Green Mode PWM Power Switch Programmable Fsw

FEATURES

- **Programmable Switching Frequency (Fsw)**
- **Built-in 600V Power MOSFET**
- **Proprietary "Optimized Soft Start"**
- **Low Pass Filter for Clock Generation**
- **Very Low Start-up Current**
- **Proprietary "Smooth Frequency Foldback" and Burst Mode Operation for Green Mode Operation**
- **Proprietary "Hybrid Frequency Jittering"**
- **Current Mode Control**
- **Built-in Slope Compensation**
- **Leading Edge Blanking (LEB)**
- **All Pins Floating Protection**
- **Audio Noise Free Operation**
- **OVP (Over Voltage Protection) on VDD**
- **OLP (Over Load Protection)**
- **Cycle-by-cycle Current Limiting (OCP)**

APPLICATIONS

- **SMPS for VCR, SVR, STB, DVD and DVCD**
- **Set-Top Box Power**
- **Auxiliary Power Supply for PC, LCD TV**
- **PDA Power Supplies**
- **Adaptor for Camcorder and Digital Cameras**
- **Open-frame SMPS**
- **Power Adaptors**

GENERAL DESCRIPTION

The COX3210/3211/3212 series are specially designed for off-line SMPS with minimal external components. They combine a high voltage power MOSFET and a high performance current mode PWM IC in one chip, which can reduce the total component count, and at the same time increase productivity and system reliability.

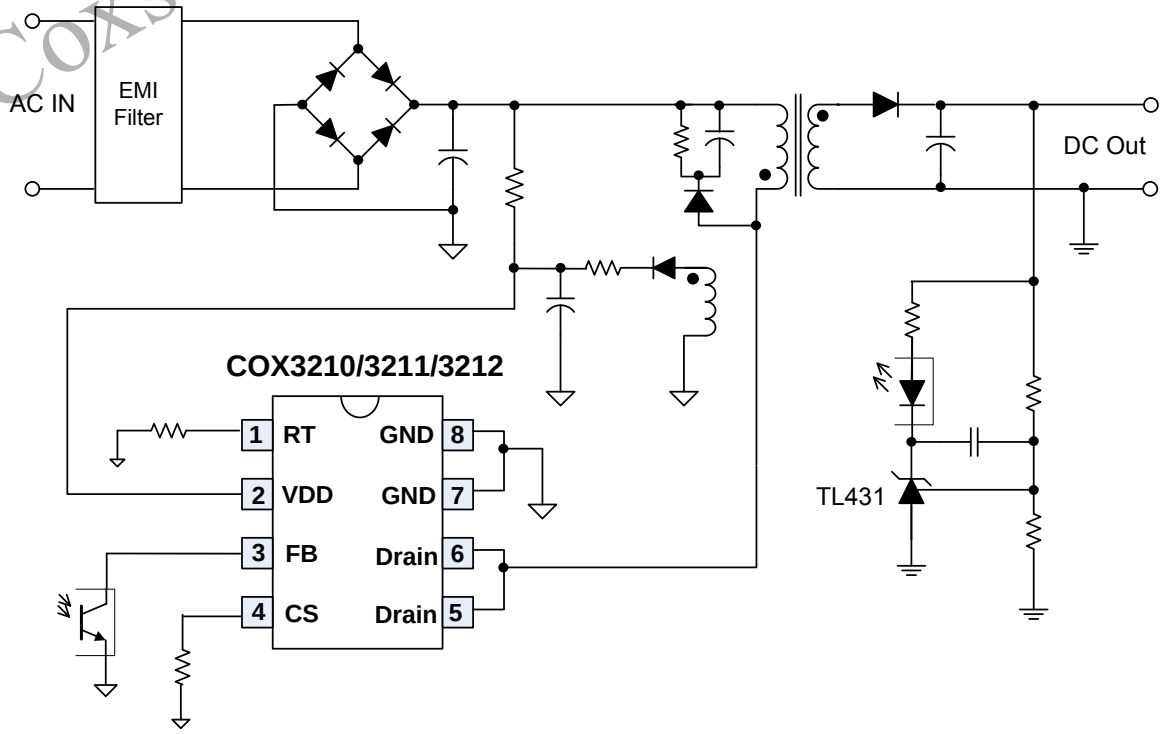
In COX3210/3211/3212, the PWM switching frequency can be externally programmed, which can ease system design greatly.

To improve EMI performance, the IC series integrate Coxsemi's Proprietary "Hybrid Frequency Jittering" for the oscillator to reduce conduction EMI emission of a power supply. When the output power demands decrease, the IC series enter into Coxsemi's Proprietary "Smooth Frequency Foldback" for high power conversion efficiency without audio noise generated. When the current set-point falls below a given value, e.g. the output power demand diminishes, the IC series automatically enter into burst mode and provides excellent efficiency without audio noise.

The COX3210/3211/3212 series integrate functions and protections of Under Voltage Lockout (UVLO), VDD Over Voltage Protection (OVP), Soft Start, Cycle-by-cycle Current Limiting (OCP), Over Load Protection (OLP), All Pins Floating Protection, RT Pin Short-to-GND Protection, VDD Clamping, Leading Edge Blanking (LEB).

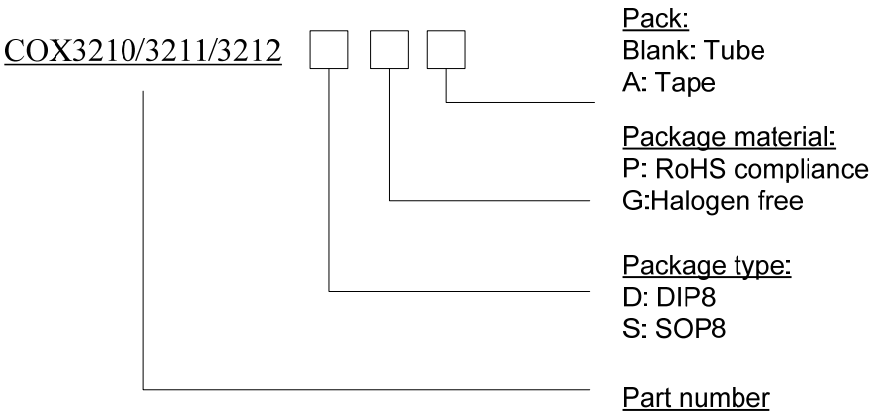
COX3210 is available in SOP-8 package, COX3211and COX3212 are available in DIP-8 package.

TYPICAL APPLICATION



Ordering Information

Part Number	Description
COX3210SP	SOP8, RoHS compliance in Tube
COX3210SPA	SOP8, RoHS compliance in tape
COX3211DP	DIP8, RoHS compliance in Tube
COX3212DP	DIP8, RoHS compliance in Tube

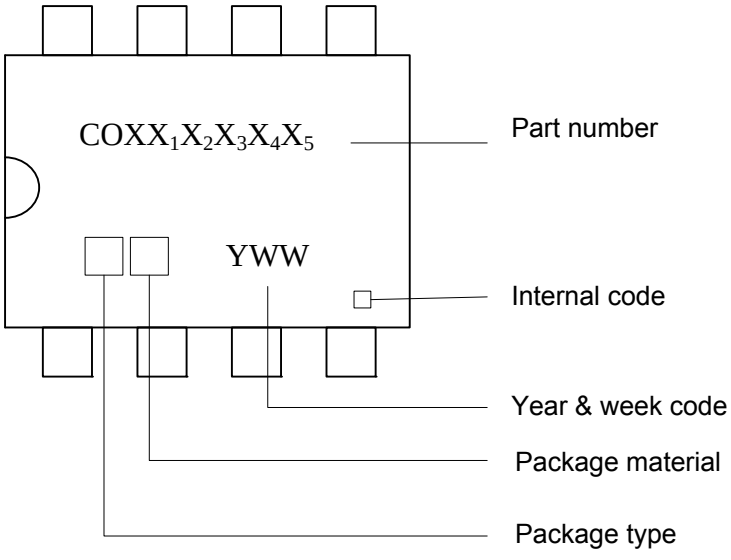


Output Power Table(1)

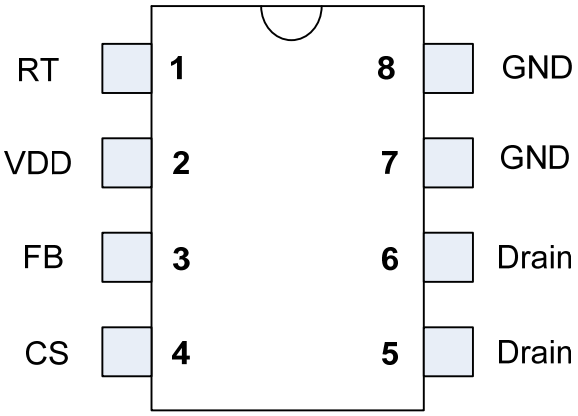
Part Number	230VAC ± 15%(2)		85-265VAC	
	Adapter(3)	Open Frame(4)	Adapter(3)	Open Frame(4)
COX3210SP	6W	9W	5W	7W
COX3211DP	14W	20W	9W	13W
COX3212DP	17W	26W	11W	16W

Note 1. The Max. output power is limited by junction temperature
Note 2. 230VAC or 100/115VAC with doublers
Note 3. Typical continuous power in a non-ventilated enclosed adapter with sufficient drain pattern as a heat sink at 50 °C ambient.
Note 4. Max. practical continuous power in a open-frame design with sufficient drain pattern as a heat sink at 50 °C ambient.

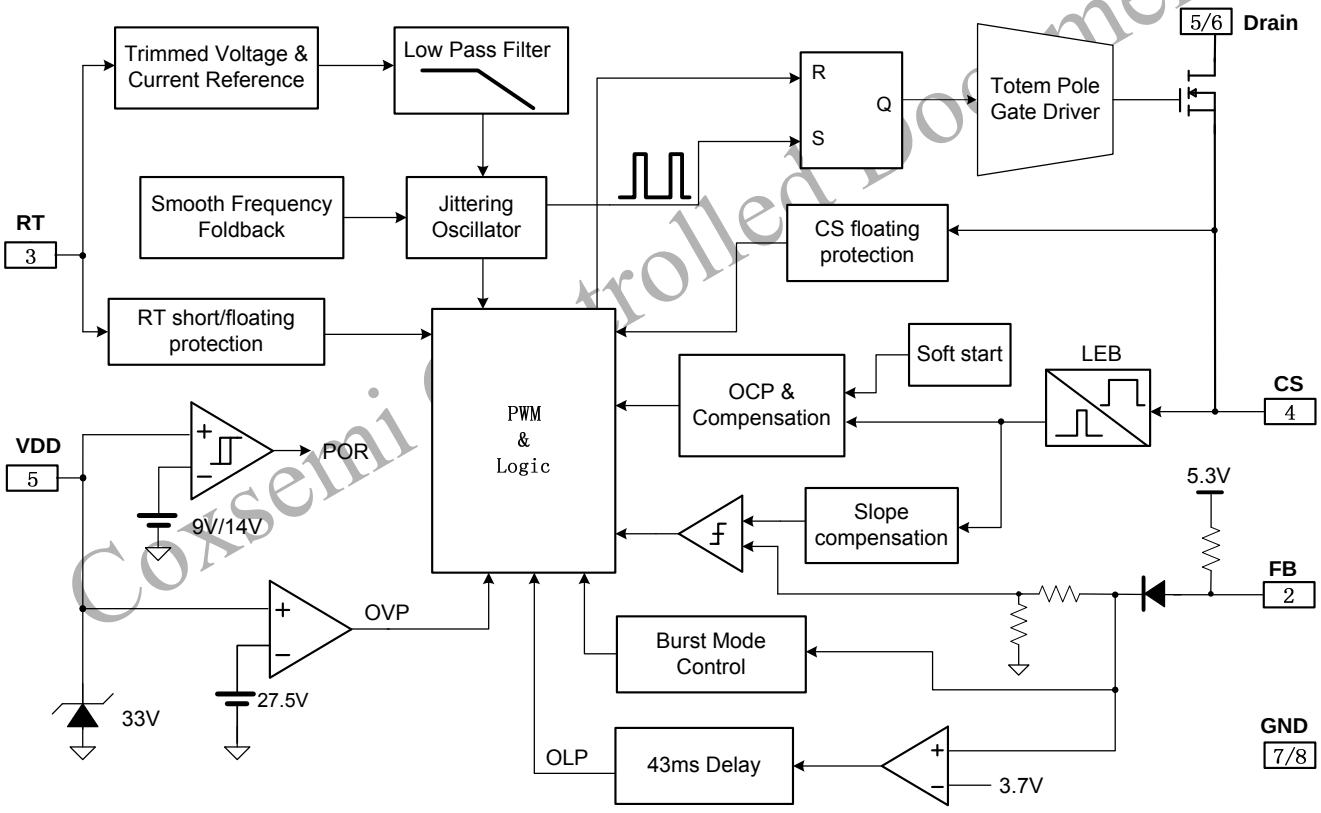
Marking Information



Pin Configuration



Block Diagram



Pin Description

Pin Num	Pin Name	I/O	Description
1	RT	I	Set the switching frequency by connecting a resistor between RT and GND. This pin has floating/short-to-GND protection.
2	VDD	P	IC power supply pin.
3	FB	I	Voltage feedback pin. PWM duty cycle is determined by this pin voltage and the current sense signal at Pin 4.
4	CS	I	Current sense input pin.
5-6	Drain	P	High voltage power MOSFET drain connection.
7-8	GND	P	IC ground pin.

Absolute Maximum Ratings(5)

Parameter	Value	Unit
VDD DC Supply Voltage	33	V
VDD DC Clamp Current	10	mA
Drain pin	-0.3 to 600	V
FB, RT, CS voltage range	-0.3 to 7	V
Maximum Junction Temperature	150	°C
Operating Temperature Range	-40 to 85	°C
Storage Temperature Range	-55 to 150	°C
Lead Temperature (Soldering, 10sec.)	260	°C
ESD Capability, HBM (Human Body Model)	2.5	kV
ESD Capability, MM (Machine Model)	250	V

Thermal Impedance

Symbol	Parameter	Value	Unit
8-DIP			
θ_{JA}	Junction-to-Ambient Thermal Resistance(6)	84	°C/W
8-SOP			
θ_{JA}	Junction-to-Ambient Thermal Resistance	151	°C/W

Recommended Operation Conditions(7)

Parameter	Value	Unit
Supply Voltage, VDD	11 to 25	V
Operating Frequency	50 to 130	kHz
Operating Ambient Temperature	-40 to 85	°C

ELECTRICAL CHARACTERISTICS

(T_A = 25°C, RT=100K ohm, VDD=18V, if not otherwise noted)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
Supply Voltage (VDD) Section						
I_Startup	VDD Start up Current	VDD =12.5V, Measure current into VDD		5	20	uA
I_VDD_Op	Operation Current	V_{FB}=3V		2.3	3.3	mA
UVLO(ON)	VDD Under Voltage Lockout Exit (Startup)		13	14	15	V
UVLO(OFF)	VDD Under Voltage Lockout Enter		8	9	10	V
VDD_OVP	VDD Over Voltage Protection trigger		25	27.5	30	V
V_{DD}_Clamp	VDD Zener Clamp Voltage	I(V_{DD}) = 15 mA		33		V
T_Softstart	System Soft Start Time			3		ms
Feedback Input Section(FB Pin)						
A_{VCS}	PWM Input Gain	$\Delta V_{FB}/\Delta V_{cs}$		2.0		V/V
V_{FB}_Open	FB Open Voltage			5.3		V
I_{FB}_Short	FB short circuit current	Short FB pin to GND, measure current		1.1		mA
VFB_min_duty	FB under voltage gate clock is off.			1.0		V
V_{TH}_PL	Power Limiting FB Threshold Voltage			3.7		V
T_D_PL	Power limiting Debounce Time(8)		39	43	47	ms

Z_{FB}_IN	Input Impedance			5		Kohm
Current Sense Input Section (CS Pin)						
T_blanking	CS Input Leading Edge Blanking Time			250		ns
Vth_OC_min	Internal current limiting threshold	Zero duty cycle	0.70	0.75	0.80	V
T_D_OC_controller	Over Current Detection and Control Delay for Controller			70		ns
Oscillator Section						
F_{SW}	Normal Oscillation Frequency		60	65	70	KHZ
$\Delta F(shuffle)/F_{SW}$	Frequency shuffling range(9)		-4		4	%
Δf_Temp	Frequency Temperature Stability(9)	-40°C to 85°C		5		%
Δf_VDD	Frequency Voltage Stability(9)	VDD = 12-25V		5		%
Duty_max	Maximum Duty cycle		75	80	85	%
RT_range	Operating RT Range		50	100	150	Kohm
V_RT_open	RT open voltage			2		V
F_BM	Burst Mode Base Frequency			22		KHZ
Power MOSFET Section(10)						
BVdss	Power MOSFET Drain Source Breakdown Voltage	VDD=0V, I(Drain)=250uA	600			V
Rdson(11)	Static Drain-Source On Resistance	COX3210 VDD=15V, T_J=25 °C, I_D=0.5A		9.5	12	Ω
		COX3211		9.5	12	Ω
		COX3212		4	5.5	Ω
Idss	Zero Gate Voltage Drain Current				1	uA
$Td_{(on)}$	Turn-on delay time	COX3210		5.5		ns
		COX3211		6		ns
		COX3212		9		ns
$Td_{(off)}$	Turn-off delay time	COX3210		13		ns
		COX3211		14		ns
		COX3212		24		ns

Note 5. Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and 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 affect device reliability.

Note 6. Free-standing, with no heat-sink, under natural convection.

Note 7. The device is not guaranteed to function outside its operating conditions.

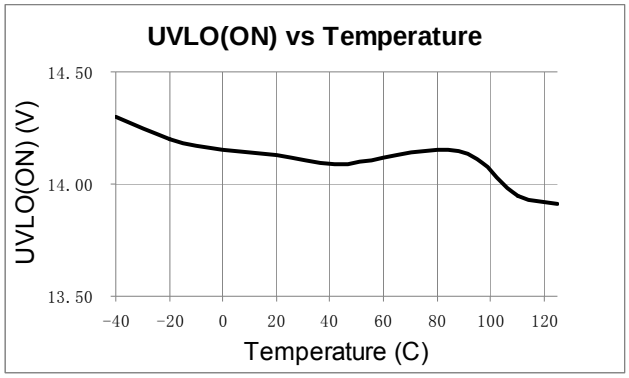
Note 8. The OLP debounce time is proportional to the period of switching cycle.

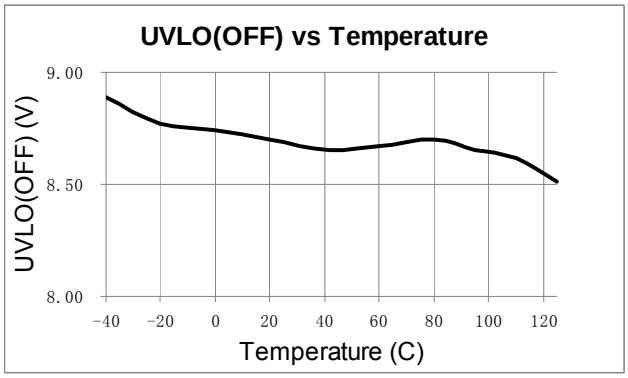
Note 9. Guaranteed by design.

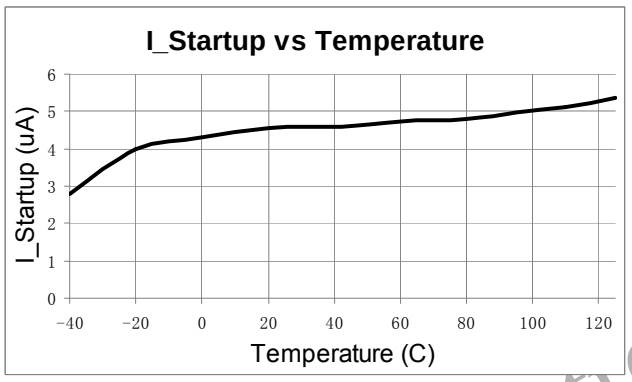
Note 10. These parameters, although guaranteed, are not 100% tested in production

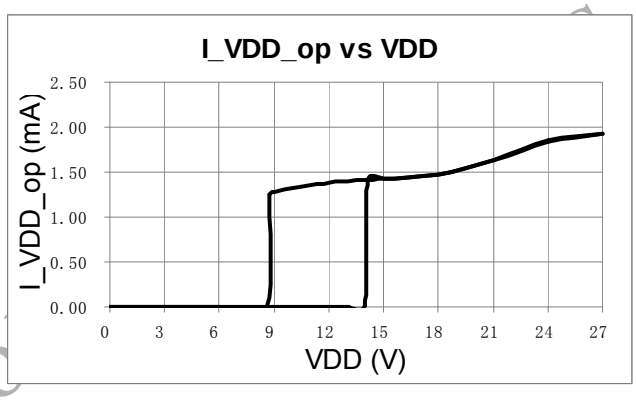
Note 11. Pulse test: Pulse width=300us, duty=2%.

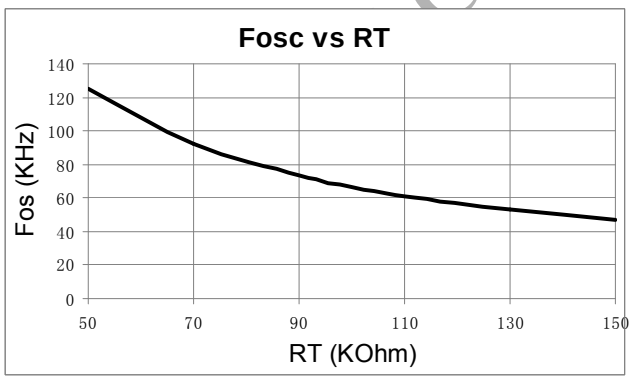
CHARACTERIZATION PLOTS

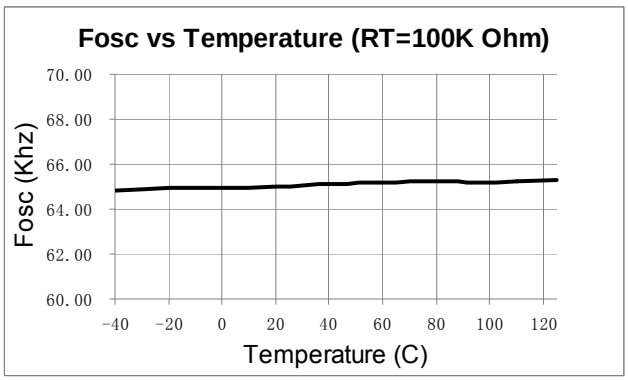


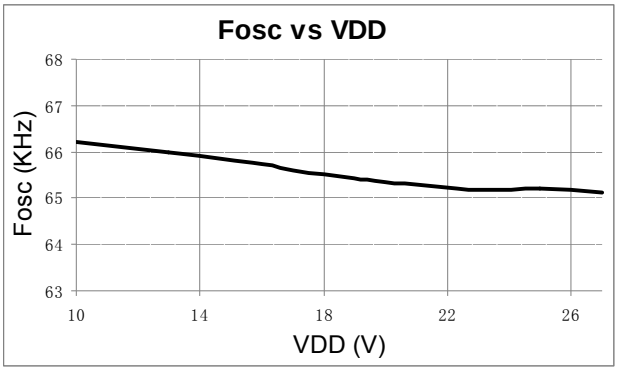


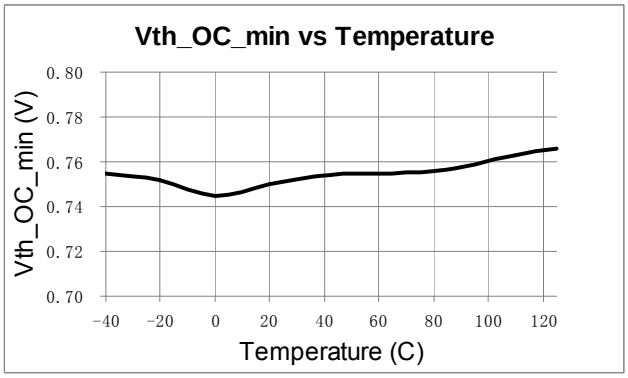


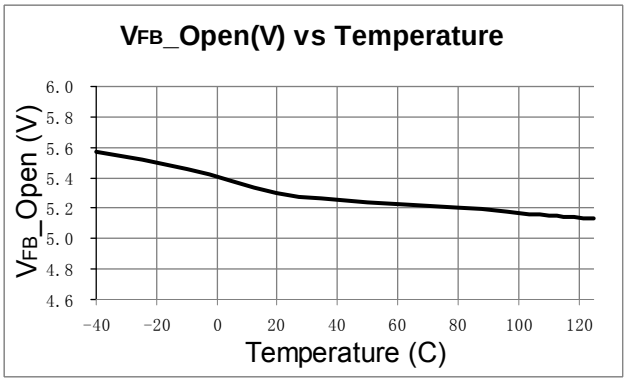


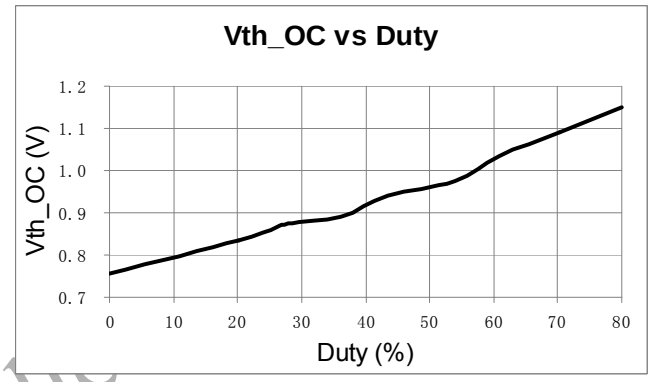


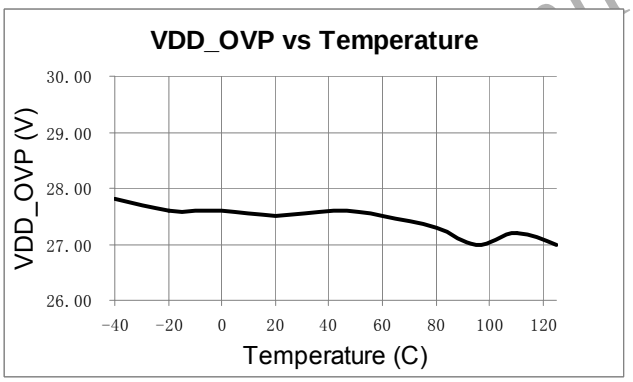


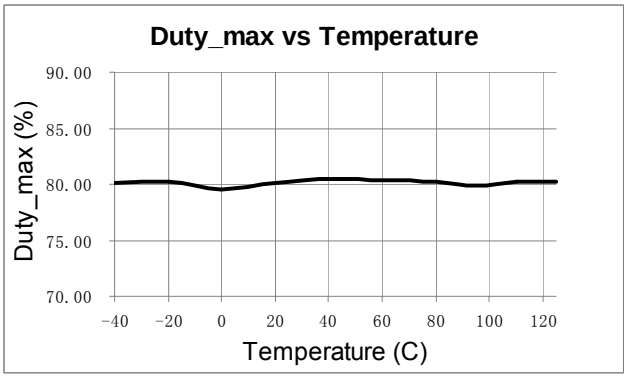

Fosc vs VDD
Fosc (KHz)
68
67
66
65
64
63
10
14
18
22
26
VDD (V)

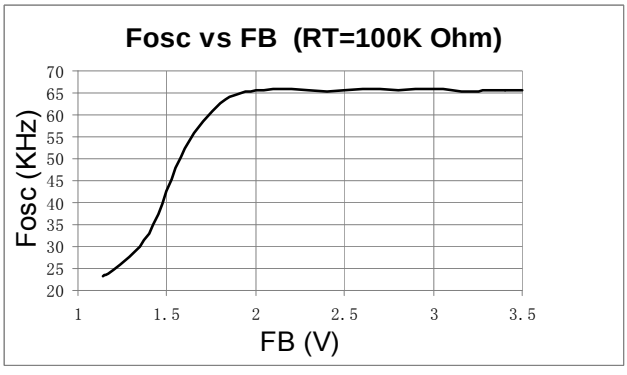

Vth_OC_min vs Temperature
Vth_OC_min (V)
0.80
0.78
0.76
0.74
0.72
0.70
-40
-20
0
20
40
60
80
100
120
Temperature (C)

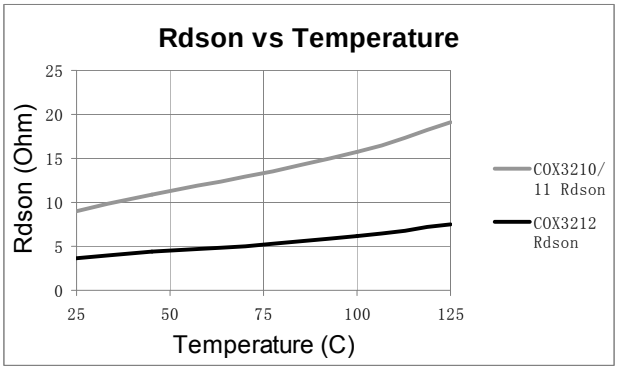

VFB_Open(V) vs Temperature
VFB_Open (V)
6.0
5.8
5.6
5.4
5.2
5.0
4.8
4.6
-40
-20
0
20
40
60
80
100
120
Temperature (C)


Vth_OC vs Duty
Vth_OC (V)
1.2
1.1
1.0
0.9
0.8
0.7
0
10
20
30
40
50
60
70
80
Duty (%)


VDD_OVP vs Temperature
VDD_OVP (V)
30.00
29.00
28.00
27.00
26.00
-40
-20
0
20
40
60
80
100
120
Temperature (C)


Duty_max vs Temperature
Duty_max (%)
90.00
85.00
80.00
75.00
70.00
-40
-20
0
20
40
60
80
100
120
Temperature (C)


Fosc vs FB (RT=100K Ohm)
Fosc (KHz)
70
65
60
55
50
45
40
35
30
25
20
1
1.5
2
2.5
3
3.5
FB (V)


Rdson vs Temperature
Rdson (Ohm)
25
20
15
10
5
0
25
50
75
100
125
Temperature (C)
COX3210/11 Rdson
COX3212 Rdson

OPERATION DESCRIPTION

The COX3210/3211/3212 series are highly integrated green mode PWM power switch for offline flyback converter applications. The versatile protection features and high performance make it a vey competitive for small power converter applications.

● Start-up Current and Operating Current

The typical startup current of COX3210/3211/3212 series is only about 5uA so that a high resistance startup resistor can be used to minimize power loss. For an AC/DC adapter with universal input range, a 2M Ohm, 1/8W startup resistor can be used to provide a fast startup and yet low power dissipation design solution.

The operating current has been reduced to 2.3mA. The low operating current enables a better efficiency and reduces the requirement of VDD hold up capacitance.

● Optimized Soft Start

Soft start can help to prevent the transformer saturation and reduce the stress on the secondary diode during startup. COX3210/3211/3212 series feature a Proprietary “Optimized soft start”. The soft start process is realized by exponentially increasing threshold of OCP threshold. When the OCP threshold reaches to 0.65V, soft start process is over, as shown in Fig.1 Since usually the output voltage rises exponentially after power on, this “Optimized soft start” control can be a trade off between soft start time and stress on the external power device.

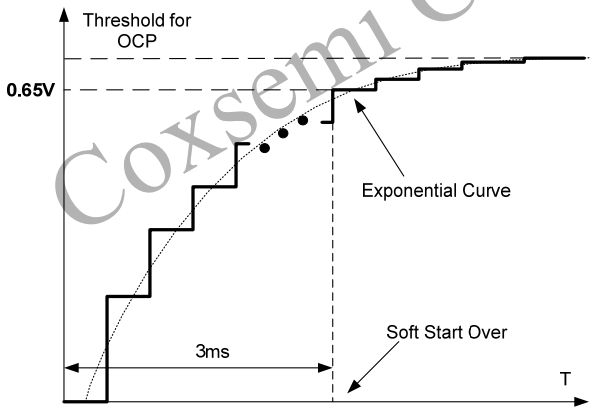


Fig.1

● Programmable Switching Frequency Generation with Built-in Low Pass Filter

In COX3210/3211/3212 series, the normal switching frequency can be externally programmed by connecting a resistor from RT pin to GND according to the equation below:

$$F_{OSC}(KHz) = \frac{6500}{RT(K\Omega)}$$

It can typically operate between 50kHz to 130kHz.

In power MCM (multi chip module) IC, the generation of voltage, current and clock of power controller are susceptible to the interference caused by the internal packaged power MOSFET. In COX3210/3211/3212 series, the reference is low pass filtered for clock generation, which can increase system reliability.

● Hybrid Frequency Jittering

To reduce system EMI, COX3210/3211/3212 series integrate a Proprietary “Hybrid Frequency Jittering” to operate the system with ±4% frequency jittering around setting frequency.

● Leading Edge Blanking (LEB)

Each time the power MOSFET is switched on, a turn-on spike occurs across the sensing resistor. The spike is caused by primary side capacitance and secondary side rectifier reverse recovery. To avoid premature termination of the switching pulse, an internal leading edge blanking circuit is built in. During this blanking period (250ns, typical), the PWM comparator is disabled and cannot switch off the gate driver. Thus, external RC filter with a small time constant is enough for current sensing.

● Built-in Slope Compensation

In the conventional application, the problem of the stability is a critical issue for current mode controlling, when it operates in higher than 50% of the duty-cycle. In COX3210/3211/3212 series, the slope compensation circuit is integrated by adding voltage ramp onto the current sense input voltage for PWM generation. This greatly improves the close loop stability at CCM and prevents the sub-harmonic oscillation and thus reduces the output ripple voltage.

● Constant Power Limiting

In COX3210/31211/3212 series, a proprietary “Constant Power Limiting” block is integrated to achieve constant max. output power capability over universal AC input range. Based on the duty cycle information, the IC generates OCP threshold according to a proprietary analog algorithm.

● Green Mode Operation

Since the main power dissipation at light/zero load in a switching mode power supply is from the switching loss which is proportional to the PWM switching frequency. To fulfill green mode requirement, it is necessary to reduce the switching cycles under such conditions either by skipping some switching pulses or by reducing the switching frequency.

Smooth Frequency Foldback

In COX3210/3211/3212 series, a Proprietary “Smooth Frequency Foldback” block is integrated to foldback the PWM switching frequency when the loading is light. Compared to the other frequency reduction implementations, this “Smooth frequency

foldback" technique can reduce the PWM frequency smoothly without audible noise.

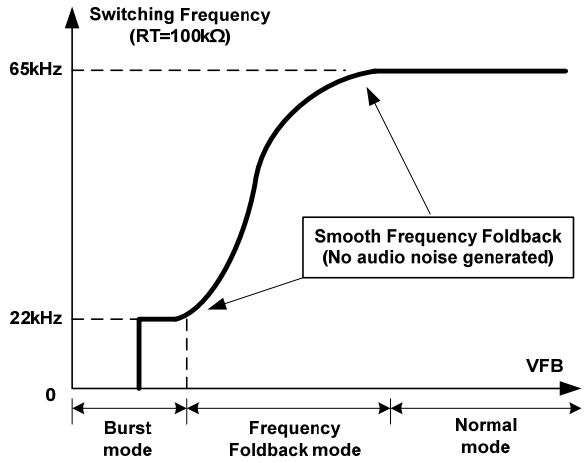


Fig.2

Burst Mode Control

When the loading is very small, the system enters into burst mode. When VFB drops below Vskip, COX3210/3211/3212 series will stop switching and output voltage starts to drop, which causes the VFB to rise. Once VFB rises above Vskip, switching resumes. Burst mode control alternately enables and disables switching, thereby reducing switching loss in standby mode.

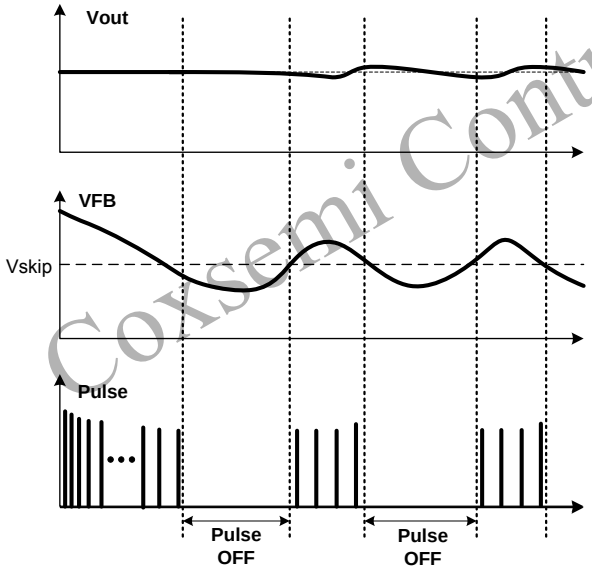


Fig.3

● Protections

COX3210/3211/3212 series provide many protections that can protect system from being damaged and enhance the system reliability. All the protections are listed as below:

Auto Recovery Mode Protection

As shown in Fig.4, once a fault condition is detected, PWM switching will stop. This will cause VDD to fall because no power is delivered form the auxiliary winding. When VDD falls to UVLO(OFF) (typical 9V), the protection is reset and the operating current reduces to the startup current, which causes VDD to rise, as shown in Fig.4. The system begins switching when VDD reaches to UVLO(ON) (typical 14V). However, if the fault still exists, the system will experience the above mentioned process. If the fault has gone, the system resumes normal operation. In this manner, the auto restart can alternatively enable and disable the switching until the fault condition is disappeared.

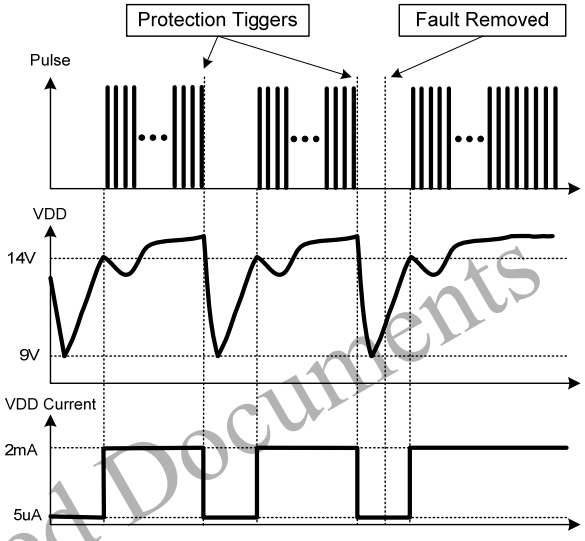


Fig.4

Over Load Protection (OLP)

When over load occurs, a fault is detected. If this fault is present for more than 43ms (typical), the protection will be triggered, the IC will experience an auto-recovery mode protection as mentioned above. The 43ms delay time is to prevent the false trigger from the power-on and turn-off transient

All Pins Floating and RT Pin Short-to-GND Protection

In COX3210/3211/3212 series, if CS and RT pin floating or RT pin short-to-GND occurs, the protection is triggered immediately and the system will experience the process of auto-recovery mode protection.

VDD OVP (Over Voltage Protection)

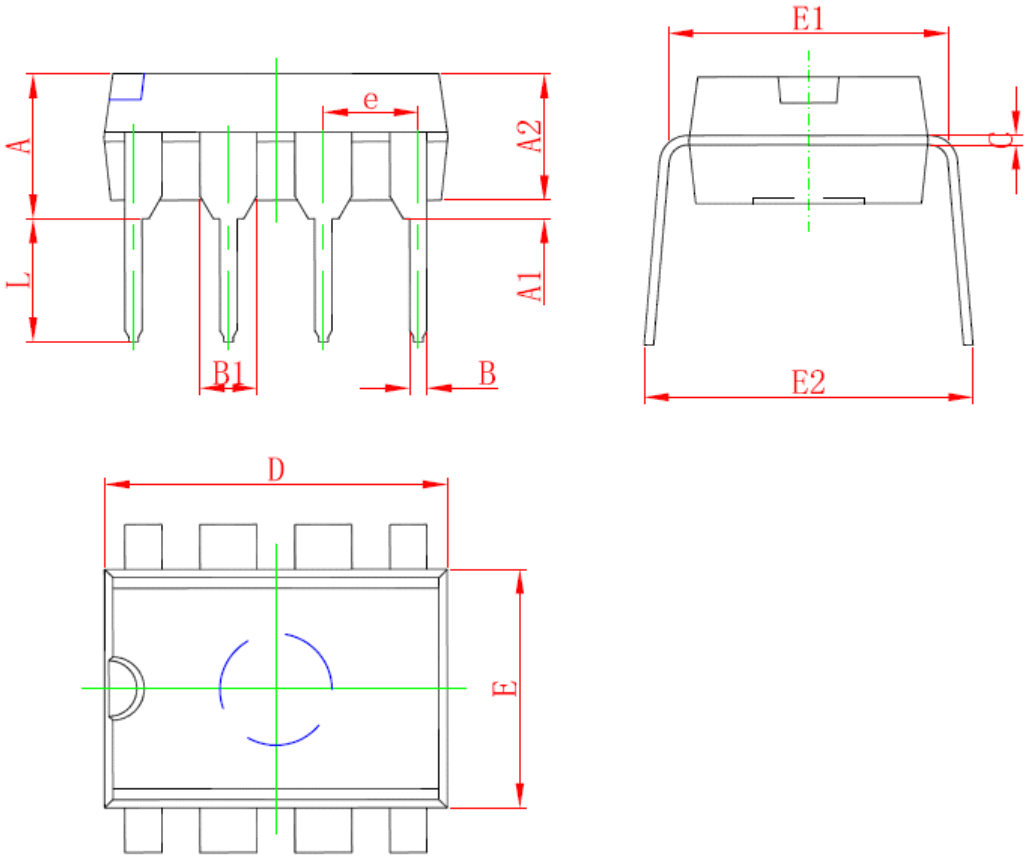
VDD OVP (Over Voltage Protection) is implemented in COX3210/3211/3212 series and it is a protection of auto-recovery mode.

Cycle-by-Cycle Current Limiting

It is a basic protection and can be implemented easily in current mode PWM controller.

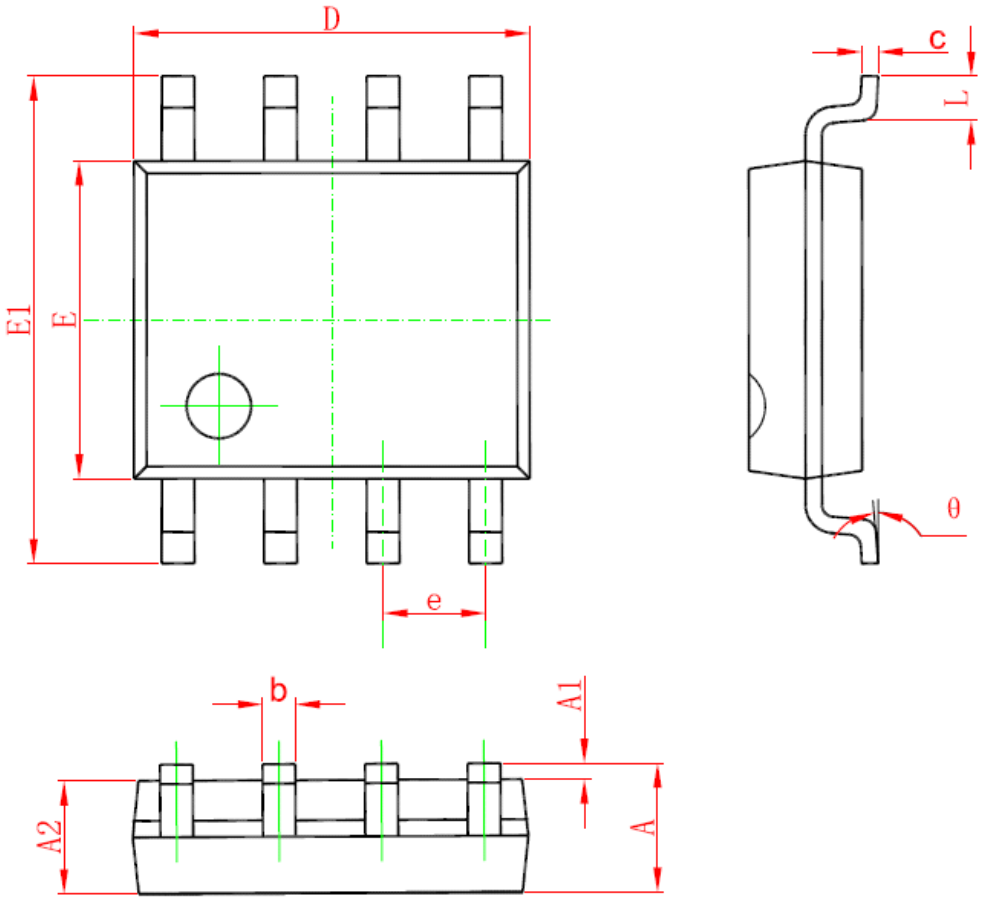
PACKAGE MECHANICAL DATA

DIP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	5.334	0.146	0.210
A1	0.381		0.015	
A2	3.175	3.600	0.125	0.142
B	0.350	0.650	0.014	0.026
B1	1.524 (BSC)		0.06 (BSC)	
C	0.200	0.360	0.008	0.014
D	9.000	10.160	0.354	0.400
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540 (BSC)		0.1 (BSC)	
L	2.921	3.810	0.115	0.150
E2	8.200	9.525	0.323	0.375

SOP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.650	0.049	0.065
b	0.310	0.510	0.012	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.150	0.185	0.203
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.05 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

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