JW1550

Active Clamp Flyback Controller

Preliminary Specifications Subject to Change without Notice

DESCRIPTION

JW®1550 is an active clamp flyback controller for offline flyback converter applications. The JW1550 can be adopted to reduce switching loss and provide high efficiency in whole load range.

JW1550 provide two control outputs, the main power switch control and the active clamp switch control.

JW1550 also has X-cap discharge function to discharge the X-cap when the input is unplugged, which lowers standby power.

The JW1550 is available in QFN4X4-20 package.

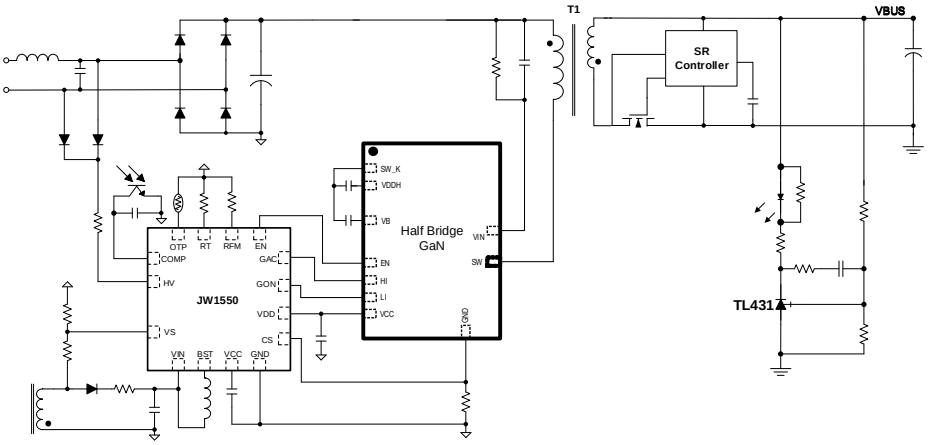
FEATURES

- 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/UVP, VS OVP/UVP, SCP, Brown-In/Out, OTP, CS Open and Short Protection
- QFN4X4-20 Package

APPLICATIONS

- Adaptor

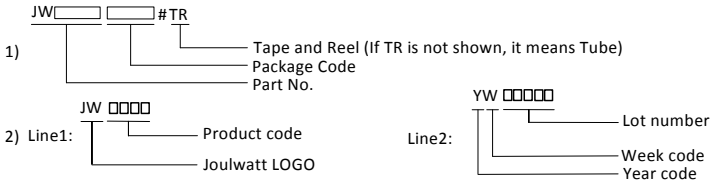
TYPICAL APPLICATION



ORDER INFORMATION

DEVICE[1)]	PACKAGE	TOP MARKING[2)]	ENVIRONMENTAL[3)]
JW1550QFNAH#TR	QFN4X4-20	JW1550 YW□□□□□	Green

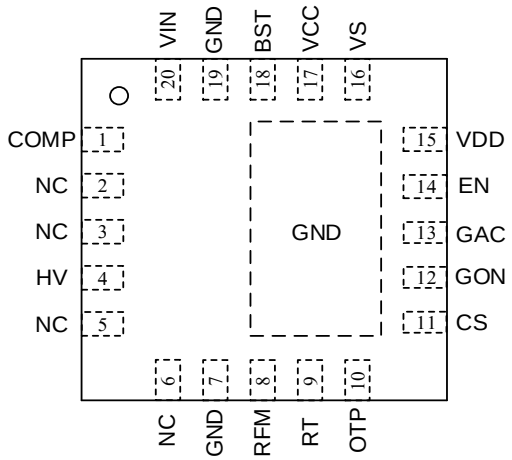
Notes:



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
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}	θ_{JC}
QFN4X4-20	43.4	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 RECOMMEND OPERATION CONDITIONS.
2) 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=25℃，unless otherwise noted						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNIT**
Supply Voltage Management						
Supply Current from HV	I_{VIN_CH}	Current available from HV @VIN=6V, HV=30V	1.2	1.8	2.4	mA
VCC Turn On Threshold	V_{CC_ON}		13.8	14.8	15.8	V
VCC Turn Off Threshold	V_{CC_OFF}		9.6	10.6	11.6	V
Quiescent Current	I_{VCC_Q}	V_{COMP}=0V , V_{CS}=0V，VCC=12V, output not switching	70	100	130	uA
Operation Current	I_{VCC_OP}	VCC=12V, fs=1.5MHz, $C_{GON/GAC}$=open	1.6	2	2.4	mA
VIN UVP Threshold	V_{IN_UVP}		1.5	2	2.5	V
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
Boost Frequency	f_{BST}		1.2	1.6	2	MHz
Feedback Management (Pin COMP)						
COMP Open Voltage	V_{COMP_OPEN}		2.9	3	3.1	V
Internal Pull-up Resistor	R_{COMP}		10.5	11.5	12.5	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_{D_OLP}		75	80	85	ms
Internal Soft Start Time	t_{SS}		4	7.5	11	ms
Current Sampling Management (Pin CS)						
Minimum on Time	t_{ON_MIN}		150	185	220	ns
SCP Blanking Time	t_{BLK}		90	130	170	ns
Maximum on Time	t_{ON_MAX}		10	11.5	13	us
Minimum Current Set Point	V_{CS_MIN}	VCC=17V, COMP=0.4V to enter Burst Mode	110	135	160	mV
Maximum Current Set Point	V_{CS_MAX}	VCC=17V, COMP=3V	540	600	660	mV
Short-circuit Protection Set	V_{SC}		0.9	1	1.1	V

T_A=25℃，unless otherwise noted						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN**	**TYP**	**MAX**	**UNIT**
Point						
CS UVP Threshold	V_{CS_UVP}		200	245	290	mV
Line-compensation Current Ratio[5)]	K_{LC}		/	0.02	/	A/A
Propagation Delay of CS Comparator High to GON Low[5)]	$t_{D(CS)}$	V_{CS} step from 0V to 1V	/	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	3	/	mA
Maximum Sink Current	I_{SNK}		25	30	/	mA
Delay from EN High to GON High	$t_{D(EN-GON)}$		33	39.5	46	us
Delay from GON Low to GAC High[5)]	$t_{D(GON-GAC)}$		/	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}	$f_{MAX}=25+\frac{5*10^4}{R_{FM}(k\Omega)}$ R_{FM}=105kΩ	400	475	550	kHz
Burst Frequency	f_{Burst}		22	26	30	kHz
Protection Management						
Thermal Shutdown Threshold[5)]	T_{SD}		/	150	/	ºC
Thermal Shutdown Recovery Hysteresis[5)]	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	2.25	2.5	V
NTC Pull-up Current, out of Pin	I_{NTC}		90	105	130	uA
Brown in Current Threshold[5)]	I_{VS_BI}		410	467	523	uA
Brown out Current Threshold[5)]	I_{VS_BO}		352	400	448	uA
VS OVP Current Threshold[5)]	I_{VS_OV}		724	800	896	uA
VS UVP Current Threshold[5)]	I_{VS_UV}		20	66.6	120	uA

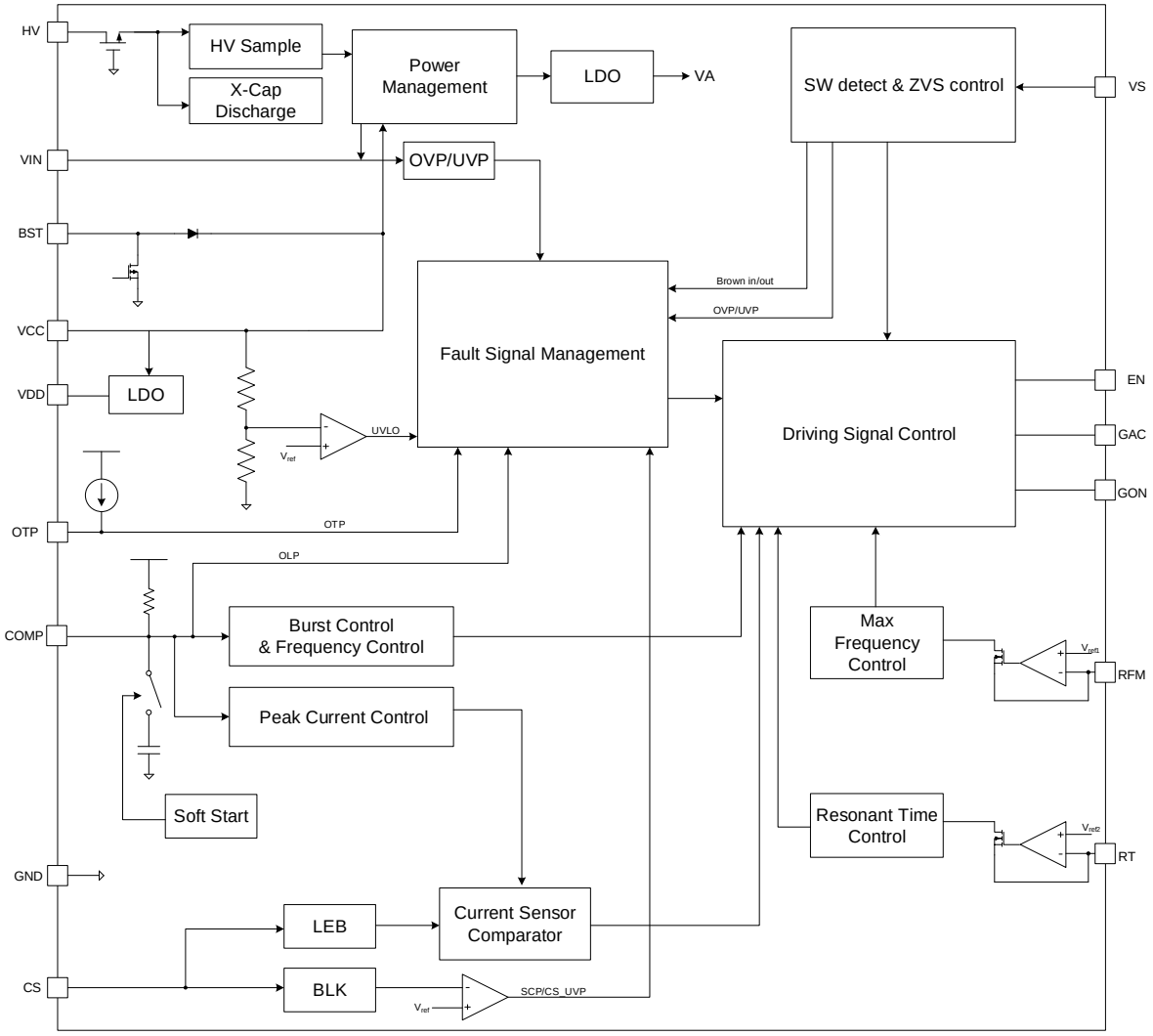
Note：

5) Guaranteed by design.

PIN DESCRIPTION

Pin QFN4X4-20	Name	Description
1	COMP	Compensation pin
2	NC	
3	NC	
4	HV	High voltage pin for startup
5	NC	
6	NC	
7	GND	Power ground
8	RFM	Switching converter frequency set
9	RT	Resonant time set
10	OTP	Over temperature protection pin
11	CS	Source of primary switch. Input of the primary current sense signal
12	GON	Enable main primary switch
13	GAC	Enable active clamp switch
14	EN	Enable pin to disable IC
15	VDD	13V regulator output
16	VS	Voltage sensing input pin
17	VCC	Power supply output
18	BST	Boost switching point
19	GND	Power ground
20	VIN	Power supply input

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

JW1550 is an active clamp flyback controller for offline flyback converter applications.

1. Start-Up

Initially, the current source which is drawn from the HV pin drives the controller. The post stage 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 or VCC falls below V_{CC_OFF}.

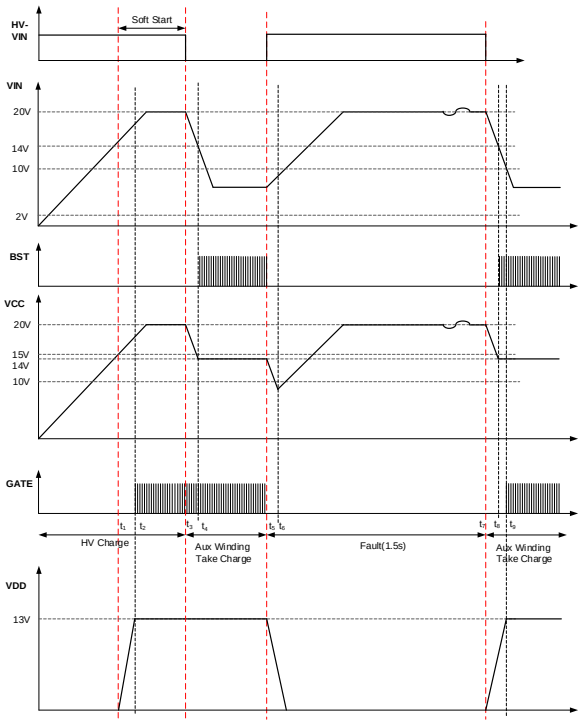


Figure 1: VCC UVLO

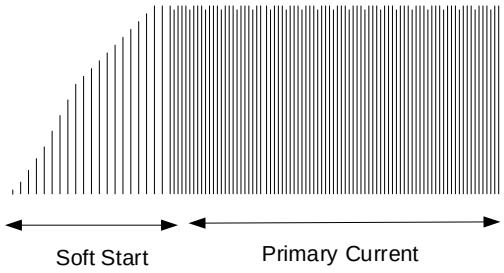


Figure 2: Soft Start

An internal soft-start circuit is included in JW1550 in order to reduce stress on the primary side switch, secondary diode and smoothly establish the output voltage during start-up. The internal soft-start time is about 5ms.

2. Normal Operation

2.1 Peak Current and Frequency Control

JW1550 uses an adaptive multi-mode control to improve overall range efficiency. When load is heavy, JW1550 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. When COMP decreases further, the controller enters DCM(PFM/PWM) mode, the switching frequency is folded back to 25kHz while freezing the peak current. When the load decrease to a given level, the controller freezes the frequency at 25kHz while decreasing its peak current until JW1550 enters Burst mode. During Burst mode, the peak current reaches its minimum value.

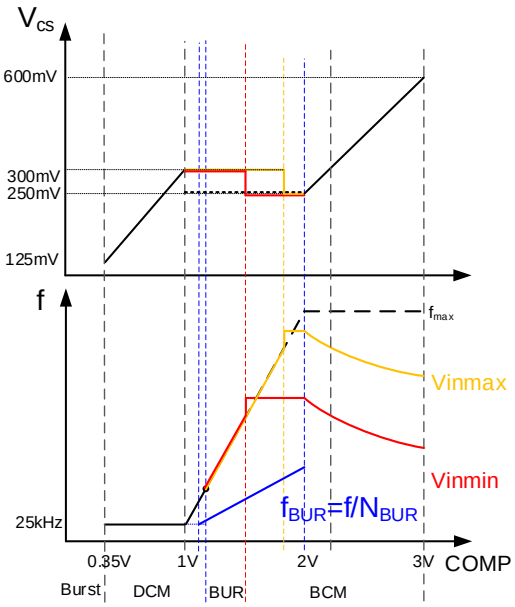


Figure 3: Peak Current and Frequency

JW1550 provides two signals GON and GAC to control the primary-side 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. Then the primary switch can be turned on again with ZVS or valley switching.

2.2 BCM Operation

JW1550 operates in boundary conduction mode (BCM) at heavy load. In BCM, the converter operates with ZVS by proper control of GAC.

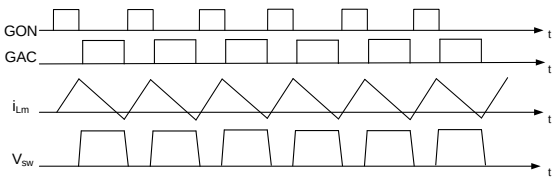


Figure 4: BCM Waveforms

2.3 BUR Operation

When COMP<2V, the JW1550 features BUR operation with N_{BUR} cycles which the peak current and switching frequency are fixed and BUR frequency f_{BUR} is changing.

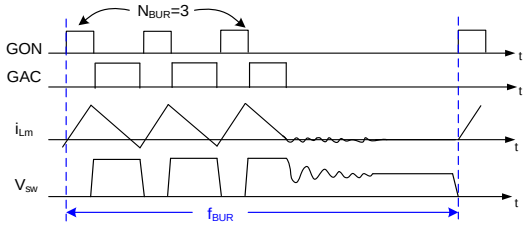


Figure 5: BUR Waveforms

2.3 DCM(PFM/PWM) Operation

The JW1550 features discontinuous conduction mode (DCM) operation at light load, where the JW1550 turns off the auxiliary switch when the magnetizing current is zero.

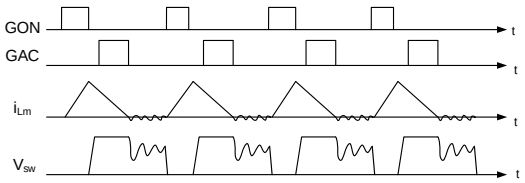


Figure 6: DCM Waveforms

2.4 Burst Operation

The JW1550 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 the post stage 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.

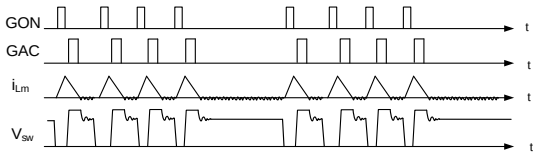


Figure 7: Burst Waveforms

3. Other Functions and Features

3.1 Boost Converter

To improve the efficiency of wide range output, JW1550 integrates a Boost converter internally. An inductor between VIN and BST pin is required for proper operation.

The Boost converter will enter burst mode in light load to improve efficiency further.

3.2 X-Cap Discharge Function

X-cap is typically positioned across a power supply's input terminals to filter differential mode EMI noise. These components pose a potential hazard because they can store unsafe levels of voltage energy after the AC line is disconnected. Generally, resistors in parallel to the X-cap provide a discharge path to meet safety standards. However, this method produces a constant loss while the AC is connected, and contributes to no-load and standby input power consumption. Smart X-cap discharger is included in JW1550 to discharge X-cap only when AC lines unplug is detected.

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

$$t_{\mathrm{d}}(\mathrm{ns}) = K_{\mathrm{d}} * R_{\mathrm{td}}(\mathrm{k\Omega})$$

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 JW1550 can be set by RFM pin to meet different applications. The f_{MAX} is controlled by the resistor connected between RFM pin and GND pin which can be represented as

$$f_{\mathrm{MAX}}(\mathrm{kHz}) = 25 + \frac{5*10^4}{R_{\mathrm{FM}}(\mathrm{k\Omega})}$$

3.5 QR Frequency Quivering

To achieve good EMI performance, frequency quivering method is integrated in JW1550. The frequency quivering in QR operation is achieved by peak current 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 between the CS pin and the current comparator input. The current comparator is disabled and can't turn off the gate during the blanking time.

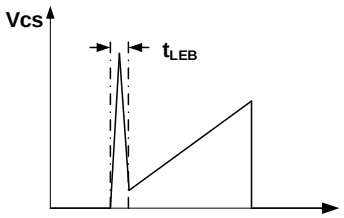


Figure 8: LEB Blanking

3.7 Line Voltage Compensation

The variation of max output power in QR system can be rather large if no compensation is provided. By placing a resistor externally in series on the current sense resistors and the CS pin, JW1550 can compensate the increased output power limit at higher AC voltage.

4. Protections

4.1 VIN OVP/UVP

VIN is the input voltage for the Boost converter. It has internal OVP and UVP 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)

JW1550 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_{D_OLP}. Then the controller shuts down and restarts after t_{FRD}.

4.4 Short-Circuit Protection (SCP)

The JW1550 has short-circuit protection if V_{CS} reaches V_{SCP} after a reduced leading-edge blanking time t_{BLK} for three consecutive cycles. If SCP is trigged, the controller 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_{SC} within t_{BLK}, 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, the JW1550 will integrate the current from VS pin when GON is high. If V_{CS} is below the V_{CS_UVP} when the integral reaches 3.05nC, a CS-UVP fault is asserted and the device shuts down and restarts after t_{FRD}.

4.6 Output OVP/UVP (VS OVP/UVP)

The output over-voltage protection is determined by the voltage feedback on the VS pin. If the voltage sample on VS exceeds over-voltage protection threshold for three consecutive switching cycles, a VS-OVP fault is asserted and the device shuts down and restarts after t_{FRD}.

If the voltage sample on VS pin continues below the under-voltage protection threshold for three consecutive switching cycles, a VS-UVP fault is asserted and the device shuts down and restarts after t_{FRD}.

4.7 Over Temperature Protection (OTP)

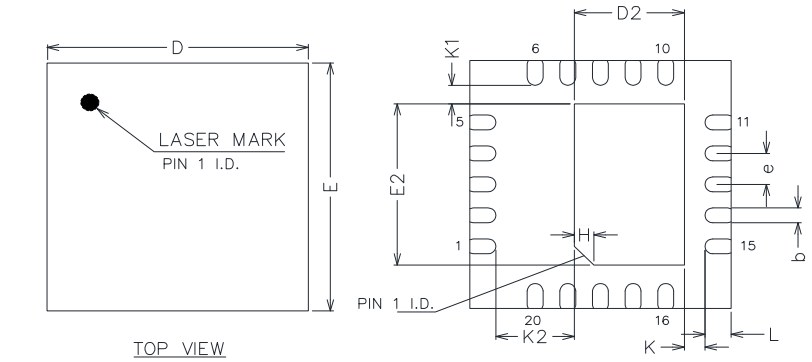
The JW1550 uses an external NTC resistor (R_{NTC}) tied to the OTP pin to program a thermal shutdown temperature near the hotspot of the converter. If the OTP voltage stays lower than the NTC shut-down threshold (V_{NTCTH1}), an OTP fault event is triggered, and V_{NTCTH1} is increased to the NTC recovery threshold (V_{NTCTH2}). The JW1550 resumes operation when the OTP voltage stays higher than V_{NTCTH2}.

4.8 Thermal Shutdown

When the junction temperature of JW1550 exceeds T_{SD}, the controller shuts down. The JW1550 resumes operation when the temperature drops below T_{SD} -T_{HYS}.

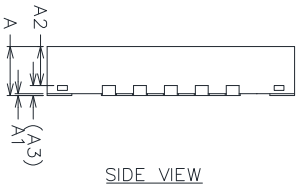
PACKAGE OUTLINE

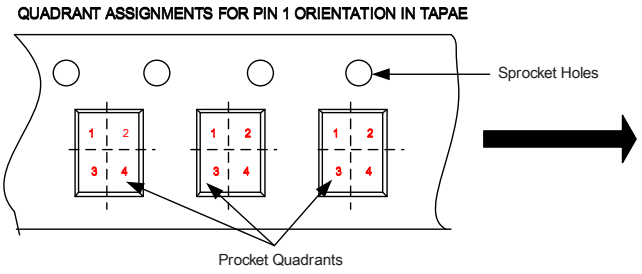
QFN4x4-20 UNIT: mm



(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	





Package Type	Pin1 Quadrant
QFN4*4-20	1

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