General Description

The CT551X is a high performance AC/DC power supply controller for battery charger and adapter applications. The CT551X uses Pulse Frequency Modulation (PFM) method to build discontinuous conduction mode (DCM) fly-back power supplies.

The CT551X provides accurate constant voltage, constant current (CV/CC) regulation without requiring an opto-coupler and the secondary control circuitry. The CT551X can achieve excellent regulation and high average efficiency, meet CEC DOE VI & CoC V5.

The CT551X has a proprietary cable voltage drop compensation function. Internal random frequency modulation to reduce system EMI.

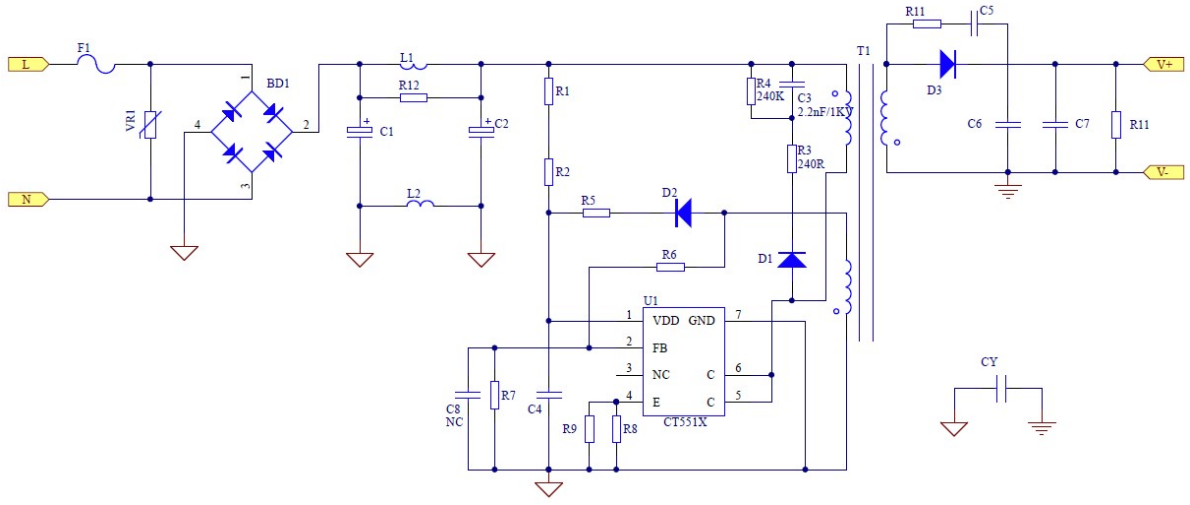
The CT551X integrates functions and protections of Under Voltage Lockout (UVLO), VDD over Voltage Protection (VDD OVP), Cycle-by-cycle Current Limiting (OCP), Short Load Protection (SLP), On-Chip Thermal Shutdown, VDD Clamping, etc

The CT5512S/CT5513S/CT5514S are available in SOP-7 package and CT5515D is available in DIP-7 package.

Features

- Built-in 800V BJT
- Quasi-Resonant Primary Side Regulation (QR-PSR) Control with High Efficiency
- Standby power<70mw
- Low stat-up current <1uA
- High efficiency(Meet Energy Star 6.0)
- Multi-Mode PSR Control
- Fast Dynamic Response
- Built-in Dynamic Base Drive
- Audio Noise Free Operation
- ±5% CC and CV Regulation
- Programmable Cable Drop Compensation (CDC) in CV Mode
- Built-in AC Line & Load CC Compensation
- Build in Protections:
  - Programmable AC Brownout & Line OVP
  - Short Load Protection (SLP)
  - Cycle-by-Cycle Current Limiting (OCP)
  - Leading Edge Blanking (LEB)
  - On-Chip Thermal Shutdown (OTP)
  - VDD OVP & UVP & Clamp

Typical Application



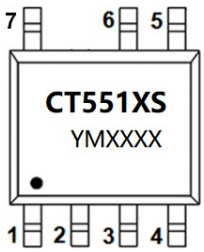
Ordering Information

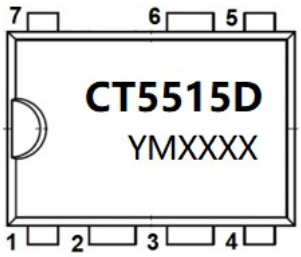
Part Number	Package	Package Method	Marking
CT5512S（SOP-7）	SOP-7	Tape 4,000pcs/Roll	CT5512S XXXXXX
CT5513S（SOP-7）	SOP-7	Tape 4,000pcs/Roll	CT5513S XXXXXX
CT5514S（SOP-7）	SOP-7	Tape 4,000pcs/Roll	CT5514S XXXXXX
CT5515D（DIP-7）	DIP-7	Tube 50pcs/Tube	CT5515D XXXXXX

Pin Assignment

CT551X--Part Number (4 digits);
V：Version(1 digit, optional)

XXXXXX--Date Code (6 digits)





Pin Description

Pin	Pin Name	Description
VDD	1	IC Supply Voltage input
FB	2	Feedback input
NC	3	Not Connect
CS	4	Current sense input
C	5/6	Collector of internal BJT
GND	7	IC Ground

Recommended Operation Conditions

Part Number	230VAC ± 15%(2)	85-265VAC
CT5512S	6.5W	5W
CT5513S	12W	10W
CT5514S	15W	12W
CT5515D	18W	15W

Note 1. The Max. output power is limited by junction temperature

Note 2. Typical continuous power in a non-ventilated enclosed adapter with sufficient drain pattern as a heat sink at 50℃ ambient.

Absolute Maximum Ratings

Parameter	Symbol	Parameter Range	Unit
C pin Voltage(C)	V_C	-0.3~800	V
Supply Voltage（VCC）	V_{VCC}	30	V
FB pin Voltage （FB）	V_{FB}	-0.7~7	V
CS pin voltage （CS）	V_{CS},V_E	-0.3~7	V
OUT pin output current	I_{OUT}	Internal limited	A
Maximum Power Dissipation (Ta=25°C)	P_{tot}	0.45@ SOP-7	W
		0.90@ DIP-7	
Thermal Resistance Junction-ambient	Rthj-a	145@ SOP-7	°C/W
		80@ SOP-7	
Operating Junction Temperature	T_J	-40～150	°C
Storage Temperature Range	T_{STG}	-55～150	°C
V_{ESD_HBM}	Human Body Model	2,000	V
V_{ESD_MM}	Machine Model	200	V

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Exposure to Absolute Maximum Rating conditions for extended periods may affect device reliability。

Recommended Operation Conditions

Parameter	Value	Unit
Supply Voltage, V_{CC}	5 to 19	V
Operating Ambient Temperature	-40 to 85	°C
Maximum Switching Frequency @ Full Loading	70	kHz
Minimum Switching Frequency @ Full Loading	35	kHz

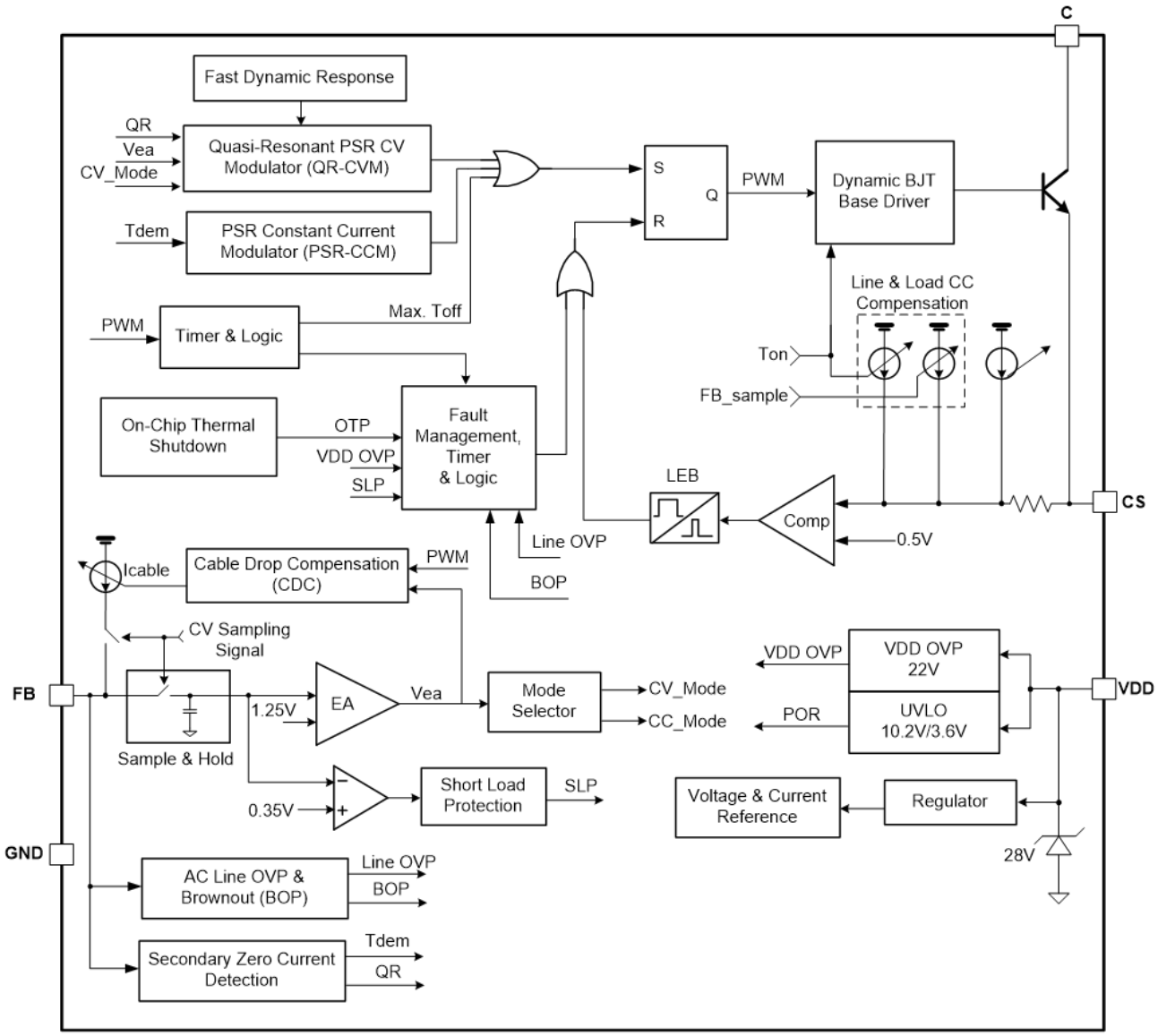
Note2. The device is not guaranteed to function outside its operating conditions.

Electronic Characteristics

T_C =25°C,V_{CC} = 20V,unless otherwise specified						
Symbol	**Parameter**	**Test Conditions**	**Min**	**Typ**	**Max**	**Unit**
Supply Voltage Section(V_{CC} Pin)						
I_{VDD_st}	Start-up current into VDD pin	VDD<V_{DD_ON}		3	20	uA
I_{VDD_Op}	Operation Current			0.8	1.5	mA
$I_{VDD\_standby}$	Standby Current			0.5	1	mA
V_{DD_ON}	VDD Under Voltage Lockout Exit		9	10.2	11.5	V
V_{DD_OFF}	VDD Under Voltage Lockout Enter		3	3.6	4.5	V
V_{DD_OVP}	VDD OVP Threshold		20	22	24	V
V_{DD_Clamp}	VDD Zener Clamp Voltage	I(V_{DD}) = 7 mA		28		V
Control Function Section (FB Pin)						
V_{FBREF}	Internal Error Amplifier (EA) Reference Input		1.23	1.25	1.27	V
V_{FB_SLP}	Short Load Protection (SLP) Threshold			0.35		V
T_{FB_Short}	Short Load Protection (SLP) Debounce Time			36		ms
V_{FB_DEM}	Demagnetization Comparator Threshold			-40		mV
T_{off_min}	Minimum OFF time			2		us
T_{on_max}	Maximum ON time			20		us
T_{off_max}	Maximum OFF time			2.8		ms
I_{Cable_max}	Maximum Cable Drop Compensation(CDC) Current		25	28	32	uA
T_{SW} /T_{DEM}	Ratio between Switching Period and Demagnetization Time in CC Mode			2/1		
I_L	AC Line OVP Threshold Current		870	915	960	uA
I_B	AC Brownout Threshold Current		200	245	250	uA
$T_{\_OVP}$	AC Line OVP Debounce time	Before start up		4		Tsw

		After start up		128		ms
$T_{\_B}$	AC Line BOP Debounce time	Before start up		1		Tsw
		After start up		40		ms
Current Sense Input Section (CS Pin)						
T_{LEB}	CS Input Leading Edge Blanking Time			500		ns
$V_{cs(max)}$	Current limiting threshold		490	500	510	mV
T_{D_OC}	Over Current Detection and Control Delay			100		ns
Power BJT Section (C Pin)						
BV_{CBO}	Collector-Base Breakdown Voltage		800	-		V
Ic	Maximum Collector Current		2.0 @CT5512S			A
			3.0 @CT5513S			
			4.0 @CT5514S			
			8.0 @CT5515D			
On-Chip Thermal Shutdown						
T_Z	Intelligent Thermal Control Threshold	Output Power Shut Down	---	155	--	℃
T_{OTP}	OTP Threshold	Restart		140	--	℃

Functional Block Diagram



Applications Information

Functional Description

The CT551X is a high performance, multi mode, highly integrated Quasi Resonant Primary Side Regulation (QR-PSR) power switch. The built-in high precision CV/CC control with high level protection features makes it suitable for offline small power converter applications.

System Start-Up Operation

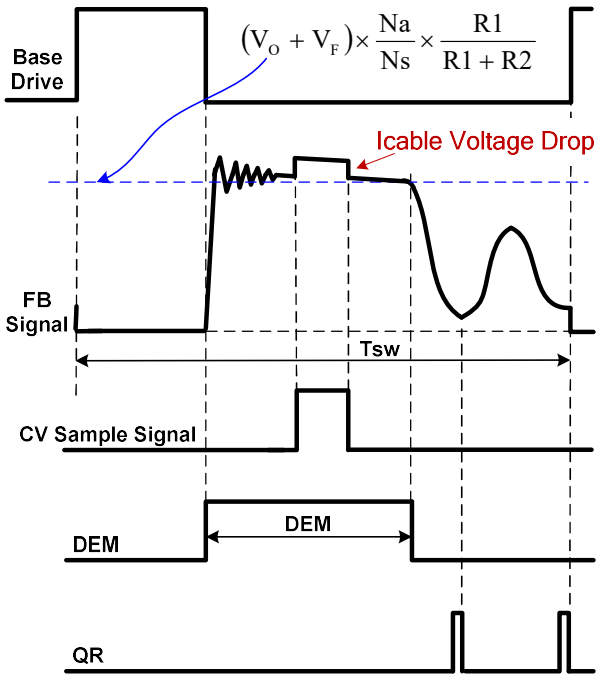
Before the IC starts to work, it consumes only startup current (typically 3uA) which allows a large value startup resistor to be used to minimize the power loss and the current flowing through the

startup resistor charges the VDD hold-up capacitor from the high voltage DC bus. When VDD reaches UVLO turn-on voltage of 10.2V (typical), CT551X begins switching and the IC operation current is increased to be 0.8mA (typical). The hold-up capacitor continues to supply VDD before the auxiliary winding of the transformer takes the control of VDD voltage.

Once CT551X enters very low frequency FM (Frequency Modulation) mode, the operating current is reduced to be 500uA typically, which helps to reduce the standby power loss.

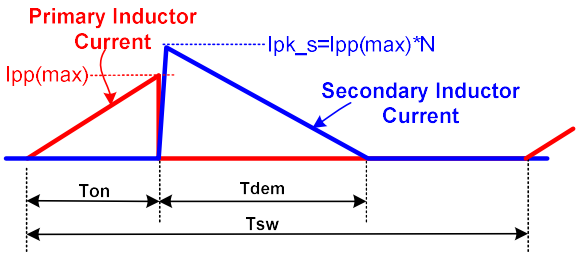
Quasi Resonant PSR CV Modulation (QR-CVM)

In Primary Side Regulation (PSR) control, the output voltage is sensed on the auxiliary winding during the transfer of transformer energy to the secondary. Following Fig. illustrates the timing waveform of CV sampling signal, demagnetization signal (DEM) and quasi-resonant (QR) trigger signal in CT551X. When the CV sampling process is over, the internal sample/hold (S&H) circuit captures the error signal and amplifies it through the internal Error Amplifier (EA). The output of EA is sent to the Quasi Resonant PSR CV Modulator (QR-CVM) for CV regulation. A valley is selected to trigger new PWM cycle by the output of the QR-CVM bock, which is determined by the load. The internal reference voltage for EA is trimmed to 1.25V with high accuracy.



During the CV sampling process, an internal variable current source is flowing to FB pin for Cable Drop Compensation (CDC). Thus, there is a step at FB pin in the transformer demagnetization process, where Vo and VF is the output voltage and diode forward voltage; R1 and R2 is the resistor divider connected from the auxiliary winding to FB Pin, Ns and Na are secondary winding and auxiliary winding respectively.

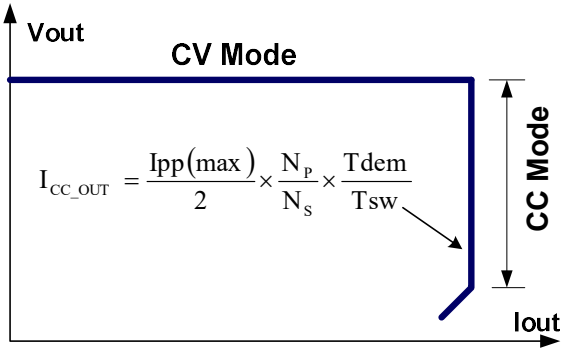
When heavy load condition, the Mode Selector (as shown in “Block Diagram”) based on EA output will switch to CC Mode automatically.



PSR Constant Current Modulation (PSR-CCM)

Timing information at the FB pin and current information at the CS pin allow accurate regulation of the secondary average current. The control law dictates that as power is increased in CV regulation and approaching CC regulation the primary peak current is at Ipp(max), as shown in Fig. on the right.

Referring Fig. on the right, the primary peak current, transformer turns ratio, secondary demagnetization



time (Tdem), and switching period (Tsw) determines the secondary average output current Iout. Ignoring leakage inductance effects, the equation for average output current is shown. When the average output current Iout reaches the regulation reference in the Primary Side Constant Current Modulator (PSR-CCM) block, the CT551X operates in pulse frequency modulation (PFM) mode to control the output current at any output voltage at or below the voltage regulation target as long as the auxiliary winding can keep VDD above the UVLO turn-off threshold.

In CT551X, the ratio between Tdem and Tsw in CC mode is 1/2. Therefore, the average output current can be expressed as:

$$I_{CC\_OUT}(mA) \cong \frac{1}{4} \times N \times \frac{500mV}{Rcs(\Omega)}$$

Where,

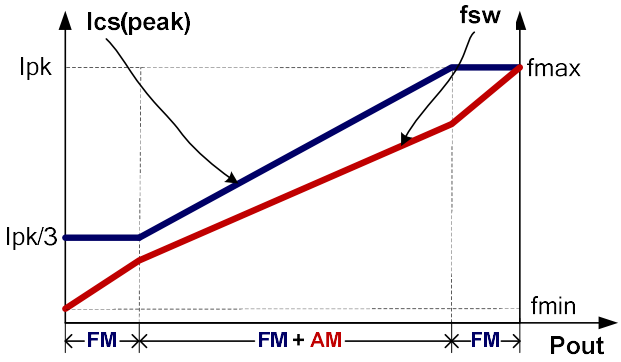
N----The turn ratio of primary side winding to secondary side winding.

Rcs--- the sensing resistor connected between the power BJT emitter to GND.

Multi Mode Control in CV Mode

To meet the tight requirement of averaged system efficiency and no load power consumption, a hybrid of frequency modulation (FM) and amplitude modulation (AM) is adopted in CT551X which is shown in the below Fig.

Around the full load, the system operates in FM mode. When normal to light load conditions, the IC operates in FM+AM mode to achieve excellent regulation and high efficiency. When the system is near zero loading, the IC operates in FM again for standby power reduction. In this way, the no-load consumption can be less than 70mW.



Programmable AC Brownout & Line-OVP

By monitoring the current flowing out of FB PIN (I_{FB}), when the primary BJT is turned on, the controller protects the SMPS against the abnormal condition. When I_{FB} falls below I_BO (typical 245uA), brownout is triggered, the controller stops pulsing after 40ms later. when I_{FB} is above I_{Line_OVP} (typical 915uA), line OVP is triggered and stops pulsing after 128ms later. By adjusting the R_{FBH}, the up FB setting resistor, the AC Line-OVP threshold V_{Line_OVP} can be modified:

$$V_{Line\_OVP} \approx \frac{1}{\sqrt{2}} \times I_{Line\_OVP} \times R_{FBH} \times \frac{Np}{Na}$$

Where, Np is the Primary winding turns, Na is the Auxiliary winding turns;

The ratio between AC brownout & Line-OVP threshold VB and VLine_OVP is constant:

$$\frac{V_{Line\_ovp}}{V_B} \approx 3.73$$

Fast Dynamic Response

In CT551X, the dynamic response performance is optimized to meet USB charge requirements.

On Chip Thermal Shutdown (OTP)

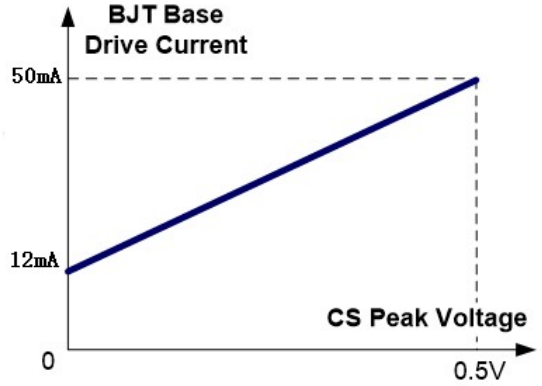
When the CT551X temperature is over 155℃, the IC shuts down. Only when the IC temperature drops to 140℃, IC will restart.

Audio Noise Free Operation

As mentioned above, the multi-mode CV control with a hybrid of FM and AM provides frequency modulation. An internal current source flowing to CS pin realizes CS peak voltage modulation. In CT551X, the optimized combination of frequency modulation and CS peak voltage modulation algorithm can provide audio noise free operation from full loading to zero loading.

Dynamic BJT Base Drive

CT551X integrates a dynamic base drive control to optimize efficiency. The BJT base drive current ranges from 12mA to 35mA (typical), and is dynamically controlled according to the power supply load change. The higher the output power, the higher the based current. Specifically, the base current is related to CS peak voltage, as shown in Fig on the right.



Short Load Protection (SLP)

In CT551X, the output is sampled on FB pin and then compared with a threshold of UVP (0.35V typically) after an internal blanking time (36ms typical).

In CT551X, when sensed FB voltage is below 0.35V, the IC will enter into Short Load Protection (SLP) mode, in which the IC will enter into auto recovery protection mode.

VDD Over Voltage Protection (OVP) and Zener Clamp

When VDD voltage is higher than 22V (typical), the IC will stop switching. This will cause VDD fall down to be lower than VDD_OFF (typical 3.6V) and then the system will restart up again. An internal 28V (typical) zener clamp is integrated to prevent the IC from damage.

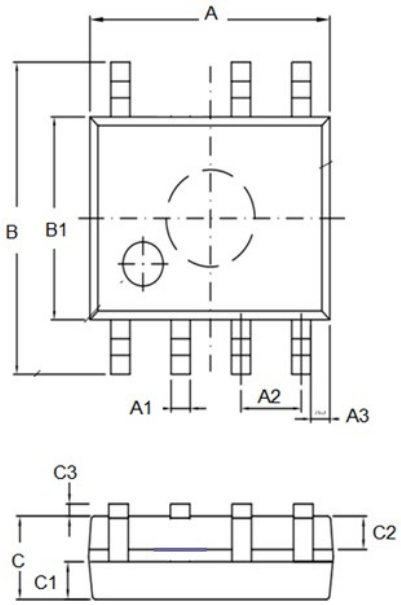
Frequency Shuffling function

The CT551X has built-in frequency shuffling function to reduce system EMI.

SOP-7 MECHANICAL DATA

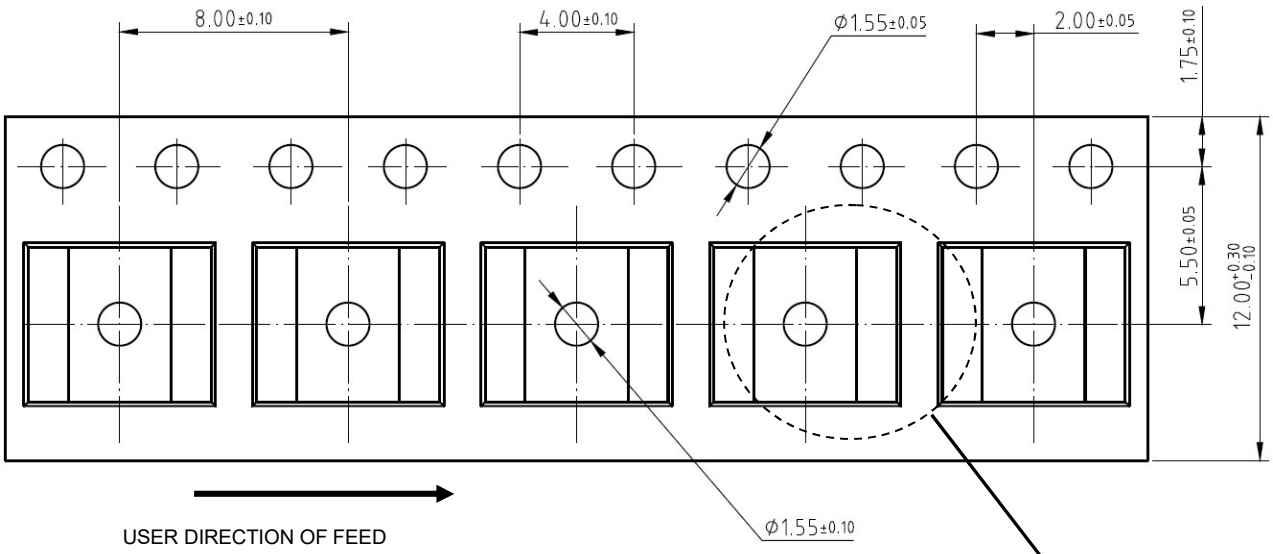
UNIT：mm

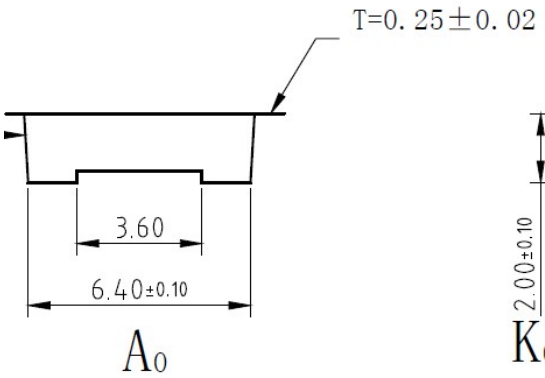
SYMBOL	min	nomarl	max	SYMBOL	min	nomarl	max
A	4.80		5.00	C	1.30		1.50
A1	0.37		0.47	C1	0.55		0.75
A2		1.27 TYP		C2	0.55		0.65
A3		0.41 TYP		C3	0.05		0.20
B	5.80		6.20	C4	0.19	0.20TYP	0.23
B1	3.80		4.00	D		1.05TYP	
B2		5.0TYP		D1	0.40		0.62

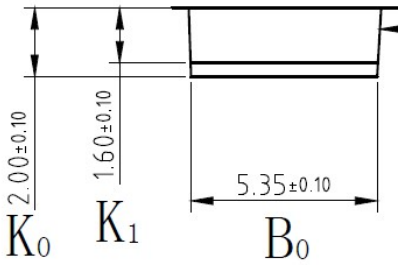


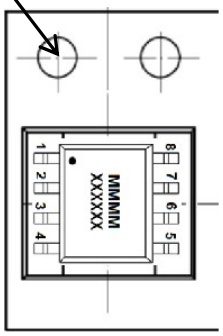
SOP-7/8 (13")TAPE AND REEL DATA

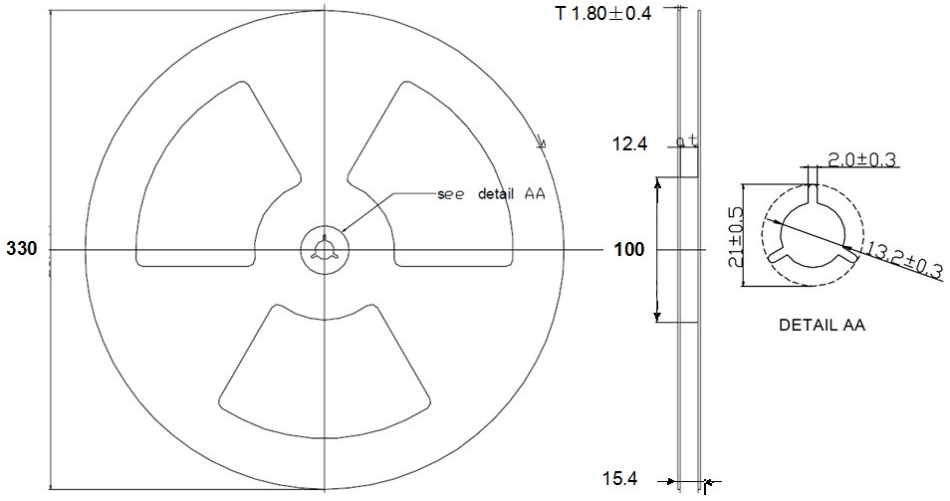
UNIT：mm









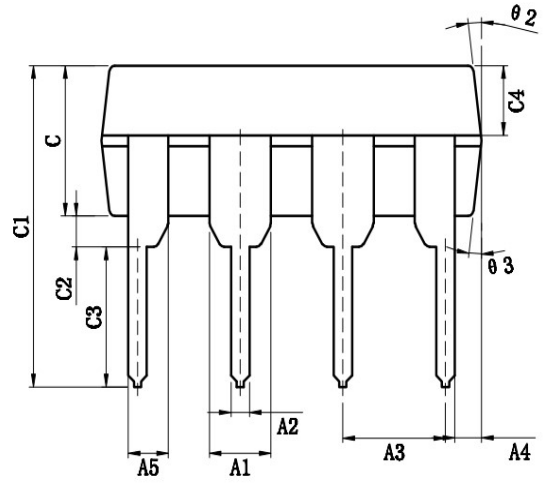


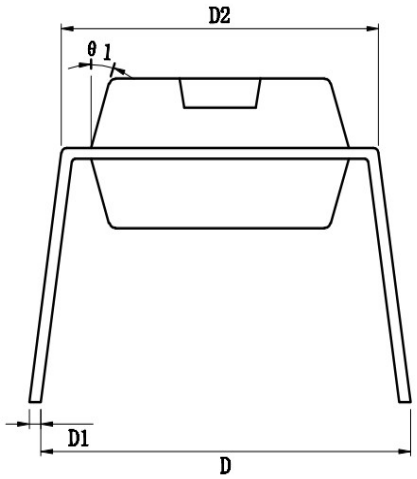
13" REEL

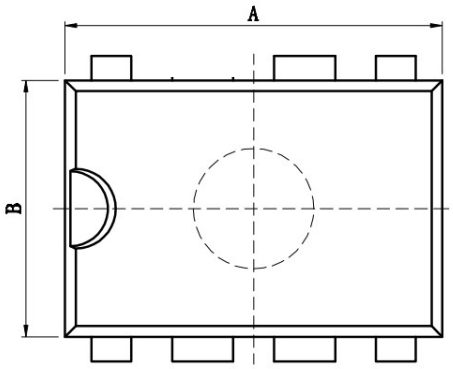
DIP-7 MECHANICAL DATA

UNIT：mm

SYMBOL	min	nomarl	max	SYMBOL	min	nomarl	max
A	9.00		9.20	C2		0.50TYP	
A1	1.474		1.574	C3	3.20		3.40
A2	0.41		0.51	C4	1.47		1.57
A3	2.44		2.64	D	8.20		8.80
A4		0.51TYP		D1	0.244		0.264
A5		0.99TYP		D2	7.62		7.87
B	6.10		6.30	Θ1		17°TYP4	
C	3.20		3.40	Θ2		10°TYP4	
C1	7.10		7.30	Θ3		8°TYP	







Revision history

Revision	Release data	Description
1.0	2018-03-18	Initial Version