Wide VCC Range HF QR Controller with Lossless sensing GaN Integrated

1. Description

The MK2706 is a high-frequency quasi-resonant (QR) controller optimized for PD/fast-charge applications. It integrates Meraki's GaN Control technology, featuring lossless current sensing and safe driving capabilities.
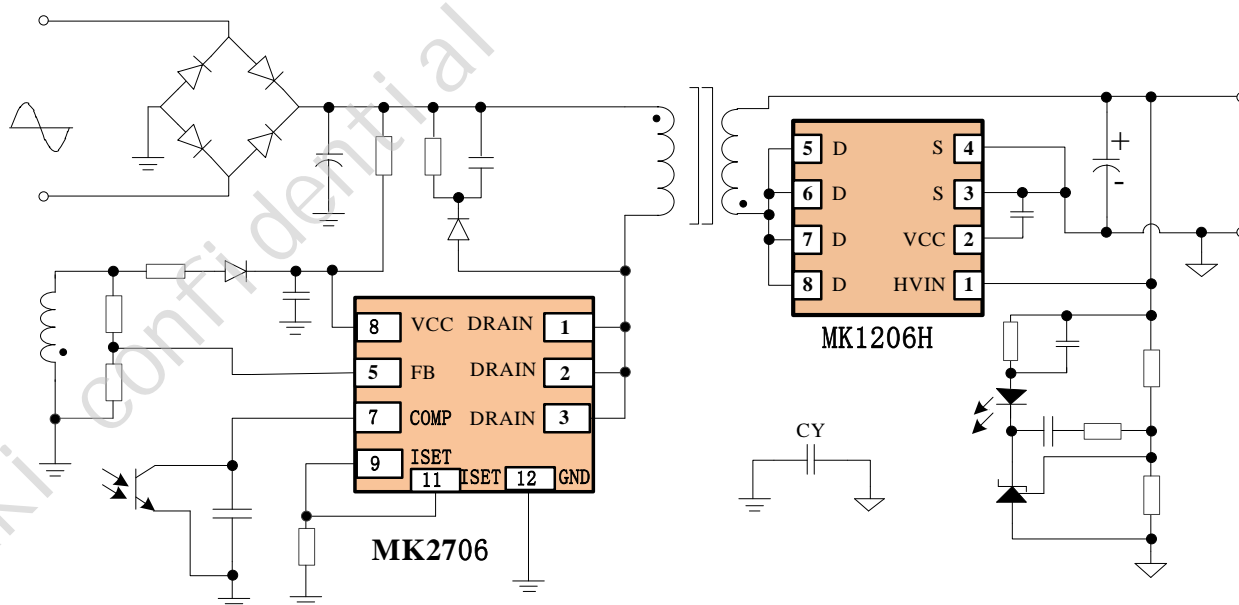
To achieve high efficiency across universal input voltages and varying loads, the MK2706 adaptively operates in DCM/QR mode. At light loads, it switches to burst mode for improved efficiency.

the device provides comprehensive protections including: output over-voltage protection (ovp), output over-power protection (opp), vcc over-voltage protection, brown-in/brown-out protection, iset short-circuit protection.

2. Typical Applications

- 65W AC/DC PD/Adapter
- High Power Density Power Supply

3. Features

- Built-in 700V 170mR GaN FET
- Lossless Current Sensing
- Safe Driving Capability
- Wide VCC Operating Range (9V-85V)
- Operating Frequency up to 130kHz
- Proprietary Soft-start Scheme to Achieve Low SR Vds Stress
- Optimized Efficiency to Easily Meets Energy Efficiency Standards
- ISET Short Protection
- OPP/SSCP Protection
- Brown in/Brown out Function
- VCC OVP/VO OVP Protection
- Support PPS Wide Range Output
- Tiny DFN6X8 Package

4. Simplified Application

5. Ordering Information

Ordering No.	Description
MK2706IDG	DFN6X8, 3000 pcs/reel

6. Package Reference
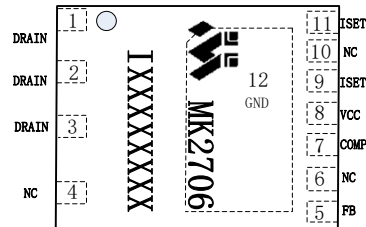
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DFN6X8 Top View

6.1 Absolute Maximum Ratings[1]

VCC……………………………………………… -0.3V to +100V

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

ISET…………………………………………… -0.7V to +5.5V

DRAIN……………………………………………-3V to +700V

I_D…………………………………………………………10A[2]

I_{DM}………………………………………………………22A[3]

Junction Temperature ………………………………… +155℃

6.2 Recommended Operation Conditions

VCC …………………………………………………9V to 85V

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

6.3 Thermal Resistance[4]

θ_{JA}……………………………………………………45 °C/W

θ_{JC}……………………………………………………2°C/W

Notes:

(1) Exceeding these ratings may damage the device;

(2) Tj = 125°C; The maximum continuous drain current is calculated based on the maximum allowable junction temperature;

(3) Tc = 25 °C, Tpulse = 10μs ；Limit was extracted from characterization test, not measured during production；

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

7. Pin Functions

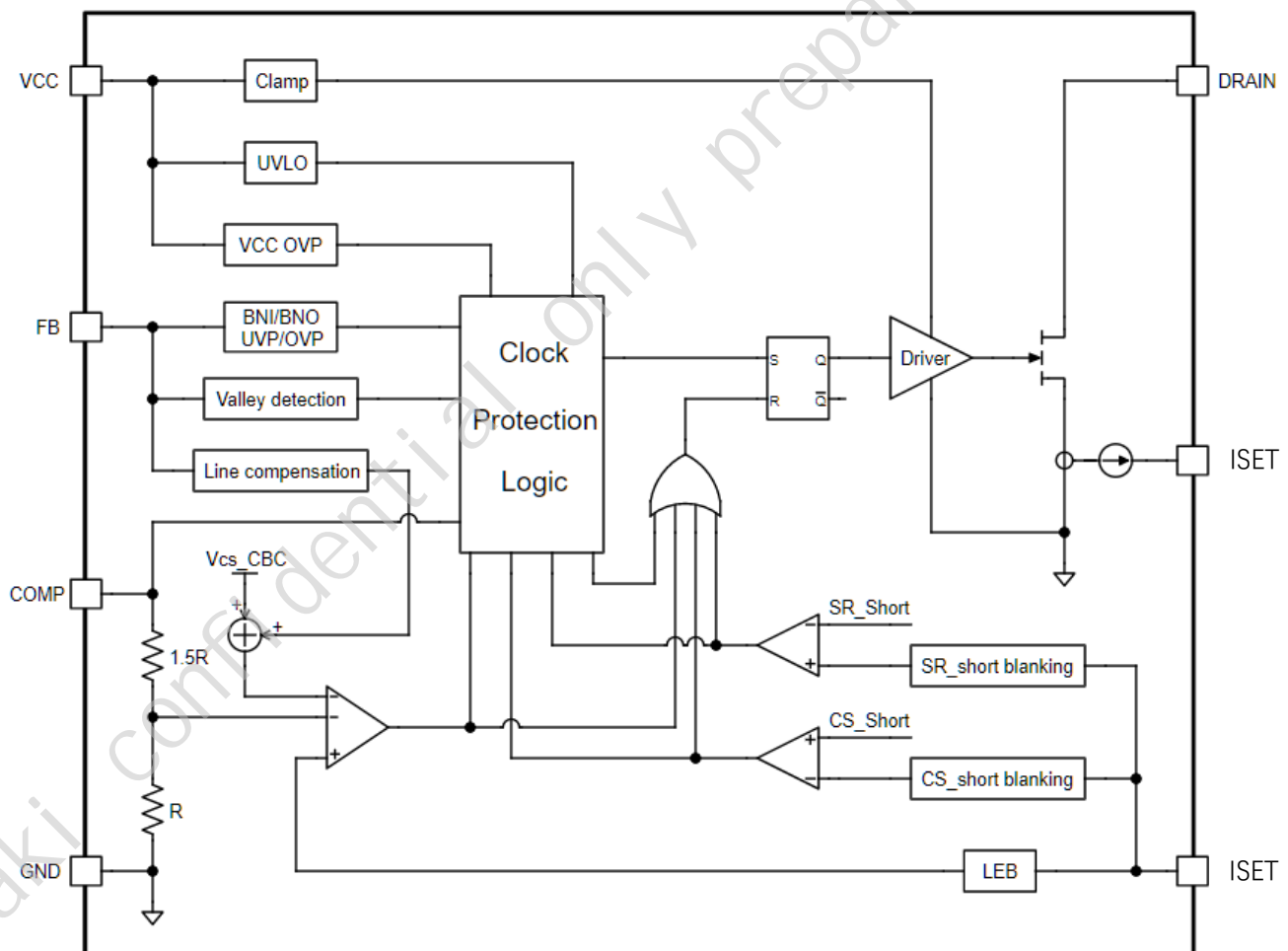| Pin #	Name	Description
1、2、3	DRAIN	HV Power GaN Drain
4、6、10	NC	NC
5	FB	Auxiliary Voltage Sense
7	COMP	Voltage Feedback
8	VCC	Power Supply
9、11	ISET	Current Setting (PIN9 and PIN11 must be connected together in the application)
12	GND	Ground

8. Block Diagram

Figure 1. Functional Block Diagram

9. Electrical Characteristics

VCC=12V, T$_A$=25°C, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
GaN Section						
Maximum Drain Voltage	V$_{DS\_max}$		700			V
Static Drain to Source on Resistance	R$_{DSON}$			170		mΩ
Supply Management Section						
VCC UVLO Rising	V$_{CC\_ON}$		15.5	17.2	19.9	V
VCC UVLO Falling	V$_{CC\_OFF}$		6	7.3	8.4	V
VCC UVLO Hysteresis	V$_{CC\_HYST}$		8.5	10	11.2	V
VCC Startup Current	I$_{STARTUP}$		2	5	8	uA
VCC Normal Operating Current	I$_{OP}$	COMP=2V	0.3	0.6	1.5	mA
Burst Operating Current	I$_{BURST}$	COMP=0V, GATE=1nF to GND	240	290	340	uA
VCC OVP Threshold	V$_{CC\_OVP}$		87	93	100	V
VCC Clamp Threshold	V$_{CC\_CLAMP}$		89	102	110	V
Comp Input Section						
COMP Open Voltage	V$_{COMP\_OP}$	COMP Pin Open-circuited	4	4.4	4.8	V
COMP Short-circuit Current	I$_{COMP\_SHORT}$	COMP=0V	130	160	190	uA
Burst Mode Entry Voltage	V$_{BM\_ET}$		0.27	0.30	0.33	V
Burst Mode Hysteresis	V$_{BM\_HY}$		0.02	0.05	0.09	V
OPP Protection Threshold	V$_{OPP}$		2.8	3.0	3.2	V
OPP Deglitch Time*	T$_{D\_OPP}$			T$_{SS}$*6		mS
Current Sense Input Section						
Soft Start Time of ISET Threshold	T$_{SS}$		4	7	10	mS
Secondary Rectifier Short-circuit trigger voltage (OC FAULT)	V$_{SR\_SH}$		1.1	1.2	1.3	V
SR Short-circuit Deglitch cycles*				3		cycles
Cycle by Cycle Current Limit(low line)	V$_{CS\_CBCL}$	V$_{FB}$<1V,I$_{FB}$=100uA	0.79	0.85	0.91	V

Cycle by Cycle Current Limit(high line)	V_{CS_CBCH}	$V_{FB}<1V, I_{FB}=300uA$	0.56	0.63	0.7	V
ISET Short Protection Threshold	V_{CS_SH}			0.05		V
ISET Short Deglitch cycles*	T_{CS_SH}			3		cycles
Current Sense Gain	K	Id=2.5A	1705	1758	1811	-
FB Input Section						
Brown-in Detection Threshold	I_{BNI}		78	94	109	uA
Brown-out Detection Threshold	I_{BNO}		69	85	100	uA
Brown-out Deglitch Time*	T_{BL_BNO}			T_{SS}*7		mS
FB OVP Threshold	V_{FB_OVP}		3.3	3.6	3.9	V
FB OVP Deglitch Time*	T_{BL_OVP}			7		
FB UVP Threshold (Output Short)	V_{FB_ST}		0.17	0.20	0.23	V
FB UVP Threshold (Output Short) Deglitch Time*	T_{BL_ST}			7		cycles
UVP Blanking Time after SS*	T_{D_ST}			T_{SS}*2		mS
FB High Threshold	V_{FB_H}		1.7	1.9	2.1	V
FB Middle Threshold	V_{FB_M}		1	1.1	1.2	V
Control Law						
Normal Mode Frequency	F_{SW_max}		110	130	150	kHz
Green Mode Frequency	F_{SW_green}		21	25	29	kHz
Dithering Range*				±6		%
Dithering Period*				8		mS
Maximum Toff Time	T_{off_MAX}		80	110	140	uS
Thermal Shutdown Threshold*	Th_{SD}			155		℃
Thermal Shutdown Hysteresis*	Th_{SD_hys}			30		℃

Note:

* Guaranteed by design

10. Operation Descriptions

VCC and Startup

The MK2706's start-up current $I_{STARTUP}$ is only ~5uA so that a large value of start-up resistor can be used to charge up VCC while minimizing power loss during start-up. Once VCC reaches above the V_{CC_ON} (~17.2V) threshold, the MK2706 starts switching.

Soft Start

The MK2706 features an internal soft start T_{SS} (~7mS) to reduce electrical stress in the power system during start-up. To further reduce voltage stresses from high peak current and high frequency switching, the MK2706 operates at optimized frequencies and control modes accordingly to the output voltages and the start-up status of the synchronous rectifier controller.

Operation Curve

The MK2706 has multiple working modes, which can be switched by monitoring the voltage change of COMP. Since the COMP voltage change is consistent with the load change, the MK2706 can automatically switch to the optimal operating mode according to different load conditions. The operation curve of the MK2706 operating mode is shown as in Figure 2:
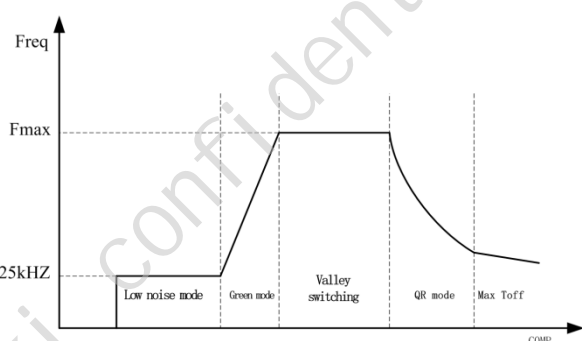

Figure 2: operation curve

Brown in/ Brown out

When the power GaN is turned on, the voltage at auxiliary windings is negative, which makes Brown-in/Brown-out protection feasible by detecting the current at FB pin. When system starts up, and the power GaN is turned on, the current flowing out of FB pin is equal to:

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

If this current is larger than I_{BNI} for four switching cycles, the controller enables soft start. Otherwise, Brown-in restart protection is triggered.

During normal operation, if the current at FB is less than I_{BNO} for at least T_{BL_BNO} (~49mS), the controller enters Brown-out restart protection.
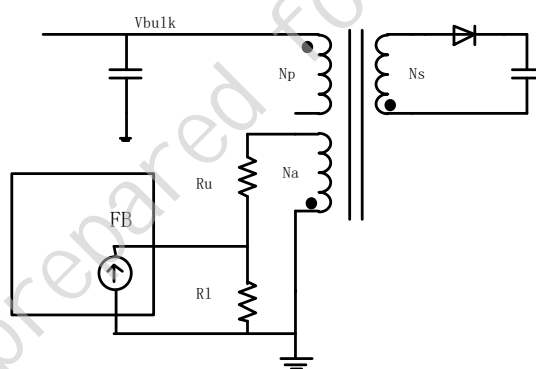

Figure 3: Brown in/Brown out

Current Sense

The MK2706 is current mode PWM controller. The voltage detected on ISET pin is compared with the voltage loop feedback voltage inside the chip to determine the duty ratio. When COMP is at its maximum, the MK2706 also limits the peak current of the primary edge every switching cycle, and its maximum current limit value is $K*V_{CS\_CBC}/R_{ISET}$.

Since ISET resistance is approximately 1758 times of original CS, the spike at the ISET resistance at the moment when the driver is switched on is significantly reduced. However, the MK2706 still keeps ~300nS leading-edge blanking time to prevent PWM controller from mis-triggering.

Line Compensation

The MK2706 uses the detected input line voltage through the current at FB pin to generate the offset voltage added on internal current signal to compensate the output OPP power level. This mechanism helps to achieve flat OPP power level over different input voltage.

Voltage Feedback Loop

COMP is the voltage loop feedback pin which is connected to TL431 output through opto-coupler. In order to support a wide COMP range, a ratio of 1/2.5 resistor divider is used before it goes into PWM comparator.

A ceramic capacitor is suggested to be placed parallel to the resistor which is series with opto-coupler diode.

FB Voltage Detection

The MK2706 detects the transformer core demagnetization by monitoring the signal at the auxiliary windings through FB pin.
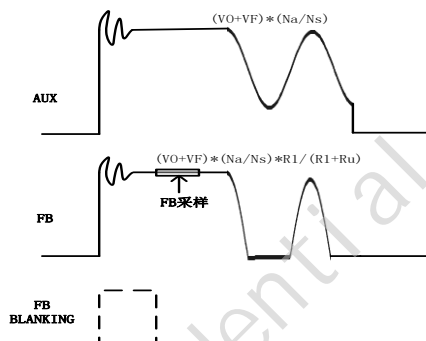

Figure 4: FB detection

After a period of demagnetization time (~1.4uS) of the transformer, the FB sampling voltage is compared with different thresholds. The MK2706 can complete the following functions:

1. Output over voltage protection (OVP): FB is above V_{FB_OVP} (~3.6V) for 7 switching cycles;
2. Output under voltage protection (output short circuit protection): FB is below V_{FB_ST} (~0.2V) for 7 switching cycles;
3. Based on the detected output voltage, the operating control curve is determined.

Valley Switching

After secondary side rectification is complete, the drain voltage starts oscillating with a frequency of approximately $1/2\,\pi\sqrt{Coss \times Lp}$, where Lp is the inductance of primary winding of the transformer and C_{OSS} is capacitance on the drain of primary GaN. When the oscillation ringing is below 0V at the auxiliary winding, the MK2706 clamps the FB pin to 0V, and senses the current at the FB pin. When the current out of FB reaches a designed value, a "possible" valley is locked and the MK2706 turns on after propagation delay.

Protection Function

Reliable power supply system is achieved with restart protections including cycle-by-cycle current limit, over-power protection (OPP), output over-voltage protection, etc. Detailed protection features are described in the following sessions.

The MK2706 protection triggers, will stop the driver, the VCC discharge current makes the VCC capacitor voltage drop. When the VCC voltage drops to V_{CC_OFF} (~7.2V), the VCC capacitor starts charging and reaches V_{CC_ON} (~17.2V), restarting the drive and completing the restart.
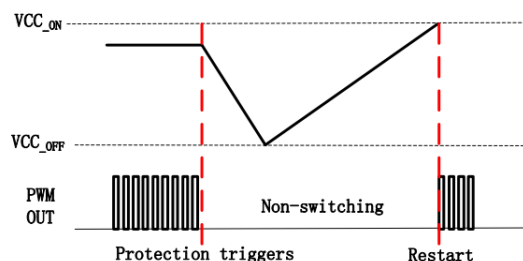

Figure 5: Restart mode

Mk2706 Protection Features	Mk2706 Protection Schemes
OPP	RESTART
VO_OVP	RESTART
VCC_OVP	RESTART
ISET_SHORT	RESTART
SSCP	RESTART
FB_UVP (VO_SCP)	RESTART

Over Power Protection

The OPP protection is achieved by monitoring COMP voltage. If COMP voltage is above V_{OPP} (~3V) for at least 6 times of soft-start time, i.e. Tss*6 (~42mS), the MK2706 enters restart mode.

Cycle by Cycle Current Limiting

The current-mode controller compares the ISET signal with the COMP signal cycle-by-cycle. However, during an output short circuit or an open opto-coupler fault, the COMP voltage can rise excessively, leading to high peak currents and transformer saturation. To mitigate this, the MK2706 implements an additional protection scheme, which compares the ISET voltage with V_{CS_CBC} cycle-by-cycle. After the blanking time of approximately 300ns, if the ISET voltage reaches V_{CS_CBC}, the chip immediately halts the driver output.

Secondary Side SR Short Circuit Protection

If the secondary side synchronous rectifier is short circuited, the peak current increases rapidly after the power GaN is turned on. Therefore, the protection is needed to react in much less wait time. The MK2706 reduces current sense blanking time to 90ns when the ISET pin detects a voltage above V_{SR_SH} (~1.2V) threshold. It immediately stops the driver output. If this condition persists for three consecutive cycles, the MK2706 determines that a secondary SR short circuit has occurred, and it stops the driver and enters the restart mode.

ISET Short Protection

If ISET still fails to reach V_{CS_SH} (~0.05V) after 5us of primary GaN turning on, the MK2706 will force driver shutdown. If this condition occurs for three consecutive periods, the MK2706 enters restart mode.

VCC OVP

Whenever the VCC voltage is higher than the OVP threshold voltage V_{CC_OVP} (~93V), the output gate drive circuit will be shut down to stop the switching of the power GaN, and the MK2706 enters the restart mode.
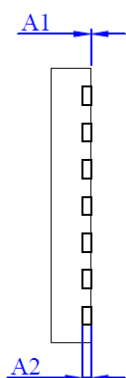
OTP

The MK2706 provides internal over-temperature protection with a trigger point of ~155°C and a hysteresis temperature of ~30°C.
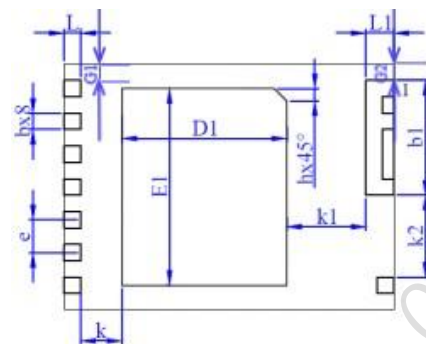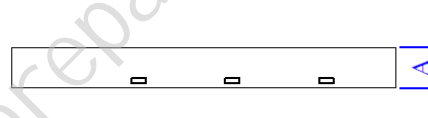
11. Package Information (DFN6X8)
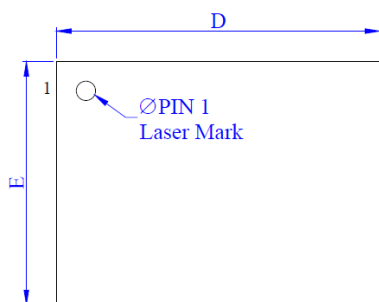

Top view

Side view

Bottom view

Side view

Symbol	Dimensions In Millimeters		
	MIN	**NOM**	**MAX**
A	0.80	0.85	0.90
A1	0.00	-	0.05
b	0.35	0.40	0.45
b1	2.70	2.80	2.90
D	7.90	8.00	8.10
D1	3.90	4.00	4.10
E	5.90	6.00	6.10
E1	4.70	4.80	4.90
e	0.8 BSC		
h	0.20	0.30	0.40
k	0.8 MIN		
K1	1.7 MIN		
K2	1.8 MIN		
L	0.30	0.40	0.50
L1	0.575	0.675	0.775
G1	0.35	0.40	0.45
G2	0.35	0.40	0.45

12. Tape and Reel Information

Device	Package Type	Pins	SPQ (pcs)	A (mm)	B (mm)	K (mm)	P (mm)	P0 (mm)	W (mm)	Pin1 Quadrant
MK2706IDG	DFN6x8-11L	11	3000	6.3±0.1	8.3±0.1	1.0±0.1	8.0±0.1	4.0±0.1	16.0±0.3	Q2
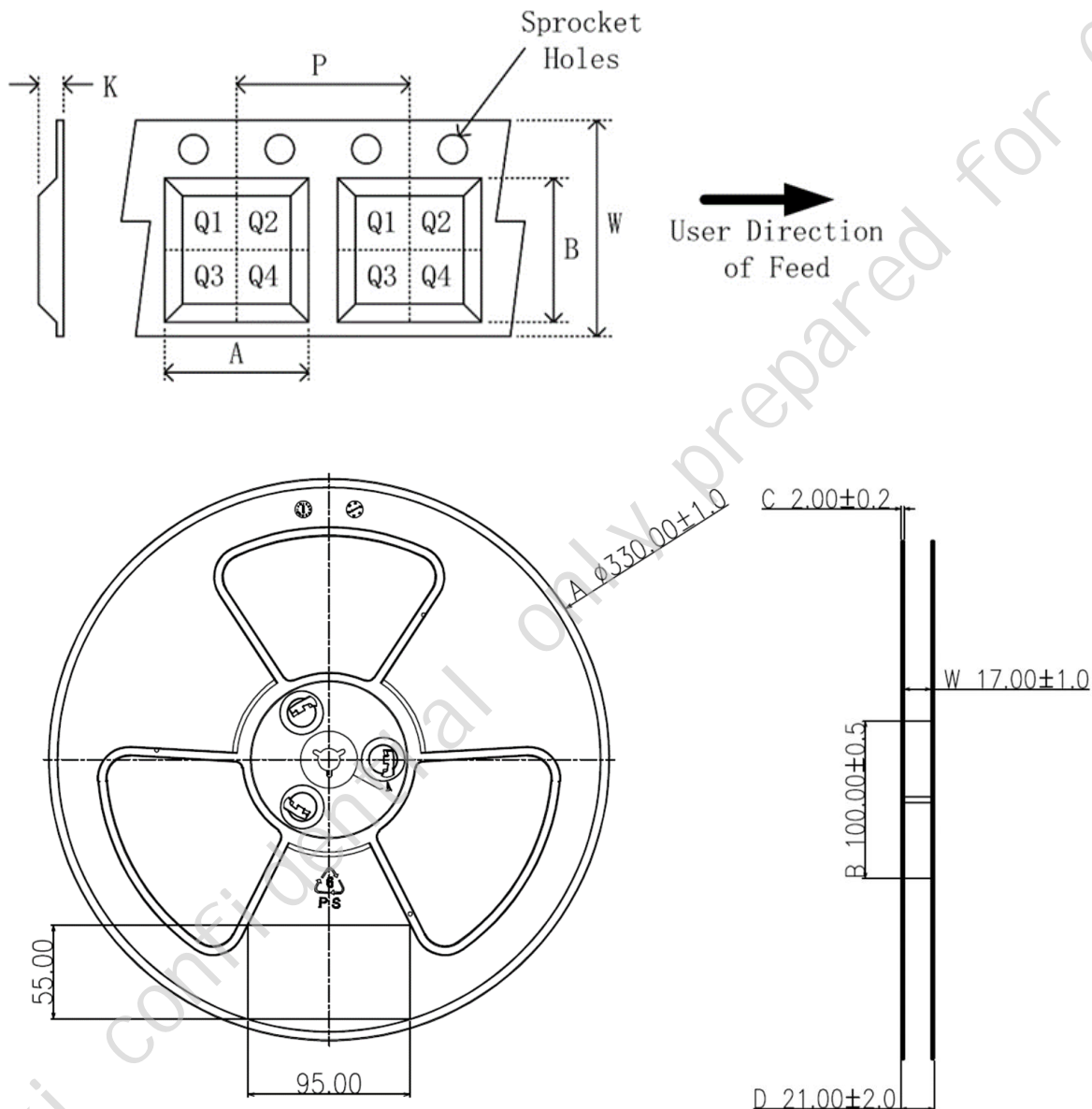
13. Tape and Reel Box Dimensions

Device	Package Type	Pins	SPQ (pcs)	Length (mm)	Width (mm)	Height (mm)
MK2706IDG	DFN6x8-11L	11	6000	360	360	65