XCS921 Series

Driver Transistor Built-In Synchronous Step-Down DC/DC Converters for CSR, BC2

Preliminary

- **P channel driver transistor built-in**
- **Synchronous (N channel switching transistor built-in)**
- **Input voltage range : 2.2V ~ 5.5V**
- **Output voltage : 1.8V**
- **Oscillation frequency : 1.2MHz**
- **Output current : 300mA**
- **Maximum duty ratio : 100 %**
- **PWM/PFM auto switching control**
- **Ceramic capacitor compatible**
- **Ultra small packages : SOT-25 & USP-6B**

■ APPLICATIONS

- For CSR Bluetooth chip sets BC2
- Bluetooth headset

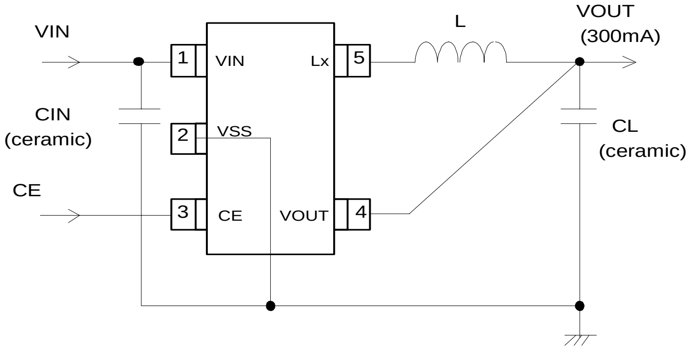
■ GENERAL DESCRIPTION

The XCS921 series is a highly efficient step-down DC/DC converter IC which provide stable operation for CSR's BlueCore2 Bluetooth chip set.
The XCS921 has a built-in 0.6 Ω P-channel driver transistor and 0.7Ω N-channel switching transistor and can be used with ceramic capacitors.
The IC gives high efficiency and a stable power supply with an output current of 300 mA configured using only a coil and two capacitors connected externally.
Operating voltage is from 2.2 V to 5.5V. Output voltage is internally fixed to 1.8V (accuracy: ± 2.0%) and switching frequency is fixed at 1.2MHz.
The operation mode of the XCS921 series is 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 0μA (TYP.)
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 1.4 V or lower. Two types of packages, 250 mW (SOT-25) and 100 mW (USP-6B), are available.

■ FEATURES

P ch driver Tr. Built-in	: On resistance 0.6Ω
N ch driver Tr. Built-in	: On resistance 0.7Ω
Output Voltage	: 1.8V
	Fixed output voltage accuracy ±2%
Oscillation frequency	: 1.2MHz
Stand-by function	: Istb = 0μA (TYP.)
Soft start circuit built-in	
Current limiter circuit built-in	: 500mA
Ceramic capacitor compatible	

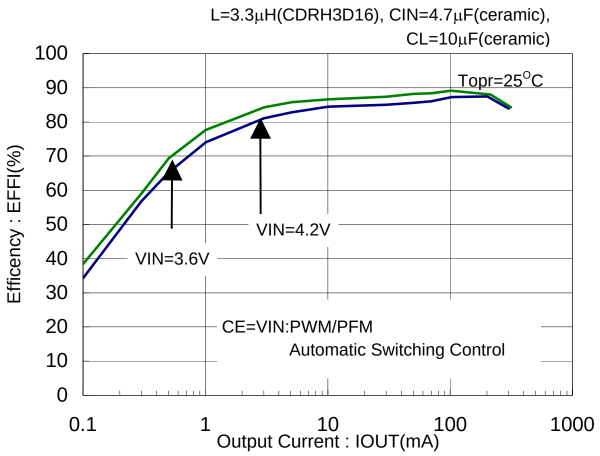
■ TYPICAL APPLICATION CIRCUIT



L :	3.3μH	
CIN :	4.7μF	(ceramic)
CL :	10μF	(ceramic)

■ TYPICAL PERFORMANCE CHARACTERISTICS

XCS921A18C



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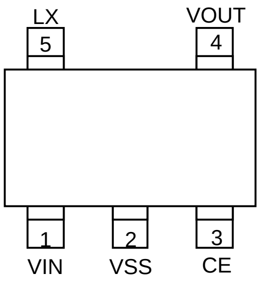
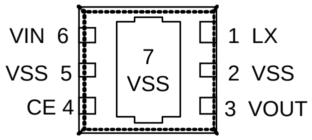
■ PIN CONFIGURATION



SOT-25 (TOP VIEW)



USP-6B (BOTTOM VIEW)

■ PIN ASSIGNMENT

PIN NUMBER		PIN NAME	FUNCTIONS
SOT-25	USP-6B		
1	6	VIN	Power Input
2	2, 5, 7 (*)	VSS	Ground
3	4	CE	Chip Enable
4	3	VOUT	Output Voltage Sense
5	1	LX	Switching Output

* Please short the VSS pin (pin # 2, 5) when use.
* Please do not connect a heat dissipation pad to the circuitry. If the pad needs to be connected to other pins, it should be connected to the VSS pin.

■ PRODUCT CLASSIFICATION

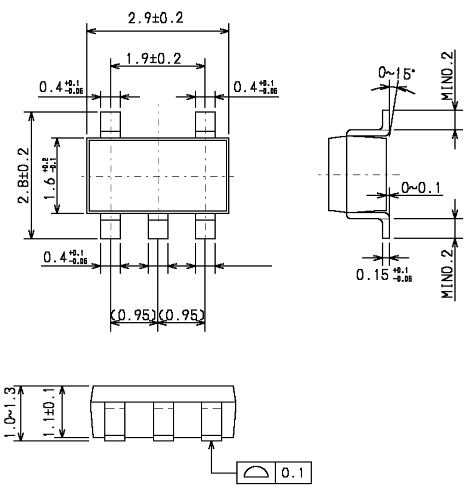
- Part Number XCS921A18CMR
  XCS921A18CDR

- Ordering Information XCS921 ①②③④⑤⑥ PWM/PFM Automatic Switching Control

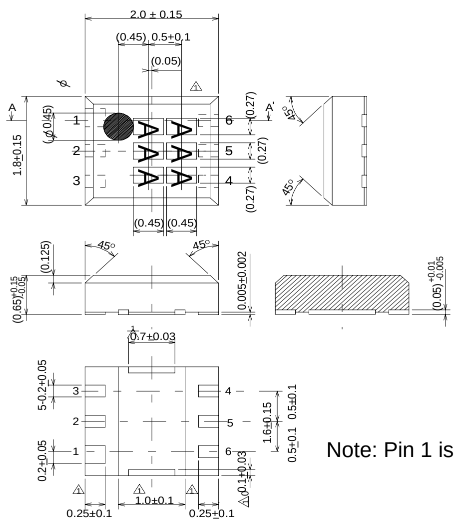
SYMBOL	DESCRIPTION
①	Transistor built-in, output voltage internally set (VOUT product), soft start internally set. A : Current limiter 500mA
②, ③	Denotes output voltage : ex.) 1.8V Output ➩ ② = 1, ③ = 8
④	Denotes oscillation frequency : C : 1.2MHz
⑤	Denotes package types : M : SOT-25 D : USP-6B
⑥	Denotes device orientation : R : Embossed tape : Standard feed L : Embossed tape : Reverse feed

■ PACKAGING INFORMATION

○ SOT-25

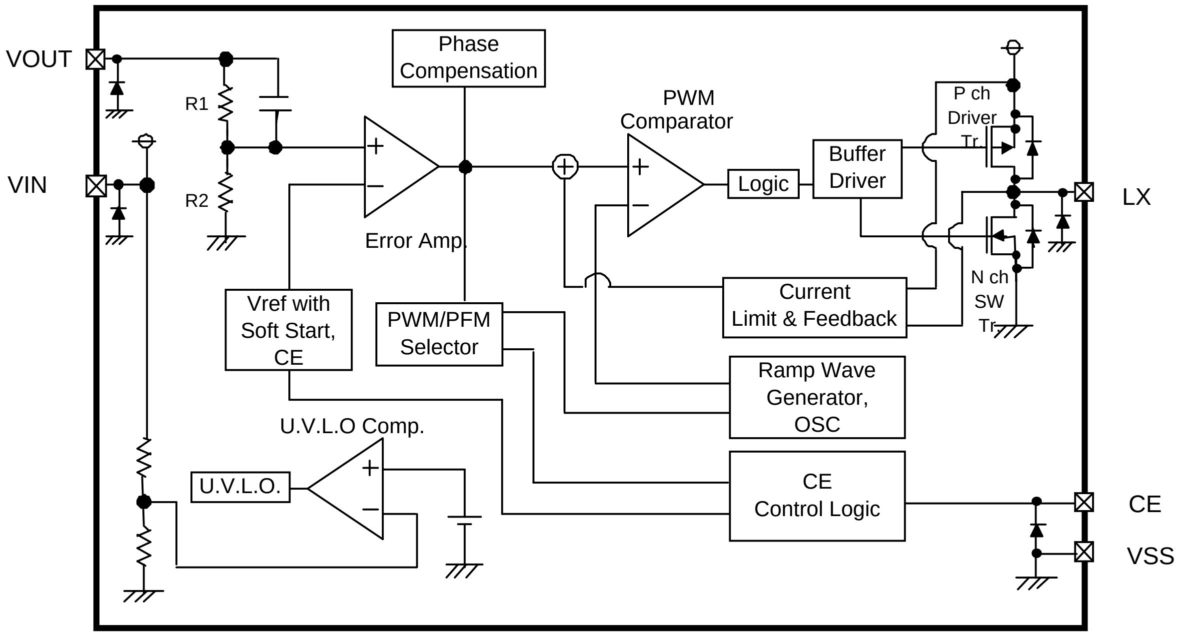


○ USP-6B



Note: Pin 1 is thicker than other pins.

■ BLOCK DIAGRAM



■ 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 pin voltage		VCE	- 0.3 ~ VIN + 0.3	V
Lx pin current		ILX	± 1000	mA
Power Dissipation	SOT-25	Pd	250	mW
	USP-6B		100	
Operational Temperature Range		Topr	- 40 ~ + 85	°C
Storage Temperature Range		Tstg	- 55 ~ + 125	°C

■ ELECTRICAL CHARACTERISTICS

XCS921A18CM VOUT=1.8V, FOSC=1.2MHz, Ta=25°C

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT	CIRCUIT
Output Voltage	VOUT	When connected to ext. components CE=VIN, IOUT=30mA	1.764	1.800	1.836	V	①
Operating Voltage Range	VIN		2.2	-	5.5	V	①
Maximum Output Current	IOUTmax	When connected to ext. components	300	-	-	mA	①
U.V.L.O Voltage	VUVLO	CE=VIN, VOUT=0V, Voltage which LX pin voltage holding "L" level (*1)	1.00	1.40	1.78	V	②
Supply Current	IDD	CE=VIN, VOUT=fixed voltage x 1.1V	-	70	115	μA	③
Stand-by Current	ISTB	CE=VSS, VOUT=fixed voltage x 1.1V	-	0	1.0	μA	③
Oscillation Frequency	FOSC	When connected to ext. components Fixed PWM control, IOUT=30mA	1020	1200	1380	kHz	①
PFM Switch Current	IPFM	When connected to ext. components CE=VIN, IOUT=1mA	-	190	-	mA	①
Maximum Duty Cycle	MAXDTY	CE=VIN, VOUT=0V	100	-	-	%	④
Minimum Duty Cycle	MINDTY	CE=VOUT=VIN	-	-	0	%	④
Efficiency (*2)	EFFI	When connected to ext. components, CE=VIN=3.0V, IOUT=100mA	-	90	-	%	①
LX SW "H" ON Resistance	RLXH	CE=VIN, VOUT=0V, ILx=100mA (*3)	-	0.6	1.2	Ω	⑤
LX SW "L" ON Resistance	RLXL	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	⑥
LX SW "L" Leak Current	ILeakL	VIN=VOUT=5.0V, CE=0V, Lx=5.0V	-	0.01	1.0	μA	⑥
Current Limit	ILIM	VIN=CE=5.0V, VOUT=0V (*7)	-	500	-	mA	⑦
Output Voltage Temperature Characteristics	$\frac{\triangle VOUT}{VOUT \cdot \triangle topr}$	IOUT=30mA - 40°C≦Topr≦85°C	-	±100	-	ppm/°C	①
CE "H" Voltage	VCEH	VOUT=0V, When CE voltage is applied LX determine "H"	0.9	-	VIN	V	⑧
CE "L" Voltage	VCEL	VOUT=0V, When CE voltage is applied LX determine "L" (*8)	VSS	-	0.3	V	⑧
CE "H" Current	ICEH	CE=VIN=5.5V, VOUT=0V	-0.1	-	0.1	μA	⑧
CE "L" Current	ICEL	CE=0V, VIN=5.5V, VOUT=0V	-0.1	-	0.1	μA	⑧
Soft start time	TSS	When connected to ext. components CE=0V ⇨ VIN, IOUT=1mA	0.5	1.0	3.0	ms	①
Latch Time	Tlat	When connected to ext. components VIN=CE=5.0V, short VOUT by 1Ω resistance (*6)	1.0	-	20.0	ms	⑨

Test condition : Unless otherwise stated, VIN = 3.6V

*1 Including hysteresis operating voltage range.

*2 EFFI = [(Output Voltage x Output Current) / (Input Voltage x Input Current)] x 100

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

*4 R & D value

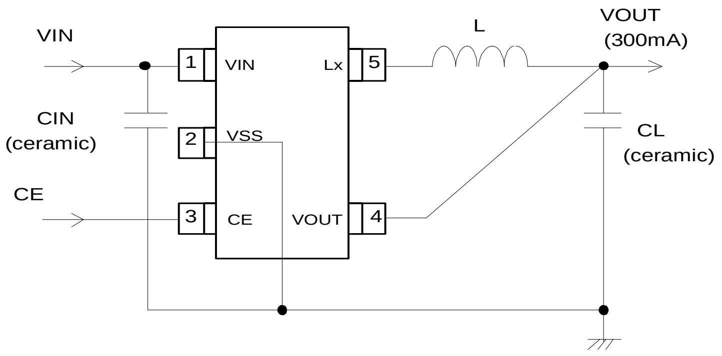
*5 When temperature is high, a current approximately 20μA (maximum) may leak.

*6 Time until it short-circuits VOUT with GND through 1 Ω of resistance from a state of operation and is set to VOUT=0V from current limit pulse generating.

*7 When VIN is less than 2.4V, limit current may not be reached because voltage falls caused by ON resistance.

*8 The Lx pin is pulled down by the external resistors.

■ TYPICAL APPLICATION CIRCUIT



❍ FOSC = 1.2MHz
L : 3.3μH
CIN : 4.7μF (ceramic)
CL : 10μF (ceramic)

* XCS921 Series Wire Connection

■ OPERATIONAL EXPLANATION

Each unit of the XCS921 series consists of a reference voltage source, ramp wave circuit, error amplifier, PWM comparator, phase compensation circuit, output voltage adjustment resistors, P-channel MOS driver transistor, N-channel MOS synchronous rectification switch, current limiter circuit, U.V.L.O. circuit and others. The XCS921 series ICs compare, using the error amplifier, the voltage of the internal voltage reference source with the feedback voltage from the VOUT pin through resistors R1 and R2. Phase compensation is performed on the resulting error amplifier output, to input a signal to the PWM comparator to determine the turn-on time during PWM operation. The PWM comparator compares, in terms of voltage level, the signal from the error amplifier with the ramp wave from the ramp wave circuit, and delivers the resulting output to the buffer driver circuit to cause the Lx pin to output a switching duty cycle. This process is continuously performed to ensure stable output voltage. The current feedback circuit monitors the P-channel MOS driver transistor current for each switching operation, and modulates the error amplifier output signal to provide multiple feedback signals. This enables a stable feedback loop even when a low ESR capacitor, such as a ceramic capacitor, is used, ensuring stable output voltage.

<Reference Voltage Source>

The reference voltage source provides the reference voltage to ensure stable output voltage of the ICs.

<Ramp Wave Circuit>
The ramp wave circuit determines switching frequency. The frequency is fixed internally in 1.2MHz. Clock pulses generated in this circuit are used to produce ramp waveforms needed for PWM operation, and to synchronize all the internal circuits.

<Error Amplifier>
The error amplifier is designed to monitor output voltage. The amplifier compares the reference voltage with the feedback voltage divided by the internal resistors (R1 and R2). When a voltage lower than the reference voltage is fed back, the output voltage of the error amplifier increases. The gain and frequency characteristics of the error amplifier output are fixed internally to deliver an optimized signal to the mixer.

■ OPERATIONAL EXPLANATION (Continued)

<Current Limit>

The current limiter circuit of the XCS921 series monitors the current flowing through the P-channel MOS driver transistor connected to the LX pin, and features a combination of the constant-current type current limit mode and the operation suspension mode.

① When the driver current is greater than a specific level, the constant-current type current limit function operates to turn off the pulses from the LX pin at any given timing.

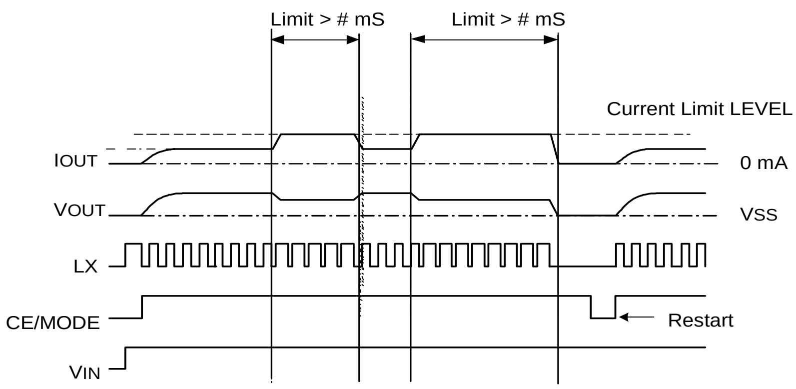
② When the driver transistor is turned off, the limiter circuit is then released from the current limit detection state.

③ At the next pulse, the driver transistor is turned on. However, the transistor is immediately turned off in the case of an over current state.

④ When the over current state is eliminated, the IC resumes normal operation.

The IC waits for the over current state to end by repeating the steps ① through ③. If an over current state continues for several msec and the above three steps are repeatedly performed, the IC performs the function of latching the OFF state of the driver transistor, and goes into operation suspension mode.

Once the IC is in suspension mode, operations can be resumed by either turning the IC off via the CE pin, or by restoring power to the VIN pin. The suspension mode does not mean a complete shutdown, but a state in which pulse output is suspended; therefore, the internal circuitry remains in operation. The constant-current type current limit can be set at 500 mA.



<U.V.L.O. circuit>

When the VIN pin voltage becomes 1.4 V or lower, the P-channel output driver transistor is forced OFF to prevent false pulse output caused by unstable operation of the internal circuitry. When the VIN pin voltage becomes 1.8 V or higher, switching operation takes place. By releasing the U.V.L.O. function, the IC performs the soft start function to initiate output startup operation.

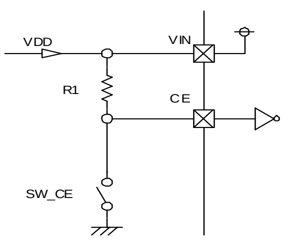
The soft start function operates even when the VIN pin voltage falls momentarily below the U.V.L.O. operating voltage.

The U.V.L.O. circuit does not cause a complete shutdown of the IC, but causes pulse output to be suspended; therefore, the internal circuitry remains in operation.

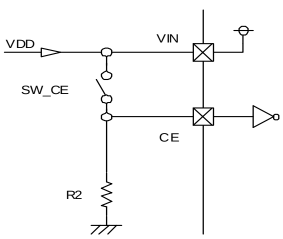
<CE Pin>

The XCS921 series will enter into the shut down mode when a low level signal is input to the CE pin. During the shut down mode, the current consumption of the IC becomes 0 μA (TYP.), with a state of high impedance at the LX pin and VOUT pin. The IC starts its operation by inputting a high level signal to the CE pin. The input of the CE pin is a CMOS input and the sink current is 0 μA (TYP.).

< XCS921 series CE pin >



(A)



(B)

(A)

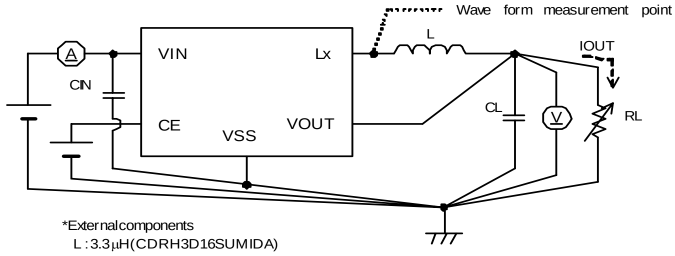
SW_CE	STATE
ON	Chip Disable
OFF	Chip Operating

(B)

SW_CE	STATE
ON	Chip Operating
OFF	Chip Disable

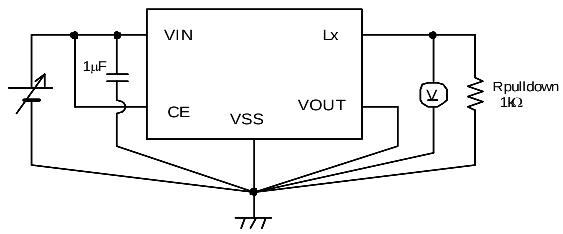
■ TEST CIRCUITS

< Circuit ① >



*External components
L : 3.3µH (CDRH3D16 SUMIDA)
CIN : 4.7µF (ceramic)
CL : 10µF (ceramic)

< Circuit ② >



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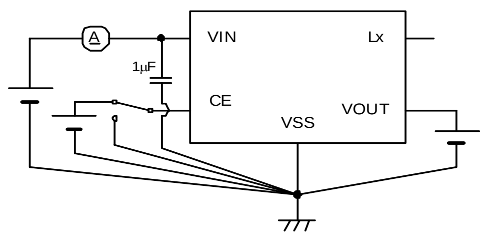

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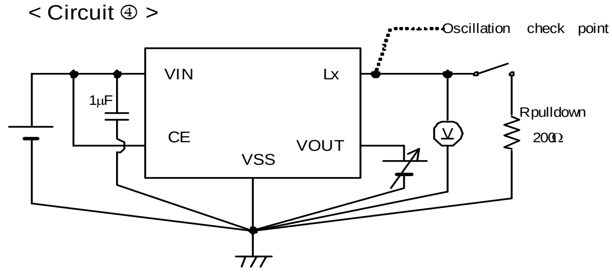

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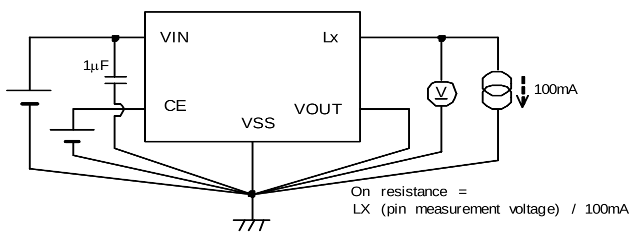

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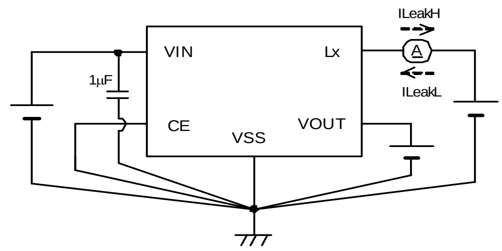

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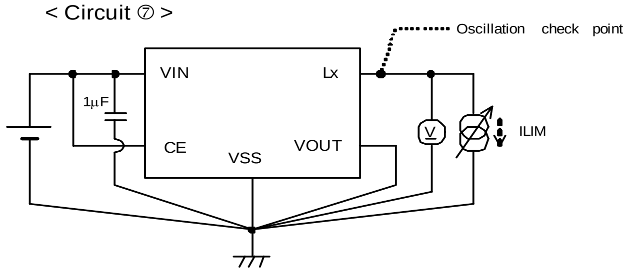

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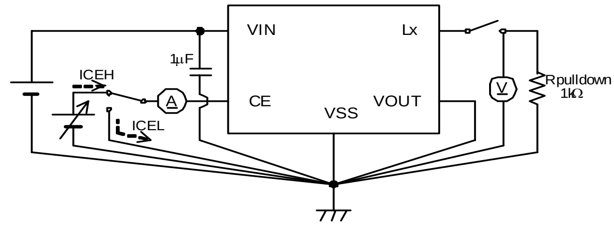

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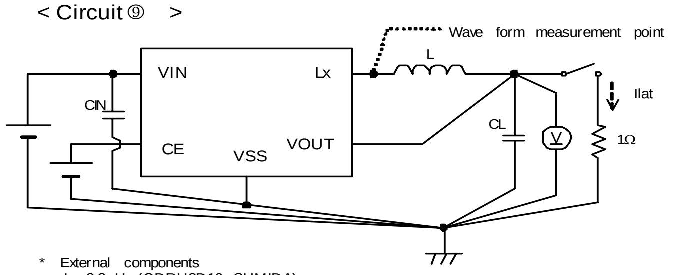

* External components
L : 3.3µH (CDRH3D16 SUMIDA)
CIN : 4.7µF (ceramic)
CL : 10µF (ceramic)

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■ NOTES ON USE

- Application Information

1. The XCS921 series are designed for use with an output ceramic capacitor. If, however, the potential difference between input and output is too large, a ceramic capacitor may fail to absorb the resulting high switching energy and oscillation could occur on the output . If the input-output potential difference is large, connect an electrolytic capacitor in parallel to compensate for insufficient capacitance.
2. Spike noise and ripple voltage arise in a switching regulator as with a DC/DC converter. These are greatly influenced by external component selection, such as the coil inductance, capacitance values, and board layout of external components. Once the design has been completed, verification with the actual components should be done.
3. Depending on the dropout voltage, or load current, some pulses may be skipped, and the ripple voltage may increase.
4. When the difference between VIN and VOUT is large, very narrow pulses will be outputted, and there is the possibility that some cycles may be skipped completely.
5. When the difference between VIN and VOUT is small, and the load current is heavy, very wide pulses will be outputted and there is the possibility that some cycles may be skipped completely: in this case, the Lx pin may not go low at all.
6. Peak current of the coil is controlled by the current limit circuit. Since the peak current increases when dropout voltage or load current is high, current limit starts operating, and this can lead to instability. When peak current becomes high, please adjust the coil inductance value and fully check the circuit operation. In addition, please calculate the peak current according to the following formula:

   Ipk = (VIN - VOUT) x On Duty / (L x FOSC) + IOUT

   L : Coil inductance value

   FOSC : Oscillation frequency

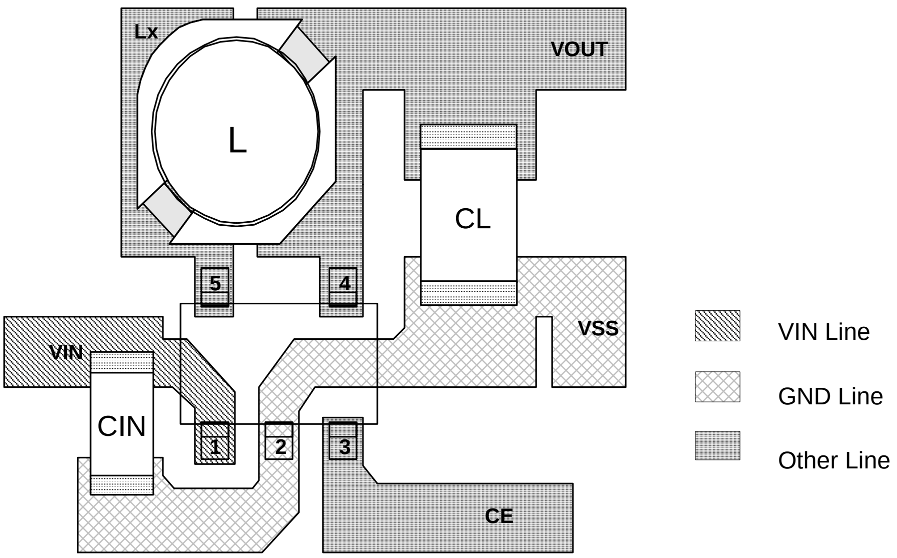
7. When peak current which exceeds limit current flows within the specified time, the built-in Pch driver transistor is turned off. During time until it detects limit current and before the built-in transistor can be turned off, the current for limit current flows; therefore, care must be taken when selecting the rating for the coil or the schottky diode.
8. When VIN is less than 2.4V, limit current may not be reached because voltage falls caused by ON resistance.
9. Depending on the state of a substrate, neither the case where the latch time becomes long because it is released of a limit current detection state, nor latch operation may work. Please arrange input capacity near the IC as much as possible.
10. An operating voltage lower than the minimum value may lead to unstable operations.
11. Please use this IC within the stated absolute maximum ratings.

■ NOTES ON USE (Continued)

- Instructions on Pattern Layout
  1. In order to stabilize VDD's voltage level, we recommend that a by-pass capacitor (CIN) be connected as close as possible to the VIN & VSS pins.
  2. Please mount each external component as close to the IC as possible, and connect it to GND directly.
  3. Wire external components as close to the IC as possible and use thick, short connecting traces to reduce the circuit impedance.
  4. Make sure that the PCB GND traces are as thick as possible, as variations in ground potential caused by high ground currents at the time of switching may result in instability of the IC.

- Pattern Layouts

❍ SOT-25



❍ USP-6B