristics

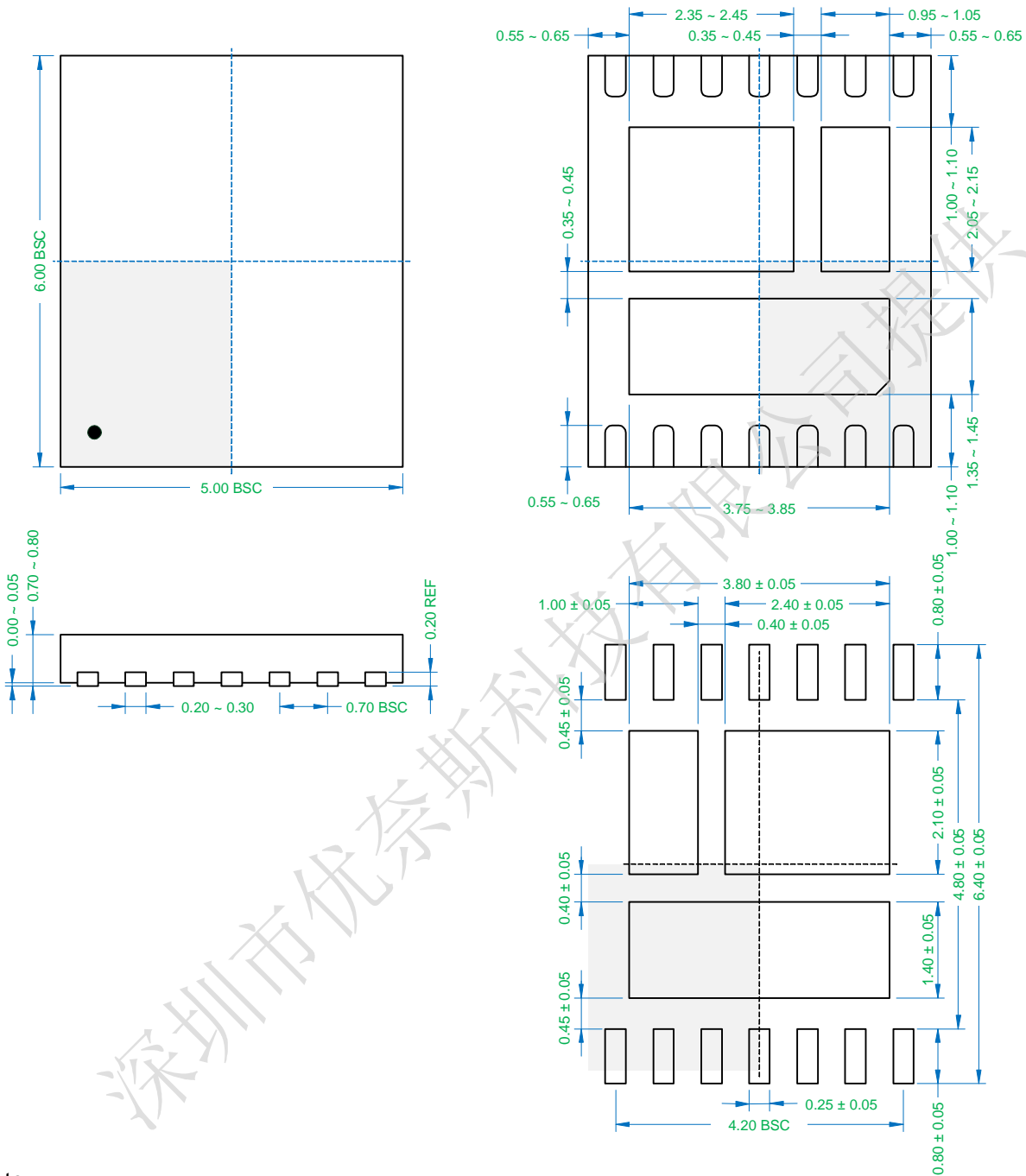
Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
DP/DM Threshold Levels						
DP/DM Threshold Levels	V_{DP-0}	Delta from initial V_{DP}	100	125	150	mV
	V_{DM-1}	V_{DM} : V_{DP} rising	1.95	2.05	2.15	V
	V_{DP-1}	V_{DM-1}/V_{DP-1} hysteresis	--	100	--	mV
	V_{DM-2}	V_{DM} : V_{DP} rising	0.325	0.35	0.375	V
	V_{DP-2}	V_{DM-2}/V_{DP-2} hysteresis	--	50	--	mV
DP/DM at Mode 1						
DP Floating Voltage	V_{DP}		2.65	2.75	2.85	V
DM Floating Voltage	V_{DM}		2.65	2.75	2.85	V
DP Pin Output Impedance	Z_{DP}		24	30	36	kW
DM Pin Output Impedance	Z_{DM}		24	30	36	kW
Debounce Time for Exiting Mode 1		$V_{DP} > V_{DP-0}$	1.6	2.0	2.4	ms
		$V_{DM} < V_{DM-1}$ or $V_{DP} < V_{DP-1}$	12	15	18	ms
DP/DM at Mode 2						
DP and DM Short Circuit Switch			--	10	20	W
DM Pull Low Resistance			16	20	24	kW
DP Pull Low Resistance			320	400	480	kW
Recycle Time for Entering Mode 1			1.6	2.0	2.4	s
Debounce Time for Entering Mode 3			1.0	1.2	1.5	s
DP/DM at Mode 3						
DP Pull Low Resistance			320	400	480	kW
DM Pull Low Resistance			16	20	24	kW
Debounce Time for DM Low			32	40	48	ms
Debounce Time for DP Low			32	40	48	ms
Deglitch Time for DM/DP Change		Quick Charge 2.0 mode	32	40	48	ms
		Quick Charge 3.0 mode	100	150	200	us
Duration for Voltage Step		Quick Charge 2.0 Mode	48	60	72	us
Output Voltage Incremental/ Decremental Step			--	200	--	mV

Electrical Characteristics

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
CC1/CC2						
CC1/CC2 Open Circuit Voltage			--	5.2	--	V
CC1/CC2 Pull High Resistance			--	10	--	kΩ
Upper Bound for Attachment		CC1/CC2 falling	--	2.2	--	V
		CC1/CC2 rising	--	2.7	--	V
Lower Bound for Attachment			--	0.8	--	V
Debounce Time for Attachment			--	100	--	ms
Debounce Time for Detachment			--	15	--	ms
Soft Start						
Soft Start Time	t_{SS}		--	5.0	--	ms
Recycle Time			--	1000	--	ms
Discharge Function						
Discharge Period			--	500	--	ms
Discharge Current		$V_{OUT} = 5.15V$	--	50	--	mA
High/Low Side Switches						
High Side Switch On-Resistance	$R_{DS(ON)}$	$I_L = 0.1A$	--	30	--	mΩ
Low Side Switch On-Resistance	$R_{DS(ON)}$	$I_L = 0.1A$	--	30	--	mΩ
LX Rising Time		$I_L = 1A$	--	30	--	ns
LX Falling Time		$I_L = 1A$	--	50	--	ns

Package Information

WDFN5x6-14L



Note

- 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.
- Dimensions in Millimeters.
- Drawing not to scale.
- These dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm.