MK2606A High Frequency QR Controller

1. Description

MK2606A is a highly integrated quasi resonant (QR) controller for high performance, low standby current, and cost-effective off-line flyback converter applications.

MK2606A integrates a high-precision oscillator with a fixed 135kHz switching frequency. It incorporates certain features including soft-start, slope compensation, and frequency dithering technique. These integrated particular features significantly enhance system stability, reliability, and EMI.

MK2606A offers fairly comprehensive protection features including output over-voltage protection (OVP), output over power protection (OPP), VCC over-voltage protection, BROWN-IN/OUT, pin OPEN/SHORT protection, and output short protection.

MK2606A is available in SOT23-6 package.

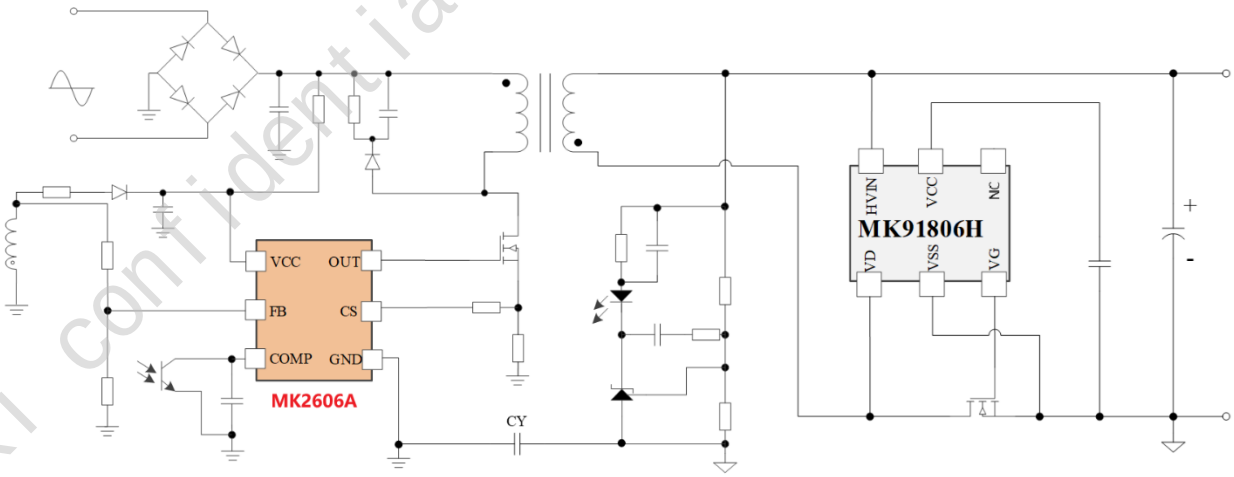
2. Features

- VCC Operating Range (9V to 30V)
- Operating Frequency up to 135kHz
- Proprietary Soft-start Scheme to Achieve Low SR Vds Stress
- Optimized High Efficiency at Light Load
- OPP/SSCP Protection
- Brown-in /Brown-out Function
- VCC OVP /VO OVP Protection
- Pin OPEN/SHORT Protection
- External Programmable OTP Protection
- Frequency dithering for improved EMI
- Tiny SOT23-6 Package

3. Typical Applications

- AC/DC Adapter
- AC/DC general power supply

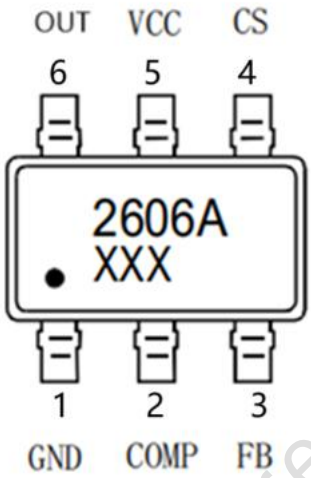
4. Simplified Application



5. Ordering Information

Ordering No.	Description
MK2606AGSA	SOT23-6, 3000 pcs/reel

6. Package Reference



XXX: Lot code

SOT23-6

6.1 Absolute Maximum Ratings(1)

VCC..... -0.3V to +35V

COMP, FB..... -0.3V to +5.5V

CS..... -0.7V to +5.5V

OUT..... -3V to +20V

Operating Junction Temperature..... -40℃ to +125℃

Notes:

(1) Exceeding these ratings may damage the device;

(2) Measured on JESDSD51-7, 4 layers PCB.

6.2 Recommended Operation Conditions

VCC ..... 9V to 30V

Maximum Junction Temp. (T_J)..... +125°C

6.3 Thermal Resistance(2)

θ_{JA}..... 110 °C/W

θ_{JC}.....74°C/W

7. ESD Ratings

		Value	Units
Electrostatic Discharge V_{ESD}	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
	Charged device model (CDM), per JEDEC specification JESD22-C101(2)	±1000	V

Notes:

(1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process

(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process

8. Electrical Characteristics

T_A=25°C, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Supply Management Section						
VCC UVLO Rising	V_{CC_ON}		15	17	19.6	V
VCC UVLO Falling	V_{CC_OFF}		6	7.2	8.5	V
VCC UVLO Hysteresis	V_{CC_HYST}			9.8		V
VCC Startup current	$I_{STARTUP}$		2	3	4	uA
VCC Normal Operating Current	I_{OP}	COMP=2V, GATE=1nF to GND; Fsw=130kHz	2	3	4	mA
Burst Operating Current	I_{BURST}	COMP=0V, GATE=1nF to GND	200	300	400	uA
VCC Hold Threshold	V_{CC_HOLD}		7	8.4	9.6	V
VCC OVP Threshold	V_{CC_OVP}		30	32	34	V
VCC Clamp Threshold	V_{CC_CLAMP}		34	36	38.5	V
Comp Input Section						
COMP Open Voltage	V_{COMP_OP}	COMP pin open-circuited	4	4.7	5.5	V
COMP Short-Circuit Current	I_{COMP_SHORT}	COMP=0V	100	182	250	uA
Burst Mode Entry Voltage	V_{BM_ET}		0.25	0.3	0.35	V
Burst Mode Hysteresis			0.04	0.05	0.06	V
OPP Protection Threshold	V_{OPP}		2.7	3	3.3	V
OPP Deglitch Time(1)	T_{D_OPP}			TSS*10		ms
COMP to CS Gain	A_{VCS}			2.5		V/V
Current Sense Input (CS Pin) Section						
Soft Start Time of CS Threshold	T_{SS}		6.5	9	13	ms

Leading Edge Blanking Time	T_{LEB}		200	220	300	ns
Secondary Rectifier short circuit trigger voltage (OC FAULT)	V_{SR_SH}		1.1	1.2	1.3	V
SR Short circuit deglitch cycles(1)				3		cycles
Cycle by Cycle Current Limit	V_{CS_CBC}	FB=0uA	0.84	0.88	0.94	V
Cycle by Cycle Current Limit	V_{CS_CBC}	IFB=300uA		0.7		V
Comp and Control Delay	T_{DL_CS}		170	185	200	ns
FB Input Section						
Brown-in Detection Threshold	I_{BNI}		90	100	110	uA
Brown-out Detection Threshold	I_{BNO}		80	90	100	uA
Brown-out Deglitch Time(1)	T_{BL_BNO}			Tss*7		ms
FB OVP Threshold	V_{FB_OVP}		2.88	3	3.12	V
FB OVP Deglitch Time(1)	T_{BL_OVP}			7		cycles
FB UVP Threshold (Output Short)	V_{FB_ST}		0.5	0.6	0.7	V
FB UVP Threshold (Output Short) Deglitch Time(1)	T_{BL_ST}			7		cycles
FB Sampling Time	T_{SAMPL}	CS=0.5V		1.6		us
Valley Detection Threshold	I_{FB_VALLEY}		5	10	15	uA
Gate Drive (Out Pin) Section						
GATE Low Level	V_{G_L}		0.1	0.12	0.2	V
GATE High Level	V_{G_H}	VCC=13V, Gate Load=20mA	10.5	11.2	12	V
GATE Clamp Voltage	V_{G_HC}	VCC=21V, Gate Load=0mA	11	12	12.5	V
GATE Rising Time	T_r	C_{load}=1nF	80	115		ns
GATE Falling Time	T_f	C_{load}=1nF	10	25	40	ns
Control Law						
Normal Mode Frequency	F_{sw}_max		117	135	147	kHz
Green Mode Frequency	F_{sw}_green		22	25	30	kHz
Dithering Range(1)				±6		%
Dithering Period(1)		F_{sw}=130kHz		2		ms

Maximum Toff Time(1)	T_{off_MAX}		80	105	200	us
Thermal Shutdown Threshold(1)	Th_{SD}			155		℃
Thermal Shutdown Hysteresis(1)	Th_{SD_hys}			30		℃

Note:

(1) Guaranteed by design

9. Pin Functions

Pin #	Name	Description
1	GND	Ground
2	COMP	Voltage feedback pin
3	FB	Auxiliary voltage sense
4	CS	Current Sense input
5	VCC	Power supply
6	OUT	Output to drive MOSFET

10. Block Diagram

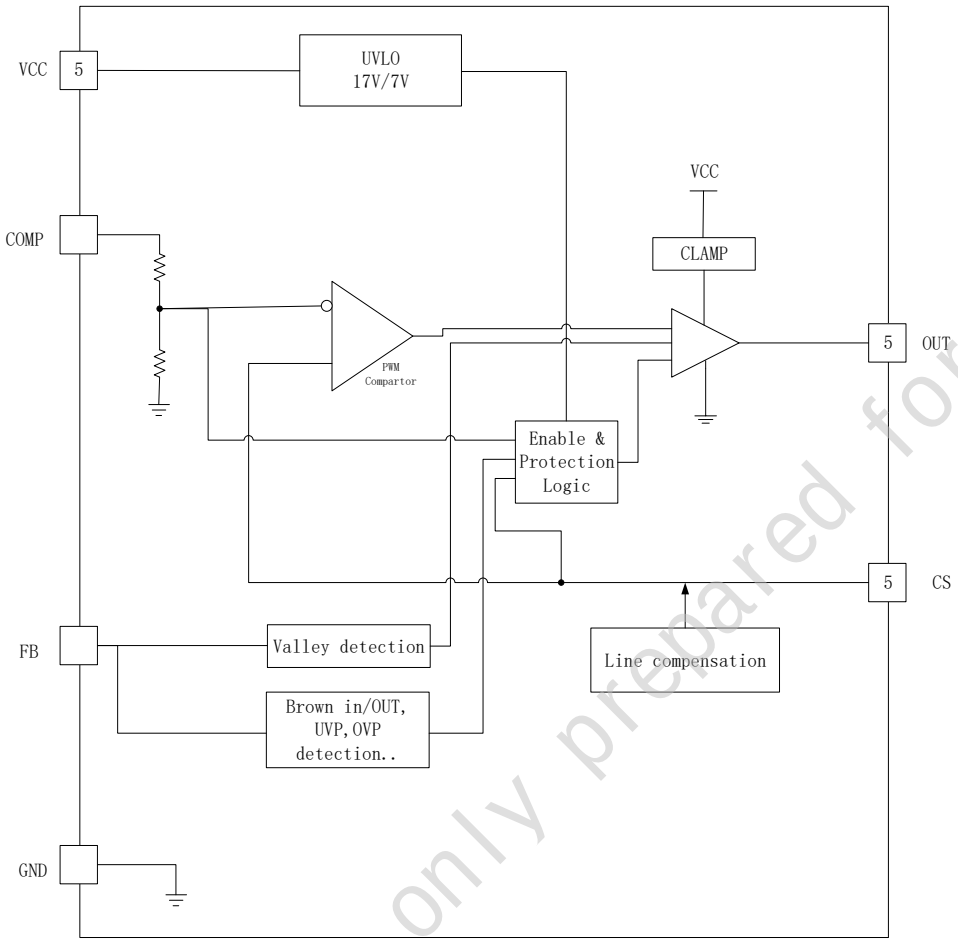


Figure 1. Functional Block Diagram

11. Operation Descriptions

VCC And Startup

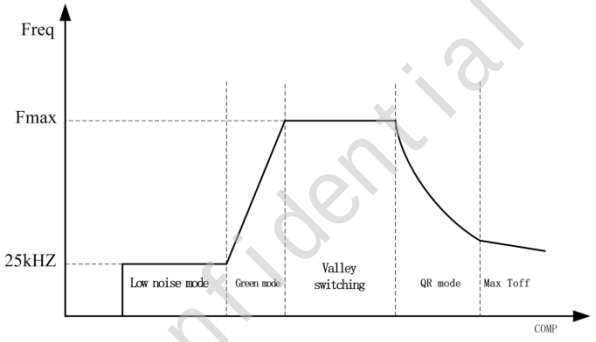
MK2606A has a start-up current of only ~3 uA, allowing the use of a high-value start-up resistor to charge up VCC while minimizing power loss during start-up. Once VCC reaches above UVLO threshold V_{CC_ON}, MK2606A starts switching.

Soft Start

MK2606A features an internal ~9ms soft-start time to reduce electrical stress in the power system during start-up. To further mitigate voltage stresses arising from high peak current and high frequency switching, MK2606A dynamically adjusts its operating frequency and control mode based on the output voltage and the start-up status of the synchronous rectifier controller.

Operation Curve

MK2606A operates in different modes determined by the COMP voltage and output voltage. To optimize efficiency across varying loads, MK2606A monitors the COMP voltage to dynamically adjust the switching frequency and operational mode.



Brown In/ Brown Out

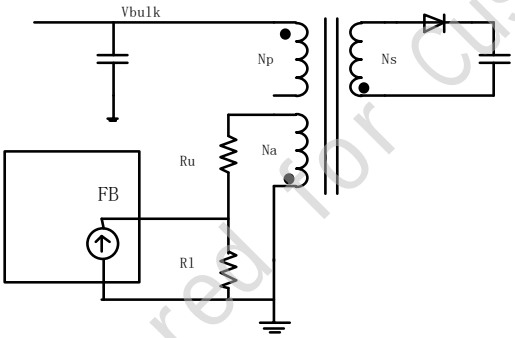
When the power MOSFET is turned on, the voltage at auxiliary windings is negative which makes Brown-in/Brown-out protection feasible.

When system starts up, power MOSFET is on, the current flow out of FB pin is equal to:

$$\frac{V_{BULK} * Na}{Ru * Np}$$

If this current exceeds threshold I_{BNI} for four consecutive switching cycles, the controller starts to soft-start; otherwise, Brown-in auto-recovery protection is triggered.

During normal operation, when power MOSFET is turned on, the current at FB is below threshold I_{BN0} for T_{BL_BNO} (~63ms) period, the controller enters Brown-out auto-recovery protection.



Current Sense

MK2606A is a current-mode PWM controller featuring cycle-by-cycle current limiting. Switch current is monitored via a sense resistor connected to the CS pin. An internal leading-edge blanking circuit with T_{LEB} blanking time blocks the voltage spikes detected during the initial turn-on phase of the power MOSFET, which are caused by snubber diode reverse recovery and surge gate current. The maximum cycle-by-cycle current limit threshold is determined by the formula: V_{CS_CBC}/R_{CS}.

Line Compensation

MK2606A employs the input line voltage detected via the current at FB pin (I_{FB}) to generate an offset voltage. This offset is added to the internal current signal to compensate the output OPP power level. This mechanism ensures a consistent OPP power level over different input voltages.

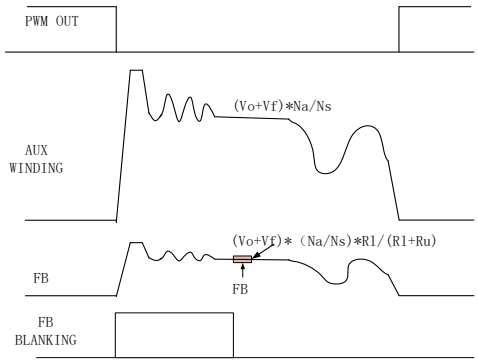
FB Voltage Detection

MK2606A monitors the signal from the auxiliary windings via the FB pin to detect transformer core demagnetization.

During the demagnetization period, the MK2606S monitors the FB voltage to implement the following functions:

1. Output Over-Voltage Protection (OVP):
Initiates protection if FB exceeds V_{FB_OVP} (~3V) for 7 consecutive switching cycles.

2. Output Under-Voltage Protection (Short Circuit):
Activates if FB drops below V_{FB_ST} (~0.6V) for 7 consecutive switching cycles.



MK2606A incorporates a FB blanking time to suppress the switching noise during the initial phase of the transformer demagnetization. The blanking time is adjusted in proportion to the Vcs voltage, as higher peak currents typically generate more pronounced switching noise.

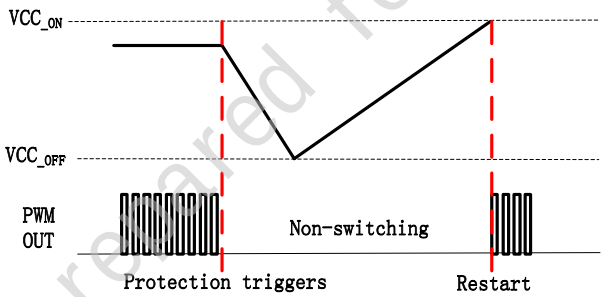
Valley Switching

After secondary side rectification, the primary MOSFET drain voltage starts oscillating at a frequency of approximately $1/2\pi\sqrt{C_{oss}\times L_P}$, where L_p is the inductance of primary winding of the transformer and C_{OSS} is output capacitance of the primary MOSFET. When the auxiliary winding ringing voltage drops below ~0V, the FB pin is clamped to ~0V. The controller monitors the current at FB pin, and upon detecting a predefined threshold, locks in a “possible” valley and turns on the MOSFET after propagation delay. If the DCM ringing dampens too rapidly to detect a valid valley, MK2606A initiates a fixed 3us delay from the falling edge of the internal oscillator clock before turning on the MOSFET.

This control strategy minimizes switching losses by synchronizing transitions with voltage valleys, enhancing efficiency across varying loads while maintaining robust protection features.

Protection

A reliable power supply system is ensured by auto-recovery protection mechanisms, including cycle-by-cycle current limiting, over-power-protection (OPP), output over-voltage protection, and more. Detailed descriptions of these protection features are provided in the subsequent sections.



MK2606A PROTECTION FEATURES	MK2606A PROTECTION SCHEMES
OPP	RESTART
VO_OVP	RESTART
VCC_OVP	RESTART
CS_SHORT	RESTART
SSCP	RESTART
FB_UVP (VO_SCP)	RESTART

Over Power Protection (OPP)

Over-power protection (OPP) is implemented by monitoring the COMP voltage. If the COMP voltage exceeds the threshold V_{OPP} for a duration equivalent to at least 16 times the soft-start period, the controller MK2606A activates auto-recovery OPP protection.

Secondary Short Circuit Protection (SSCP)

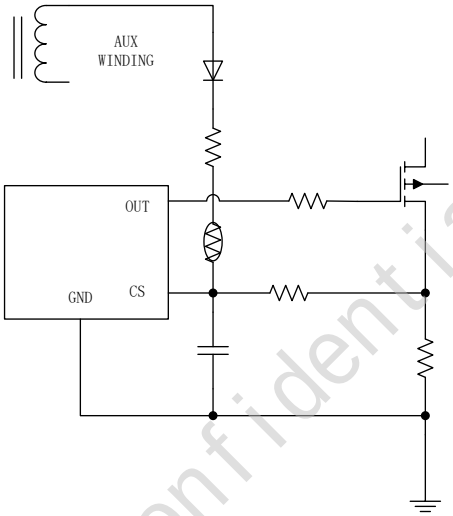
In the event of a secondary side synchronous rectifier short circuit, the peak current rises rapidly upon the power MOSFET turning on. To address this, MK2606A employs a rapid-response protection mechanism:

If the CS pin voltage exceeds the V_{SR_SH} threshold (~1.2V), indicating a potential short-circuit, the controller reduces the current sense blanking time to T_{LEB_SRSH}, and terminates the current switching cycle by turning off the power MOSFET immediately.

If this condition persists for three consecutive switching cycles, the controller transitions to auto-recovery SSCP (Synchronous Rectifier Short-Circuit Protection) mode.

VCC OVP

When the VCC voltage exceeds the over-voltage protection (OVP) threshold V_{CC_OVP}, the output gate driver is immediately shut down to stop the power MOSFET from switching, and the controller enters auto-recovery protection mode.



OTP

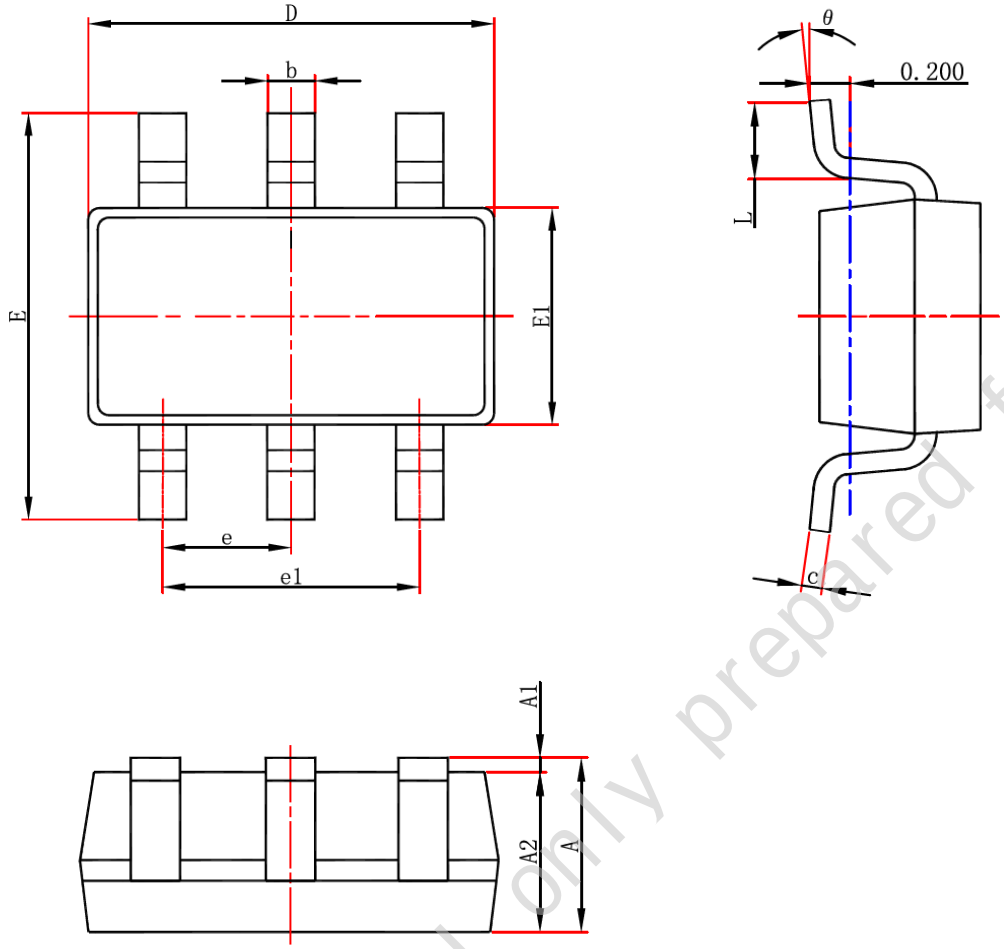
MK2606A integrates over-temperature protection (OTP) with a Th_{SD} triggering temperature. Additionally, external OTP is implemented via the CS pin, which monitors the NTC status by sensing voltage during the MOSFET off-state. If the CS voltage V_{CS} exceeds the V_{CS_CBC} threshold and remains above it for 15 consecutive cycles, OTP is triggered, and MK2606A enters auto-recovery OTP protection mode.

Pin Open Short Protection

The MK2606A incorporates multiple critical protection mechanisms to safeguard the power supply against fault conditions. Protection will be triggered in the following scenarios:

- Adjacent PIN Short
- PIN Open
- CS Short/Open

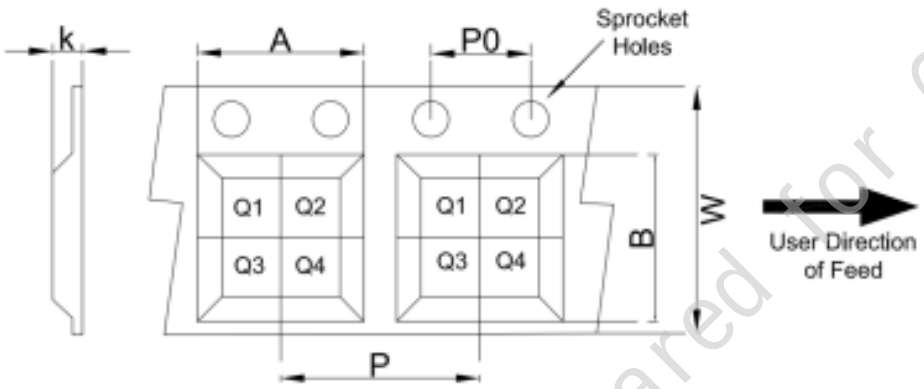
12. Package Information (SOT23-6)

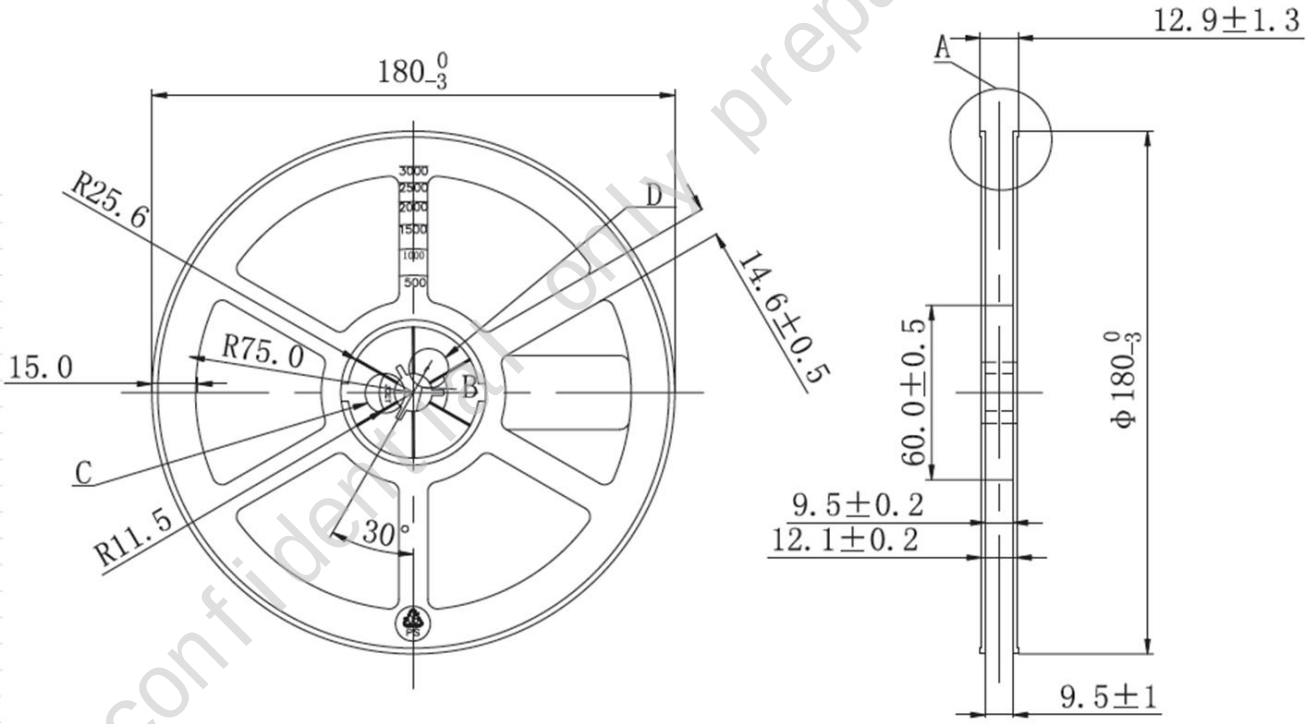


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E1	1.500	1.700	0.059	0.067
E	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

13. Reel and Tape information

Device	Package Type	Pins	SPQ (pcs)	A (mm)	B (mm)	K (mm)	P (mm)	P0 (mm)	W (mm)	Pin1 Quadrant
MK2606AGSA	SOT23-6L	6	3000	3.23±0.1	3.17±0.1	1.37±0.1	4.0±0.1	4.0±0.1	8.0±0.1	Q3





14. Tape and Reel Box Dimensions

Device	Package Type	Pins	SPQ (pcs)	Length (mm)	Width (mm)	Height (mm)
MK2606AGSA	SOT23-6L	6	30000	203	203	195