JW1556

Asymmetrical Half-Bridge Flyback Controller

DESCRIPTION

JW1556 is an asymmetrical half-bridge flyback controller for offline flyback converter applications. The JW1556 can be adopted to reduce switching loss and provide high efficiency in whole load range.

JW1556 provide two control outputs, the main power switch control and the auxiliary switch control.

JW1556 also has X-cap discharge function to discharge the X-cap when the input is unplugged, which lowers standby power.

JW1556 is available in QFN4X4-20 package.

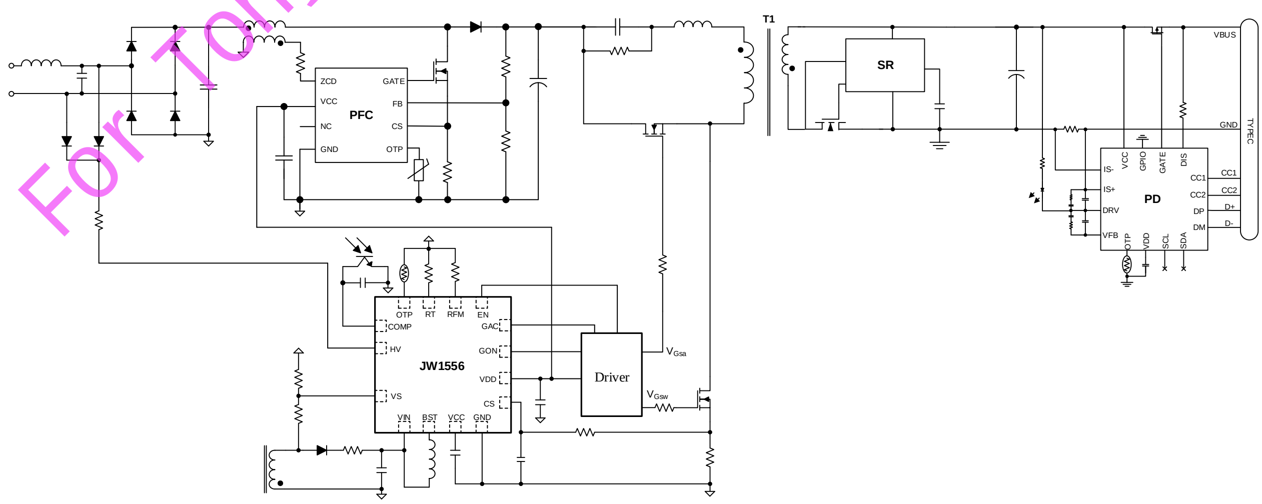
FEATURES

- Boundary Mode Operation at Heavy Load
- DCM Operation at Light Load
- Burst Mode Control
- Built-in Soft-start Function
- X-cap Discharge Function
- Include a Boost Converter, Allow Vin Range 2.5-38V
- Maximum Frequency Setting with a Single External Resistor
- Adjustable Line Compensation
- High Switching Frequency up to 1.5MHz
- Reliable Fault Protections: VIN OVP, VS OVP, SCP, Brown-In/Out, OTP, CS Open and Short Protection
- QFN4X4-20 Package

APPLICATIONS

- Adaptor

TYPICAL APPLICATION



ORDER INFORMATION

DEVICE[1)]	PACKAGE	TOP MARKING[2)]	ENVIRONMENTAL[3)]
JW1556QFNAH#TR	QFN4X4-20	JW1556 YW□□□□□	Green

Notes:

1) JW□ □#TR
- Tape and Reel (If TR is not shown, it means Tube)
- Package Code
- Part No.

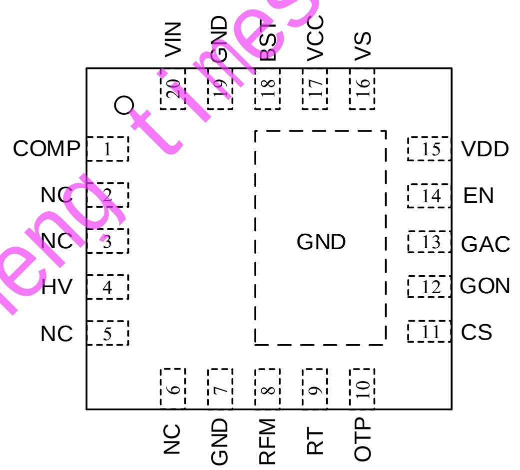
2) Line1: JW □□□□
- Product code
- JoulWatt LOGO

Line2: YW □□□□□
- Lot number
- Week code
- Year code

3) All JoulWatt products are packaged with Pb-free and Halogen-free materials and compliant to RoHS standards.

PIN CONFIGURATION

TOP VIEW



QFN4X4-20

ABSOLUTE MAXIMUM RATING[1)]

HV……..-0.3 to 600V
VDD.. -0.3 to 16V
VIN, BST, VCC.. -0.3 to 45V
VS... -1.1 to 5V, 5 to 5.5V<10us, -1.3 to -1.1V<10us
GON, GAC, EN... -0.3 to 5.5V, 5.5 to 6V<10us
All other Pins.. -0.3 to 5V, 5 to 5.5V<10us
Junction temperature[2) 3)]... 150ºC
Lead Temperature 260ºC
Storage temperature.. -65ºC to +150ºC

RECOMMENDED OPERATING CONDITIONS

HV…... 0V to 500V
VIN…..2.5V to 38V
Operating Junction Temperature ....-40ºC to 125ºC

THERMAL PERFORMANCE[4)]

	θ_{JA}	$\theta_{JC(top)}$	$\theta_{JC(bot)}$
QFN4X4-20..	43.4....	Na.....	4.1ºC/W

Note：

1) Exceeding these ratings may damage the device. These stress ratings do not imply function operation of the device at any other conditions beyond those indicated under RECOMMENDED OPERATING CONDITIONS.

2) The JW1556 includes thermal protection that is intended to protect the device in overload conditions. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.

3) The device is not guaranteed to function outside of its operating conditions.

4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

T_A = 25ºC, unless otherwise stated.

ITEM	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNITS
Supply Voltage Management						
Supply Current from HV	I_{VIN_CH}	VIN=6V, HV=30V	1.2	1.8	2.4	mA
VCC Turn On Threshold	V_{CC_ON}		14	14.8	15.6	V
VCC Turn Off Threshold	V_{CC_OFF}		10	10.6	11.2	V
Quiescent Current	I_{VCC_Q}	VCC=12V, output not switching	60	130	270	uA
Operation Current	I_{VCC_OP}	VCC=12V,fs=1.5MHz, $C_{GON/GAC}$=open	1.6	2	2.4	mA
VCC Pull-down Current before Fault Reset[5)]	I_{VCC_RST}		5	8	11	mA
VIN OVP Threshold	V_{IN_OVP}		38	40.5	43	V
VCC Operation Voltage when Boost Switching	V_{CC_MIN}		13	14	15	V
VDD Operation Voltage	V_{DD}		12	13	14	V
VDD Turn On Threshold	V_{DD_OK}		11	12	13	V
VDD Turn Off Threshold	V_{DD_OFF}		6.5	7	7.5	V
Maximum VDD current	I_{VDD}	VCC=V_{CC_ON}, VDD=0V	34	40	46	mA
Boost Frequency	f_{BST}		1.2	1.6	2	MHz
Boost Peak Current	I_{B_pk}		300	330	360	mA
Boost PWM Comparator Propagation Delay[5)]	t_{B_delay}	VIN=6V, L_B=4.7uH	21	35	49	ns
Boost Minimum on Time	$t_{BST\_MIN\_ON}$		44	60	76	ns
Boost Minimum off Time	$t_{BST\_MIN\_OFF}$		68	85	102	ns
Feedback Management (Pin COMP)						
COMP Open Voltage	V_{COMP_OPEN}		2.9	3	3.1	V
Internal Pull-up Resistor	R_{COMP}		17.5	20	22.5	kΩ
Over-Load Set Point	V_{COMP_OLP}		2.9	3	3.1	V
COMP Decreasing Level at which the Controller Enters Burst Mode	V_{COMPL}		310	345	380	mV
COMP Decreasing Level at which the Controller Exits Burst Mode	V_{COMPH}		360	390	420	mV
Power Limiting Debounce Time	t_{OLP}		75	80	85	ms
Internal Soft Start Time	t_{SS}		4.5	7.5	10.5	ms

Current Sampling Management (Pin CS)						
Leading Edge Blanking Time	t_{LEB}	GON	160	185	210	ns
Leading Edge Blanking Time for SCP Protection	t_{LEB1}	GON	95	130	165	ns
Maximum on Time	t_{ON_MAX}	GON	10	11.5	13	us
Maximum Current in BUR mode	$V_{CS\_MAX\_BUR}$	COMP=3V	565	630	695	mV
Maximum Current in BCM mode5)	$V_{CS\_MAX\_BCM}$	COMP=3V	500	560	620	mV
Medium Current in BUR mode5)	$V_{CS\_MID\_BUR}$	COMP=1~2V	/	350	/	mV
Medium Current in BCM mode5)	$V_{CS\_MID\_BCM}$	COMP=1~2V	/	280	/	mV
Minimum Current Set Point	V_{CS_MIN}	VCC=17V, COMP=0.4V to enter Burst Mode	115	140	165	mV
Short-circuit Protection Set Point	V_{SCP}		0.94	1	1.06	V
CS UVP Threshold	V_{CS_UVP}		200	245	290	mV
Line-compensation Current Ratio5)	K_{LC}		/	0.02	/	A/A
Current Comparator Propagation Delay5)	$t_{D(CS)}$	V_{CS} step from 0V to 1V	24	30	36	ns
Output Management (Pin GON/GAC/EN)						
Output High Level	V_H		5	5.25	5.5	V
Output Low Level	V_L		/	0.03	0.3	V
Maximum Source Current	I_{SRC}		2.35	2.75	3.15	mA
Maximum Sink Current	I_{SNK}		25	30	35	mA
Delay from EN High to GON High	$t_{D(EN-GON)}$		33	39.5	46	us
Delay from GON Low to GAC High5)	$t_{D(GON-GAC)}$		/	80	/	ns
Frequency and Dead time Management						
Maximum Switching Frequency	f_{SW}		1.2	1.35	1.5	MHz
Maximum Operating Frequency Set	f_{MAX}	$f_{MAX}(\text{kHz})=f_{Burst}+\frac{5*10^4}{R_{FM}(\text{k}\Omega)}$ R_{FM}=105kΩ	425	500	575	kHz
Burst Frequency	f_{Burst}		22	26	30	kHz
Frequency Quiver Amplitude5)	$\triangle f_{QVR}$		/	±8%	/	/
Peak Current Quiver Amplitude5)	$\triangle ipk_{QVR}$		/	±8%	/	/
Counting Cycles for Quiver5)	N_{QVR_CYC}		/	90	/	Cycle
Protection Management						
Thermal Shutdown Threshold5)	T_{SD}		/	150	/	ºC
Thermal Shutdown Recovery Hysteresis5)	T_{HYS}		/	50	/	ºC
Fault Reset Delay Time	t_{FRD}		1.5	1.6	1.7	s
NTC Shut-down Voltage	V_{NTCTH1}		0.9	1	1.1	V

NTC Recovery Voltage	V_{NTCTH2}		2.1	2.25	2.4	V
NTC Pull-up Current, out of Pin	I_{NTC}		95	110	125	uA
Brown in Current Threshold[5)]	I_{VS_BI}		264	300	336	uA
Brown out Current Threshold[5)]	I_{VS_BO}		176	200	224	uA
Brown out Debounce Time	t_{BO}		37.5	40	42.5	ms
VS OVP Current Threshold[5)]	I_{VS_OV}		704	800	896	uA

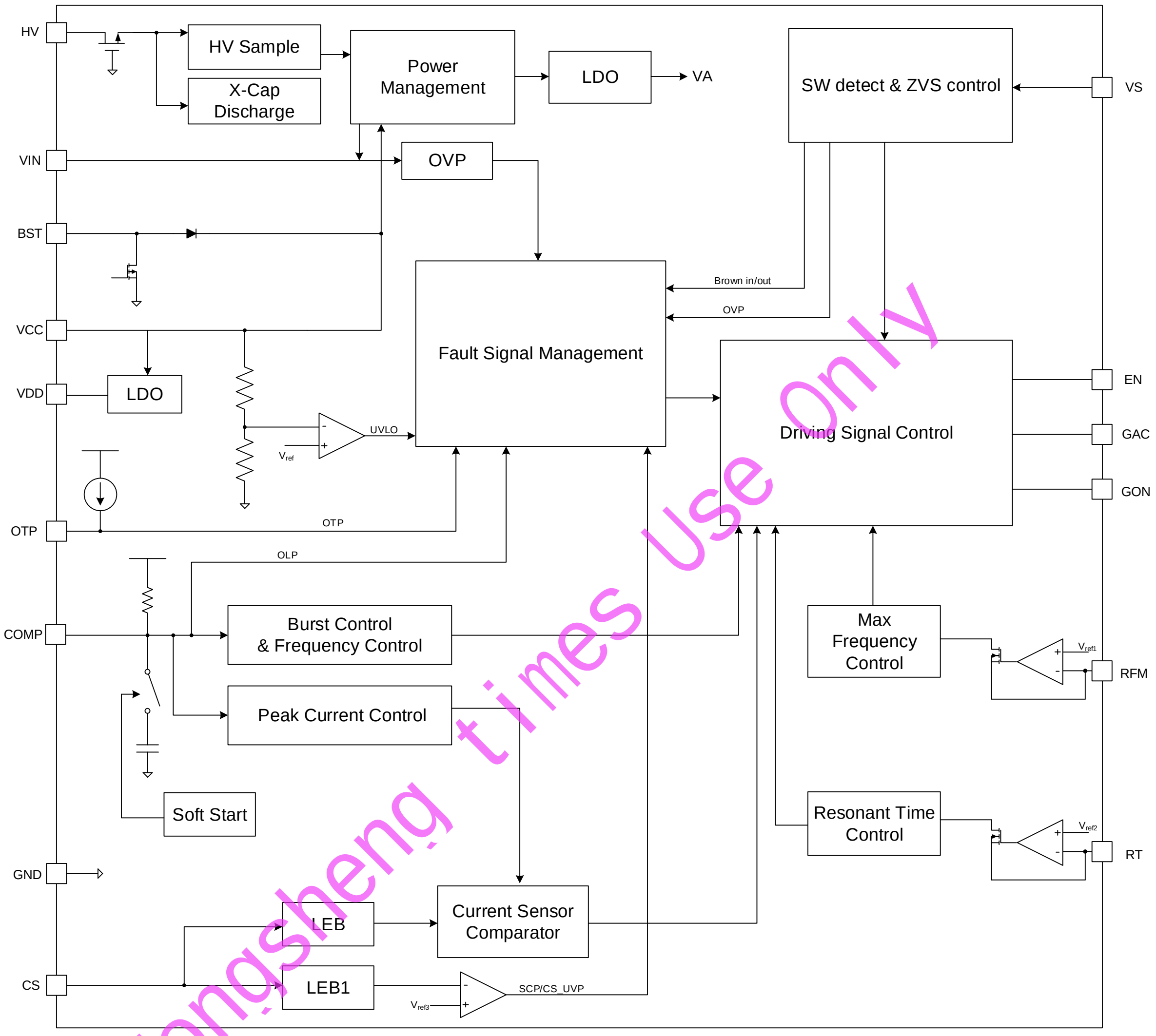
Note:

5) Guaranteed by design.

PIN DESCRIPTION

PIN QFN4X4-20	NAME	DESCRIPTION
1	COMP	Feedback input pin for the controller. Connect to an optocoupler directly.
2	NC	
3	NC	
4	HV	High voltage input pin. This pin provides source current to charge VIN. It is also used for X-cap discharge when AC input is removed.
5	NC	
6	NC	
7	GND	Power ground
8	RFM	Maximum switching frequency setting pin. A resistor R_{FM} is connected to this pin.
9	RT	Resonant period setting pin. A resistor R_T is connected to this pin. It's used for achieving adaptive ZVS function
10	OTP	External over temperature protection pin. A resistor R_{NTC} is connected to this pin for OTP protection.
11	CS	Current sensing input pin. The primary switch current is sensed by this pin for peak current control.
12	GON	Main switch logic output pin.
13	GAC	Auxiliary switch logic output pin.
14	EN	Enable logic output pin. If entering burst mode or fault conditions, this pin will keep low and shut down GON/GAC.
15	VDD	13V regulator output pin.
16	VS	Auxiliary winding voltage sensing pin. Input and output voltages are sensed by this pin from the auxiliary winding. Besides, it is used for ZCD and achieving main switch ZVS.
17	VCC	Boost output and IC power supply pin.
18	BST	Boost switching pin. Boost converter inductor is connected from VIN to this pin.
19	GND	Power ground
20	VIN	Boost input pin. The Boost converter inductor is connected from this pin to BST.

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

JW1556 is an asymmetrical half-bridge flyback controller for offline flyback converter applications.

1. Start-Up

Initially, the current source which is drawn from the HV pin charges VCC cap and drives the controller. As soon as VCC reaches turn-on threshold V_{CC_ON}, JW1556 starts switching and the start-up current source turns off after finishing soft start. The system stops switching and start-up current source turns on again when fault is triggered or VCC falls below V_{CC_OFF}.

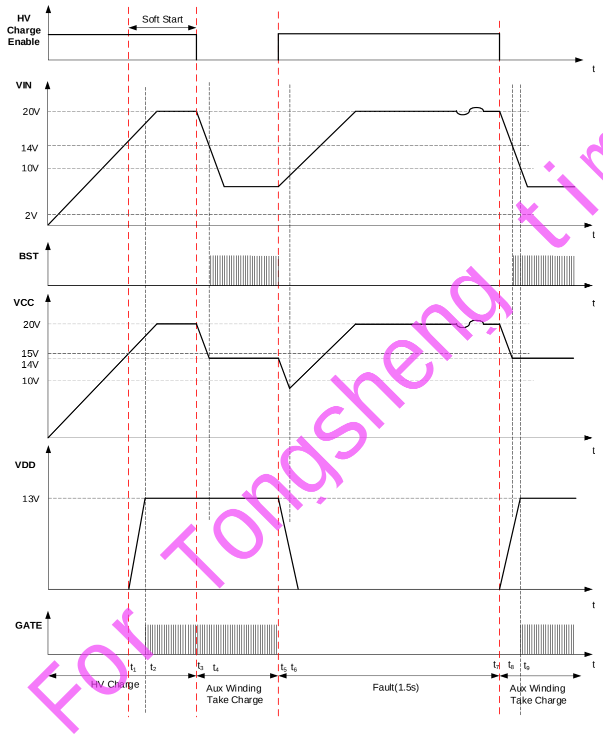


Figure 1: Start up

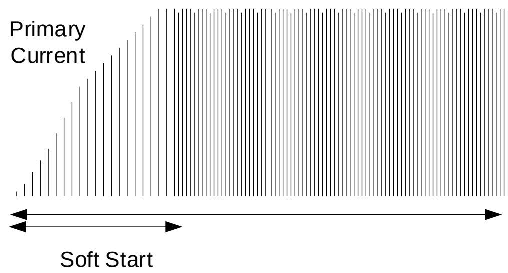


Figure 2: Soft Start

An internal soft-start circuit is included in JW1556 in order to reduce stress on the primary side switch, secondary diode and smoothly establish the output voltage during start-up. Every restart is followed by a soft start within t_{SS}.

2. Normal Operation

2.1 Peak Current and Frequency Control

JW1556 uses an adaptive multi-mode control to improve overall range efficiency. When load is heavy, JW1556 operates in BCM mode, the peak current is regulated according to the load condition. When COMP decreases, the controller enters BUR mode with N_{BUR} cycles which the peak current and switching frequency are fixed and BUR frequency is changing. N_{BUR} is set to 3 by default. When COMP decreases further, the controller enters DCM(PFM/PWM) mode, the switching frequency is folded back to f_{Burst} while freezing the peak current. When the load decrease to a given level, the controller freezes the frequency at f_{Burst} while decreasing its peak current until JW1556 enters Burst mode. During Burst mode, the peak current reaches its minimum value.

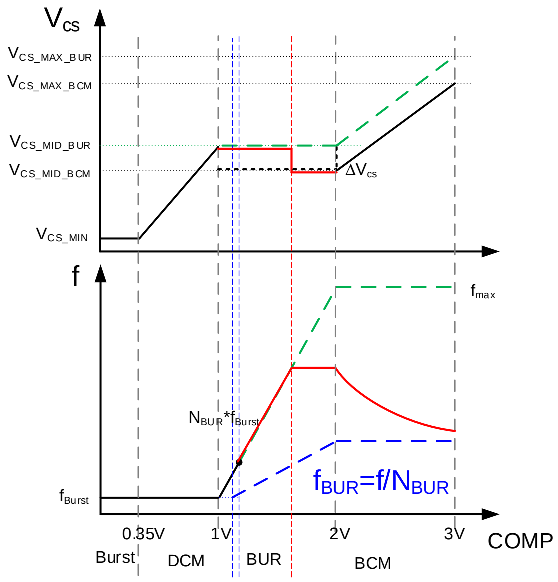


Figure 3: Peak Current and Frequency

JW1556 provides two signals GON and GAC to control the main switch and the auxiliary switch. GON is turned on at the valley of V_{sw} when reaching the setting frequency and turned off when i_{pk} reaching the setting value according to COMP. When GON is off, GAC keeps on after dead time until the magnetizing current falls around 0, then GAC will be turned off.

2.2 BCM Operation

JW1556 operates in boundary conduction mode (BCM) at heavy load. In BCM, the converter operates with ZVS by proper control of GAC.

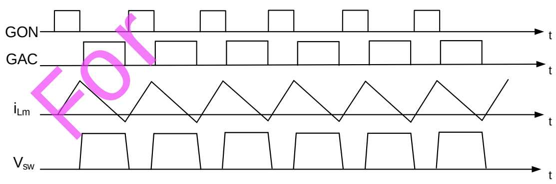


Figure 4: BCM Waveforms

2.3 BUR Operation

When switching frequency reaches the setting frequency decided by comp voltage, JW1556 features BUR operation with N_{BUR} cycles which the peak current and switching frequency are fixed and BUR frequency f_{BUR} is changing.

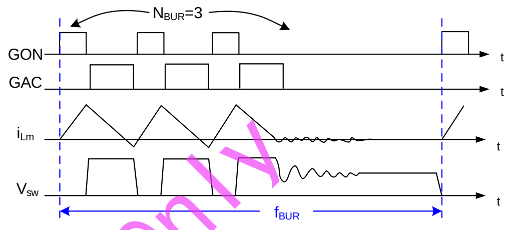


Figure 5: BUR Waveforms

2.3 DCM(PFM/PWM) Operation

JW1556 features discontinuous conduction mode (DCM) operation at light load, where the JW1556 turns off the auxiliary switch when the magnetizing current is zero.

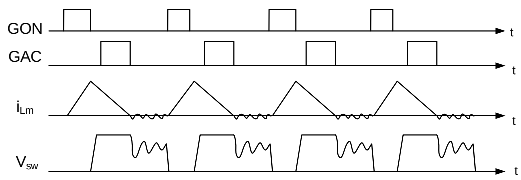


Figure 6: DCM Waveforms

2.4 Burst Operation

JW1556 implements burst mode at no load and light load to lower stand-by power consumption. As the load decreases, the COMP voltage decreases. The controller stops switching when the COMP drops below V_{COMPL} (0.35V) and exit burst mode when COMP exceeds V_{COMPH} (0.4V).

GAC keeps switching during Burst mode the same as DCM mode.

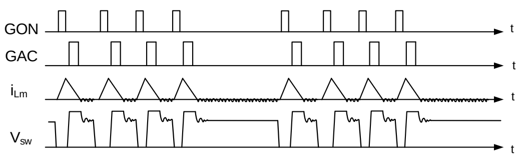


Figure 7: Burst Waveforms

3. Other Functions and Features

3.1 Boost Converter

To improve the efficiency of wide range output, JW1556 integrates a Boost converter internally. An inductor between VIN and BST pin is required for proper operation.

3.2 X-Cap Discharge Function

Safety standards such as EN60950/UL62368 require that any X-capacitors in EMI filters on the AC side should be quickly discharged to a safe level when AC cord is unplugged. EN60950 requires that the voltage across X-caps decays to 37% within 1s. EN62368 requires that the voltage across X-caps decays to 60VDC within 2s. Typically, this requirement is achieved by including a resistive discharge element in parallel with the X-cap. However, this resistance causes a continuous power dissipation that impacts the standby power performance.

In order to reduce standby power consumption, JW1556 incorporates the X-cap discharge circuit. This circuit periodically monitors the voltage across the X-cap to detect any possibility that AC source disconnection has occurred, and then discharges the X-cap by internal HV current source to the safety-voltage level within 1s or 2s. Fig.8 shows the X-cap discharge timing diagram.

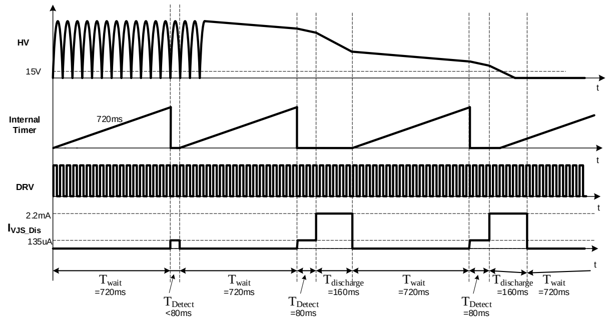


Figure 8: X-cap Discharge

3.3 Resonant Time Setting

The RT pin is used to set the parasitic resonant period to achieve better valley turn-on time. Set t_d to one quarter resonance period in DCM. The t_d is controlled by the resistor connected between RT pin and GND pin which can be represented as

$$t_d(\mathrm{ns}) = K_d \cdot R_{td}(\mathrm{k\Omega})$$

Where K_d is the ratio of t_d to R_{td}(ns/kΩ) and can be approximated as 2.8~3.2.

3.4 Maximum Frequency Setting

The maximum switching frequency limit(f_{MAX}) of JW1556 can be set by RFM pin connected between RFM pin and GND pin to meet different applications which can be represented as

$$f_{MAX}(\mathrm{kHz}) = f_{Burst} + \frac{5*10^4}{R_{FM}(\mathrm{k\Omega})}$$

3.5 QR Frequency Quivering

To achieve good EMI performance, frequency quivering method is integrated in JW1556, which is achieved by peak current and switching frequency perturbation.

3.6 Leading Edge Blanking

In order to avoid the premature termination of the switching pulse due to the parasitic capacitance, an internal leading-edge blanking (LEB) is used for the current comparator of CS pin. The current comparator is disabled and cannot turn off GON during the blanking time t_{LEB}.

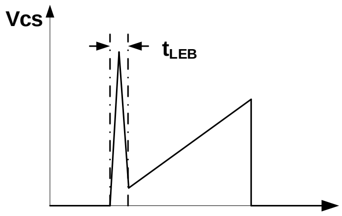


Figure 9: LEB Blanking

3.7 Line Voltage Compensation

During peak current control a propagation delay is impacting the resulting peak current limitation. JW1556 controls the peak primary current in each switching cycle by adding a line-compensation offset voltage on the CS pin through a resistor (R_{LC}) connected between the CS pin and current-sense resistor (R_{CS}). A current source flowing out of CS pin, proportional to the converter's input voltage, creates an offset voltage on R_{LC}. This current level is equal to I_{VS} times a constant gain of K_{LC} when GON is high.

$$\Delta V_{CS} = \frac{N_A \cdot (V_{Bulk} - V_{Cr})}{N_P \cdot R_{VSU}} \cdot K_{LC} \cdot R_{LC}$$

4. Protections

4.1 VIN OVP

VIN is the input voltage for the Boost converter. It has internal OVP protection. Once the fault is triggered, the controller shuts down and restarts after t_{FRD}.

4.2 Brown-in and Brown-out

The line input voltage is detected by VS pin during GON on period, and then compared to the internal run and stop thresholds. A wide separation of run and stop thresholds allows clean start-up and shut-down of the power supply with the line voltage.

4.3 Over Load Protection (OLP)

JW1556 turns off the switch when the power supply undergoes an overload. A fault signal is trigged when COMP pulls up to V_{COMP_OLP} for t_{OLP}. Then the controller shuts down and restarts after t_{FRD}.

4.4 Short-Circuit Protection (SCP)

The JW1556 has short-circuit protection if V_{CS} reaches V_{SCP} after a reduced leading-edge blanking time t_{LEB1} for three consecutive cycles. If SCP is trigged, the controller shuts down and restarts after t_{FRD}.

4.5 CS Pin Open/Short

When CS pin is open, the internal bias current will flow to the parasitic capacitance on the CS pin, V_{CS} will increase. If V_{CS} is above the V_{SCP} within t_{LEB1}, GON will be turned off right now. Once the fault is detected, the controller shuts down and restarts after t_{FRD}.

If CS pin is short, JW1556 will integrate the current from VS pin by keeping VS low when GON is high. If V_{CS} is below the V_{CS_UVP} when the integral reaches 3.05nC, a CS-UVP fault will be asserted and the controller will shut down and restart after t_{FRD}.

4.6 Output OVP(VS OVP)

The output over-voltage protection is detected by the current flowing to VS pin when GAC is high and keeping VS voltage low. If the VS current exceeds over-voltage protection threshold I_{VS_OV} for three consecutive switching cycles, a VS-OVP fault will be asserted and JW1556 will shut down and restart after t_{FRD}.

I_{VS} can be calculated as below

$$I_{VS} = \frac{V_o \cdot N_{aux}}{N_s \cdot R_{VSU}}$$

4.7 Over Temperature Protection (OTP)

JW1556 uses an external NTC resistor (R_{NTC}) tied to the OTP pin to program a thermal shutdown temperature near the hotspot of the converter. If the OTP voltage stays lower than the NTC shut-down threshold (V_{NTCTH1}) for 1ms, OTP is triggered and JW1556 turns off all of switches. JW1556 resumes operation when OTP voltage stays higher than NTC recovery threshold (V_{NTCTH2}) for 160us.

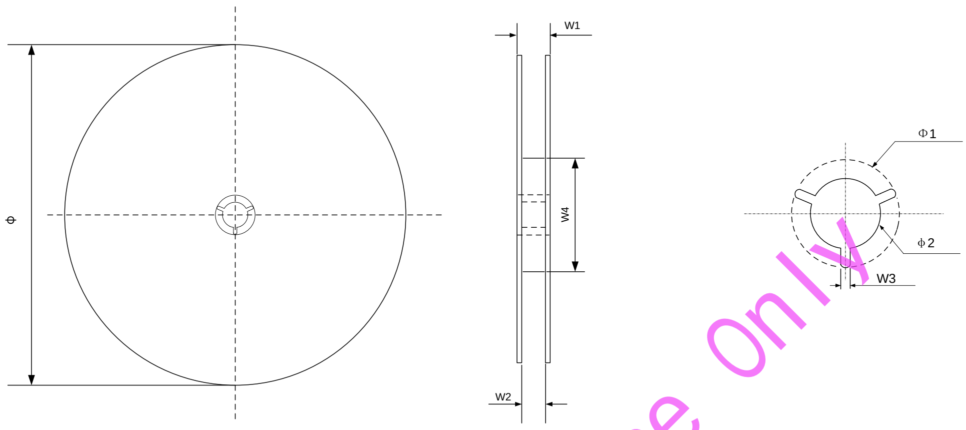
4.8 Thermal Shutdown

When the junction temperature of JW1556 exceeds T_{SD}, the controller will shut down. JW1556 resumes operation when the temperature drops below T_{SD} -T_{HYS}.

Protection	Sensing	Condition	Delay to action	Action
VIN OVP	VIN voltage	VIN>V_{IN_OVP}	none	VCC UVLO reset after t_{FRD}
Brown-in	VS current	$I_{VS(GON)}$+$I_{VS(GAC)}$ <I_{VS_BI} or $I_{VS(GON)}$<0.5*$I_{VS(GAC)}$	4 GON pulses	VCC UVLO reset after t_{FRD}
Brown-out	VS current	$I_{VS(GON)}$+$I_{VS(GAC)}$ <I_{VS_BO} or $I_{VS(GON)}$<0.5*$I_{VS(GAC)}$	t_{BO}+3 GON pulses	VCC UVLO reset after t_{FRD}
OLP	V_{COMP} voltage	$V_{COMP}\geq V_{COMP\_OLP}$	t_{OLP}	VCC UVLO reset after t_{FRD}
SCP /CS pin Open	V_{CS} voltage	$V_{CS}\geq V_{SCP}$	3 GON pulse	VCC UVLO reset after t_{FRD}
CS pin Short	V_{CS} voltage	V_{CS} can't reach V_{CS_UVP}	Every pulse	VCC UVLO reset after t_{FRD}
VS OVP	VS current	$I_{VS(GAC)}$>I_{VS_OV}	3 GON pulses	VCC UVLO reset after t_{FRD}
OTP	NTC voltage	V_{NTC}<V_{NTCTH1}	1ms	Reset until V_{NTC}>V_{NTCTH2} for 160us or VCC UVLO
Thermal shutdown	Junction temperature	T_J>T_{SD}	none	Reset until T_J<T_{SD}-T_{HYS} or VCC UVLO

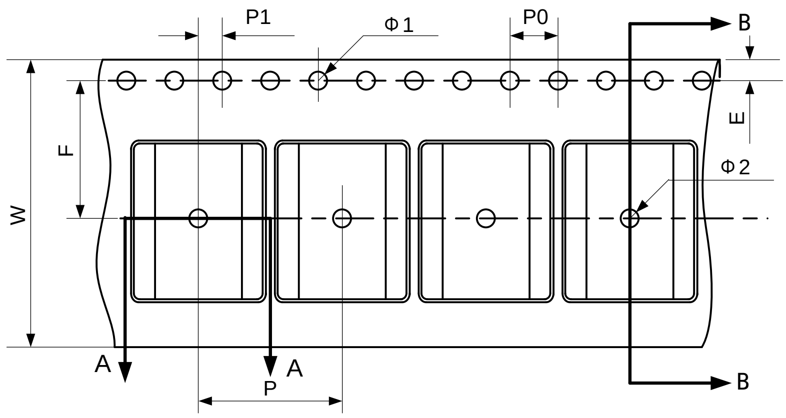
TAPE AND REEL INFORMATION

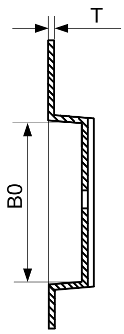
Reel UNIT: mm



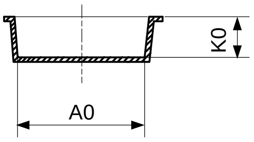
Package	Diameter Φ	Thickness W1	Width W2	W4
QFN4x4-20	330±2	17.6±2	12.4±2	100±2

Carrier Tape UNIT: mm





SECTION B-B



SECTION A-A

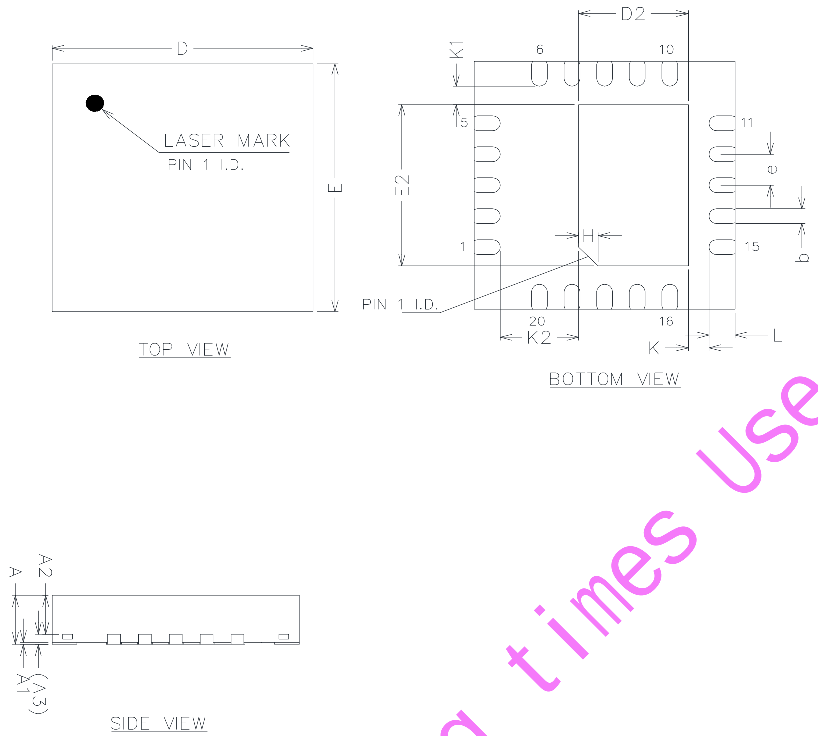
Note :

1) The carrier type is black, and colorless transparent.
2) Carrier camber is within 1mm in 100mm.
3) 10 pocket hole pitch cumulative tolerance:±0.20.
4) All dimensions are in mm.

Package	关键尺寸控制标准（单位：mm）										
	P0	P1	P	A0	B0	W	T	K0	Φ1	Φ2	E	F
QFN4X4-20	4.00±0.10	2.0±0.05	8.0±0.1	4.3±0.1	4.3±0.1	12±0.3	0.3±0.05	1.1±0.1	1.5 [illegible]	1.50min	1.75±0.1	5.50±0.05

PACKAGE OUTLINE

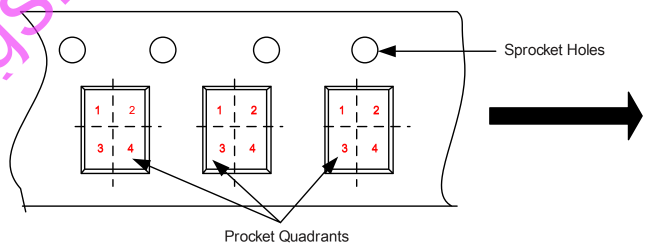
QFN4x4-20 UNIT: mm



(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A2	–	0.55	–
A3		0.20REF	
b	0.19	0.24	0.29
D	3.90	4.00	4.10
E	3.90	4.00	4.10
D2	1.585	1.685	1.785
E2	2.50	2.60	2.70
e		0.50 BSC	
H		0.30REF	
L	0.30	0.40	0.50
K		0.315 REF	
K1		0.300 REF	
K2		1.10 MIN	

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPAE



Package Type	Pin1 Quadrant
QFN4*4-20	1

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