

XC9215/9216/9217 Series

500mA Synchronous Step-Down DC/DC Converters



May 13, 2004 V4

* GO (Green Operation) Compatible

■ Synchronous Step-down DC/DC	
■ High Efficiency	92%
■ Low Ripple Rejection	10mV
■ Output Current	500mA (VIN=3.0V, VOUT=1.8V)*
■ Oscillation Frequency	600kHz, 1.2MHz
■ PWM fixed control	(XC9215 series)
■ PWM/PFM automatic switching control	(XC9216 series)
■ Manual selection of switching control	(XC9217 series)
■ Maximum Duty Ratio	100%
■ Ceramic Capacitor Compatible	
■ Ultra Small Packages	SOT-25, USP-6B

■ GENERAL DESCRIPTION

The XC9215/9216/9217 series is a group of synchronous-rectification type DC/DC converters with a built-in 0.6Ω P-channel driver transistor and 0.7Ω N-channel switching transistor, designed to allow the use of ceramic capacitors. The ICs enable a high efficiency, stable power supply with an output current of 500mA to be configured using only a coil and two capacitors connected externally.

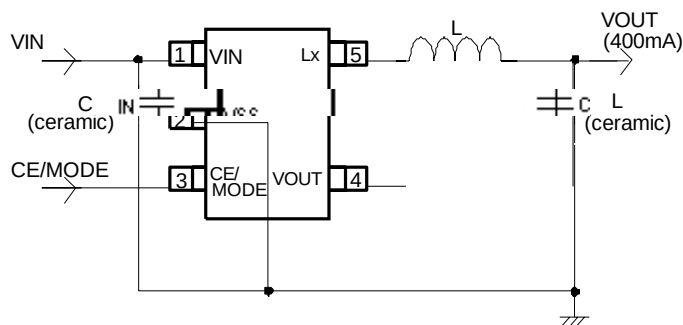
Minimum operating voltage is 2.0V. Output voltage is internally programmable in a range from 0.9V to 4.0V in increments of 0.1V (accuracy: ± 2.0%).

With the built-in oscillator, oscillation frequency is selectable from 600kHz and 1.2MHz to make available the frequency best suited to your particular application.

As for operation mode, the XC9215 series is PWM control, the XC9216 series is automatic PWM/PFM switching control and the XC9217 series can be manually switched between the PWM control mode and the automatic PWM/PFM switching control mode, allowing fast response, low ripple and high efficiency over the full range of load (from light load to high output current conditions).

The soft start and current control functions are internally optimized. During standby, all circuits are shutdown to reduce current consumption to as low as 1.0μA or less. With the built-in U.V.L.O. (Under Voltage Lock Out) function, the internal P channel driver transistor is forced OFF when input voltage becomes 1.4V or lower. Two types of package, 250mW (SOT-25) and 100 mW (USP-6B), are available.

■ TYPICAL APPLICATION CIRCUIT



■ APPLICATIONS

- Mobile phones (PDC, GSM, CDMA, IMT200 etc.)
- Bluetooth equipment
- PDAs
- Portable communication modem
- Portable games
- Cameras
- Digital cameras
- Cordless phones
- Notebook computers

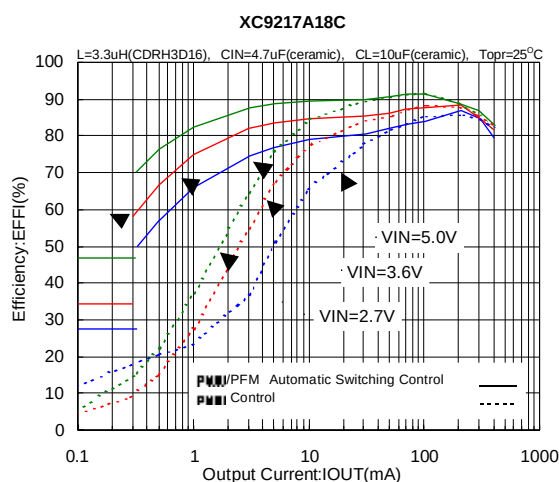
■ FEATURES

P-ch Driver Tr. Built-in	ON resistance 0.6Ω
N-ch	ON resistance 0.7Ω
Synchronous Driver Tr. Built-in	ON resistance 0.7Ω
Input Voltage Range	2.0 ~ 6.0V
Output Voltage Range	0.9V~4.0V (100mV increments)
High Efficiency	92% (TYP.) (VIN=3.0V, VOUT=1.8V, IOUT=100mA)*
Output current	500mA (VIN=3.0V, VOUT=1.8V)*
Oscillation Frequency	600kHz, 1.2MHz (Fixed frequency accuracy ±15%)
Ultra Small Packages	SOT-25 (SOT-23-5) USP-6B
Soft-start circuit built-in	
Current limiter circuit built-in (constant current & latching)	
Low ESR ceramic capacitor compatible	

* Performance depends on external components and wiring on the PCB.

■ TYPICAL PERFORMANCE CHARACTERISTICS

○ Efficiency vs. Output Current

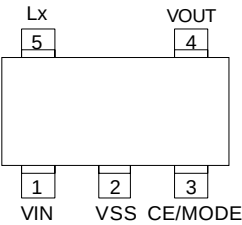


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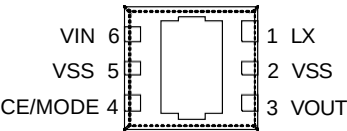
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PIN CONFIGURATION



SOT-25 (TOP VIEW)



USP-6B (BOTTOM VIEW)

* Please short the VSS pin (pin no. 2 and 5) before use.
Connection of the heat dissipation pad to any pin on the circuit is not recommended. If the pad must be connected due to a problem of heat dissipation or mounting intensity, connect to the VSS pin (pin no. 5).

PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTION
SOT-25	USP-6B		
1	6	VIN	Power Input
2	2, 5	VSS	Ground
3	4	CE / MODE	Chip Enable Mode Switch
4	3	VOUT	Output Voltage Sense
5	1	Lx	Switching Output

PRODUCT CLASSIFICATION

Ordering Information

XC9215		fixed control
XC9216		/ PFM automatic switching control
XC9217		fixed control ← PFM / PFM automatic switching, manual switching

DESIGNATOR	SYMBOL	DESCRIPTION
	A	Transistor built-in, Output voltage internally set (VOUT product), Soft start Internally set, Current limit 700mA CE input logic High Active, CE pin open (Standard)
	B	CE input logic Low Active, CE pin open (Semi-custom)
	C	CE input logic High Active, Pull-down resistor built-in (Semi-custom)
	D	CE input logic Low Active, Pull-up resistor built-in (Semi-custom)
	Integer	Output voltage: e.g. 1.5V Output → = 1, = 5
	M	Package Types: SOT-25 (SOT-23-5)
	D	USP-6B
	R	Device Orientation: Embossed Tape : Standard Feed
	L	Embossed Tape : Reverse Feed

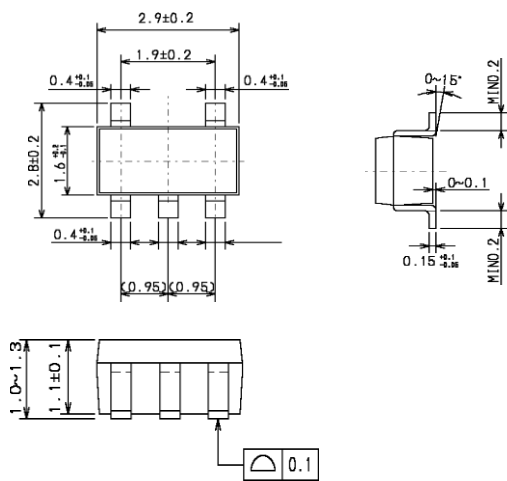
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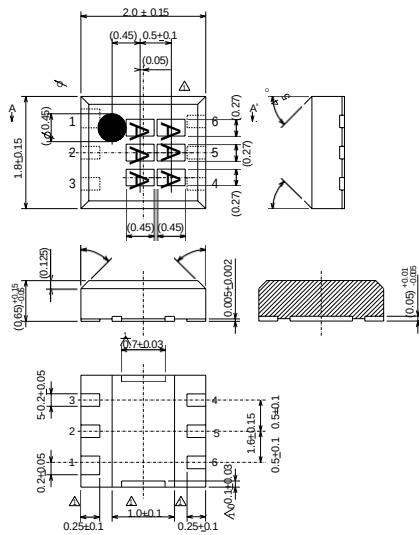


■ PACKAGING INFORMATION

○ SOT-25 (SOT-23-5)



○ USP-6B



* Pin no. 1 is thicker than other pins.

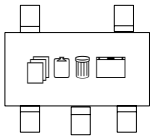
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■ MARKING RULE

○ SOT-25 (SOT-23-5)



SOT-25 (TOP VIEW)

Mark Represents product series and the type of DC/DC converter

SYMBOL	PRODUCT SERIES
E	XC9215A x x x M x
F	XC9216A x x x M x
G	XC9217A x x x M x

* Character inversion used.

Mark Represents the integer of output voltage and oscillation frequency

OUTPUT VOLTAGE	SYMBOL	
	FOSC=600kHz	FOSC=1.2MHz
	(XC92 x x A x 6 M x)	(XC92 x x A x C M x)
0.X	0	0
1.X	1	1
2.X	2	2
3.X	3	3
4.X	4	4

Mark Represents the decimal point of output voltage and oscillation frequency

OUTPUT VOLTAGE	SYMBOL	
	FOSC=600kHz	FOSC=1.2MHz
	(XC92 x x A x 6 M x)	(XC92 x x A x C M x)
X.0	0	A
X.1	1	B
X.2	2	C
X.3	3	D
X.4	4	E
X.5	5	F
X.6	6	H
X.7	7	K
X.8	8	L
X.9	9	M

* Output voltage 0.9V ~ 4.0V (100mV increments) are standard products.

Please ask our sales contact for output voltages of 50mV increments (semi-custom products).

Mark Represents production lot number

0 to 9, A to Z, reversed character of 0 to 9 and A to Z repeated (G, I, J, O, Q excepted)

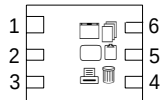
XC9215/9216/9217 Series

500mA Synchronous Step-Down DC/DC Converters



■ MARKING RULE (Continued)

○ USP-6B



USP-6B (TOP VIEW)

Mark Represents product series and the type of DC/DC converter

SYMBOL	PRODUCT SERIES
F	XC9215A x x x D x
B	XC9216A x x x D x
E	XC9217A x x x D x

* Character inversion used.

Mark Represents the type of voltage regulators

SYMBOL	PRODUCT SERIES	CURRENT LIMIT
A	XC92 x x A x x x D x	700mA

Mark Represents the integer of output voltage

OUTPUT VOLTAGE	SYMBOL (XC92 x x A x x D x)
0.X	0
1.X	1
2.X	2
3.X	3
4.X	4

Mark Represents the decimal point of output voltage

OUTPUT VOLTAGE	SYMBOL (XC92 x x A x x D x)
X.0	0
X.1	1
X.2	2
X.3	3
X.4	4
X.5	5
X.6	6
X.7	7
X.8	8
X.9	9

* Output voltage 0.9V ~ 4.0V (100mV increments) are standard products.

Please ask our sales contact for output voltages of 50mV increments (semi-custom products).

Mark Represents oscillation frequency

SYMBOL	PRODUCT SERIES	FREQUENCY
6	XC92 x x A x x 6 D x	600kHz
C	XC92 x x A x x C D x	1.2MHz

Mark Represents production lot number

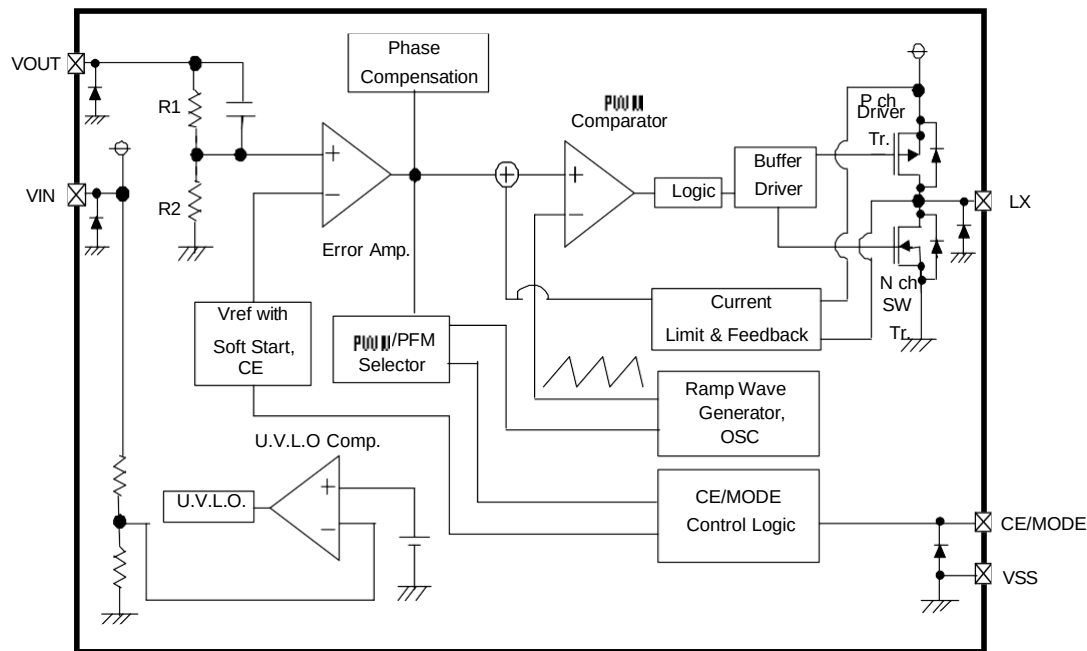
0 to 9, A to Z, reversed character of 0 to 9 and A to Z repeated (G, I, J, O, Q excepted)

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■ BLOCK DIAGRAM



Note:

The signal from CE/MODE Control Logic to PWM/PFM Selector is being fixed to "L" level inside, and XC9215 series chooses only PWM control. The signal from CE/MODE Control Logic to PWM/PFM Selector is being fixed to "H" level inside, and XC9216 series chooses only PWM/PFM automatic switching control.

■ ABSOLUTE MAXIMUM RATINGS

Ta=25°C

PARAMETER	SYMBOL	RATINGS	UNITS
VIN Pin Voltage	VIN	- 0.3 ~ 6.5	V
Lx Pin Voltage	VLx	- 0.3 ~ VIN + 0.3	V
VOUT Pin Voltage	VOUT	- 0.3 ~ 6.5	V
CE / MODE Pin Voltage	VCE	- 0.3 ~ VIN + 0.3	V
Lx Pin Current	ILx	± 1000	mA
Power Dissipation	SOT-25	Pd	250
	USP-6B		
			100
Operating Temperature Range	Topr	- 40 ~ + 85	°C
Storage Temperature Range	Tstg	- 55 ~ +125	°C

XC9215/9216/9217 Series

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ELECTRICAL CHARACTERISTICS

XC9215A18Cxx, XC9216A18Cxx, XC9217A18Cxx

VOUT=1.8V, FOSC=1.2MHz, Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	CIRCUIT
Output Voltage	VOUT	When connected to external components, CE=VIN, IOUT=30mA	1.764	1.800	1.836	V	
Operating Voltage Range	VIN		2.0	-	6.0	V	
Maximum Output Current	IOUTMAX	VIN=3.0V, When connected to external components (*10)	500	-	-	mA	
U.V.L.O Voltage	VUVLO	CE=VIN, VOUT=0V, Voltage which Lx pin voltage holding "L" level (*1)	1.0	1.4	1.78	V	
Supply Current	IDD	VIN=CE=3.6V, VOUT=fixed voltage x 1.1V	-	70	115	μA	
Stand-by Current	Istb	VIN=3.6V, CE=0V, VOUT=fixed voltage x 1.1V	-	0	1.0	μA	
Oscillation Frequency	FOSC	When connected to external components, IOUT=100mA	1020	1200	1380	kHz	
PFM Switch Current	IPFM	When connected to external components, CE=VIN, IOUT=1mA	100	140	180	mA	
Maximum Duty Ratio	MAXDTY	CE=VIN, VOUT=0V	100	-	-	%	
Minimum Duty Ratio	MINDTY	CE=VOUT=VIN	-	-	0	%	
Efficiency (*2)	EFFI	When connected to external components, CE=VIN=3.0V, IOUT=100mA	-	90	-	%	
Lx SW "H" ON Resistance	RLxH	CE=0.5VIN, VOUT=0V, ILx=100mA (*3)	-	0.6	1.2	Ω	
Lx SW "L" ON Resistance	RLxL	CE=0.5VIN, ILx=100mA (*4)	-	0.7	1.4	Ω	-
Lx SW "H" Leak Current	ILeakH	VIN=VOUT=5.0V, CE=0V, Lx=0V (*5)	-	0.01	1.0	μA	
Lx SW "L" Leak Current	ILeakL	VIN=VOUT=5.0V, CE=0V, Lx=5.0V	-	0.01	1.0	μA	
Current Limit	ILIM	VIN=CE=5.0V, VOUT=0V	600	700	-	mA	
Output Voltage Temperature Characteristics	$\frac{\Delta V_{OUT}}{V_{OUT} \times \Delta T_{opr}}$	IOUT=30mA -40°C ≤ Topr ≤ 85°C	-	+100	-	ppm/°C	
CE "H" Voltage	VCEH	VOUT=0V, When CE voltage is applied Lx determine "H"	0.9	-	VIN	V	
CE "L" Voltage	VCEL	VOUT=0V, When CE voltage is applied Lx determine "L"	VSS	-	0.3	V	
PWM "H" Level Voltage	VrP _{WM} H	When connected to external components, IOUT=1mA (*6)	-	-	VIN - 1.0	V	
PWM "L" Level Voltage	VrP _{WM} L	When connected to external components, IOUT=1mA (*6)	VIN - 0.3	-	-	V	
CE "H" Current	ICEH	VIN=CE=5.5V, VOUT=0V	- 0.1	-	0.1	μA	
CE "L" Current	ICEL	VIN=5.5V, CE=0V, VOUT=0V	- 0.1	-	0.1	μA	
Soft-Start Time	TSS	When connected to external components, CE=0V → VIN, IOUT=1mA	0.5	1.0	3.0	msec	
Latch Time	Tlat	When connected to external components, VIN=CE=5.0V, Short VOUT by 1Ω resistance (*7)	1	-	20	msec	

Test conditions: Unless otherwise stated, VIN=3.6V

(*1) Including hysteresis operating voltage range.

(*2) $EFFI = \{ (\text{Output Voltage} \times \text{Output Current}) / (\text{Input Voltage} \times \text{Input Current}) \} \times 100$

(*3) On resistance (Ω)= Lx pin measurement voltage / 100mA

(*4) R&D value

(*5) When temperature is high, a current of approximately 20μA (maximum) may leak.

(*6) The CE/MODE pin of the XC9217A series works also as an external PWM control and PWM/PFM control switching pin. When the IC is in the operation, control is switched to the PWM mode when the CE/MODE pin voltage is equal to or greater than VIN minus 0.3V, and to the automatic PWM/PFM switching mode when the CE/MODE pin voltage is equal to or lower than VIN minus 1.0V and equal to or greater than VCEH.

(*7) Time until it short-circuits DCOUT with GND through 1Ω of resistance from a state of operation and is set to DCOUT=0V from current limit pulse generating. There is no PFM switch current for XC9215 series. The PFM switch current is only for XC9216/17 series.

(*8) There is no PWM "H" Level Voltage or PWM "L" Level Voltage for XC9215/16 series. The characteristics are only for XC9217 series.

(*9)

(*10) When the difference between the input and the output is small, some cycles may be skipped completely before current maximizes.

If current is further pulled from this state, output voltage will decrease because of P-ch driver ON resistance.

XC9215/9216/9217 Series

500mA Synchronous Step-Down DC/DC Converters



ELECTRICAL CHARACTERISTICS

XC9215A33Cxx, XC9216A33Cxx, XC9217A33Cxx

VOUT=3.3V, FOSC=1.2MHz, Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	CIRCUIT
Output Voltage	VOUT	When connected to external components, CE=VIN, IOUT=30mA	3.234	3.300	3.366	V	
Operating Voltage Range	VIN		2.0	-	6.0	V	
Maximum Output Current	IOUTMAX	VIN=4.5V, When connected to external components (*10)	500	-	-	mA	
U.V.L.O Voltage	VUVLO	CE=VIN, VOUT=0V, Voltage which Lx pin voltage holding "L" level (*1)	1.0	1.40	1.78	V	
Supply Current	IDD	VIN=CE=5.0V, VOUT=fixed voltage x 1.1V	-	75	120	μA	
Stand-by Current	Istb	VIN=5.0V, CE=0V, VOUT=fixed voltage x 1.1V	-	0	1.0	μA	
Oscillation Frequency	FOSC	When connected to external components, IOUT=100mA	1020	1200	1380	kHz	
PFM Switch Current	IPFM	When connected to external components, CE=VIN, IOUT=1mA	100	140	180	mA	
Maximum Duty Ratio	MAXDTY	CE=VIN, VOUT=0V	100	-	-	%	
Minimum Duty Ratio	MINDTY	CE=VOUT=VIN	-	-	0	%	
Efficiency (*2)	EFFI	When connected to external components, CE=VIN=4.5V, IOUT=100mA	-	92	-	%	
Lx SW "H" ON Resistance	RLxH	CE=0.5VIN, VOUT=0V, ILx=100mA (*3)	-	0.5	1.0	Ω	
Lx SW "L" ON Resistance	RLxL	CE=0.5VIN, ILx=100mA (*4)	-	0.6	1.2	Ω	-
Lx SW "H" Leak Current	ILeakH	VIN=VOUT=5.0V, CE=0V, Lx=0V (*5)	-	0.01	1.0	μA	
Lx SW "L" Leak Current	ILeakL	VIN=VOUT=5.0V, CE=0V, Lx=5.0V	-	0.01	1.0	μA	
Current Limit	ILIM	VIN=CE=5.0V, VOUT=0V	600	700	-	mA	
Output Voltage Temperature Characteristics	$\frac{\Delta V_{OUT}}{V_{OUT} \times \Delta T_{opr}}$	IOUT=30mA -40°C ≤ Topr ≤ 85°C	-	±100	-	ppm/°C	
CE "H" Voltage	VCEH	VOUT=0V, When CE voltage is applied Lx determine "H"	0.9	-	VIN	V	
CE "L" Voltage	VCEL	VOUT=0V, When CE voltage is applied Lx determine "L"	VSS	-	0.3	V	
PWM "H" Level Voltage	VrP _{WM} H	When connected to external components, IOUT=1mA (*6)	-	-	VIN - 1.0	V	
PWM "L" Level Voltage	VrP _{WM} L	When connected to external components, IOUT=1mA (*6)	VIN - 0.3	-	-	V	
CE "H" Current	ICEH	VIN=CE=5.5V, VOUT=0V	- 0.1	-	0.1	μA	
CE "L" Current	ICEL	VIN=5.5V, CE=0V, VOUT=0V	- 0.1	-	0.1	μA	
Soft-Start Time	TSS	When connected to external components, CE=0V → VIN, IOUT=1mA	0.5	1.0	3.0	msec	
Latch Time	Tlat	When connected to external components, VIN=CE=5.0V, Short VOUT by 1Ω resistance (*7)	1	-	20	msec	

Test conditions: Unless otherwise stated, VIN=5.0V

(*1) Including hysteresis operating voltage range.

(*2) $EFFI = \{ (\text{Output Voltage} \times \text{Output Current}) / (\text{Input Voltage} \times \text{Input Current}) \} \times 100$

(*3) On resistance (Ω)= Lx pin measurement voltage / 100mA

(*4) R&D value

(*5) When temperature is high, a current of approximately 20μA (maximum) may leak.

(*6) The CE/MODE pin of the XC9217A series works also as an external PWM control and PWM/PFM control switching pin. When the IC is in the operation, control is switched to the PWM mode when the CE/MODE pin voltage is equal to or greater than VIN minus 0.3V, and to the automatic PWM/PFM switching mode when the CE/MODE pin voltage is equal to or lower than VIN minus 1.0V and equal to or greater than VCEH.

(*7) Time until it short-circuits DCOUT with GND through 1Ω of resistance from a state of operation and is set to DCOUT=0V from current limit pulse generating. There is no PFM switch current for XC9215 series. The PFM switch current is only for XC9216/17 series.

(*8) There is no PWM "H" Level Voltage or PWM "L" Level Voltage for XC9215/16 series. The characteristics are only for XC9217 series.

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