Messrs.

TPV Technology Ltd.

Specifications of

SSC9522S

LF No.－

RoHS Directive Compliance

Received by

Approved by	Checked by	Prepared by
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製　品　仕　様　書

品名：SSC9522S

LF No.－

鉛フリー品 Pb Free	RoHS 指令対応 RoHS Directive Compliance

承認	審査	作成
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1 適用範囲
Scope

この規格は、スイッチングレギュレータ用モノリシック IC SSC9522S について適用する。
The present specifications shall apply to a Monolithic IC type SSC9522S for switching regulators.

2 概要
Outline

種別 Type	モノリシック IC Monolithic IC
構造 Structure	樹脂封止型（トランスファーモールド） Plastic mold package (Transfer mold)
主用途 Applications	スイッチングレギュレータ Switching regulator

3 絶対最大定格 (Ta=25℃)
Absolute maximum ratings (Ta=25℃)

項目 Parameter	端子 Terminal	記号 Symbol	規格値 Ratings	単位 Unit	備考 Note
Vsen 端子電圧 Vsen terminal voltage	1-4	Vsen	−0.3〜V_{Reg}	V	
制御部電源電圧 Input voltage for control part	2-4	V_{CC}	−0.3〜+35	V	
FB 端子電圧 FB terminal voltage	3-4	V_{FB}	−0.3〜+10	V	
Css 端子電圧 Css terminal voltage	5-4	V_{Css}	−0.3〜+12	V	
RC 端子電圧 RC terminal voltage	7-4	V_{RC}	−6〜+6	V	
RV 端子電流 RV terminal current	9-4	I_{RV}	−2〜+2	mA	DC
			−100〜+100	mA	パルス 40ns Pulse 40ns
OC 端子電圧 OC terminal voltage	6-4	V_{OC}	−6〜+6	V	
VGL 端子電圧 VGL terminal voltage	11-4	VGL	V_{Reg}+0.3	V	
Reg 端子流出電流 Reg terminal source current	8-4	I_{Reg}	−20.0	mA	
VB−VS 端子間電圧 Voltage between VB and VS terminal	14-15	V_B-V_S	−0.3〜+15.0	V	
VS 端子電圧 VS terminal voltage	15-4	V_S	−1〜+600	V	
VGH 端子電圧 VGH terminal voltage	16-4	VGH	V_B+0.3	V	
動作周囲温度 Operating ambient temperature	—	T_{op}	−20〜+85	℃	
保存温度 Storage temperature	—	T_{stg}	−40〜+125	℃	
ジャンクション温度 Junction temperature	—	Tj	+150	℃	

注 この製品の 14、15、16 番端子のサージ耐量(ヒューマンボディモデル)は、1000V 保証となっております。その他の端子は 2000V 保証となります。
Note Surge voltage withstand (Human body model) of terminal No.14, 15, 16 of this IC is guaranteed 1000V. Other terminals are guaranteed 2000V.

4 電気的特性
Electrical characteristics

4-1 制御部電気的特性 特記なき場合の条件 V_{CC}＝15V（Ta=25℃）
Electrical characteristic for control part V_{CC}=15V(Ta=25℃), unless otherwise specified.

項目 Parameter	端子 Terminal	記号 Symbol	規格値 Rating MIN	TYP	MAX	単位 Unit	備考 Remark
スタート回路／回路電流 Start / Circuit current							
動作開始電源電圧 Operation start voltage	2-4	V_{CC}(ON)	10.2	11.8	13.0	V	
動作停止電源電圧 Operation stop voltage	2-4	V_{CC}(OFF)	8.8	9.8	10.9	V	
動作時回路電流 Circuit current in operation	2-4	I_{CC}(ON)	－	－	20.0	mA	
非動作時回路電流 Circuit current in non-operation	2-4	I_{CC}(OFF)	－	－	1.2	mA	V_{CC}=9V
ラッチ動作時回路電流 Circuit current in latch-operation	2-4	I_{CC}(L)	－	－	1.2	mA	V_{CC}=11V
OLP ラッチ／外部ラッチ OLP latch / Latch from outside							
FB 端子流出電流 FB terminal source current	3-4	I_{FB}	-30.5	-25.5	-20.5	μA	
FB 端子しきい値電圧 FB terminal threshold voltage	3-4	V_{FB}	6.55	7.05	7.55	V	
Css 端子しきい値電圧(1) Css terminal threshold voltage(1)	5-4	V_{Css}(1)	7.0	7.8	8.6	V	
ラッチ解除 V_{CC} 電圧 Latch circuit release V_{CC} voltage	2-4	V_{CC} (La.off)	6.7	8.2	9.5	V	$Vcc_{(La.off)}$ <$Vcc_{(OFF)}$
発振器 Oscillator							
最低周波数 Minimum frequency	11-10 16-15	$F_{(MIN)}$	26.2	28.3	31.2	kHz	
最高周波数 Maximum frequency	11-10 16-15	$F_{(MAX)}$	265	300	335	kHz	
最大デッドタイム Maximum dead-time	11-10 16-15	$T_{d(MAX)}$	1.90	2.45	3.00	μs	
最小デッドタイム Minimum dead-time	11-10 16-15	$T_{d(MIN)}$	0.25	0.50	0.75	μs	
コントロール Control							
バースト開始 FB 端子電流 Burst mode start FB terminal source current	3-4	I_{cont}(1)	-2.9	-2.5	-2.1	mA	
発振出力停止 FB 端子電流 Oscillation stop FB terminal source current	3-4	I_{cont}(2)	-3.7	-3.1	-2.5	mA	
ソフトスタート Soft start							
Css 端子チャージ電流 Css terminal charge current	5-4	I_{Css}(C)	-0.21	-0.18	-0.15	mA	
Css 端子リセット電流 Css terminal reset current	5-4	I_{Css}(R)	1.0	1.8	2.4	mA	V_{CC}=9V

項目 Parameter	端子 Terminal	記号 Symbol		規格値 Rating MIN	TYP	MAX	単位 Unit	備考 Remark
過電圧保護／過熱保護 Over voltage protection / Thermal protection								
OVP 動作 V_{CC} 電圧 OVP operating V_{CC} voltage	2-4	V_{OVP}		28.0	31.0	34.0	V	
熱保護動作温度 Thermal shutdown operating temperature	—	$Tj_{(TSD)}$		150	—	—	℃	
電流共振検出／過電流保護 Detection of current resonant／Over current protection								
電流共振外れ検出電圧 Uncontrollability detection voltage	7-4	V_{RC}		±0.055	±0.155	±0.255	V	
RC 端子しきい値電圧(Hi speed) RC terminal threshold voltage (Hi speed)	7-4	V_{RC}(S)		±2.15	±2.35	±2.55	V	
OC 端子しきい値電圧(Low) OC terminal threshold voltage(Low)	6-4	V_{OC}(L)		1.42	1.52	1.62	V	
OC 端子しきい値電圧(High) OC terminal threshold voltage (High)	6-4	V_{OC}(H)		1.69	1.83	1.97	V	
OC 端子しきい値電圧(Hi speed) OC terminal threshold voltage (Hi speed)	6-4	V_{OC}(S)		2.15	2.35	2.55	V	
Css 端子シンク電流 Css terminal sink current	5-4	I_{Css}	(L)	1.0	1.8	2.4	mA	
			(H)	12.0	20.0	28.0		
			(S)	11.0	18.3	25.0		
電圧共振検出 Detection of voltage resonant								
電圧共振検出端子電圧(1) RV terminal voltage detect Resonance voltage(1)	9-4	V_{RV}(1)		3.8	4.9	5.4	V	
電圧共振検出端子電圧(2) RV terminal voltage detect Resonance voltage(2)	9-4	V_{RV}(2)		1.20	1.77	2.30	V	
スタンバイ Stand by								
バースト周波数 Burst oscillation frequency	5-4	f_{CSS}		70	105	130	Hz	
ON／OFF ON／OFF								
Css 端子しきい値電圧(2) Css terminal threshold voltage (2)	5-4	V_{Css}(2)		0.50	0.59	0.68	V	
入力電圧検出機能 Input voltage detect function								
Vsen 端子しきい値電圧(ON) Vsen terminal threshold voltage (ON)	1-4	Vsen(ON)		1.32	1.42	1.52	V	
Vsen 端子しきい値電圧(OFF) Vsen terminal threshold voltage (OFF)	1-4	Vsen(OFF)		1.08	1.16	1.24	V	
ドライバー電源 Supply of driver circuit								
ドライバー電源電圧 V_{Reg} terminal output voltage	8-4	V_{Reg}		9.9	10.5	11.1	V	

項目 Parameter	端子 Terminal	記号 Symbol	規格値 Rating MIN	TYP	MAX	単位 Unit	備考 Remark
ハイサイドドライバー High-side driver							
ハイサイドドライバー動作開始電圧 High-side drive operation start voltage	14-15	V_{BUV}(ON)	6.3	7.3	8.3	V	
ハイサイドドライバー動作停止電圧 High-side drive operation stop voltage	14-15	V_{BUV}(OFF)	5.5	6.4	7.2	V	
ドライブ回路 Drive circuit							
出力ソース電流１ VGL,VGH terminal out-flow source Current	11-10 16-15	$IGL_{SOURCE}1$ $IGH_{SOURCE}1$	—	515	—	mA	V_{Reg}=10.5V V_B=10.5V VGL=0V VGH=0V
出力シンク電流１ VGL,VGH terminal in-flow sink Current	11-10 16-15	$IGL_{SINK}1$ $IGH_{SINK}1$	—	-685	—	mA	V_{Reg}=10.5V V_B=10.5V VGL=10.5V VGH=10.5V
出力ソース電流２ VGL,VGH terminal out-flow source Current	11-10 16-15	$IGL_{SOURCE}2$ $IGH_{SOURCE}2$	50	85	120	mA	V_{Reg}=12V V_B=12V VGL=10.5V VGH=10.5V
出力シンク電流２ VGL,VGH terminal in-flow sink Current	11-10 16-15	$IGL_{SINK}2$ $IGH_{SINK}2$	-160	-113	-70	mA	V_{Reg}=12V V_B=12V VGL=1.5V VGH=1.5V

4-2 熱抵抗
Thermal resistance

項目 Parameter	記号 Symbol	規格値 Rating MIN	TYP	MAX	単位 Unit	備考 Remarks
MIC ジャンクション・エアー間 MIC junction-air	θj-a	—	—	95	℃/W	

4-3 測定条件
Measurement conditions

項目 Parameter	測定回路 Measure-ment circuit	測定条件 Measurement conditions
動作開始電源電圧 Operation start voltage	1	発振動作が開始する V_{CC} 電圧値(Vsen=3V) V_{CC} Voltage to start oscillation operation.(Vsen=3V)
動作停止電源電圧 Operation stop voltage		発振動作が停止する V_{CC} 電圧値(Vsen=3V) V_{CC} Voltage to stop oscillation operation.(Vsen=3V)
動作時回路電流 Circuit current in operation	2	最高周波数発振動作時、I_{CC} 電流値(I_{FB}=-2mA) I_{CC} current in oscillation at maximum frequency.(I_{FB}=-2mA)
非動作時回路電流 Circuit current in non-operation	1	動作開始前の I_{CC} 電流値(Vcc=9V、Vsen=3V) Quiescent I_{CC} current.(Vcc=9V、Vsen=3V)
ラッチ動作時回路電流 Circuit current in latch-operation		OVP 動作後の V_{CC}=11V 時の I_{CC} 電流値(Vsen=3V) In-flow current into V_{CC} terminal in latch operating at V_{CC}=11V. (Vsen=3V)
FB 端子流出電流 FB terminal source current	3	I_{FB} 電流値(V_{FB}=5V) I_{FB} current.(V_{FB}=5V)
FB 端子しきい値電圧 FB terminal threshold voltage		発振動作が停止する V_{FB} 電圧値 V_{FB} voltage to stop oscillation operation.
Css 端子しきい値電圧(1) Css terminal threshold Voltage(1)	4	発振動作が停止する V_{Css} 電圧値(Vcc=15V、Voc=0V) Css terminal voltage to stop oscillation operating. (Vcc=15V、Voc=0V)
ラッチ解除 Vcc 電圧 Latch circuit release Vcc voltage	1	OVP 動作後 V_{CC} をある電圧降下させた後 V_{CC}=15V にすると発振する。この時の降下させた V_{CC} 電圧値(Vsen=3V) A certain V_{CC} Voltage that has once to be reached when decreasing the V_{CC} voltage after OVP in order to restart the oscillation at V_{CC}=15V when V_{CC} is increased again from this certain voltage.(Vsen=3V)
最低出力周波数 Minimum frequency		出力周波数(Vcc=15V、Vsen=3V) Oscillation frequency.(Vcc=15V、Vsen=3V)
最高出力周波数 Maximum frequency	2	出力周波数(I_{FB}=-2.0mA) Oscillation frequency.(I_{FB}=-2.0mA)
最大デッドタイム Maximum dead-time	1	$F_{(MIN)}$時出力デッドタイム(Vsen=3V) Output dead-time at $F_{(MIN)}$(Vsen=3V)
最小デッドタイム Minimum dead-time	2	$F_{(MAX)}$時出力デッドタイム(I_{FB}=-2mA) Output dead-time at $F_{(MAX)}$(I_{FB}=-2mA)
バースト開始 FB 端子電流 Burst circuit start FB terminal current		I_{FB}=-2.0mA から上昇させ、I_{Css}>0uA になる I_{FB} 電流値 FB terminal in-flow current at I_{Css}>0uA by increase I_{FB} from -2.0mA.
発振出力停止 FB 端子電流 Oscillation stop FB terminal current		I_{FB}=-2.0mA から上昇させ、発振停止する I_{FB} 電流値 FB terminal out-flow current to stop oscillation operation by increase I_{FB} from -2.0mA.
Css 端子チャージ電流 Css terminal charge current	4	I_{Css} 電流値(Vcc=15V、V_{Css}=0V、V_{OC}=0V) Css terminal in-flow current.(Vcc=15V、V_{Css}=0V, V_{OC}=0V)
Css 端子リセット電流 Css terminal reset current		I_{Css} 電流値(V_{CC}=9V、V_{Css}=3V、V_{OC}=0V) Css terminal in-flow current.(V_{CC}=9V, V_{Css}=3V, V_{OC}=0V)
OVP 動作 V_{CC} 電圧 OVP operating V_{CC} voltage	1	V_{CC}=15V から上昇させ、発振停止する V_{CC} 電圧値(Vsen=3V) V_{CC} voltage to stop oscillation operation by increase V_{CC} from 15V.(Vsen=3V)

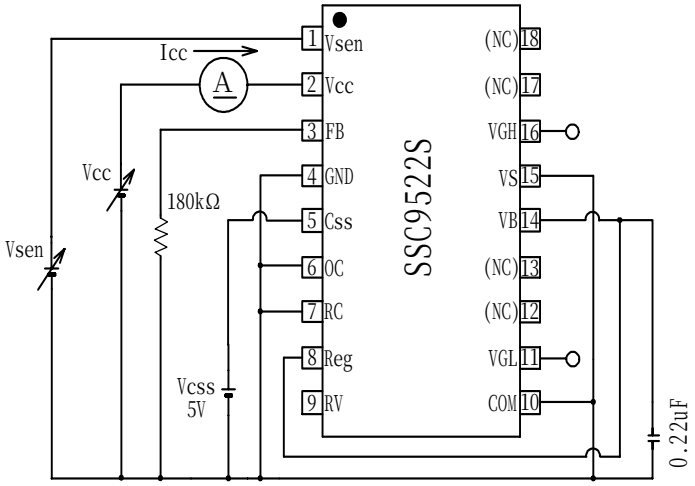
項目 Parameter	測定回路 Measure-ment circuit	測定条件 Measurement conditions
電流共振外れ検出電圧 Uncontrollability detection voltage	6	RC 端子に 150kHz の方形波を印加し、出力周波数=150kHz±5%以内となる V_{RC} 電圧 V_{RC} voltage at which oscillation frequency = 150kHz ± 5% by input a Pyramid roof wave of 150kHz on RC terminal.
RC 端子しきい値電圧(Hi speed) RC terminal threshold voltage (Hi speed)	7	V_{RC}=0 から上昇(下降)させ、I_{Css}≧10mA となる V_{RC} 電圧値 V_{RC} voltage to make I_{Css} ≧ 10mA by increase (decrease) V_{RC} from 0V.
OC 端子しきい値電圧(Low) OC terminal threshold voltage (Low)	4	V_{OC}=0 から上昇させ、I_{Css}≧1.0mA となる V_{OC} 電圧値 (Vcc=15V、V_{Css}=3V) V_{OC} Voltage to make I_{Css} ≧1.0mA by increase V_{OC} from 0V. (Vcc=15V、V_{Css}=3V)
OC 端子しきい値電圧(High) OC terminal threshold voltage (High)		V_{OC}=0 から上昇させ、I_{Css}≧10mA となる V_{OC} 電圧値 (Vcc=15V、V_{Css}=3V) V_{OC} Voltage to make I_{Css}≧10mA by increase V_{OC} from 0V. (Vcc=15V、V_{Css}=3V)
OC 端子しきい値電圧(Hi speed) OC terminal threshold voltage (Hi speed)		出力周波数≦25kHz となる V_{OC} 電圧値 (Vcc=15V、V_{Css}=5V) V_{OC} voltage to make oscillation frequency ≦25kHz. (Vcc=15V、V_{Css}=5V)
Css 端子シンク電流(Low) Css terminal sink current (Low)		I_{Css} 電流値(Vcc=15V、V_{Css}=3V、Voc=1.65V) Css terminal in-flow current.(Vcc=15V 、 V_{Css}=3V 、 Voc=1.65V)
Css 端子シンク電流(High) Css terminal sink current (High)		I_{Css} 電流値(Vcc=15V、V_{Css}=3V、Voc=2V) Css terminal in-flow current.(Vcc=15V、V_{Css}=3V、Voc=2V)
Css 端子シンク電流(Hi speed) Css terminal sink current (Hi speed)	6	I_{Css} 電流値(Vcc=19V、V_{RC}=2.8V) Css terminal in-flow current.(Vcc=19V、V_{RC}=2.8V)
電圧共振検出端子電圧(1) RV terminal voltage detected Resonance voltage(1)	10	V_{RV}=3V から上昇させ、発振動作が停止する V_{RV} 電圧値 V_{RV} voltage to stop oscillation operation by increase V_{RV} from 3V.
電圧共振検出端子電圧(2) RV terminal voltage detected Resonance voltage(2)		V_{RV}=3V から降下させ、発振動作が停止する V_{RV} 電圧値 V_{RV} voltage to stop oscillation operation by decrease V_{RV} from 3V.
バースト周波数 Burst oscillation frequency	5	I_{FB}=-3.5mA 時の Css 端子発振周波数 Css terminal oscillation frequency at I_{FB}=-3.5mA
Css 端子しきい値電圧(2) Css terminal threshold voltage (2)	4	V_{Css}=0V から上昇させ、発振開始する V_{Css} 電圧値 (Vcc=19V、Vsen=3V、Voc =0V) V_{Css} voltage to stop oscillation operation by increase V_{Css} from 0V .(Vcc=19V、Vsen=3V、Voc =0V)
Vsen 端子しきい値電圧(ON) Vsen terminal threshold voltage (ON)	1	Vsen=0V から上昇させ、発振開始する Vsen 電圧値 (Vcc=15V) Vsen voltage to start oscillation operation.(Vcc=15V)
Vsen 端子しきい値電圧(OFF) Vsen terminal threshold voltage (OFF)		Vsen=3V から降下させ、発振停止する Vsen 電圧値 (Vcc=15V) Vsen voltage to stop oscillation operation.(Vcc=15V)
ドライバー電源電圧 V_{Reg} terminal output voltage	2	発振動作時、V_{Reg} 電圧値(I_{FB}=-2mA) V_{Reg} voltage at oscillation operation.(I_{FB}=-2mA)

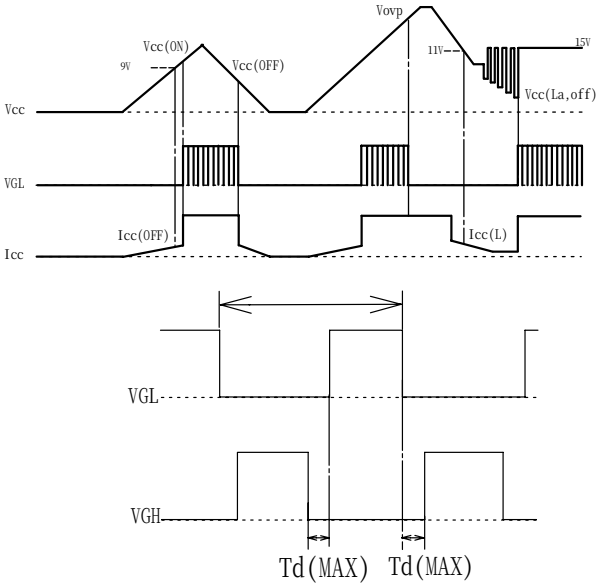
項目 Parameter	測定回路 Measure -ment circuit	測定条件 Measurement conditions
ハイサイドドライバー動作開始電圧 High-side drive operation start voltage	8	V_B=0V から上昇させ、VGH が発振開始する V_B 電圧値 Voltage V_B to start VGH oscillation operation by increase V_B from 0V.
ハイサイドドライバー動作停止電圧 High-side drive operation stop Voltage		V_B=10V から降下させ、VGH が発振停止する V_B 電圧値 Voltage V_B to stop VGH oscillation operation by decrease V_B from 10V.
出力ソース電流１ VGL,VGH terminal out-flow source current	9	V_{Reg} /V_B=10.5V, VGL/VGH=0V 時の VGL/VGH 流出電流 VGL/VGH terminal out-flow current at V_{Reg} /V_B = 10.5V, VGL/VGH = 0V
出力シンク電流１ VGL,VGH terminal in-flow sink current		V_{Reg}/V_B=10.5V, VGL/VGH=10.5V 時の VGL/VGH 流入電流 VGL/VGH terminal in-flow current at V_{Reg} /V_B = 10.5V, VGL/VGH = 10.5V
出力ソース電流２ VGL,VGH terminal out-flow source current		V_{Reg} /V_B=12V, VGL/VGH=10.5V 時の VGL/VGH 流出電流 VGL/VGH terminal out-flow current at V_{Reg} /V_B = 12V, VGL/VGH = 10.5V
出力シンク電流２ VGL,VGH terminal in-flow sink current		V_{Reg} /V_B=12V, VGL/VGH=1.5V 時の VGL/VGH 流入電流 VGL/VGH terminal in-flow current at V_{Reg} /V_B = 12V, VGL/VGH = 1.5V

4-4 検査回路図

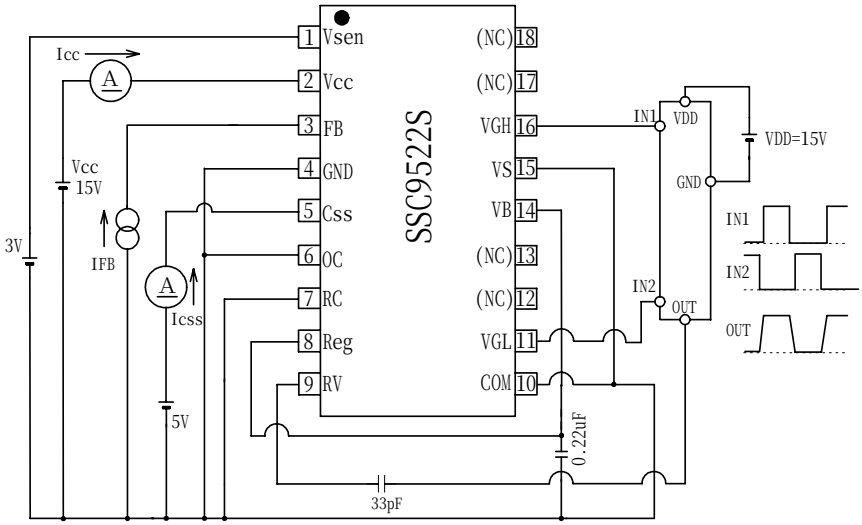
Measurement Circuit

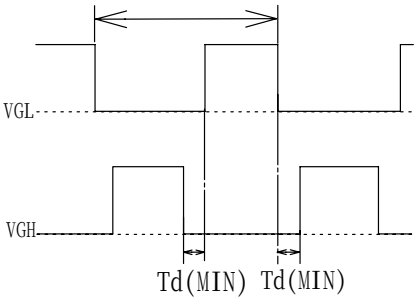
検査回路 1 Measurement Circuit 1



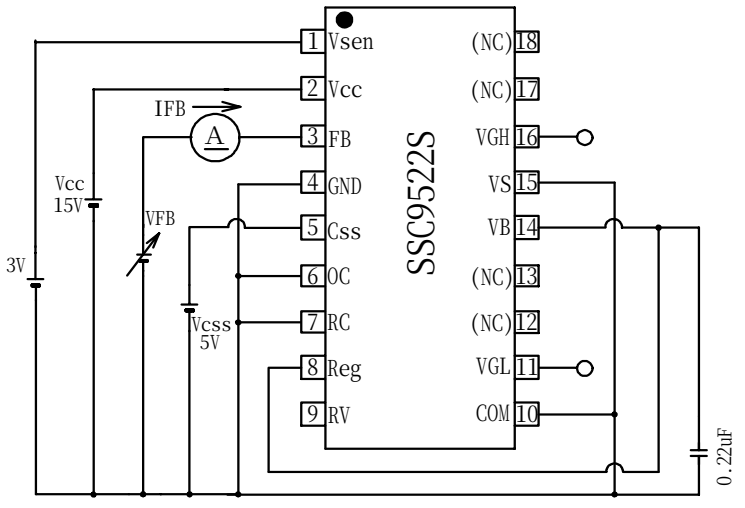


検査回路 2 Measurement Circuit 2

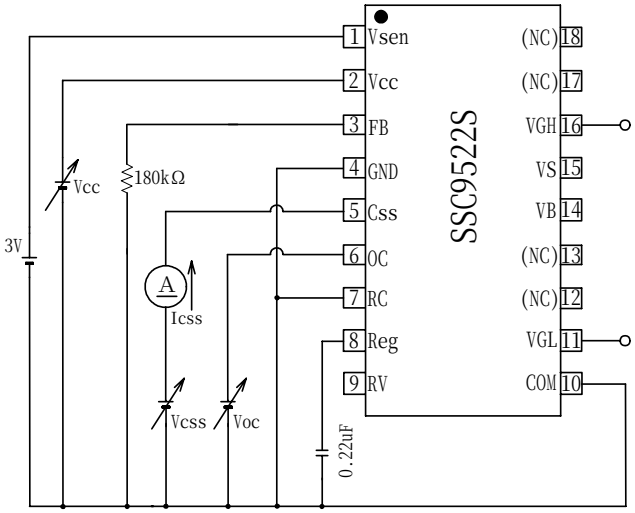




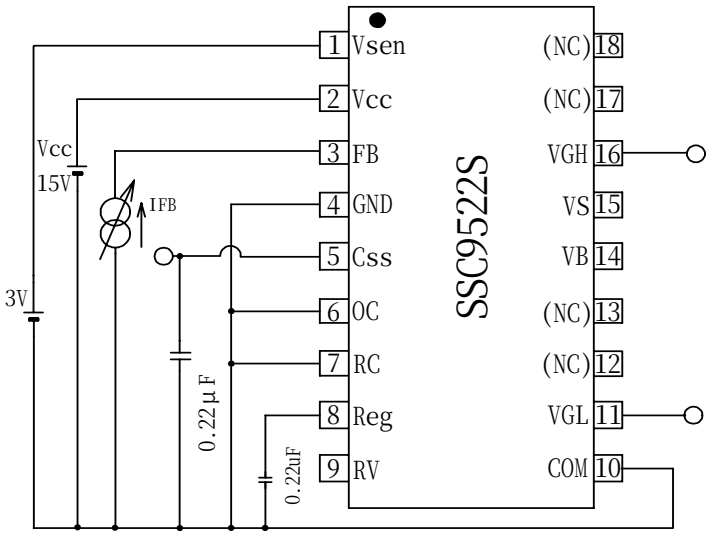
検査回路 3 Measurement Circuit 3



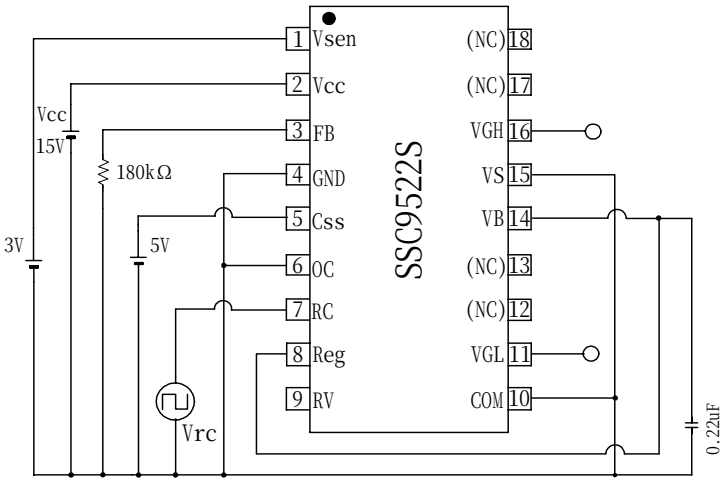
検査回路 4　Measurement Circuit 4

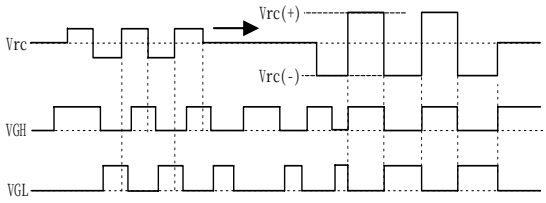


検査回路 5　Measurement Circuit 5

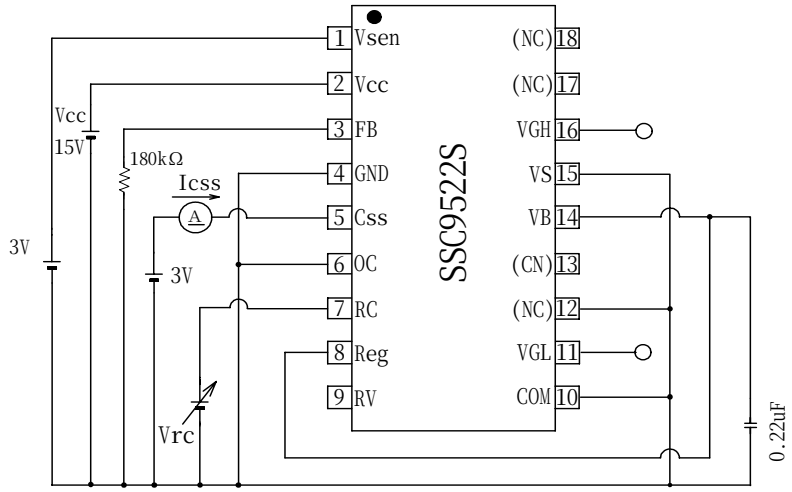


検査回路 6　Measurement Circuit 6

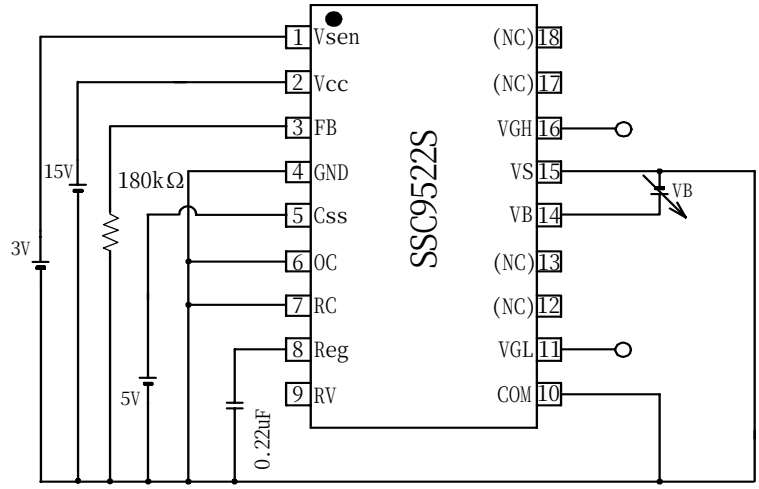




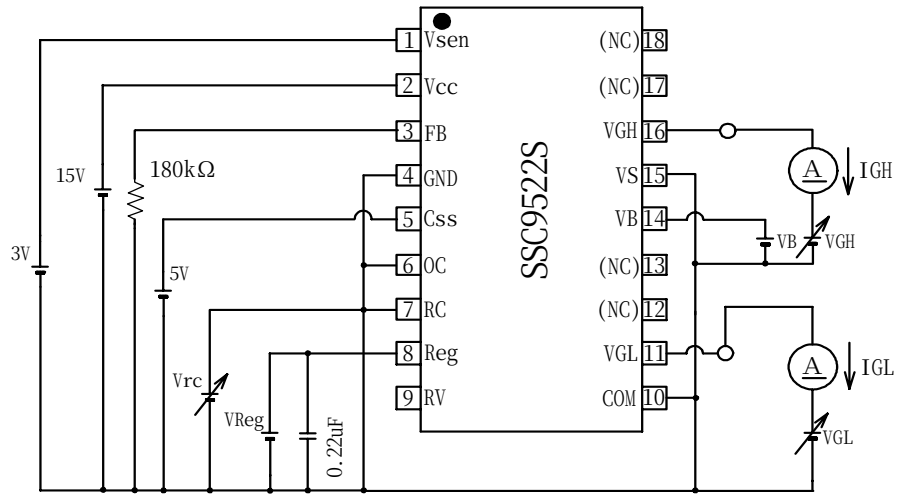
検査回路 7　Measurement Circuit 7



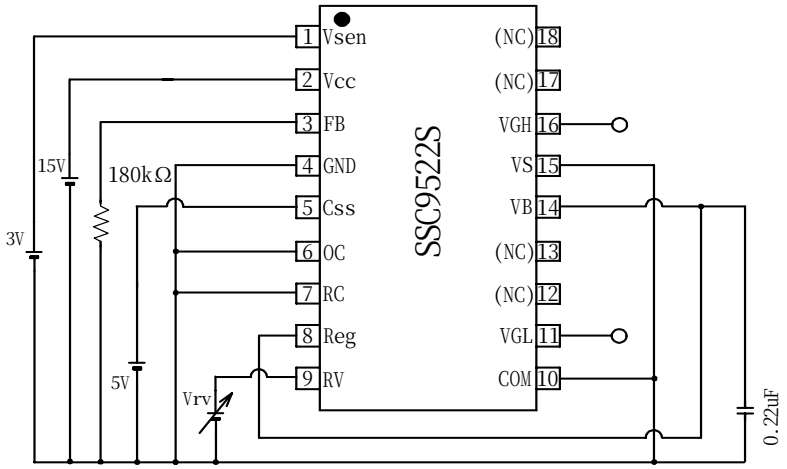
検査回路 8　Measurement Circuit 8



検査回路 9　Measurement Circuit 9

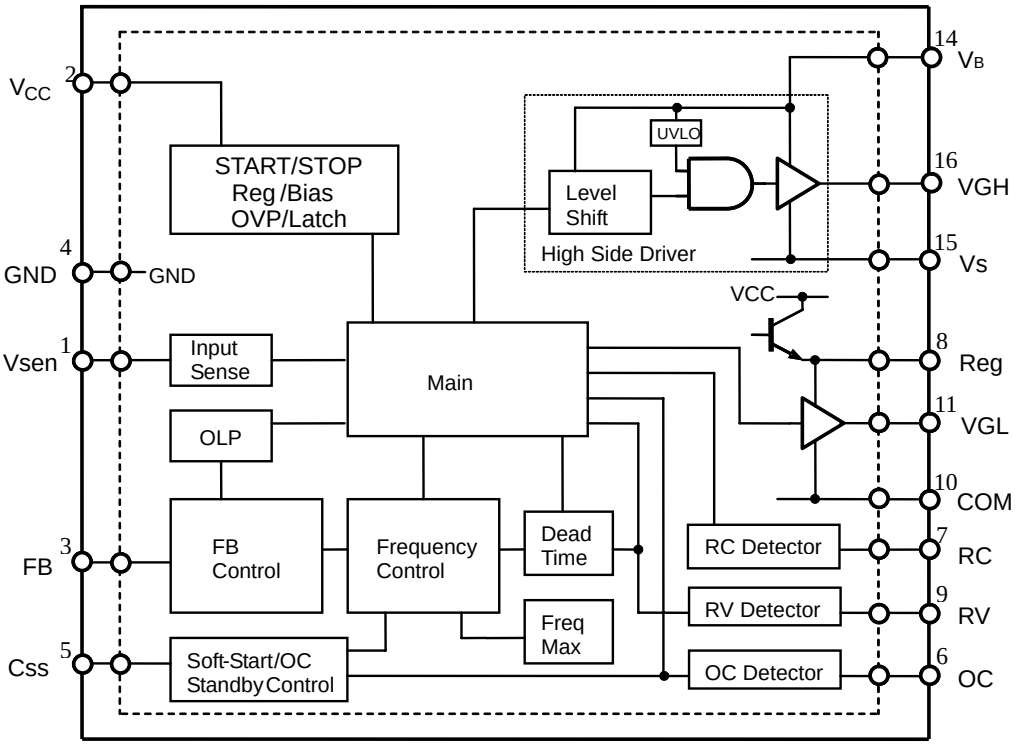


検査回路 10　Measurement Circuit 10



5 ブロックダイアグラム

Block diagram

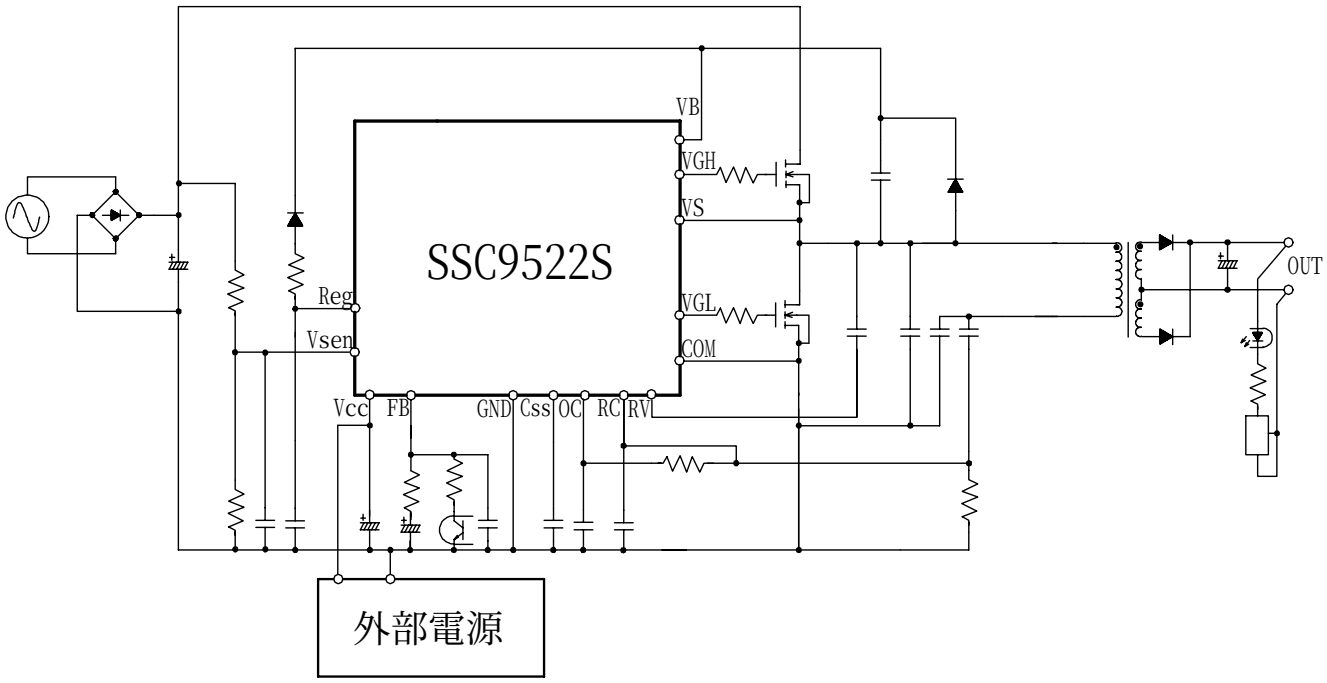


6 各端子機能

Function of terminal

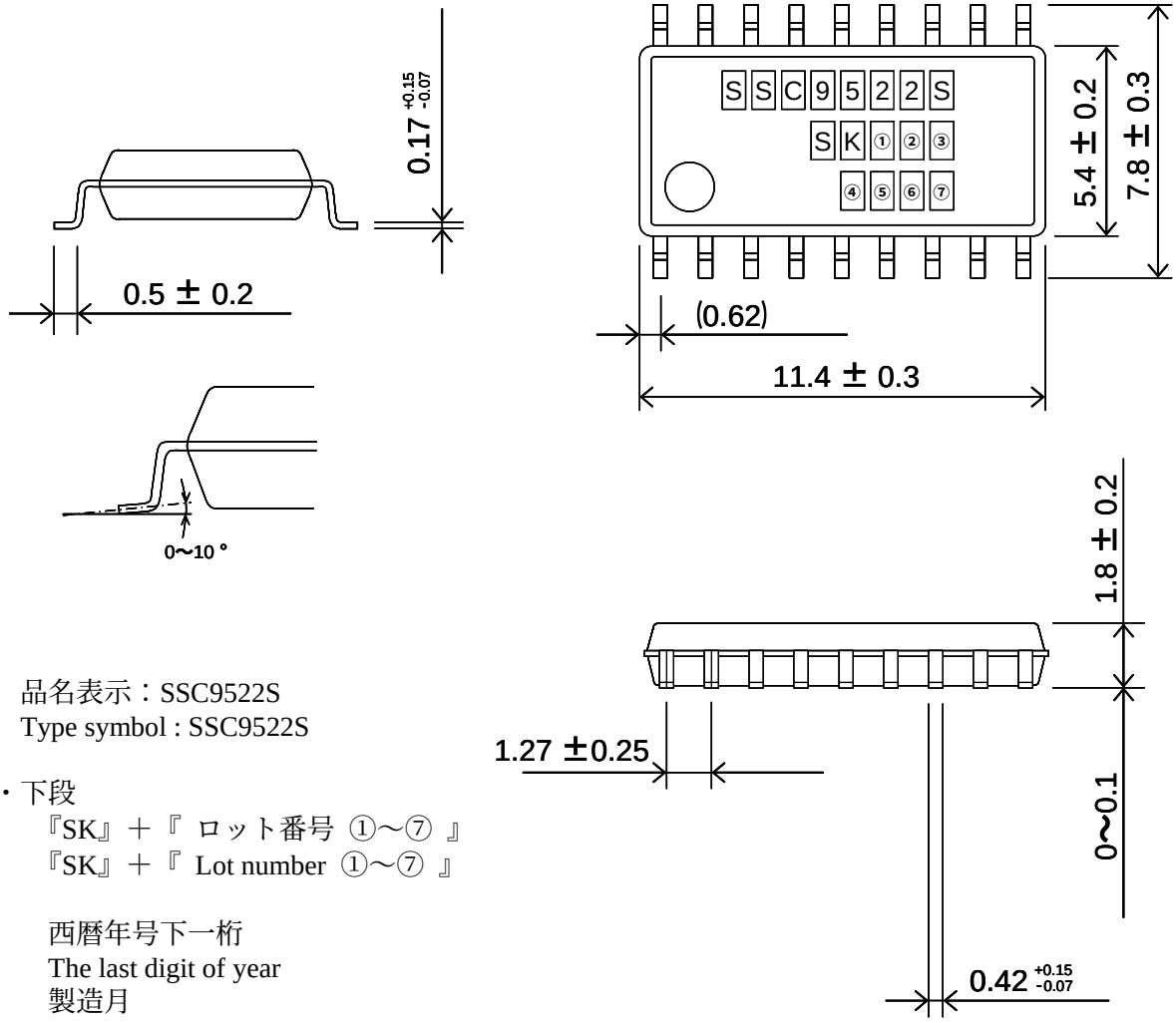
端子番号 Terminal	記　号 Symbol	名　　称 Description	機　　能 Functions
1	Vsen	入力(AC ライン)電圧検出端子 Detection of input AC line voltage terminal	入力(AC ライン)電圧検出端子 Detection of input AC line voltage
2	V_{CC}	電源端子 Power supply terminal	制御部電源端子 Supply voltage for control
3	FB	FB 端子 Feed back terminal	定電圧制御／過負荷検出端子 Control for output/detection of over load
4	GND	制御部グランド端子 Ground for control terminal	制御部グランド Ground for control
5	Css	Css 端子 Soft start capacitor terminal	ソフトスタート用コンデンサ接続端子 Terminal for connection of capacitor for soft start
6	OC	OC 端子 Over current detection terminal	過電流検出端子 Detection of over current
7	RC	RC 端子 Resonance current detection terminal	共振電流検出端子 Detection of resonance current
8	Reg	Reg 端子 Internal regulator terminal	ゲートドライブ回路用電源入力 Supply voltage output for gate drive circuit
9	RV	RV 端子 Resonance voltage terminal	電圧共振検出端子 Detection of resonance voltage
10	COM	パワー部グランド端子 Ground for power terminal	パワー部グランド Ground for power
11	VGL	ローサイドゲートドライブ端子 Low-side gate drive terminal	ローサイドゲートドライブ Low-side gate drive
12，13 17，18	NC	NC	非接続 None
14	V_B	ハイサイドゲートドライブ電源端子 High-side gate drive supply terminal	ハイサイドゲートドライブ電源入力 Supply voltage for High-side gate drive
15	V_S	ハイサイドドライバフローティンググランド端子 High-side drive floating ground terminal	ハイサイドドライバフローティンググランド High-side drive floating ground
16	VGH	ハイサイドゲートドライブ端子 High-side gate drive terminal	ハイサイドゲートドライブ High-side gate drive

7 応用回路例
Example application circuit



8 外形
Package information

8-1 外形、寸法および材質
Package type, physical dimensions and material



単位：mm
Dimensions in mm

上段. 品名表示：SSC9522S
Type symbol : SSC9522S

中段・下段
『SK』＋『 ロット番号 ①～⑦ 』
『SK』＋『 Lot number ①～⑦ 』

・① 西暦年号下一桁
The last digit of year

・② 製造月
Month
1～9 月：「1～9（アラビア数字）」
1 to 9 for Jan. to Sep.
10 月：「O（アルファベット）」
O for Oct.
11 月：「N」
N for Nov.
12 月：「D」
D for Dec.

・③ 製造日
day
1～10 日 ：1
1～10day
11～20 日 ：2
11～20day
21～31 日 ：3
21～31day

・④～⑦
弊社管理記号
letter Sanken registration symbol

製品重量：約 0.27g
Weight : Approx. 0.27g

端子材質：Cu
Material of terminal : Cu

端子の処理：半田メッキ
Treatment of terminal : Solder plating

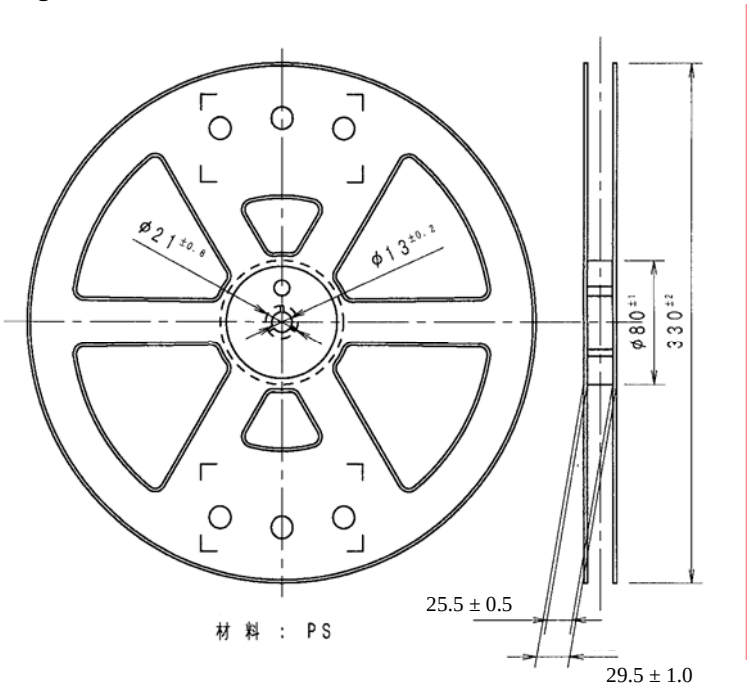
8-2 外観
Appearance
本体は、汚れ、傷、亀裂等なく美麗であること。
The body shall be clean and shall not bear any stain, rust or flaw.

8-3 標示
Marking
表示は本体に品名及びロット番号を明瞭かつ容易に消えぬようレーザーで捺印すること。
The type number and lot number shall be marked on the body with laser enough to be read and firmly enough to not be erased easily.

9 梱包仕様
Packing specifications

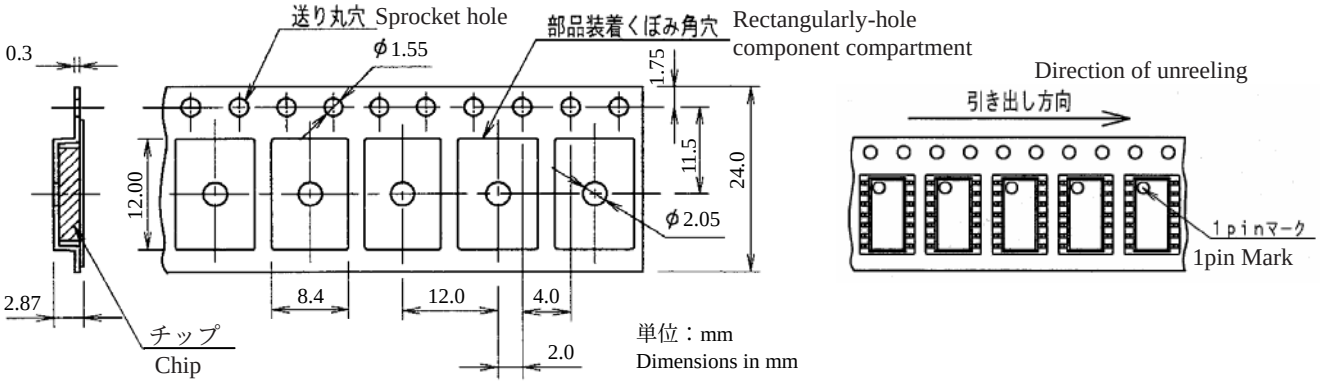
9-1 最小荷姿
Minimum type of packing

(1) リール寸法図
Reel Drawings



単位：mm
Dimensions in mm

(2) キャリアテープ寸法図
Carrier Tape Drawings



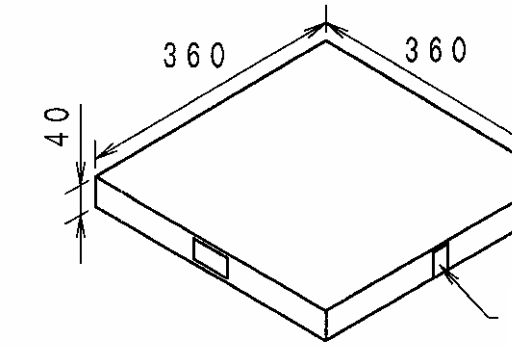
単位：mm
Dimensions in mm

(3) 数量
Quantity

2000 個／リール
2000pcs per reel

9-2 単位毎荷姿
Reel packing

(1) 内箱
Inner box



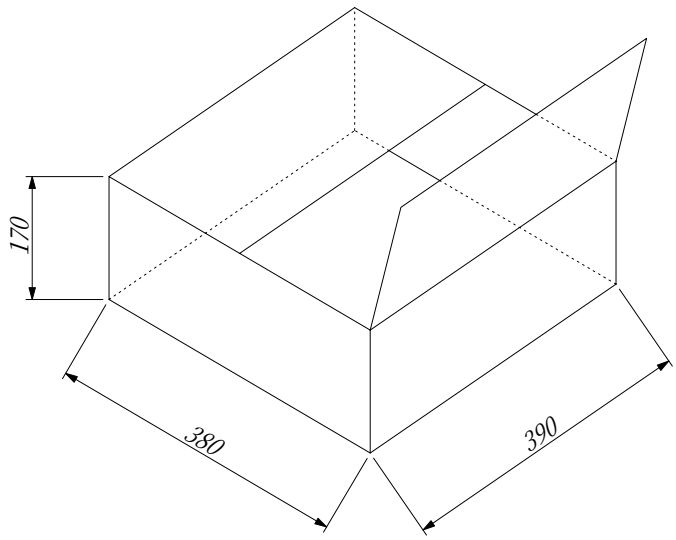
単位：mm
Dimensions in mm

(2) 収納数　上記リールを 1 リール収納
Capacity：1 reel per box

9-3 単位毎荷姿
Reel packing

(1) 外箱
Outer box

(2) 収納数　上記内箱を 3 箱収納
Capacity： 3 inner box per outer box (Maximum quantity of products :6000 pcs)



単位：mm
Dimensions in mm

１０　使用上の注意
Cautions and warnings

⚠ 使用上の注意 CAUTION/ WARNING

保管環境、特性検査上の取り扱い方法によっては信頼度を損なう要因となりますので、注意事項に留意されますようお願いいたします。
Since reliability can be affected adversely by improper storage environment and handling methods during Characteristic tests, please observe the following cautions.

１０－１　保管上の注意事項
Cautions for Storage

- 保管環境は、常温(5～35℃)、常湿（40～75%）中が望ましく、高温多湿や温湿度変化の大きな場所を避けてください。
  Ensure that storage conditions comply with the standard temperature (5 to 35℃) and the standard relative humidity (around 40 to 75%) and avoid storage locations that experience extreme changes in temperature or humidity.

- 腐食性ガス等の有毒ガスが発生しない塵埃の少ない場所で直射日光を避けてください。
  Avoid locations where dust or harmful gases are present and avoid direct sunlight.

- 長期保管したものは、使用前に半田付け性やリードの錆等について再点検してください。
  Reinspect for rust in leads and solderability that have been stored for a long time.

１０－２　特性検査、取り扱い上の注意事項
Cautions for characteristic Tests and Handling

- 受入検査等で特性検査を行う場合は、測定器からのサージ電圧の印加、端子間ショートや誤接続等に十分ご注意ください。また定格以上の測定は避けてください。
  When characteristic tests are carried out during inspection testing and other standard tests periods, protect the devices from surge of power from the testing device, shorts between the devices and the heatsink.

１０－３ 半田付け方法
Soldering

- 半田付けの際は、下記条件以内でできるだけ短時間に作業をするよう、ご配慮ください。
  When soldering the products, please be sure to minimize the working time, within the following conditions.

  ・260℃　10s　（フロー、2 回）（Flow 2 times）
  ・380℃　3.5s　（半田ごて）　（Soldering iron）

１０－４　静電気破壊防止のための取扱注意
Considerations to protect the Products from Electrostatic Discharge

- デバイスを取り扱う場合は、人体アースを取ってください。人体アースはリストストラップ等を用い、感電防止のため、１ＭΩの抵抗を人体に近い所へ入れてください。
  When handling the devices, operator must be grounded. Grounded wrist straps be worn and should have at least １ＭΩ of resistance near operators to ground to prevent shock hazard.

- デバイスを取り扱う作業台は導電性のテーブルマットやフロアマット等を敷きアースを取ってください。
  Workbenches where the devices are handled should be grounded and be provided with conductive table and floor mats.

- カーブトレーサーなどの測定器を使う場合、測定器もアースを取ってください。
  When using measuring equipment such as a curve tracer, the equipment should also be grounded.

- 半田付けをする場合、半田ごてやディップ槽のリーク電圧がデバイスに印加されるのを防ぐため、半田ごての先やディップ槽をアースしてください。
  When soldering the devices, the head of a soldering iron or a solder bath must be grounded in other to prevent leak voltage generated by them from being applied to the devices.

- デバイスを入れる容器は、弊社出荷時の容器を用いるか、導電性容器やアルミ箔等で、静電対策をしてください。
  The devices should always be stored and transported in our shipping containers or conductive containers, or be wrapped up in aluminum foil.

１０－５　その他
Others

- 本書に記載されている動作例及び回路例は、使用上の参考として示したもので、これらに起因する弊社もしくは第三者の工業所有権、知的所有権、その他の権利の侵害問題について弊社は一切責任を負いません。
  Application and operation examples described in this document are quoted for the sole purpose of reference for the use of the products herein and Sanken can assume no responsibility for any infringement of industrial property rights, intellectual property rights or any other rights of Sanken or any third party which may result from its use.

- 本書に記載されている製品のご使用にあたって、これらの製品に他の製品・部材を組み合わせる場合、或いは、これらの製品に物理的、化学的その他何らかの加工・処理を施す場合には、使用者の責任に於いてそのリスクをご検討の上行ってください。
  When using the products specified herein by either (i) combining other products or materials therewith or (ii) physically, chemically or otherwise processing or treating the products, please duly consider all possible risks that may result from all such uses in advance and proceed therewith at your own responsibility.

- 弊社は品質、信頼性の向上に努めていますが、半導体製品では、ある確率での欠陥、故障の発生は避けられません。部品の故障により結果として、人身事故、火災事故、社会的な損害を発生させないよう、使用者の責任に於いて、装置やシステム上で十分な安全設計及び確認を行って下さい。
  Although Sanken undertakes to enhance the quality and reliability of its products, the occurrence of failure and defect of semiconductor products at a certain rate is inevitable.
  Users of Sanken products are requested to take, at their own risk preventative measures including safety design of the equipment or systems against any possible injury, death, fires or damages to the society due to device failure or malfunction.

- 本書に記載されている製品は、一般電子機器（家電製品、事務機器、通信端末機器、計測機器など）に使用されることを意図しております。
  高い信頼性が要求される装置（輸送機器とその制御装置、交通信号制御装置、防災・防火装置、各種安全装置など）への使用をご検討及び、一般電子機器であっても長寿命を要求される場合につきましては、必ず弊社販売窓口へのご相談及び納入仕様書への記載をお願いします。
  極めて高い信頼性が要求される装置（航空宇宙機器、原子力制御、生命維持のための医療機器など）には弊社の文書による合意がない限り使用しないで下さい。
  Sanken products listed in this document are designed and intended for the use as components in general purpose electronic equipment or apparatus (home appliances, office equipment, telecommunication equipment, measuring equipment, etc.).
  Whenever Sanken products are intended to be used in the applications where high reliability is required (transportation equipment and its control systems, traffic signal control systems or equipment, fire/crime alarm systems, various safety devices, etc.), and whenever long life expectancy is required even in general purpose electronic equipment or apparatus, please contact your nearest Sanken sales representative to discuss and obtain written consent of your specifications.
  The use of Sanken products without the written consent of Sanken in the applications where extremely high reliability is required (aerospace equipment, nuclear power control systems, life support systems, etc.) is strictly prohibited.

- 弊社のデバイスをご使用、またはこれを使用した各種装置を設計する場合、定格値に対するディレーティングをどの程度行うかにより、信頼性に大きく影響いたします。
  ディレーティングとは信頼性を確保または向上するため、各定格値から負荷を軽減した動作範囲を設定したり、サージやノイズなどについて考慮することを言います。ディレーティングを行う要素には、一般的には電圧、電流、電力などの電気的ストレス、周囲温度、湿度などの環境ストレス、半導体デバイスの自己発熱による熱ストレスがあります。これらのストレスは、瞬間的数値あるいは最大値、最小値についても考慮する必要があります。
  なおパワーデバイスやパワーデバイス内蔵 IC は、自己発熱が大きく接合部温度(Tj)のディレーティングの程度が、信頼性を大きく変える要素となりますので充分にご配慮ください。
  In the case that you use our semiconductor devices or design your products by using our semiconductor devices, the reliability largely depends on the degree of derating to be made to the rated values. Derating may be interpreted as a case that an operation range is set by derating the load from each rated value or surge voltage or noise is considered for derating in order to assure or improve the reliability. In general, derating factors include electric stresses such as electric voltage, electric current, electric power etc., environmental stresses such as ambient temperature, humidity etc. and thermal stress caused due to self-heating of semiconductor devices. For these stresses, instantaneous values, maximum values and minimum values must be taken into consideration.
  In addition, it should be noted that since power devices or IC's including power devices have large self-heating value, the degree of derating of junction temperature (Tj) affects the reliability significantly.

- 本書に記載された製品は耐放射線設計をしておりません。
  Anti radioactive ray design is not considered for the products listed herein.

- 弊社物流網外での輸送、製品落下等によるトラブルについて当社は一切責任を負いません。
  Sanken assumes no responsibility for any troubles, such as dropping products caused during transportation out of Sanken's distribution network.

TPV
TPV TECHNOLOGY LIMITED

Approval sheet Checklist

TPV's P/N		TPV's Part Description	
Supplier's P/N	SSC9522S		
Supplier Name	Sanken Electric Co. , Ltd.	Date	2011 / 09 / 20

Check Items

Item	Content	Include	Not Include	Page No.	Check Result	Remark
1	Supplier's product part name	V				
2	Supplier's part number					
3	Supplier's part numbering define					
4	Outline package & drawing	V				
5	Dimensions	V				
6	Marking	V				
7	Electrical characteristics	V				
8	Tj or Tc specification	V				
9	Storage environment conditions	V				
10	Taping/Packing specification	V				
11	IR reflow					
12	Reliability test					
	12-1 Pre-Condition					
	12-2 TCT					
	12-3 THB					
	12-4 HAST					
	12-5 HTST					
	12-6 HTOL					
	12-7 Solderability test					
	12-8 ESD					
	12-9 Latch up					
	12-10 MSL Level					
13	RoHS/GP document					
	13-1 Raw Material List	V				
	13-2 Guarantee Letter	V				
	13-3 3rd test report(SGS/ETC…)					
	13-4 Tin Whisker report (Pin pitch<0.5mm)					

TPV

TPV TECHNOLOGY LIMITED

Product Information

Product Name : SSC9522S

Process : 1 μm, 2 Poly 2 Metal layer *1

Die Size : 2.91×1.03 mm / 3.35×1.65 mm

Testing Fault Coverage : --- %

DPM(Defect Per Million): 20 PPM *5

Design Center Location : Saitama Japan

Burn-In Test : ☒No, ☐Yes, ___ ℃, ___ hrs

Packing Specifications: ☐Tray ☒Reel ☐Tube *3

Lead Coplanarity spec. : 0.1 mm

Start Date of Production : 2011/08

Wafer Diameter : 6 inch *1

Chip(Die) Coating : ☐No , ☒Yes *1

MTTF(Mean Time To Failure: --- FIT

Circuit Design Center : Sanken Electric Co. ,Ltd.

Test Ambient Temp. at : --- ℃, 23±5 ℃, --- ℃, *1

Moisture Sensitive Level : 1 *1

Packing with MBB *2 : ☐Yes , ☒No *1

Lead Plating thickness spec. : 0.005～0.015 mm

☐ Fab Site – 1 *1		☐ Fab Site -2 *1	
Fab. Company	Fab. Location	Fab. Company	Fab. Location
Polar Semiconductor , Inc.	MN USA		
Trace Code for Fab site :		Trace Code for Fab site :	

☐ Chip Probing (Wafer Sort) Site - 1		☐ Chip Probing (Wafer Sort) Site -2	
C/P Testing House	C/P Location	C/P Testing House	C/P Location
Yamagata Sanken Co. ,Ltd.	Yamagata Japan		

☐ Assembly Site – 1 *1		☐ Assembly Site – 2 *1	
Assembly House Company	Aoi Electronics Co. ,LTD.	Assembly House Company	
Assembly House Location	Kagawa Japan	Assembly House Location	
Molding Compound	Epoxy	Molding Compound	
Epoxy	---	Epoxy	
Bonding Wire Diameter	30 μm	Bonding Wire Diameter	
Bonding Wire Material	Au	Bonding Wire Material	
Lead Frame Material	Copper	Lead Frame Material	
Ink for Top Surface	Laser	Ink for Top Surface	
Plating or Solder Ball Composition and thickness	Sn 97.5% Ag 2.5%	Plating or Solder Ball Composition and thickness	
Trace Code for Assy house	---	Trace Code for Assy house	

Supplier Name: Sanken Electric Co., Ltd **Supplier Signatory:** Daiji Uehara

Date: 2011 / 09 / 20

Product Information

☐ Assembly Site – 3 *1	
Assembly House Company	
Assembly House Location	
Molding Compound	
Epoxy	
Bonding Wire Diameter	
Bonding Wire Material	
Lead Frame Material	
Ink for Top Surface	
Plating or Solder Ball Composition and thickness	
Trace Code for Assy house	

☐ Assembly Site – 4 *1	
Assembly House Company	
Assembly House Location	
Molding Compound	
Epoxy	
Bonding Wire Diameter	
Bonding Wire Material	
Lead Frame Material	
Ink for Top Surface	
Plating or Solder Ball Composition and thickness	
Trace Code for Assy house	

☐ Final Test Site – 1 *1	
Final Test Company	Aoi Electronics Co. ,LTD.
Final Test Location	Kagawa Japan
100% Lead Scan before Shipping	
Trace Code for F/T	

☐ Final Test Site – 2 *1	
Final Test Company	
Final Test Location	
100% Lead Scan before Shipping	
Trace Code for F/T	

☐ Final Test Site – 3 *1	
Final Test Company	
Final Test Location	
100% Lead Scan before Shipping	
Trace Code for F/T	

☐ Final Test Site – 4 *1	
Final Test Company	
Final Test Location	
100% Lead Scan before Shipping	
Trace Code for F/T	

*1 : Any change of IC Circuit Design, Wafer Mask, , Manufacturer Location, Material, Diameter, Electric Testing parameter, Product Data Sheet, Marking on top side surface, Supplier must issue PCN(Product Process Change) to TPV and get TPV approval to TPV and get TPV RD-CE approval

*2 : MBB : Moisture Barrier Bag (J-STD-033)

*3 : Any Information change of Label Marking, Supplier must issue PCN(Product Process Change) to TPV.

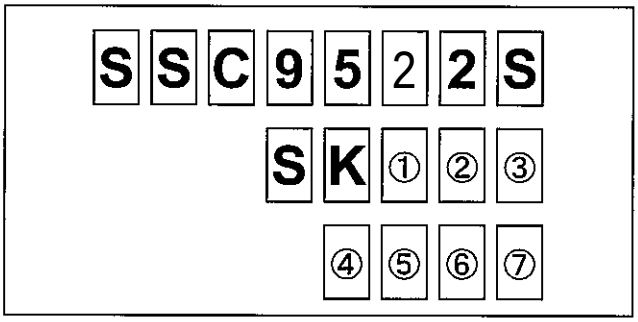
*4 Product version recognition must be shown on the Shipping Label of outer and Inner box, Product version recognition must be shown marking of the top side surface of product.

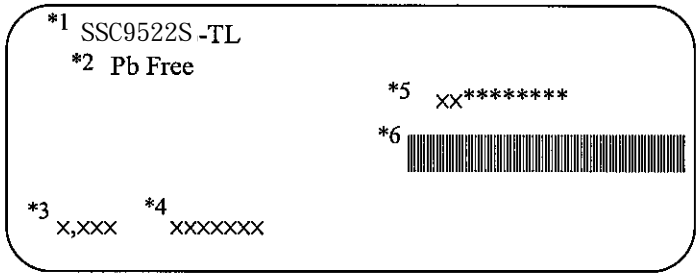
*5: DPM: Means Defect per million for customer.

Other : Product which shipped to TPV, Product date code must be within one year.

Product Information

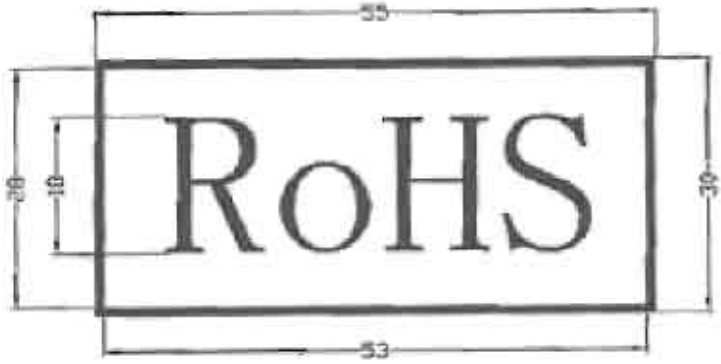
Product Naming Rule	
Naming	Explanation (Supplier must indicate how to recognize the Product version)
SSC9522S	SSC95: Series Symbol 12 : Development Number S: PKG Symbol

Marking Rule of Product Top Side Surface *1		
Marking Information	Column	Explanation (Supplier must indicate how to recognize the Product version)
	Column 1	Type Symbol
	Column 2	SK + Lot number
	Column 3	Sanken Registration Symbol
	Column 4	
	Column 5	
	Column 6	

Marking Rule of Outer Box Label *3		
Marking Information	Column	Explanation (Supplier must indicate how to recognize the Product version)
	Column 1	SSC9522S : Type Symbol TL : Reel Type
	Column 2	Pb Free Symbol
	Column 3	Amount
	Column 4	Marking Symbol No.①~No.⑦
	Column 5	Assembly Lot Number
	Column 6	Bar Cord

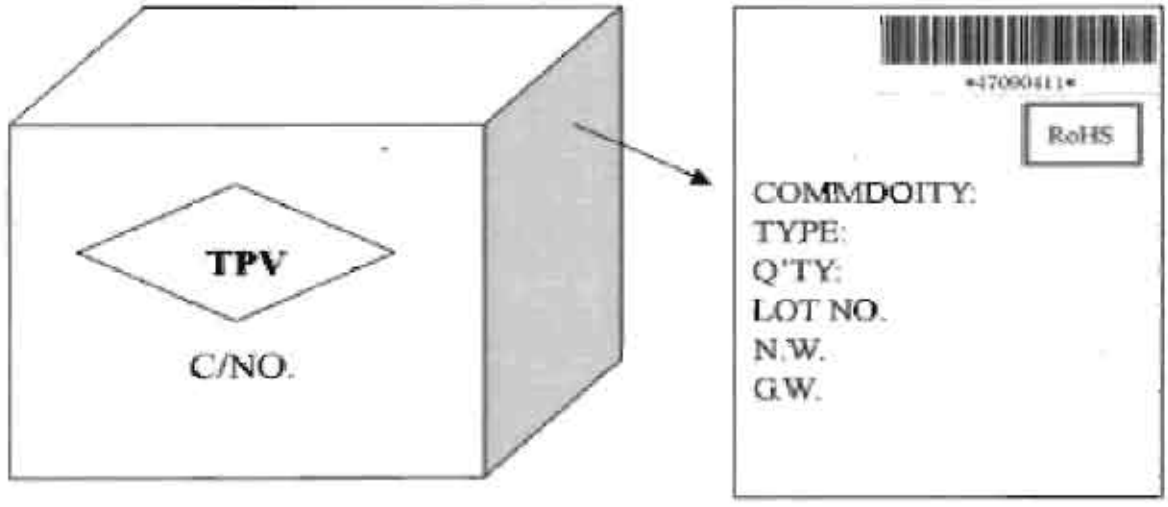
SANKEN 半导体

Label Size



字體：藍色宋體”RoHS”需垂直居中，水平居中

#Carton



Carton size:Anomaly

#TPV RoHS product stick RoHS blue word seal on the upper-right corner of the side mark of carton

RoHS 零件可焊性/ 耐焊接熱標準

RoHS Component Solderability/Resistance to Soldering Heat SPEC

一DIP 零件, Wave Solder 要求
(DIP Component , Wave Solder)

可焊性規格: 條件: 溫度255-5/+0 ℃ 時間2.5±0.5 sec
Solderability : Test Condition : TEMP. 255 -5/+0 ℃ Time. 2.5±0.5 sec
判定: 引腳沾錫面積90% 以上
Judgment: 90% coverage.
詳細參數見附件[RoHS 零件可焊性標準]
Please see attachment for details

耐焊接熱規格: 條件: 溫度270 -0/+2 ℃ 時間10±0.5 sec [端子]
Resistance to Soldering Heat: Test Condition : TEMP. 270 -0/+2 ℃ Time. 10±0.5 sec (Terminal)
條件: 溫度270 -0/+2 ℃ 時間20±0.5 sec [本體]
Resistance to Soldering Heat: Test Condition : TEMP. 270 -0/+2 ℃ Time. 20±0.5 sec (Body)
判定: 機械特性電器特性符合規格定義要求
Judgment: Meet the original Mechanical and Electrical SPEC.
詳細參數見附件[RoHS 零件耐焊接熱標準]
Please see attachment for details

二SMD 零件, Solder Reflow 要求
(SMT Component , Solder reflow)

可焊性規格: 條件: 溫度255 -5/+0 ℃ 時間2.5±0.5 sec
Solderability : Test Condition : TEMP. 255 -5/+0 ℃ Time. 2.5±0.5 sec
判定: 引腳沾錫面積90% 以上
Judgment: 90% coverage.
詳細參數見附件[RoHS 零件可焊性標準]
Please see attachment for details

耐焊接熱規格: 條件: 溫度265 -0/+5 ℃ 時間10 -0/+5 sec
Resistance to Soldering Heat: Test Condition : TEMP. 265 -0/+5 ℃ Time. 10-0/+5 sec (Terminal)
判定: 機械特性電器特性符合規格定義要求
Judgment: Meet the original Mechanical and Electrical SPEC.
詳細參數見附件[RoHS 零件耐焊接熱標準]
Please see attachment for details

參考附件Attchment:
一RoHS 零件可焊性標準
二RoHS 零件耐焊接熱標準
三Temperature-Time profiles (Wave Solder and Solder Reflow)
四AOC Solder Paste SPEC.

此份規格載入各RoHS 零件承認書內
This SPEC will be included in NEW APPROVAL SHEET

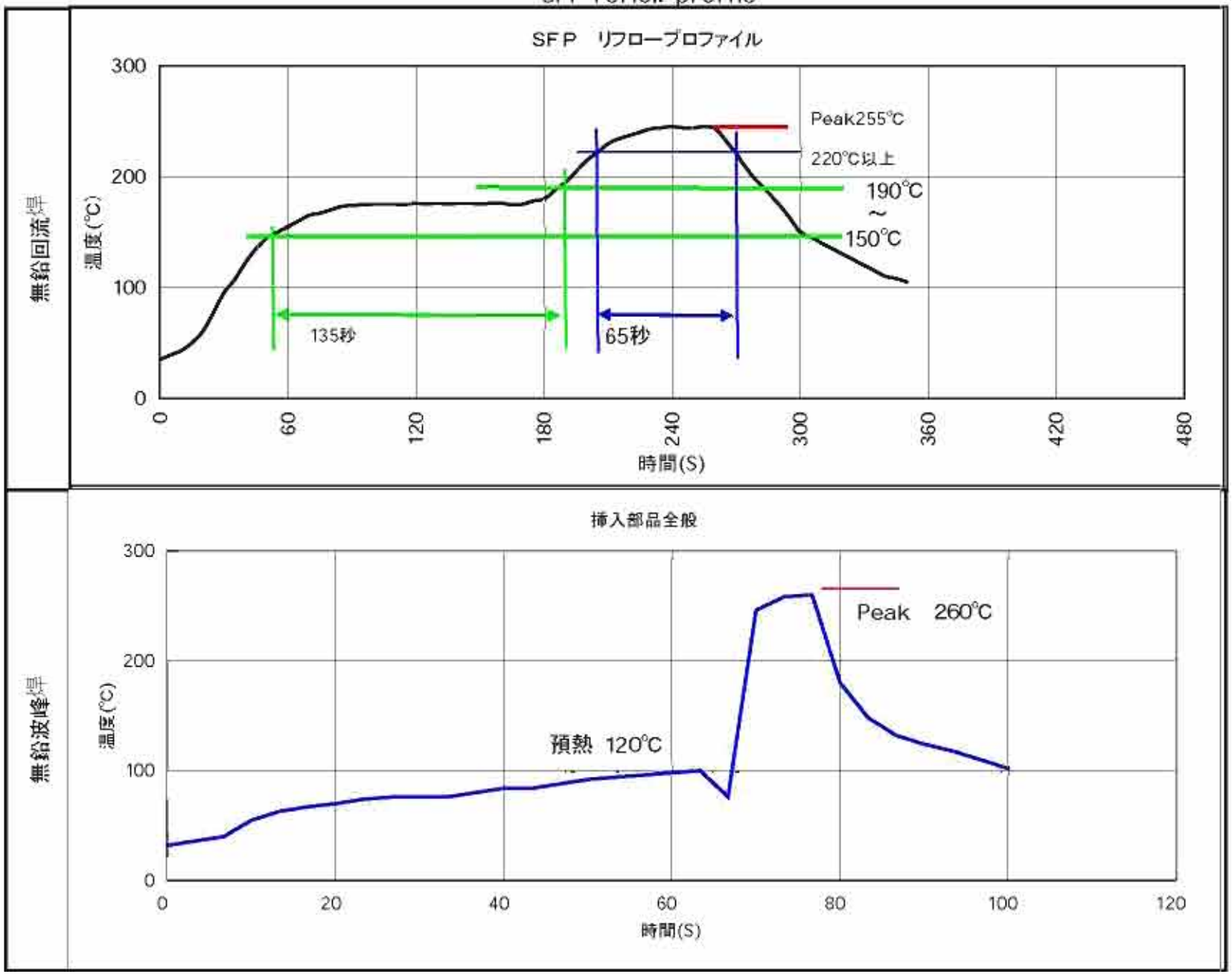
供應商名稱 弘勝鋒有限公司
Supplier Name

負責人 陳祥昌
Signature

蓋章
Company Seal

Actually pacakge thermal profile

SPF reflow profile



Reliability Test Data

信頼性試験データ

TPV Technology Ltd. 御中

Type 名称	for switching regulators IC ｽｲｯﾁﾝｸﾞﾚｷﾞｭﾚｰﾀ用IC	SSC9522S(Pb free) SSC9522S(Pbフリー品)

This reliability test data will apply to SSC9522S(Pb free).
本信頼性試験データはSSC9522S(Pbフリー品)について信頼性を保証したものです。

Applicable Device: SSC9522S(Pb free)
対象品 SSC9522S(Pbフリー品)

Moisture Sensitivity Level (JEDEC J-STD-020C)
耐湿ﾚﾍﾞﾙ (JEDEC J-STD-020C)
Moisture Sensitivity Level - 1
耐湿ﾚﾍﾞﾙ -1

1. Failure Criteria (Ta=25℃)
故障判定基準

A: Appearance 外観 — The body shall be clean and bear no stain, rust or flaw. 汚れ、傷、亀裂等無く綺麗であること。

B: Solderability はんだ付着率 — More than 95% coverage. 95%以上付着のこと。

DATE ISSUED: 発行日	28,Sep.2011 2011年9月28日	Device Quality Assurance Department Quality Assurance Headquarters 品質保証本部 デバイス品質保証部	
PREPARED BY: 作成	M. Tamura		
CHECKED BY: 審査	H. Okuno		
APPROVED BY: 承認	Y. Katoh	REF. NO RE11219A	1／5

C: Electric characteristics （１）

電気的特性

Measurement Items **測定項目**	Symbols **記号**	Measurement Conditions **測定条件**	Rating **規格値** Min. **最 小**	Max. **最 大**	Units **単位**	Remarks **備 考**
Operation start voltage **動作開始電源電圧**	VCC(ON)		8.16	15.6	V	L× 0.8 U× 1.2
Operation stop voltage **動作停止電源電圧**	VCC(OFF)		7.04	13.08	V	L× 0.8 U× 1.2
Circuit current in operation **動作時回路電流**	ICC(ON)		−	24	mA	L× 0.8 U× 1.2
Circuit current in non-operation **非動作時回路電流**	ICC(OFF)	VCC=9V	−	1.44	mA	L× 0.8 U× 1.2
Circuit current in latch-operation **ラッチ動作時回路電流**	ICC(L)	VCC=11V	−	1.44	mA	L× 0.8 U× 1.2
FB terminal source current **FB端子流出電流**	IFB		−36.6	−16.4	μA	L× 1.2 U× 0.8
FB terminal threshold voltage **FB端子しきい値電圧**	VFB		5.24	9.06	V	L× 0.8 U× 1.2
Css terminal threshold voltage(1) **Css端子しきい値電圧(1)**	VCss(1)		5.6	10.32	V	L× 0.8 U× 1.2
Latch circuit release VCC voltage **ラッチ解除VCC電圧**	VCC	Vcc(La.off) <Vcc(OFF)	5.36	11.4	V	L× 0.8 U× 1.2
Minimum frequency **最低周波数**	F(MIN)		20.96	37.44	kHz	L× 0.8 U× 1.2
Maximum frequency **最高周波数**	F(MAX)		212	402	kHz	L× 0.8 U× 1.2
Maximum dead-time **最大デットタイム**	Td(MAX)		1.52	3.6	μs	L× 0.8 U× 1.2
Minimum dead-time **最小デットタイム**	Td(MIN)		0.2	0.9	μs	L× 0.8 U× 1.2
Burst mode start FB terminal source current **バースト開始FB端子電流**	Icont(1)		−3.48	−1.68	mA	L× 1.2 U× 0.8
Oscillation stop FB terminal source current **発振出力停止FB端子電流**	Icont(2)		−4.44	−2	mA	L× 1.2 U× 0.8
Css terminal charge current **Css端子チャージ電流**	ICss(C)		−0.252	−0.12	mA	L× 1.2 U× 0.8
Css terminal reset current **Css端子リセット電流**	ICss(R)	VCC=9V	0.8	2.88	mA	L× 0.8 U× 1.2
OVP operating VCC voltage **OVP動作VCC電圧**	VOVP		22.4	40.8	V	L× 0.8 U× 1.2
Uncontrollability detection voltage **電流共振外れ検出電圧**	±VRC		0.044	0.306	V	L× 0.8 U× 1.2
RC terminal threshold voltage **RC端子しきい値電圧(Hi speed)**	±VRC(S)		2.24	3.96	V	L× 0.8 U× 1.2
OC terminal threshold voltage(Low) **OC端子しきい値電圧(Low)**	VOC(L)		1.136	1.944	V	L× 0.8 U× 1.2
OC terminal threshold voltage (High) **OC端子しきい値電圧(High)**	VOC(H)		1.352	2.364	V	L× 0.8 U× 1.2
OC terminal threshold voltage (Hi speed) **OC端子しきい値電圧(Hi speed)**	VOC(FL)		1.72	3.06	V	L× 0.8 U× 1.2
RV terminal voltage detect Resonance voltage(1) **電圧共振検出端子電圧(1)**	VRV(1)		3.04	6.48	V	L× 0.8 U× 1.2
RV terminal voltage detect Resonance voltage(2) **電圧共振検出端子電圧(2)**	VRV(2)		0.96	2.76	V	L× 0.8 U× 1.2

C: Electric characteristics （2）
電気的特性

Measurement Items 測定項目	Symbols 記号		Measurement Conditions 測定条件	Rating 規格値 Min. 最 小	Rating 規格値 Max. 最 大	Units 単位	Remarks 備 考
Css terminal sink current **Css端子シンク電流**	ICss	(L)		0.8	2.88	mA	L× 0.8 U× 1.2
		(H)		9.6	33.6	mA	L× 0.8 U× 1.2
		(FL)		8.8	30	mA	L× 0.8 U× 1.2
Burst oscillation frequency **バースト周波数**	fCSS			56	156	Hz	L× 0.8 U× 1.2
Css terminal threshold voltage (2) **Css端子しきい値電圧(2)**	VCss(2)			0.4	0.816	V	L× 0.8 U× 1.2
Vsen terminal threshold voltage (ON) **Vsen端子しきい値電圧(ON)**	Vsen(ON)			1.056	1.824	V	L× 0.8 U× 1.2
Vsen terminal threshold voltage (OFF) **Vsen端子しきい値電圧(OFF)**	Vsen(OFF)			0.864	1.488	V	L× 0.8 U× 1.2
VReg terminal output voltage **ドライバー電源電圧**	VReg			7.92	13.32	V	L× 0.8 U× 1.2
High-side drive operation start voltage **ハイサイドドライバー動作開始電圧**	VBUV(ON)			5.04	9.96	V	L× 0.8 U× 1.2
High-side drive operation stop voltage **ハイサイドドライバー動作停止電圧**	VBUV(OFF)			4.4	8.64	V	L× 0.8 U× 1.2
VGL,VGH terminal out-flow source Current **出力ソース電流2**	IGLSOURCE2		VReg /VB=12V VGL /VGH=10.5V	40	144	mA	L× 0.8 U× 1.2
	IGHSOURCE2		VGL/VGH=10.5V				
VGL,VGH terminal in-flow sink Current **出力シンク電流2**	IGLSINK2		VReg /VB=12V	−192	−56	mA	L× 0.8 U× 1.2
	IGHSINK2		VGL/VGH=1.5V				

※ U:Maximum value 規格上限値　　L:Minimum value 規格下限値

2.Test Conditions

試験条件

Test Items 試験項目	Test Conditions 試験条件	Time 試験期間
High Temperature Operating Life **動作寿命試験**	EIAJ ED-4701 101 Tj=125±5℃	1000 h
High Temperature Storage **高温保存試験**	EIAJ ED-4701 201 Ta=150±5℃	1000 h
High Temperature Bias **高温バイアス試験**	EIAJ ED-4701 101 Ta=150℃,Vcc=35V,Vs=600V	1000 h
Low Temperature Storage **低温保存試験**	EIAJ ED-4701 202 Ta=-40±5℃	1000 h
Temperature Humidity Storage **高温高湿保存試験**	EIAJ ED-4701 103 Test code C Ta=85±3℃,R.H=85(+5/-10)%	1000 h
Temperature Humidity Bias **高温高湿バイアス試験**	EIAJ ED-4701 102 Ta=85±3℃,R.H=85(+5/-10)%,Vcc=28V,Vs=480V	1000 h
Unsaturated Pressurized Vapor **不飽和蒸気加圧試験**	EIAJ ED-4701 103 Ta=121℃,R.H=100%,(203kPa)	96 h
Temperature Cycle **温度サイクル試験**	EIAJ ED-4701 105 Ta=-40℃,30分～R.T,5分～150℃,30分	100 c
Thermal Shock **熱衝撃試験**	EIAJ ED-4701 307 [100(+0/-5)℃(5mins)～0(+5/-0)℃(5mins)]1cy	100 c
Solderability 1 **はんだ付け性試験 1**	EIAJ ED-4701 303 Aging(1)/Condition A 105℃,100%,4h+230±5℃,5±1s,Pb-Sn(Sn-37Pb)	1 t
Solderability 2 **はんだ付け性試験 2**	EIAJ ED-4701 303 Aging(1)/Condition A 105℃,100%,4h+245±5℃,M705(Sn-3.0Ag-0.5Cu)	1 t
Resistance to Soldering Heat 1(Flow) **はんだ耐熱性試験 1(フロー)**	EIAJ ED-4701 302 Test code B,Method Ⅲ-B :260(+0/-10)℃,10±1s	2 t
Resistance to Soldering Heat 2(Reflow) **はんだ耐熱性試験 2(リフロー)**	EIAJ ED-4701 302 Method Ⅰ 予備加熱:180℃,90±30s/本加熱:260℃ピーク,250℃,10±1s	2 t
Resistance to Soldering Heat 3(Manual) **はんだ耐熱性試験 3(手付け)**	EIAJ ED-4701 302 Test code B,Method Ⅳ-A 380±10℃,3.5±0.5s	1 t
Terminal Strength 1(Pull) **端子強度試験 1(引張)**	EIAJ ED-4701 401 Method Ⅰ 2.5N ,10±1s	1 t
Terminal Strength 2(Bend) **端子強度試験 2(曲げ)**	EIAJ ED-4701 401 Method Ⅲ 1.25N ,90°	2 t
Vibration **振動試験**	EIAJ ED-4701 403 100Hz-2000Hz-100Hz(4min), 200m/s2,4cycles each for X,Y,Z	Total 48 min
Drop **落下試験**	75cm,On the Maple tree	3 t
Moisture Resistance Cyclic **温湿度サイクル試験**	EIAJ ED-4701 203 60℃,93%,25℃,93%,-10℃/cycle-24h	10 c
Permanence of Marking **耐溶剤性試験**	EIAJ ED-4701 501 Isopropyl alcohol(JIS K 1522)23±5℃,5mins	1 t
Salt mist **塩水噴霧試験**	EIAJ ED-4701 204 Mass ratio:5±1%,35℃	1 t
Electrostatic Discharge 1 **静電破壊試験 1**	Machine Model C＝200pF,R＝0Ω,±200V at each pin	1 t
Electrostatic Discharge 2 **静電破壊試験 2**	EIAJ ED-4701 304:Human body Model C=100pF,R=1.5kΩ,±1000V at each pin	1 t
Latch up **ﾗｯﾁｱｯﾌﾟ試験**	EIAJ ED-4701 306:Capacitor charge Model C＝200pF,R＝0Ω,±200V at each pin	1 t

3.Test Results

試験結果

Test Items **試験項目**	Sample Size **試料数**	Failure **故障数**	Criterion **判定規格**	Remarks **備考**
High Temperature Operating Life **動作寿命試験**	22	0	A,C	
High Temperature Storage **高温保存試験**	22	0	A,C	
High Temperature Bias **高温バイアス試験**	22	0	A,C	
Low Temperature Storage **低温保存試験**	22	0	A,C	
Temperature Humidity Storage **高温高湿保存試験**	22	0	A,C	
Temperature Humidity Bias **高温高湿バイアス試験**	22	0	A,C	
Unsaturated Pressurized Vapor **不飽和蒸気加圧試験**	22	0	A,C	
Temperature Cycle **温度サイクル試験**	22	0	A,C	
Thermal Shock **熱衝撃試験**	22	0	A,C	
Solderability 1 **はんだ付け性試験 1**	11	0	B	Pb-Sn37 solder **Pb-Sn はんだ**
Solderability 2 **はんだ付け性試験 2**	11	0	B	Sn-3.0Ag-0.5Cu solder **Sn-3.0Ag-0.5Cu はんだ**
Resistance to Soldering Heat 1(Flow) **はんだ耐熱性試験 1(ﾌﾛｰ)**	11	0	A,C	Flow **ﾌﾛｰ**
Resistance to Soldering Heat 2(Reflow) **はんだ耐熱性試験 2(ﾘﾌﾛｰ)**	11	0	A,C	Reflow **ﾘﾌﾛｰ**
Resistance to Soldering Heat 3(Manual) **はんだ耐熱性試験 3(手付け)**	11	0	A,C	Manual **手付け**
Terminal Strength 1(Pull) **端子強度試験 1(引張)**	11	0	A,C	
Terminal Strength 2(Bend) **端子強度試験 2(曲げ)**	11	0	A,C	
Vibration **振動試験**	11	0	A,C	
Drop **落下試験**	11	0	A,C	
Moisture Resistance Cyclic **温湿度サイクル試験**	11	0	A,C	
Permanence of Marking **耐溶剤性試験**	11	0	A	
Salt mist **塩水噴霧試験**	11	0	A,C	
Electrostatic Discharge 1 **静電破壊試験 1**	5	0	A,C	Machine model **ﾏｼﾝﾓﾃﾞﾙ**
Electrostatic Discharge 2 **静電破壊試験 2**	5	0	A,C	Human model **人体モデル**
Latch up **ﾗｯﾁｱｯﾌﾟ試験**	5	0	A,C	Capacitor discharge model **ｺﾝﾃﾞﾝｻ放電法**

No Use Guarantee Letter

Raw material name and supplier list

We declared that the parts and assemblies supplied to your company, wherein its raw material, packaging material don't contain environmental management substance which are specified in TPV's standard RDEMS-01.

And: the composition of each raw material of these parts and assemblies are reported as below:

1、P/N of parts: SSC9522S

The raw materials listed at below are all the used one of the part.

ITEM	Raw Material	Raw Material Supplier	Cd	Pb	Cr^{6+}	Hg	PBB/PBDE	Cl	Br	PAHs	Report No.of 3rd party lab
			concentration (ppm)	concentration (ppm)	concentration (ppm)	concentration (ppm)	concentration (ppm)	concentration (ppm)	concentration (ppm)	concentration (ppm)	
Lead frame	I am closed	—	<1	<10	<2	<5	PBB:<25 PBDE:<25	0	0	0	フレーム42アロイ JP-2007/100038
Epoxy resin	I am closed	—	<2	<2	<2	<2	PBB:<5 PBDE:<5	0	0	0	EMEG620A KA/2008/50258
Die atttach	I am closed	—	<2	<2	<2	<2	PBB:<5 PBDE:<5	0	0	0	CRM-1038 KA/2007/90112
Wire	I am closed	—	<2	<2	<2	<2	PBB:<5 PBDE:<5	0	0	0	TG-V-SH JP/2007/071628
Solder plating	I am closed	—	<2	<2	<0.01	<2	PBB:<5 PBDE:<5	0	0	0	Sn-Ag JP/2007/061242
Die	I am closed	—	<5	<10	<5	<1	—	0	0	0	G7C-092-2

2. Pls also attach the files of chemical test report, composition table and MSDS of objective substance of plastic, paint, ink and wiring harness etc.

Noted: Please fill in all detailed message of parts, raw material and auxiliary materials.

And please make sure all the filled message of supplier name, type name of material on above are correct and in details.

Chief/ Position: Hisao Abe／QUALITY ASSURANCE

Full name of company: SANKEN ELECTRIC CO., LTD

Stamp of company: SANKEN ELECTRIC CO., LTD

SANKEN ELECTRIC CO.,LTD Environmental

Management Substances Guarantee Letter

We (includes our subsidiary, affiliated company) here guarantee that all the products and parts (attachment, all parts with the product, includes package) shipped to TPV and affiliated companies (includes directly shipping or via third parties) are contained free of those prohibited materials which listed on TPV standard (RDEMS-01) or its latest version; the laws and ordinances must be observed and followed.

1. Cadmium and cadmium compounds
2. Lead and Lead compounds
3. Mercury and mercury compounds
4. Hexavalent chromium compounds
5. PBB,PBDE(including DecaBDE)
6. Polychlorinated biphenyls (PCB)
7. Polychlorinated naphthalenes (PBN)
8. Polychlorinated terphenyls (PCT)
9. Short-chain chlorinated paraffins (SCCP)
10. Tributyltin (TBT) ,Triphenyltin(TPT) and Tributyltin Oxide(TBTO) compounds
11. Ozone Depleting Substances
12. Asbestos
13. Specific azo compounds
14. Formaldehyde
15. Beryllium and its compounds
16. Nickel and nickel compounds
17. Polyvinyl chloride (PVC) and PVC blends
18. Specific phthalates(DEHP,DBP,BBP,DINP,DIDP,DNOP,DNHP)
19. PAHs (Polynuclear Aromatic Hydrocarbon)
20. PFOS
21. Specific benzotriazole
22. Halogen
23. Other Environment Management Substances

Signature: Hisao Abe

SANKEN ELECTRIC CO.,LTD

Position: QUALITY ASSURANCE

Date: 2008/08/05

Cachet: ASSISTANT MANAGER

Test Report Number : TWNC0017688401

Applicant 申請商: Taiwan First Victor Co., Ltd. Date : Oct 13, 2010
15F-5 No 16 Sec 4 San-Ho Road
San-Chung City Taipei Hsien
Taiwan ROC

Kaltec International Co., Ltd.
7Fl., No 6-10 Sec 2,
Shuang Shi Road, Panchiao Taipei
Taiwan ROC

Sample Description 樣品敘述:
One (1) group of submitted samples said to be :
以下測試樣品乃供應商所提供及確認:

Sample Description 樣品名稱	:	Sanken Semiconductors SMD Package (A)Body (B)Pin
Style / Item No. 產品型號	:	ICs-(SAI-,SPI-,SI-,SE-,SSC-,DDA014)-SERIES
Country Of Origin 原產地	:	Japan
Date Sample Received 收件日期	:	Oct 04, 2010
Date Test Started 開始測試日期	:	Oct 06, 2010

Test Conducted 測試執行 :
As requested by the applicant, for details please refer to attached pages.
依申請商之要求 , 細節請參考附頁 .

Authorized By:
On Behalf Of Intertek Testing Services
Taiwan Limited

K. Y. Liang
Director

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Number : TWNC0017688401

Test Conducted

(Ⅰ) Test Result Summary 測試結果 :

Testing Item 測試項目	Result 結果 (ppm)	
	(A)	(B)
Heavy Metal / 重金屬		
Cadmium (Cd) content / 鎘含量	ND	ND
Lead (Pb) content / 鉛含量	ND	ND
Mercury (Hg) content / 汞含量	ND	ND
Chromium VI (Cr^{6+}) content / 六價鉻含量 (for non-metal material 非金屬材質)	ND	--
Chromium VI (Cr^{6+}) content / 六價鉻含量 (by spot test on metal 金屬材質之點測試)	--	Negative
Chromium VI (Cr^{6+}) content / 六價鉻含量 (by boiling water extraction on metal金屬材質之沸水法) (mg/kg with $50cm^2$)	--	Negative (< 0.02) (#)

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Number : TWNC0017688401

Test Conducted

(Ⅰ) Test Result Summary 測試結果 :

Testing Item 測試項目	Result 結果 (ppm)	
	(A)	(B)
Polybrominated Biphenyls (PBBs) / 多溴聯苯		
Monobrominated Biphenyls (MonoBB) / 單溴聯苯	ND	--
Dibrominated Biphenyls (DiBB) / 二溴聯苯	ND	--
Tribrominated Biphenyls (TriBB) / 三溴聯苯	ND	--
Tetrabrominated Biphenyls (TetraBB) / 四溴聯苯	ND	--
Pentabrominated Biphenyls (PentaBB) / 五溴聯苯	ND	--
Hexabrominated Biphenyls (HexaBB) / 六溴聯苯	ND	--
Heptabrominated Biphenyls (HeptaBB) / 七溴聯苯	ND	--
Octabrominated Biphenyls (OctaBB) / 八溴聯苯	ND	--
Nonabrominated Biphenyls (NonaBB) / 九溴聯苯	ND	--
Decabrominated Biphenyl (DecaBB) / 十溴聯苯	ND	--
Polybrominated Diphenyl Ethers (PBDEs) / 多溴聯苯醚		
Monobrominated Diphenyl Ethers (MonoBDE) / 單溴聯苯醚	ND	--
Dibrominated Diphenyl Ethers (DiBDE) / 二溴聯苯醚	ND	--
Tribrominated Diphenyl Ethers (TriBDE) / 三溴聯苯醚	ND	--
Tetrabrominated Diphenyl Ethers (TetraBDE) / 四溴聯苯醚	ND	--
Pentabrominated Diphenyl Ethers (PentaBDE) / 五溴聯苯醚	ND	--
Hexabrominated Diphenyl Ethers (HexaBDE) / 六溴聯苯醚	ND	--
Heptabrominated Diphenyl Ethers (HeptaBDE) / 七溴聯苯醚	ND	--
Octabrominated Diphenyl Ethers (OctaBDE) / 八溴聯苯醚	ND	--
Nonabrominated Diphenyl Ethers (NonaBDE) / 九溴聯苯醚	ND	--
Decabrominated Diphenyl Ether (DecaBDE) / 十溴聯苯醚	ND	--

Remarks: ppm = parts per million based on weight of tested sample = mg/kg
備註 = 百萬分之一，依據測試樣品重量計算
ND = Not Detected = 未檢測出
< = Less Than = 小於
mg/kg with $50cm^2$ = milligram per kilogram with 50 square centimeter
= 公斤分之毫克，依據樣品面積的50平方公分計算
Negative = A negative test result indicated positive observation was not found at the time of testing. When the spot test showed a negative result, the boiling water extraction procedure shall be used to verify the result.
此陰性結果顯示樣品在分析過程中無發現任何陽性現象的存在，此外，當點測試的結果爲陰性時，樣品應執行沸水萃取的測試程序以確認分析結果。
= Due to the insufficient sample area, reduced total sample surface of 10 cm^2 was used and the dilution factor was adjusted accordingly.
樣品面積不足，測試改取樣品總面積 $10cm^2$ 並進行適當調整。

Responsibility Of Chemist 分析人員 : Irene Chiou / Kevin Liu / Cathy Chen

Date Sample Received 樣品收件日期 : Oct 04, 2010
Testing Period 樣品測試期間 : Oct 06, 2010 to Oct 08, 2010

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Test Conducted

(Ⅱ) RoHS Requirement 限值:

Restricted Substances 限用物質	Limits 限值
Cadmium (Cd) content / 鎘含量	0.01% (100ppm)
Lead (Pb) content / 鉛含量	0.1% (1000ppm)
Mercury (Hg) content / 汞含量	0.1% (1000ppm)
Chromium VI (Cr^{6+}) content / 六價鉻含量	0.1% (1000ppm)
Polybrominated Biphenyls (PBBs) /多溴聯苯	0.1% (1000ppm)
Polybrominated Diphenyl Ehters (PBDEs) / 多溴聯苯醚	0.1% (1000ppm)

The above limits were quoted from 2002/95/EC and amendment 2005/618/EC for homogeneous material.
本限值是依據歐盟指令 2002/95/EC 與其更新指令 2005/618/EC 針對均質材質所訂定。

(Ⅲ) Test Method 測試方法:

Testing Item 測試項目	Testing Method 測試方法	Reporting Limit 報告極限
Cadmium (Cd) content 鎘含量	With reference to IEC 62321 edition 1.0:2008 in clause 8/9/10, by microwave digestion until the tested samples are totally dissolved and determined by ICP-OES. 參考IEC 62321, 2008年第一版第8/9/10章, 以微波消化法測試樣品直到樣品完全溶解並用感應耦合電漿原子放射光譜儀分析。	2 ppm
Lead (Pb) content 鉛含量	With reference to IEC 62321 edition 1.0:2008 in clause 8/9/10, by microwave digestion until the tested samples are totally dissolved and determined by ICP-OES. 參考IEC 62321, 2008年第一版第8/9/10章, 以微波消化法測試樣品直到樣品完全溶解並用感應耦合電漿原子放射光譜儀分析。	2 ppm
Mercury (Hg) content 汞含量	With reference to IEC 62321 edition 1.0:2008 in clause 7, by microwave digestion until the tested samples are totally dissolved and determined by ICP-OES. 參考IEC 62321, 2008年第一版第7章, 以微波消化法測試樣品直到樣品完全溶解並用感應耦合電漿原子放射光譜儀分析。	2 ppm

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Test Conducted

(Ⅲ) Test Method 測試方法:

Testing Item 測試項目	Testing Method 測試方法	Reporting Limit 報告極限
Chromium VI (Cr^{6+}) content (for non-metal material) 六價鉻含量 (非金屬材質)	With reference to IEC 62321 edition 1.0:2008 in annex C, by alkaline digestion and determined by UV-Vis spectrophotometer. 參考IEC 62321, 2008年第一版附錄C, 以鹼液消化並用紫外光-可見光分光光度計分析。	1 ppm
Chromium VI (Cr^{6+}) content (by spot test on metal) 六價鉻含量 (金屬材質之點測試)	With reference to IEC 62321 edition 1.0:2008 in annex B, by spot test. 參考 IEC 62321, 2008 年第一版附錄 B, 以點測試法分析。	Negative (< 1 mg/kg)
Chromium VI (Cr^{6+}) content (by boiling water extraction on metal) 六價鉻含量 (金屬材質之沸水法) (mg/kg with $50cm^2$)	With reference to IEC 62321 edition 1.0:2008 in annex B, by boiling water extraction and determined by UV-Vis spectrophotometer. 參考 IEC 62321, 2008 年第一版附錄 B, 以沸水萃取並用紫外光-可見光分光光度計分析。	0.02 mg/kg with $50cm^2$
Polybrominated Biphenyls (PBBs) 多溴聯苯	With reference to IEC 62321 edition 1.0:2008 in annex A, by solvent extraction and determined by GC-MSD and further HPLC confirmation when necessary 參考IEC 62321, 2008年第一版附錄A, 以溶劑萃取並用氣相層析質譜儀分析, 必要時會以高效能液相層析-二極體陣列偵檢器進行確認。	5 ppm
Polybrominated Diphenyl Ethers (PBDEs) 多溴聯苯醚	With reference to IEC 62321 edition 1.0:2008 in annex A, by solvent extraction and determined by GC-MSD and further HPLC confirmation when necessary 參考IEC 62321, 2008年第一版附錄A, 以溶劑萃取並用氣相層析質譜儀分析, 必要時會以高效能液相層析-二極體陣列偵檢器進行確認。	5 ppm

Remark: Reporting Limit = Quantitation limit of analyte in sample
備註 報告極限 = 測試樣品之定量偵測極限

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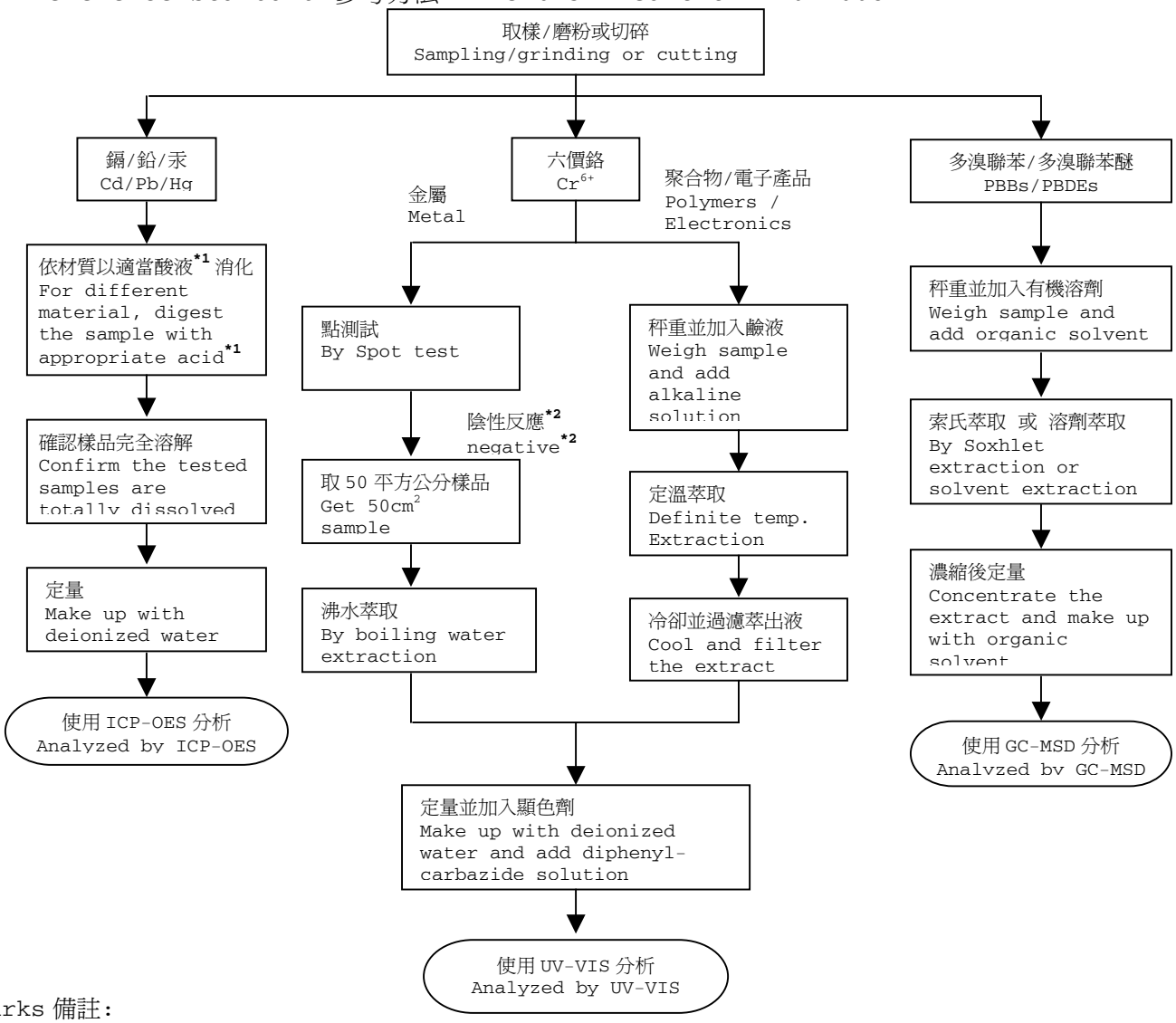
Test Conducted

(Ⅳ) Measurement Flowchart 測試流程圖:

Test For Cd/Pb/Hg/Chromium (VI)/PBBs/PBDEs Contents RoHS六項測試流程圖

Reference Standard 參考方法: IEC 62321 edition 1.0:2008



Remarks 備註:

*1: List Of Appropriate Acid 各材質添加酸液如下表:

Material 樣品材質	Acid Added For Digestion 添加酸液種類
Polymers / 聚合物	HNO_3,HCl,HF,H_2O_2,H_3BO_3 硝酸、鹽酸、氫氟酸、雙氧水、硼酸
Metals / 金屬	HNO_3,HCl,HF 硝酸、鹽酸、氫氟酸
Electronics / 電子產品	HNO_3,HCl,H_2O_2,HBF_4 硝酸、鹽酸、雙氧水、氟硼酸

*2: If the result of spot test is positive, Chromium VI would be determined as detected.
若點測試的結果爲陽性反應，則直接判定爲測試樣品含有六價鉻。

End Of Report

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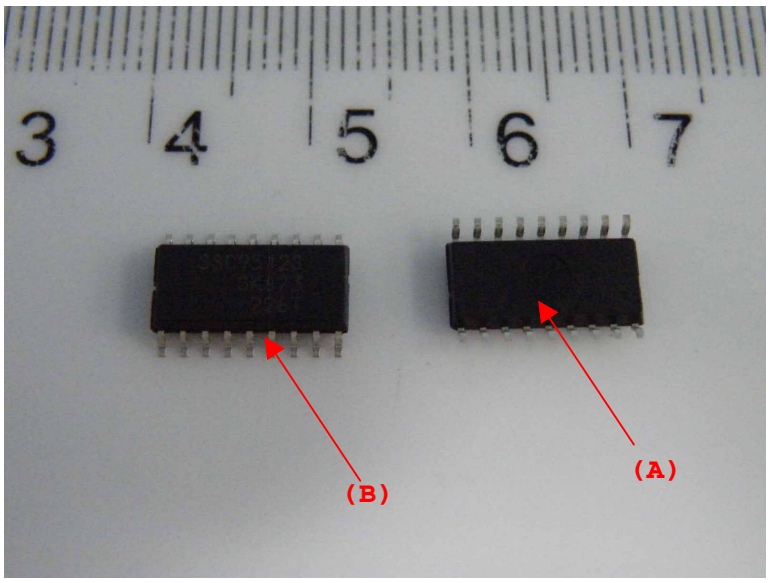
Number : TWNC0017688401

Test Conducted

Photo



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SSC9522S
Application Note Rev.0.3

The contents in this application note are preliminary, and are subject to changes without notice.

Taiwan Sanken Electric Co., Ltd.

http://www.sanken-ele.co.jp

Contents

1. General Descriptions

The SSC9522S is a controller IC (SMZ method) for half-bridge resonant type power supply, incorporating a floating drive circuit for High-side MOSFET drive.

※SMZ = Soft-switched Multi-resonant Zero Current switch

All switching periods work with soft switching operation.

The IC is in SOP18 package, and suitable for high performance power supply system with small size, high efficiency and low noise, because for various power supply specifications, more effective and easier design works are achievable with effective functions as the Automatic Dead Time Adjustment, the Uncontrollable Operation Detection and so on.

※Uncontrollable Operation Detection = there are two areas in resonant circuit impedance; capacitance area and inductance area. The Uncontrollable Operation occurs in capacitance area (the frequency is lower than the resonant frequency, f_O), the output voltage can not be controlled and the switching operation becomes hard switching.

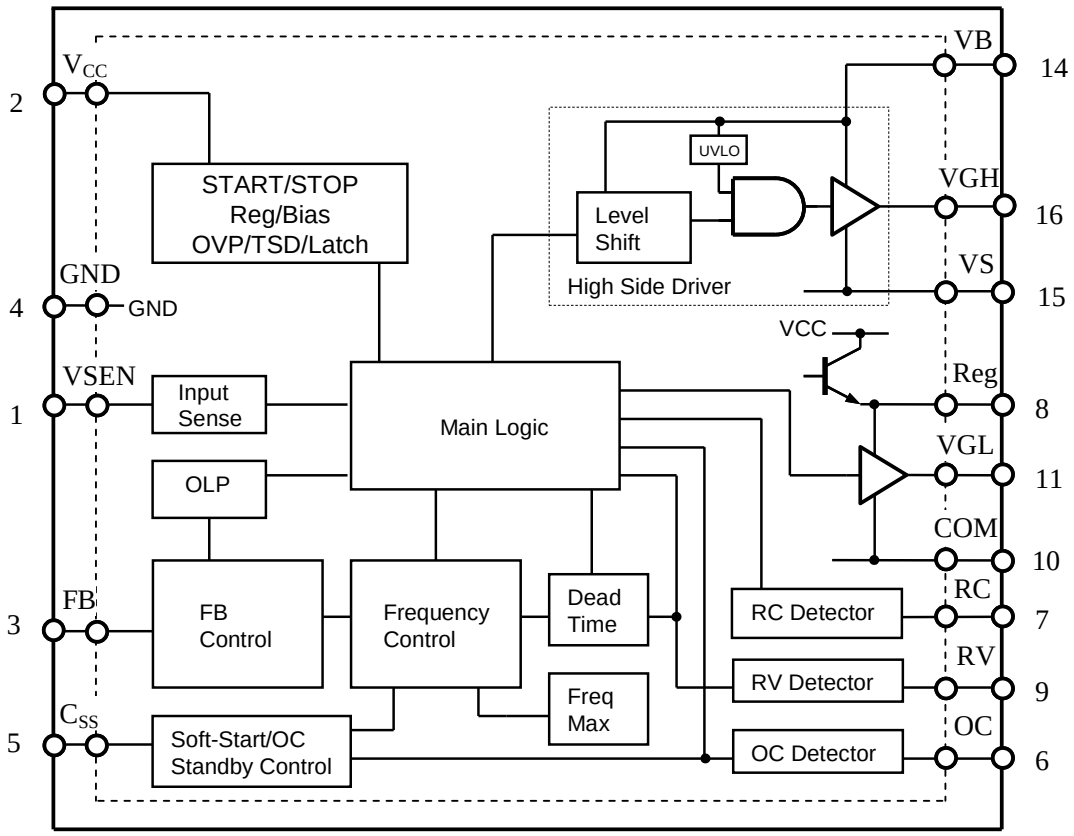
2. Features

Features and benefits include the followings:

- SOP18 package
- Built-in floating drive circuit for High-side MOSFET
- Soft Start Function, reducing of power MOSFET stress and preventing Uncontrollable Operation, at startup
- Uncontrollable Operation Detection Function on pulse-by-pulse basis, improving the ability of transformer output wattage because the frequency range is available up to the resonant frequency, f_O, and reducing power MOSFET stress
- Automatic Dead Time Adjustment Function, not being necessary to make the dead time adjustment for each power supply specification
- Protection Functions
  - Line Undervoltage Protection Function (Brown-In／Brown-Out Function) ---------- Prevention of excessive input current and overheat at low input voltage
  - External Latch Function ---------- Latch shutdown by external signal input
  - Overcurrent Protection Function (OCP) ---------- Three steps protection corresponding to overcurrent levels
  - Overvoltage Protection Function (OVP) ---------- Latch shutdown
  - Overload Protection Function (OLP) ---------- Latch shutdown
  - Thermal Shutdown Functions (TSD) ---------- Latch shutdown

3. Functional Block Diagram and Terminal List

Functional Block Diagram

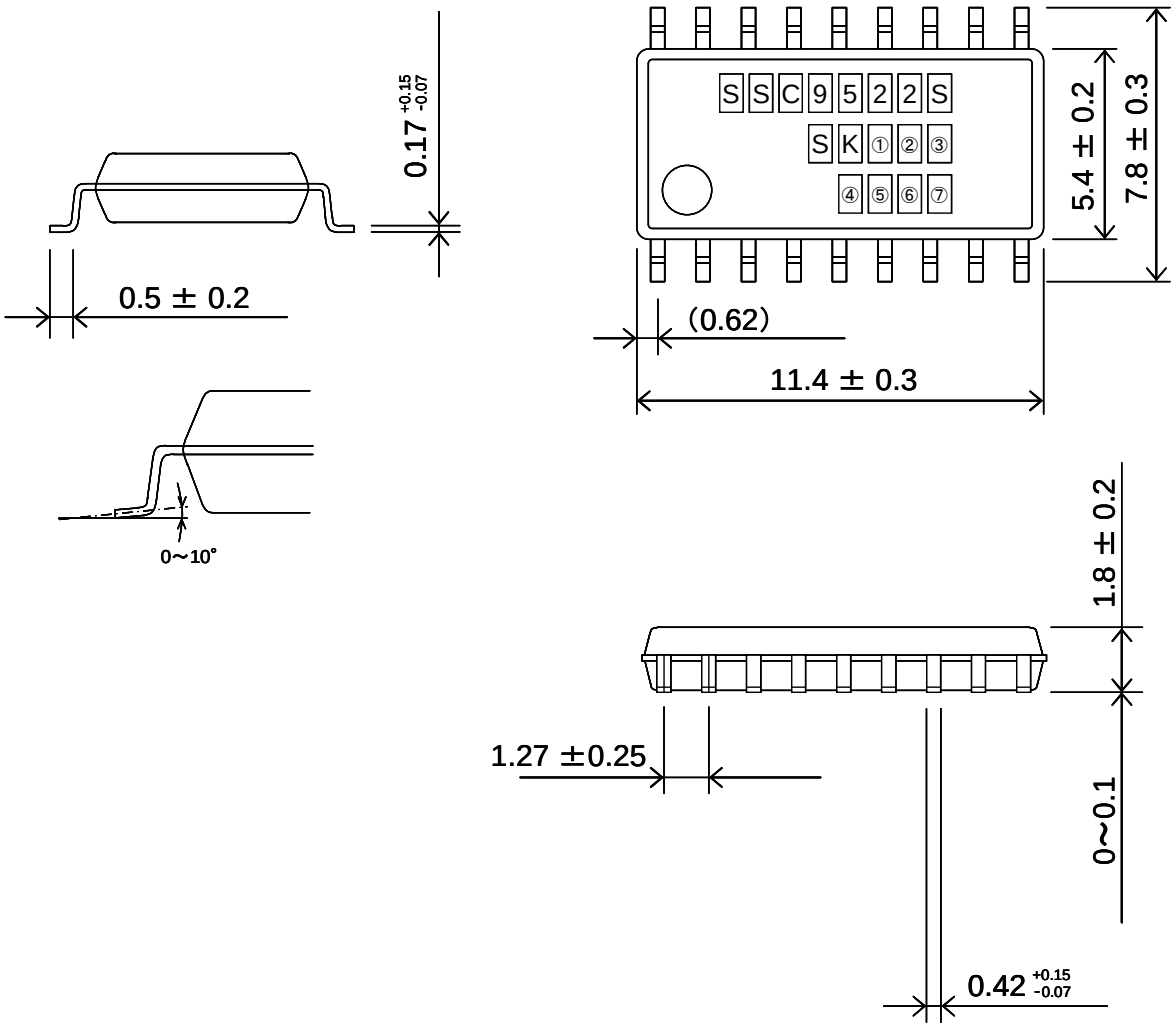


Terminal List Table

Terminal	Symbol	Functions
1	VSEN	AC line input voltage detection
2	V_{CC}	Power supply input for control circuit
3	FB	Constant voltage control signal input／Overload protection signal input
4	GND	Ground for control part
5	C_{SS}	Soft start capacitor connection
6	OC	Overcurrent protection signal input
7	RC	Resonant current signal input
8	Reg	Power supply output for gate drive
9	RV	Resonant voltage signal input
10	COM	Ground for power part
11	VGL	Low-side gate drive output
12, 13 17, 18	(NC)	(None)
14	VB	High-side gate drive voltage input
15	VS	High-side drive floating ground
16	VGH	High-side gate drive output

4. Package Information

The device is encapsulated in a standard 18 pin SOP package.



Dimensions in mm
Weight: Approx. 0.27g
Material of terminal: Cu
Treatment of terminal：solder plating

Upper tier：
Type symbol：SSC9522S
Middle, Lower tier：
『SK』＋『 Lot number ①—⑦ 』
・①：The last digit of year
・②：Month
1 to 9 for Jan. to Sep.
O for Oct.
N for Nov.
D for Dec.
・③：day
1st—10th ：1
11th—20th ：2
21st—31st ：3
・④～⑦：Sanken registration symbol

5. Electrical Characteristics

5.1 Absolute Maximum Ratings

Ta = 25°C, unless otherwise specified

Parameter	Terminal	Symbol	Ratings	Unit	Notes
VSEN terminal voltage	1−4	V_{SEN}	−0.3 toV_{REG}	V	
V_{CC} terminal voltage	2−4	V_{CC}	−0.3 to +35	V	
FB terminal voltage	3−4	V_{FB}	−0.3 to +10	V	
C_{SS} terminal voltage	5−4	V_{Css}	−0.3 to +12	V	
RC terminal voltage	7−4	V_{RC}	−6 to +6	V	
RV terminal current	9−4	I_{RV}	−2 to +2	mA	DC
			−100 to +100	mA	Pulse 40ns
OC terminal voltage	6−4	V_{OC}	−6 to +6	V	
VGL terminal voltage	11−4	V_{GL}	−0.3 to V_{REG}+0.3	V	
Reg terminal source current	8−4	I_{REG}	−20.0	mA	
Voltage between VB and VS terminal	14−15	V_B−V_S	−0.3 to +15.0	V	
VS terminal voltage	15−4	V_S	−1 to +600	V	
VGH terminal voltage	16−4	V_{GH}	V_S−0.3 to V_B+0.3	V	
Operating ambient temperature	—	T_{OP}	−20 to +85	℃	
Storage temperature	—	T_{stg}	−40 to +125	℃	
Junction temperature	—	T_j	+150	℃	

※Surge voltage withstand (Human body model) of No.14 to No.16 terminal is guaranteed 1000V.
Other terminals are guaranteed 2000V.

5.2 Electrical characteristics

V_{CC}=15V, Ta=25℃, unless otherwise specified.

Parameter	Terminal	Symbol	Ratings			Unit	Notes
			MIN	TYP	MAX		
Start／Circuit current							
Operation start voltage	2−4	$V_{CC(ON)}$	10.2	11.8	13.0	V	$V_{CC(OFF)}$ <$V_{CC(ON)}$
Operation stop voltage	2−4	$V_{CC(OFF)}$	8.8	9.8	10.9	V	
Circuit current in operation	2−4	$I_{CC(ON)}$	—	—	20.0	mA	
Circuit current in non-operation	2−4	$I_{CC(OFF)}$	—	—	1.2	mA	V_{CC}=9V
Circuit current in latch-operation	2−4	$I_{CC(L)}$	—	—	1.2	mA	V_{CC}=11V
OLP latch／External Latch							
FB terminal source current	3−4	I_{FB}	−30.5	−25.5	−20.5	μA	
FB terminal threshold voltage	3−4	V_{FB}	6.55	7.05	7.55	V	
C_{SS} terminal threshold voltage(1)	5−4	$V_{Css(1)}$	7.0	7.8	8.6	V	
Latch circuit release V_{CC} voltage	2−4	$V_{CC(La.Off)}$	6.7	8.2	9.5	V	$V_{CC(La.OFF)}$ <$V_{CC(OFF)}$
Oscillator							
Minimum frequency	11−10 16−15	$F_{(MIN)}$	26.2	28.3	31.2	kHz	
Maximum frequency	11−10 16−15	$F_{(MAX)}$	265	300	335	kHz	
Maximum dead-time	11−10 16−15	$t_{d(MAX)}$	1.90	2.45	3.00	μs	
Minimum dead-time	11−10 16−15	$t_{d(MIN)}$	0.25	0.50	0.75	μs	
Control							
Burst mode start FB terminal source current	3−4	$I_{CONT(1)}$	−2.9	−2.5	−2.1	mA	
Oscillation stop FB terminal source current	3−4	$I_{CONT(2)}$	−3.7	−3.1	−2.5	mA	
Soft start							
C_{SS} terminal charge current	5−4	$I_{Css(C)}$	−0.21	−0.18	−0.15	mA	
C_{SS} terminal reset current	5−4	$I_{Css(R)}$	1.0	1.8	2.4	mA	V_{CC}=9V
Overvoltage protection／Thermal protection							
OVP operating V_{CC} voltage	2−4	V_{OVP}	28.0	31.0	34.0	V	
Thermal shutdown operating temperature	—	$T_{j\,(TSD)}$	150	—	—	℃	
Detection of current resonant／Overcurrent protection							
Uncontrollability detection voltage	7−4	V_{RC}	±0.055	±0.155	±0.255	V	
RC terminal threshold voltage (Hi speed)	7−4	$V_{RC(S)}$	±2.15	±2.35	±2.55	V	
OC terminal threshold voltage(Low)	6-4	$V_{OC(L)}$	1.42	1.52	1.62	V	
OC terminal threshold voltage (High)	6-4	$V_{OC(H)}$	1.69	1.83	1.97	V	
OC terminal threshold voltage (Hi speed)	6-4	$V_{OC(S)}$	2.15	2.35	2.55	V	

Parameter	Terminal	Symbol		Ratings MIN	Ratings TYP	Ratings MAX	Unit	Notes
C_{SS} terminal sink current	5−4	I_{Css}	(L)	1.0	1.8	2.4	mA	
			(H)	12.0	20.0	28.0		
			(S)	11.0	18.3	25.0		
Detection of voltage resonant								
RV terminal voltage detect Resonance voltage(1)	9−4	$V_{RV(1)}$		3.8	4.9	5.4	V	
RV terminal voltage detect Resonance voltage(2)	9−4	$V_{RV(2)}$		1.20	1.77	2.30	V	
Stand by								
Burst oscillation frequency	5−4	f_{Css}		70	105	130	Hz	
ON／OFF								
C_{SS} terminal threshold voltage (2)	5−4	$V_{Css(2)}$		0.50	0.59	0.68	V	
Input voltage detect function								
VSEN terminal threshold voltage (ON)	1−4	$V_{SEN(ON)}$		1.32	1.42	1.52	V	
VSEN terminal threshold voltage (OFF)	1−4	$V_{SEN(OFF)}$		1.08	1.16	1.24	V	
Supply of driver circuit								
Reg terminal output voltage	8−4	V_{REG}		9.9	10.5	11.1	V	
High-side driver								
High-side drive operation start voltage	14−15	$V_{BUV(ON)}$		6.3	7.3	8.3	V	
High-side drive operation stop voltage	14−15	$V_{BUV(OFF)}$		5.5	6.4	7.2	V	
Drive circuit								
VGL,VGH terminal source current 1	11−10 16−15	$IGL_{SOURCE1}$ $IGH_{SOURCE1}$		—	515	—	mA	V_{Reg}=10.5V V_B=10.5V V_{GL}=0V V_{GH}=0V
VGL,VGH terminal sink current 1	11−10 16−15	IGL_{SINK1} IGH_{SINK1}		—	−685	—	mA	V_{Reg}=10.5V V_B=10.5V V_{GL}=10.5V V_{GH}=10.5V
VGL,VGH terminal source current 2	11−10 16−15	$IGL_{SOURCE2}$ $IGH_{SOURCE2}$		50	82	120	mA	V_{Reg}=12V V_B=12V V_{GL}=10.5V V_{GH}=10.5V
VGL,VGH terminal sink current 2	11−10 16−15	IGL_{SINK2} IGH_{SINK2}		−160	−113	−70	mA	V_{Reg}=12V V_B=12V V_{GL}=1.5V V_{GH}=1.5V

5.3 Thermal resistance

Parameter	Symbol	Ratings MIN	Ratings TYP	Ratings MAX	Unit	Notes
MIC junction to air	θ_{j-a}	—	—	95	℃/W	

6. Typical Application Circuit

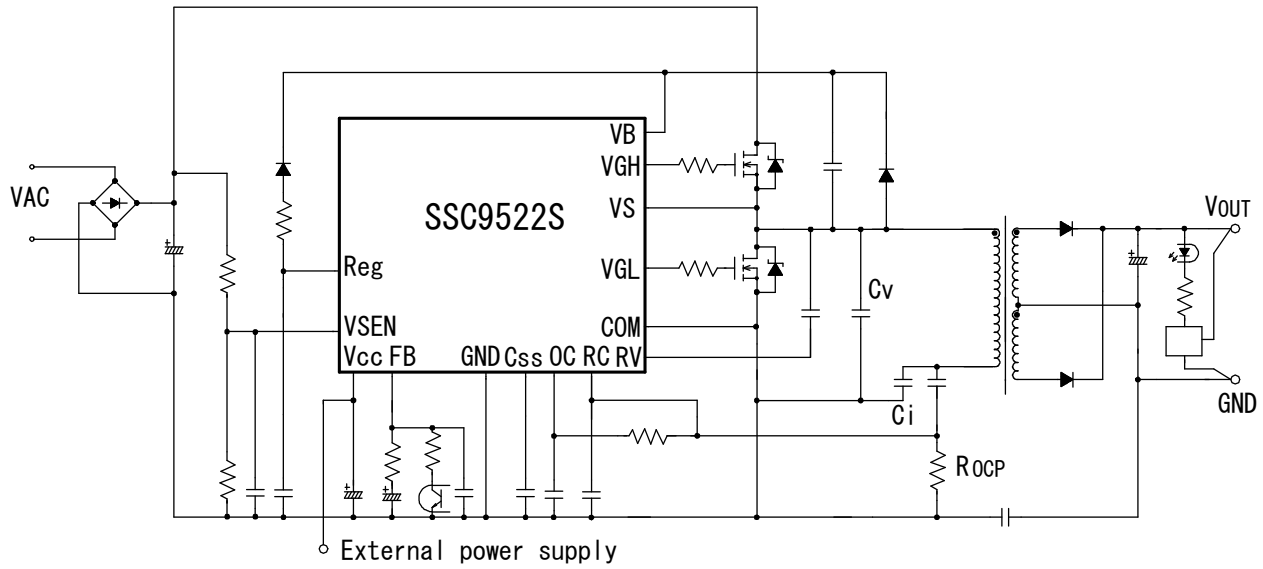


Figure 6 Typical application circuit example

7. Functional Descriptions

The polarity of current is shown as "+"for sink current and "−" for source current based on IC.

7.1 Resonant Circuit Operation

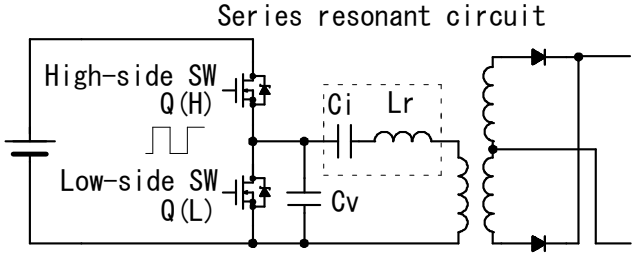


Figure 7-1 Principal of series resonant converter

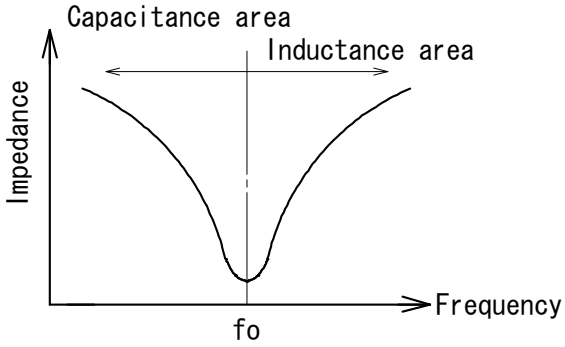


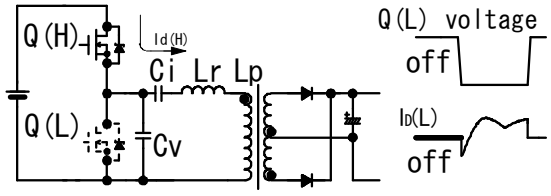
Figure 7-2 Resonant circuit impedance

Figure 7-1 depicts the principle of resonant converter. The Q(H) stands for High-side SW, the Q(L) stands for Low-side SW, the Ci stands for current resonant capacitor, and the C_V stands for voltage resonant capacitor.
When the frequency is changed, the impedance of resonant circuit is changed as shown in Figure 7-2.
Higher frequency area than the resonant frequency, f_O, is inductance area, lower frequency area is capacitance area.
Therefore, the resonant converter operates in inductance area due to soft-switching operation.

The thick waveform line of Figure 7-3 depicts Low-side SW current waveform of each timing in steady state.

①Period Operation

During Q(H) is ON, the energy is stored into series resonant circuit due to I_D(H) flowed through resonant circuit and transformer.



①Period

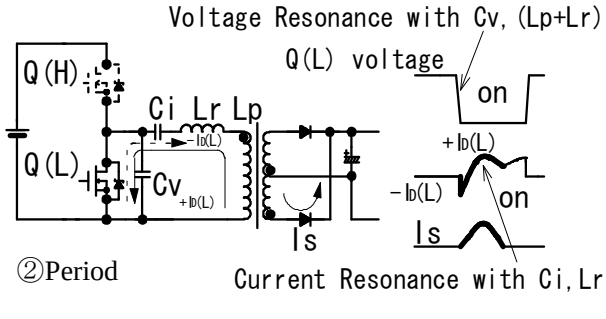
②Period Operation

When Q(H) turns off, $-I_D$(L) flows to Q(L) due to the energy stored series resonant circuit, C_V is discharged and Q(L) voltage goes down to the forward voltage of its body diode, V_F. Thus, when Q(L) turns on, ZVS (Zero Voltage Switching) and ZCS (Zero Current Switching) are achieved on Q(L).

The primary winding voltage of transformer adds Ci voltage, and the energy is transferred to the secondary circuit.

At the same time, Ci voltage goes down due to discharge.

When the primary winding voltage can not keep the secondary rectifier ON, the energy to the secondary circuit is stopped.



③Period Operation

I_D(L) keeps on flowing, and Ci keeps on discharging.

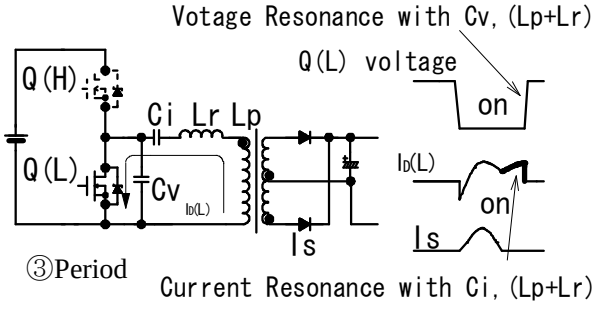


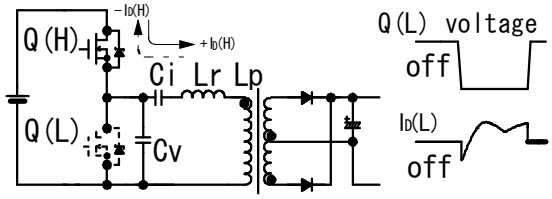
Figure 7-3-1 Resonant circuit operation

④Period Operation

When Q(L) turns off, $-I_D$(H) flows to Q(H) due to the energy stored series resonant circuit, C_V is charged and Q(L) goes up to the input voltage, Q(H) voltage is clamped with the forward voltage of its body diode, V_F. Thus, when Q(H) turns on, ZVS (Zero Voltage Switching) and ZCS (Zero Current Switching) are achieved on Q(H).

The primary winding voltage of transformer adds Ci voltage, and the energy is transferred to the secondary circuit.

At the same time, Ci voltage goes down due to discharge. When the primary winding voltage can not keep the secondary rectifier ON, the energy to the secondary circuit is stopped.



④Period

Figure 7-3-2 Resonant circuit operation

The above-mentioned operations are repeated, the energy to the secondary circuit is transferred with ZVS and ZCS operations.

7.2 Startup Operation

V_{CC} terminal voltage is provided with an external power supply as shown in Figure 7-4.

When V_{CC} terminal voltage reaches $V_{CC(ON)}$= 11.8V(TYP), the control circuit starts operation.

While the control circuit is in operation, if V_{CC} terminal voltage decreases to $V_{CC(OFF)}$= 9.8V(TYP), the control circuit stops operation by UVLO (Undervoltage lockout) circuit, and reverts to the state before startup.

Switching operation at startup starts when the following conditions are fulfilled.

- VSEN terminal voltage is $V_{SEN(ON)}$= 1.42V(TYP) and more.
- V_{CC} terminal voltage is $V_{CC(ON)}$= 11.8V(TYP) and more.
- C_{SS} terminal voltage is $V_{CSS(2)}$= 0.59V(TYP) and more.

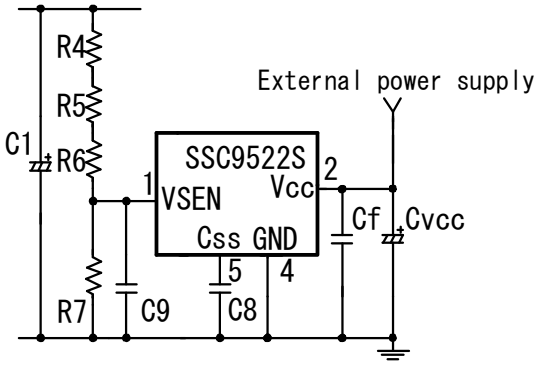


Figure 7-4 V_{CC} peripheral circuit

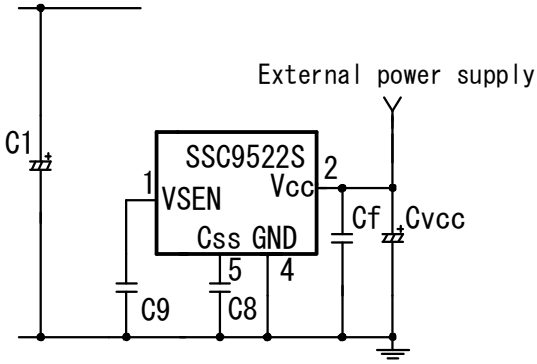


Figure 7-6 V_{CC} peripheral circuit without brown-in/brown-out function

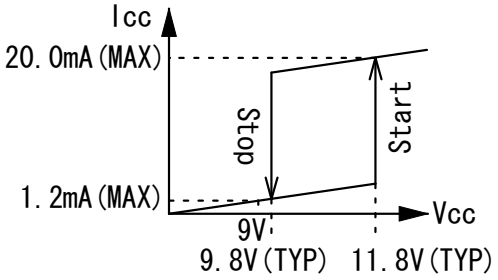


Figure 7-5 Relationship of V_{CC} and I_{CC} at Startup and Shutdown

After providing the input voltage, when the IC is turned on / off with V_{CC} terminal voltage provided from the external power supply, the startup time from $V_{CC(ON)}$= 11.8V(TYP) to the switching operation is shown below.

- In Figure 7-4, the approximate value, t_{ST1}, is as follows.

$$t_{st1} = C8 \times V_{CSS(2)} / I_{CSS(C)} \quad \text{----- (1)}$$

where $V_{CSS(2)}$= 0.59V(TYP)、$I_{CSS(C)}$= −0.18mA(TYP)

When C8 is 1μF, t_{ST1} is about 3.3ms.

- In Figure 7-6, VSEN terminal voltage is charged by the internal circuit after $V_{CC(ON)}$= 11.8V(TYP), the rising time, t_{ST2}, to $V_{SEN(ON)}$= 1.42V(TYP) is added to t_{ST1}.
  The approximate value, t_{ST2}, is as follows.
  The circuit without Brown-In / Brown-Out Functions refers to "7.8 Line Undervoltage Protection Function (Brown-In / Brown-Out Function)" section

$$t_{st2} = C9 \times 380k \quad \text{----- (2)}$$

When C8 is 1μF and C9 is 0.01μF, t_{ST1} is about 3.3ms and t_{ST2} is about 3.8ms. As a result, the total startup time is about 7.1ms.

7.3 Soft Start Function

The oscillation frequency varies with C_{SS} terminal voltage. The soft start operation is achieved by connecting the capacitor, C8, to C_{SS} terminal externally.
At startup, C8 is charged by $I_{CSS(C)}$= −0.18mA(TYP), and C_{SS} terminal voltage rises gradually.
Thus, the oscillation frequency decreases from Maximum frequency, $F_{(MAX)}$= 300kHz(TYP), and the output power of the SMPS increases.
By this soft start function at startup, both the reduction of stress on peripheral components and the prevention of uncontrollable operations are achieved.
When V_{CC} terminal voltage falls below $V_{CC(OFF)}$= 9.8V (TYP) or VSEN terminal voltage falls below $V_{SEN(OFF)}$= 1.16V(TYP) or External Latch Function or OVP latch or OLP latch or TSD latch works, C8 is discharged by $I_{CSS(R)}$= 1.8mA (TYP).

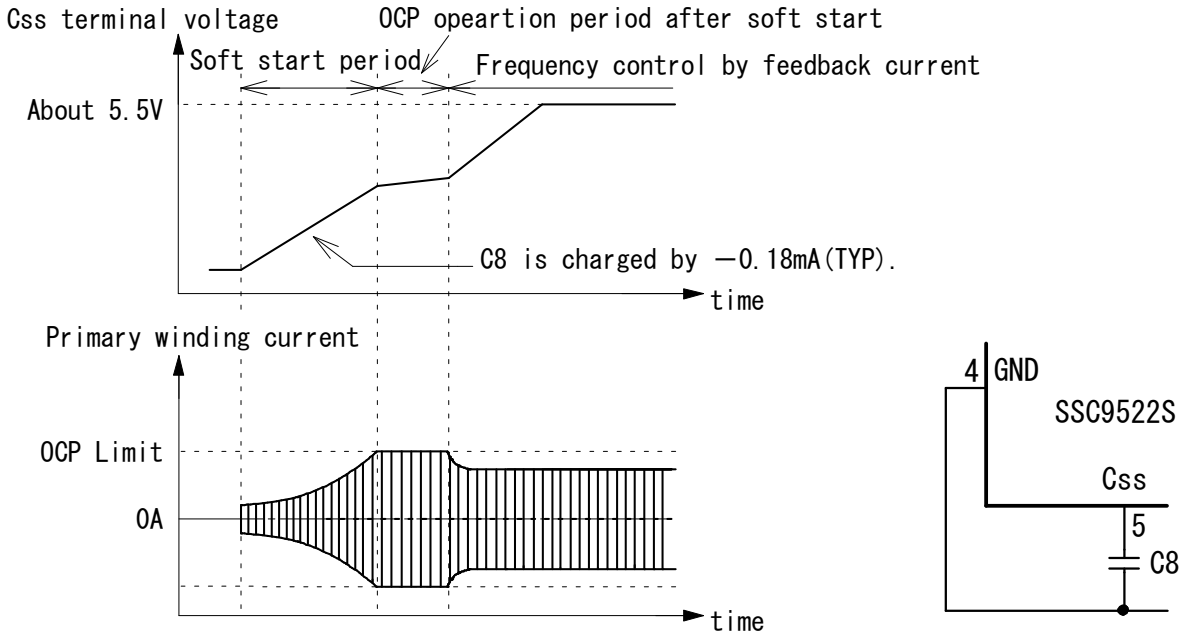


Figure 7-7 C_{SS} operation diagram

7.4 Constant Output Voltage Control

The constant output voltage is controlled by frequency control in the inductance area, by the feedback current sunk from FB terminal connected a photo-coupler.

At slight loads, the burst oscillation is achieved when the feedback current is $I_{CONT(1)}$= −2.5mA(TYP) and less. This mode reduces switching loss and restrains the output voltage of SMPS from increasing.

As the ability of the sink current from FB terminal is necessary to be sunk $I_{CONT(2)}$= −3.7mA(MIN) and less, the forward current of photo-coupler in the secondary circuit should be set in consideration of aging degradation of CTR (Current Transfer Ratio) and others.

In Figure 7-8, R2 value is recommended 560Ω.

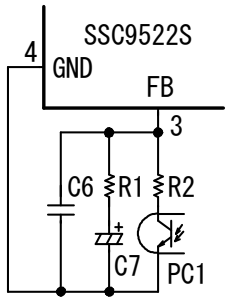


Figure 7-8 FB terminal peripheral circuit

7.5 Automatic Dead Time Adjustment Function

The Automatic Dead time Adjustment Function is incorporated, and thus, it is unnecessary to adjust the dead time for each SMPS specification.

By detecting dv/dt of Low-side MOSFET V_{DS} (Drain-to-Source voltage) waveform, the control circuit automatically controls ZVS (Zero Voltage Switching) operation on High-side / Low-side MOSFET.

A very simple peripheral circuit achieves this function, only by placing a high-voltage-type ceramic capacitor Crv (total capacitor value is about 5pF) between VS terminal and RV terminal, as shown in Figure 7-9.

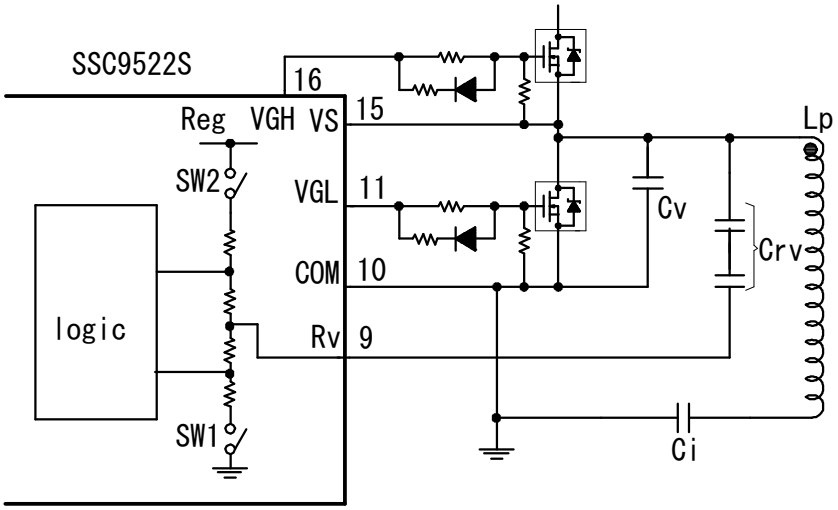


Figure 7-9 RV terminal peripheral circuit

RV terminal voltage is the divided voltage by resistors between internal reference voltage (Reg) and GND.

The differential current flown through Crv by the dv/dt of Low-side MOSFET V_{DS} waveform is provided to RV terminal. Thus, the dead time detection circuit detects dv/dt of Low-Side MOSFET.

Both the circuit current reduction and the differential circuit response improvement are achieved by turning on SW1 and SW2 together in the period needed the detection.

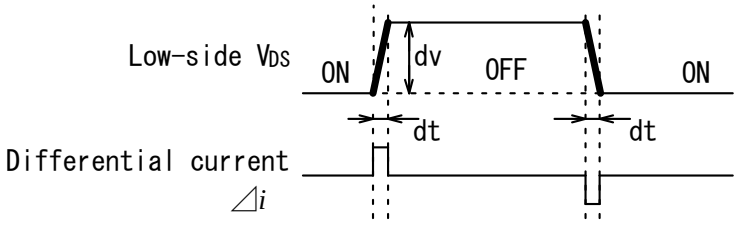


Figure 7-10 Differential current

The differential current Δi is as follows.

$$\Delta i = Crv \times (dv/dt) \qquad \text{-----(3)}$$

When the differential current Δi exceeds the current in the following equation, a smaller value of Crv is recommended.

$$\left| \Delta i \right| \leq \frac{100mA \times 40ns}{dt} \qquad \text{-----(4)}$$

When *dt* is 40ns or below, Δi is set to ±100mA.

Figure 7-11 shows the schematic operational waveforms of Automatic Dead Time Adjustment Function.

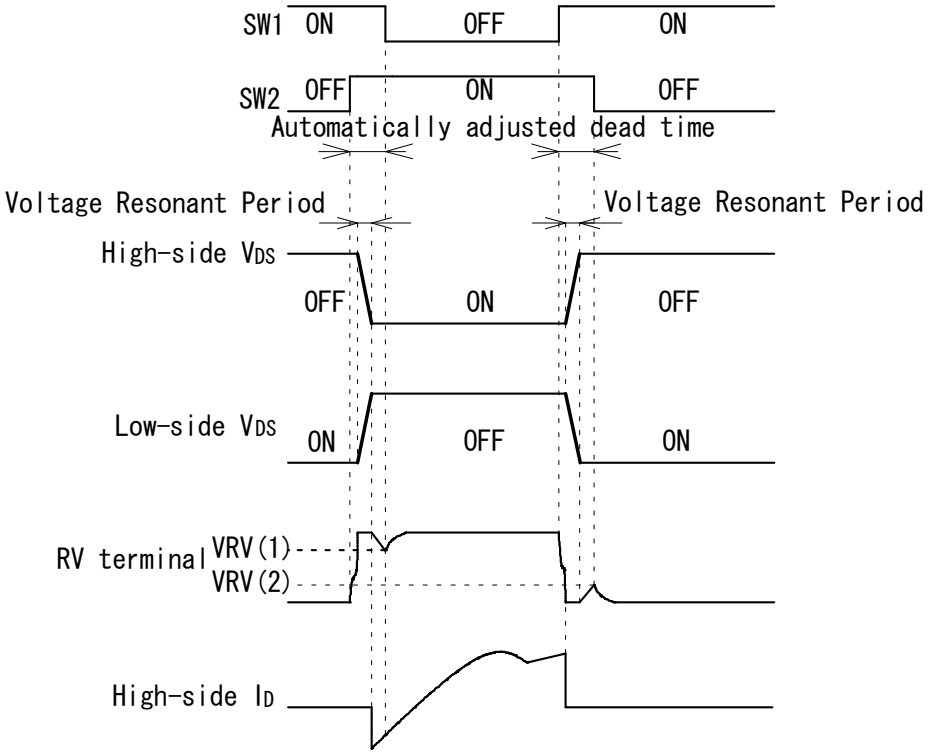


Figure 7-11 Operational waveform of Automatic Dead time Adjustment Function

- Voltage Resonant Period in Turning OFF Low-side MOSFET

  When Low-side MOSFET is turned off, SW2 is turned on while keeping SW1 turned on.
  At this time, the resonant current flows through C_V, Ci and L_P. Thus, C_V voltage rises from 0V.
  When this voltage reaches "Input voltage $+V_F$ of High-side MOSFET body diode", the resonant current flows through High-side MOSFET body diode, and the V_{DS} of Low-side MOSFET is clamped. This period is defined as Voltage Resonant Period.

  Because the differential current flown through Crv by the dv/dt of Low-side MOSFET V_{DS} waveform is provided to RV terminal, RV terminal voltage rises from the internally divided voltage by resistors, until clamped internally.
  When the Voltage Resonant Period ends and the differential current becomes zero, RV terminal voltage returns to the internally divided voltage.

  At this time, the control circuit detects the completion of Voltage Resonant Period, by detecting $V_{RV(1)}$= 4.9V (TYP). As a result, High-side MOSFET is turned on and SW1 is turned off. This period is automatically adjusted dead time.

- Voltage Resonant Period in Turning OFF High-side MOSFET

  When High-side MOSFET is turned off, SW1 is turned on while keeping SW2 turned on.
  At this time, the resonant current flows through C_V, Ci and L_P. Thus, C_V voltage falls from the input voltage.
  When this voltage falls below "$-V_F$ of Low- side MOSFET body diode", the resonant current flows through Low-side MOSFET body diode and the V_{DS} of High-side MOSFET is clamped. This period is defined as Voltage Resonant Period.

  Because the differential current flown through Crv by the dv/dt of Low-side MOSFET V_{DS} is provided to RV terminal, RV terminal voltage falls from the internally divided voltage by resistors, until clamped to internal GND level.
  When the Voltage Resonant Period ends and the differential current from RV terminal becomes zero, RV terminal voltage returns to the internally divided voltage.

  At this time, the control circuit detects the completion of Voltage Resonant Period by detecting $V_{RV(2)}$= 1.77V (TYP). As a result, Low-side MOSFET is turned on and SW2 is turned off. This period is automatically adjusted dead time.

When the dead time period becomes shorter than Voltage Resonant Period, switching losses are increased because power MOSFETs turn ON / OFF during Voltage Resonant Period, as shown in Figure 7-12.
It is usually necessary to adjust values of resonant circuit and evaluate voltage resonant operation over each condition of the SMPS specification because Voltage Resonant Period is variable on the condition of input voltage and output power of the SMPS.
However, the Automatic Dead Time Adjustment Function always makes ZVS (Zero Voltage Switching) for Voltage Resonant Period when RV terminal is provided the signals which reach $V_{RV(1)}$, $V_{RV(2)}$ threshold voltage.

Regarding ZCS (Zero Current Switching) of the IC, the minus current period of I_D (the period in which the current flows into power MOSFET body diode) should be more than 450ns as shown in Figure 7-13.

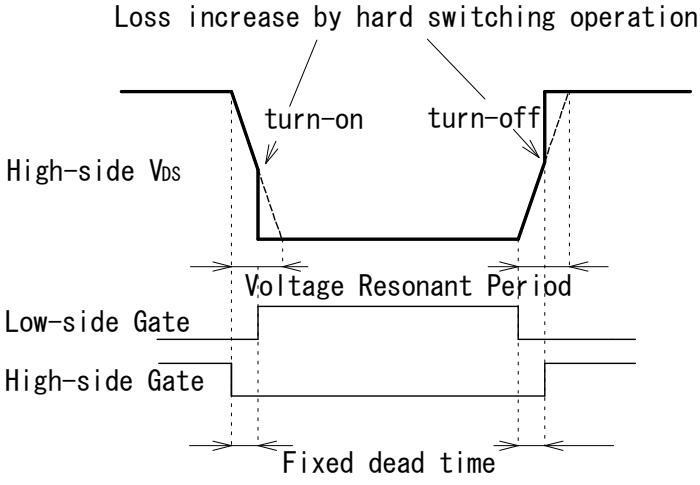


Figure 7-12 ZVS failure operation waveform

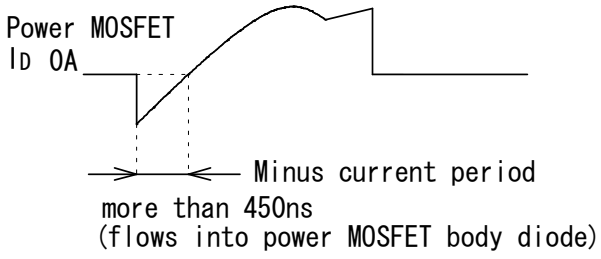


Figure 7-13 ZCS Check Point

7.6 Latch Function

The fault latch function stops switching operation with latch mode, when OVP and/or OLP and/or TSD protection functions are activated.

Releasing the latch is done by dropping the V_{CC} terminal voltage below $V_{CC(La.Off)}$= 8.2V(TYP).

7.7 External Latch Function

As the protection for abnormal operations, the latch circuit is activated when C_{SS} terminal voltage reaches $V_{CSS(1)}$= 7.8V(TYP) and more by an external circuit.
The current from the external circuit should be 100μA and more. Because the sink current flows into IC at C_{SS} terminal in OCP operation, if the current from the external circuit is lower than the sink current, C_{SS} terminal voltage could not rise
The external circuit should keep C_{SS} terminal voltage within Absolute Maximum Rating, 12V, for example, by clamping with a 10V zener diode (Figure 7-14) or other ways.

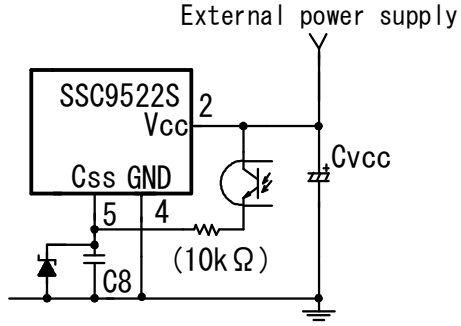


Figure 7-14 External latch example

7.8 Line Undervoltage Protection Function (Brown-In／Brown-Out Function)

VSEN terminal detects the input voltage and stops the oscillation at low input voltage (Brown-In / Brown-Out Function), this function prevents exceeding input current and overheat.

When this function is unnecessary, R4 to R7 are removed and C9 is recommended about 0.01μF to prevent malfunction caused by noise.

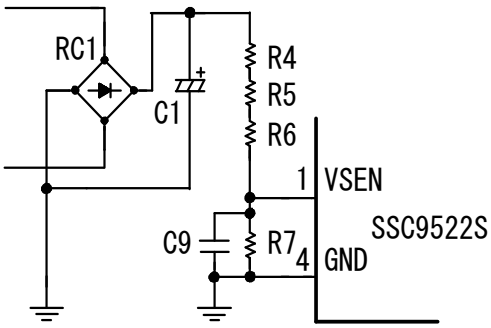


Figure 7-15 VSEN terminal peripheral circuit

The detecting voltage is set by R4 to R7 in Figure 7-15.

- When VSEN terminal voltage is $V_{SEN(ON)}$= 1.42V(TYP) and more, the control circuit starts operation.
- When VSEN terminal voltage is $V_{SEN(OFF)}$= 1.16V(TYP) and less, the control circuit stops oscillation.

The resistors, R4 to R7, and the operation voltages are as follows.

$$R4 + R5 + R6 \fallingdotseq \frac{E_{IN(ON)} - V_{SEN(ON)}}{V_{SEN(ON)}} \times R7 \ , \quad E_{IN(OFF)} \fallingdotseq \frac{V_{SEN(OFF)}}{V_{SEN(ON)}} \times E_{IN(ON)} \qquad \text{------(5)}$$

where $E_{IN(ON)}$ is the DC input voltage on which the control circuit starts operation, and $E_{IN(OFF)}$ is the DC input voltage on which the control circuit stops operation.

C9 capacitor reduces AC ripple and makes some delay time. The recommended value is about 0.1μF.
R4 to R6 applied high voltage are recommended anti-electromigration type of resistors, such as metal oxide film.
The values of R4 to R7 and C9 should be adjusted on actual operation.

7.9 Overvoltage Protection Function (OVP)

When the voltage of V_{OVP}= 28V(MIN) and more is applied between V_{CC} terminal and GND terminal, the control circuit stops oscillation in latch mode by internal OVP circuit operation,
The voltage applied to V_{CC} terminal should be below Absolute Maximum Rating, 35V.

7.10 Overload Protection Function (OLP)

When overload conditions (this state is limited by Overcurrent Protection (OCP)) continues during a certain time (delay time), the control circuit increases the switching frequency and limits the output power of the SMPS. Thus, this function reduces stresses of power MOSFETs, secondary diodes and so on.

In OCP operation, the output voltage falls down and the feedback current from secondary photo-coupler becomes zero. When the feedback current becomes zero, I_{FB}= −25.5μA(TYP) flows from FB terminal and charges C7 shown in Figure 7-16.
When FB terminal voltage reaches V_{FB}= 7.05V(TYP), the control circuit stops operation in latch mode.
This period is defined as Latch delay time, t_{DLY}, and the approximate value is as follows.

$$t_{DLY} \fallingdotseq \frac{\left(4.05V - R1 \times 25.5\mu A \right) \times C7}{25.5\mu A} \qquad \text{-----(6)}$$

When R1 is 47kΩ and C7 is 4.7μF, t_{DLY} is about 0.5sec.

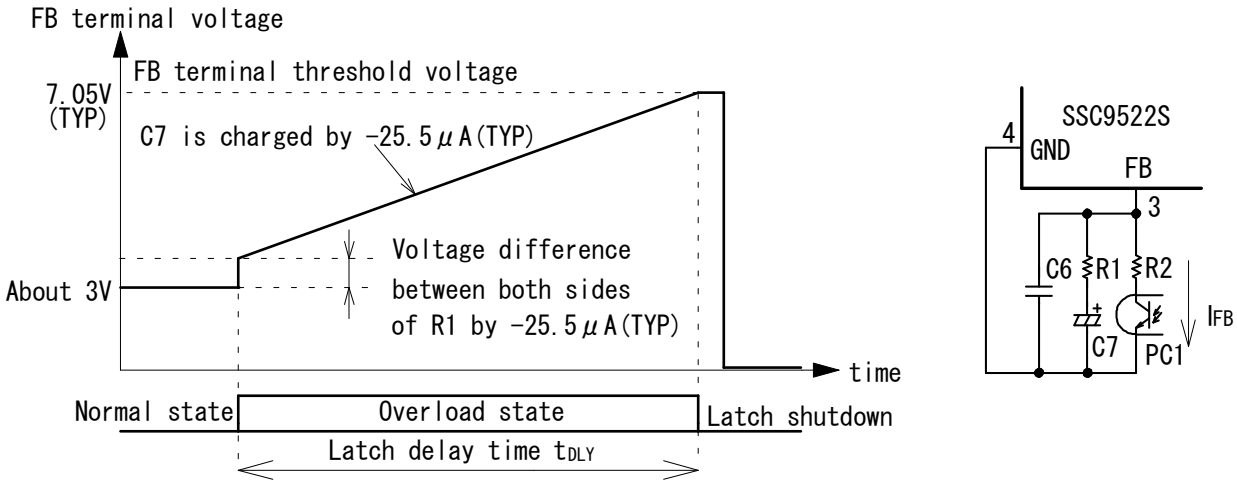


Figure 7-16 OLP operation

7.11 Overcurrent Protection Function (OCP)

Overcurrent Protection Function (OCP) detects the drain current, I_D, with pulse-by-pulse basis at OC terminal, and limits output power.

In Figure 7-17, by using a smaller capacitor for bypass capacitor C12 than the current resonant capacitor Ci, the detection current decreases. As a result, the power loss at the detecting resistor R_{OCP}, is reduced, and a smaller resistor is available.

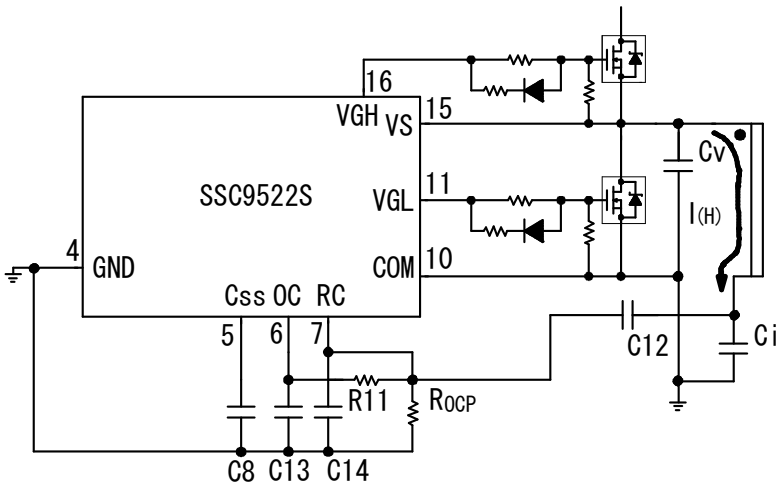


Figure 7-17 OC terminal peripheral circuit

For resonant power supplies, the values of R_{OCP}, R11, C12 and C13 should be adjusted on actual operation, because there is no convenient method to calculate the accurate resonant current value by input / output conditions and others.

The relationship among $V_{OC(L)}$, C12 and Ci is as follows.

$$R_{OCP} \fallingdotseq \frac{V_{OC(L)}}{I_{(H)} \times \frac{C12}{C12+Ci}} \qquad \text{----- (7)}$$

where $I_{(H)}$ is the drain current of High-side MOSFET as shown in Figure 7-17.

As R_{OCP} voltage is used for Uncontrollable Operation Detection as described in "7.12 Uncontrollable Operation Detection Function" section, R_{OCP} and C12 should be adjusted by both OCP detection and Uncontrollable Operation Detection.

The following values are recommended as target values.

C12 is adjusted so that R_{OCP} becomes about 100Ω, and generally it is about 1／100 of Ci.

R11 is about 470Ω and C13 is about 680pF for filter portion.

There are three steps protection corresponding to overcurrent levels as follows.

①OC Terminal Threshold Voltage (Low) : $V_{OC(L)}$

This protection works first. When OC terminal voltage exceeds $V_{OC(L)}$= 1.52V(TYP), C8 is discharged by $I_{CSS(L)}$= 1.8mA(TYP), and thus, the switching frequency increases, and the output power is limited.

When OC terminal voltage falls below $V_{OC(L)}$ in discharging C8, the discharge stops.

②OC Terminal Threshold Voltage (High) : $V_{OC(H)}$

This protection works second. When OC terminal voltage exceeds $V_{OC(H)}$= 1.83V(TYP), C8 is discharged by $I_{CSS(H)}$= 20mA(TYP), and thus, the switching frequency increases faster because $I_{CSS(H)}$ is about 11 times of $I_{CSS(L)}$, and the output power is limited.

When OC terminal voltage falls below $V_{OC(H)}$ in discharging C8, the above operation in ① is active.

③OC Terminal Threshold Voltage (Hi speed) : $V_{OC(S)}$

This protection works third. When OC terminal voltage exceeds $V_{OC(S)}$= 2.35V(TYP), power MOSFETs reverse ON / OFF, C8 is discharged by $I_{CSS(S)}$= 18.3mA(TYP), and thus, the Hi Speed OCP operation achieves so as to increase the switching frequency and to limit the output power.

This operation works to protect for exceeding overcurrent, such as the output shorted.

When OC terminal voltage falls below $V_{OC(S)}$ because of limiting the output power, the above operations in ① and ② are active.

7.12 Uncontrollable Operation Detection Function

The constant output voltage is controlled by frequency control, the switching frequency decreases when output power increases. When the switching frequency goes to capacitance area, the constant output voltage is uncontrollable, the hard switching makes loss increased, and power MOSFETs increase their stress.

This phenomenon is called Uncontrollable Operation.

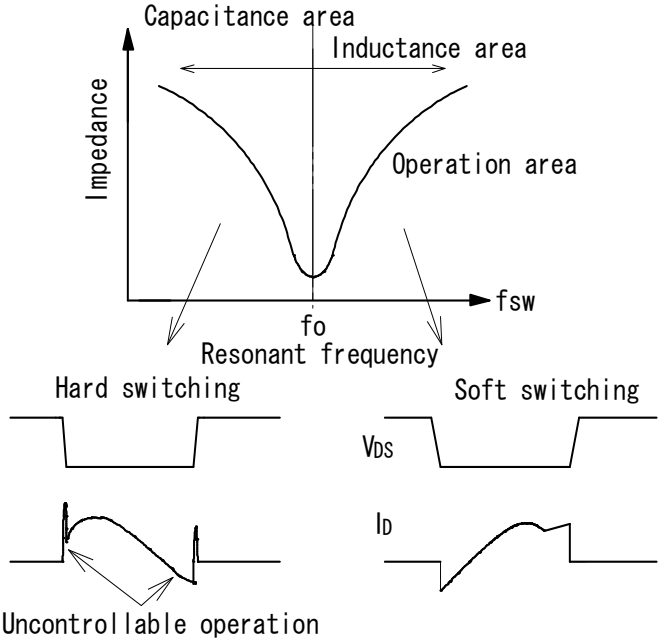


Figure 7-18 Uncontrollable operation

The Uncontrollable Operation Detection Function is incorporated in the IC. This function prevents the above-mentioned issues, and moreover, improves the ability of transformer because of enabling to operate in the resonant frequency, f_O (which makes the most of output power in series resonant circuit).

This function eliminates to adjust the minimum switching frequency to higher than the resonant frequency, f_O, for each power supply specification.

There are two Uncontrollable Operation Detection Functions.

- During High-side MOSFET turns on, when RC terminal voltage crosses V_{RC}= +0.155V(TYP) on the condition that RC terminal voltage changes from plus to minus, the control circuit detects Uncontrollable Operation (refer to RC Terminal Voltage in Capacitance Area waveform in Figure 7-19), and thus, High-side MOSFET turns off and Low-side MOSFET turns on.
- During Low-side MOSFET turns on, when RC terminal voltage crosses V_{RC}= −0.155V(TYP) on the condition that RC terminal voltage changes from minus to plus, the control circuit detects uncontrollable operation, and thus, Low-side MOSFET turns off and High-side MOSFET turns on.

By the above functions, the Uncontrollable Operation is detected with pulse-by-pulse basis.
By synchronizing the operational switching frequency with the Uncontrollable Operation frequency, it is available to prevent Uncontrollable Operation.

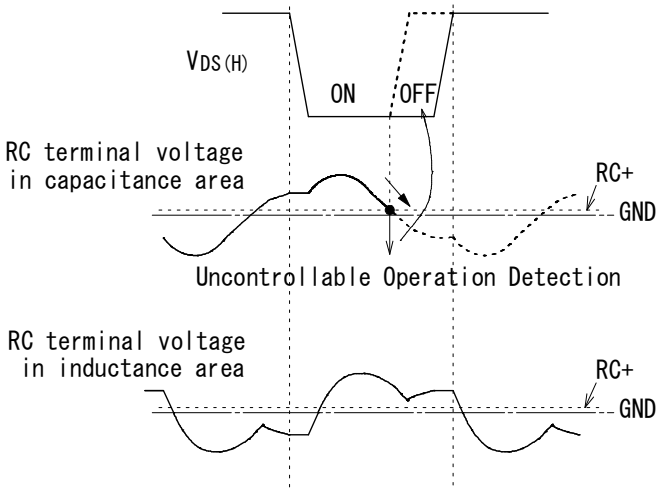


Figure 7-19 Uncontrollable Operation Detection on High-side MOSFET

For Uncontrollable Operation Detection, RC terminal should be connected to the input side of OC terminal filter circuit in order to improve the detection speed, as shown in Figure 7-20.
C14 is recommended about 100pF to prevent malfunctions caused by noise,
R_{OCP} and C12 should be adjusted as described in "7.11 Overcurrent Protection Function (OCP)" section.
In addition, R_{OCP} should be adjusted to reach V_{RC}= ±0.155V(TYP), on such conditions caused uncontrollable operation easily as SMPS is at startup, the input voltage is off, or the output is shorted.
RC terminal voltage should be within Absolute Maximum Rating, ±6V.

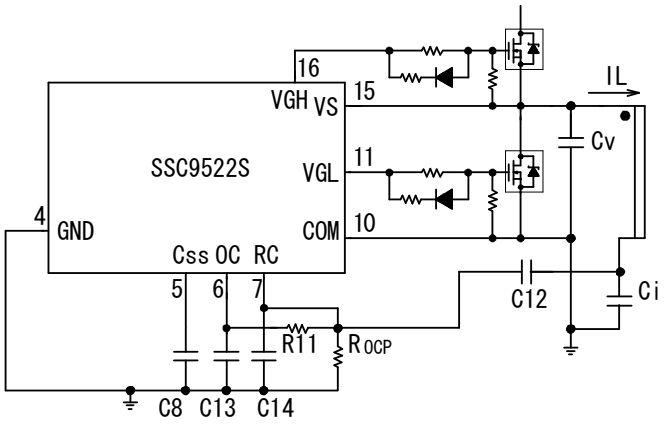


Figure 7-20 RC terminal peripheral circuit

RC terminal has $V_{RC(S)}$ threshold as well as $V_{OC(S)}$ of OC terminal functions.
When RC terminal voltage exceeds $V_{RC(S)}$ = ±2.35V(TYP), power MOSFETs reverse ON / OFF such as the Hi speed OCP operation.
Refer to "7.11 Overcurrent Protection Function (OCP) ③OC Terminal Threshold Voltage (Hi speed)" section for the Hi Speed OCP operation.

8. Design Notes

8.1 Boot strap peripheral circuit

Reg terminal is the output terminal of regulator voltage for bootstrap circuit, which drives High-side MOSFET. The bootstrap circuit is composed of D2, R9 and C11 between Reg terminal and VS terminal

The following function is incorporated, for the protection of abnormal operations caused by short circuit on C11. When the voltage between VB terminal and VS terminal falls below $V_{BUV(OFF)}$= 6.4V(TYP), the control circuit stops the High-side drive switching operation.

D2 is recommended an ultra fast speed diode with short recovery time and low leak current.

As for Sanken's diode lineup, AG01A (Vrm = 600V) of UFRD series is recommended.

C11 is recommended a film type or ceramic capacitor with low ESR and low leak current.

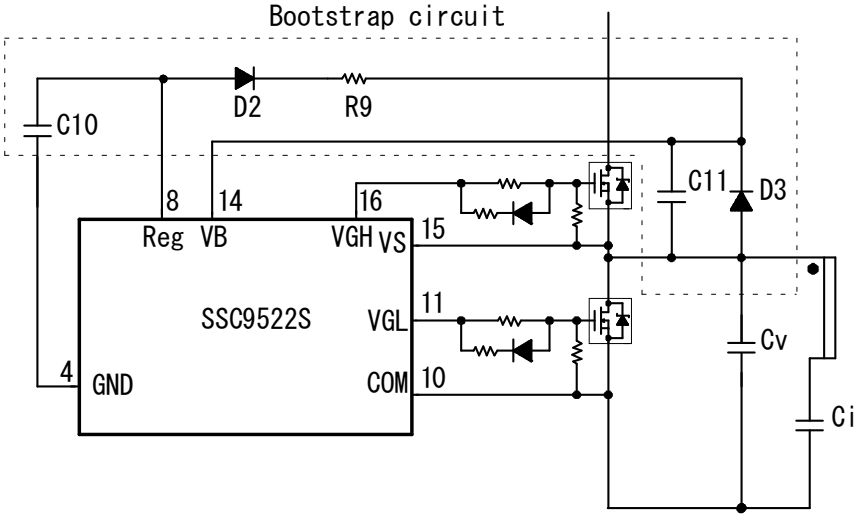


Figure 8-1 Bootstrap circuit

8.2 Gate terminal peripheral circuit

VGH terminal and VGL terminal are the gate drive terminals for external power MOSFETs.

The source peak current is −0.515A(TYP), and the sink peak current is 0.685A(TYP).

In Figure 8-2, R12, R13 and D4 should be adjusted considering power losses of power MOSFETs, gate waveforms (reduction of ringing caused by pattern layout, and others) and EMI noise.

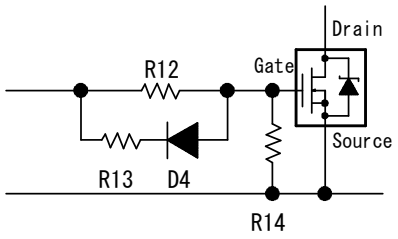


Figure 8-2 MOSFET Gate peripheral circuit

R14 prevents malfunctions caused by steep dv/dt at turning off power MOSFET. It is recommended to place a resistor in 10k to 100kΩ range close to Gate and Source of power MOSFET.

8.3 Peripheral Components

Take care to use properly rating and proper type of components.

- Input and output electrolytic capacitors : Apply proper margin to ripple current, voltage, and temperature rise. Use of high-ripple current and low impedance types, designed for switch mode power supplies, is recommended.
- Transformer : Apply proper design margin to temperature rise by core loss and copper loss.
- Current detecting resistor, R_{OCP} : Choose a low inductance and surge-proof type, because a high frequency switching current flows to R_{OCP} and some malfunction may be caused if a high inductance resistor is used.
- Current resonant capacitor, Ci : Apply a polypropylene film capacitor with low loss and high current capability.

8.4 Pattern layout and Component placement

PCB circuit trace design and component layout affect proper functioning during operation. Unless they are proper, malfunction, large noise and large power dissipation may occur.

Circuit loop traces flowing high frequency current, as shown in Figure 8-3, should be designed as wide, short and small as possible to reduce trace impedance.

In addition, earth ground traces affect radiation noise, and thus, it should be designed as wide and short as possible.

Switching mode power supplies consist of current traces with high frequency and high voltage, and thus, trace design and component layout should be done to comply with all safety guidelines.

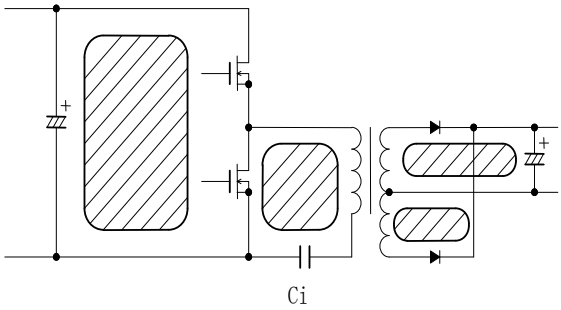


Figure 8-3 High frequency current loop

Furthermore, because an integrated power MOSFET is being used as the switching device, take account of the positive thermal coefficient of $R_{DS(ON)}$ for thermal design.

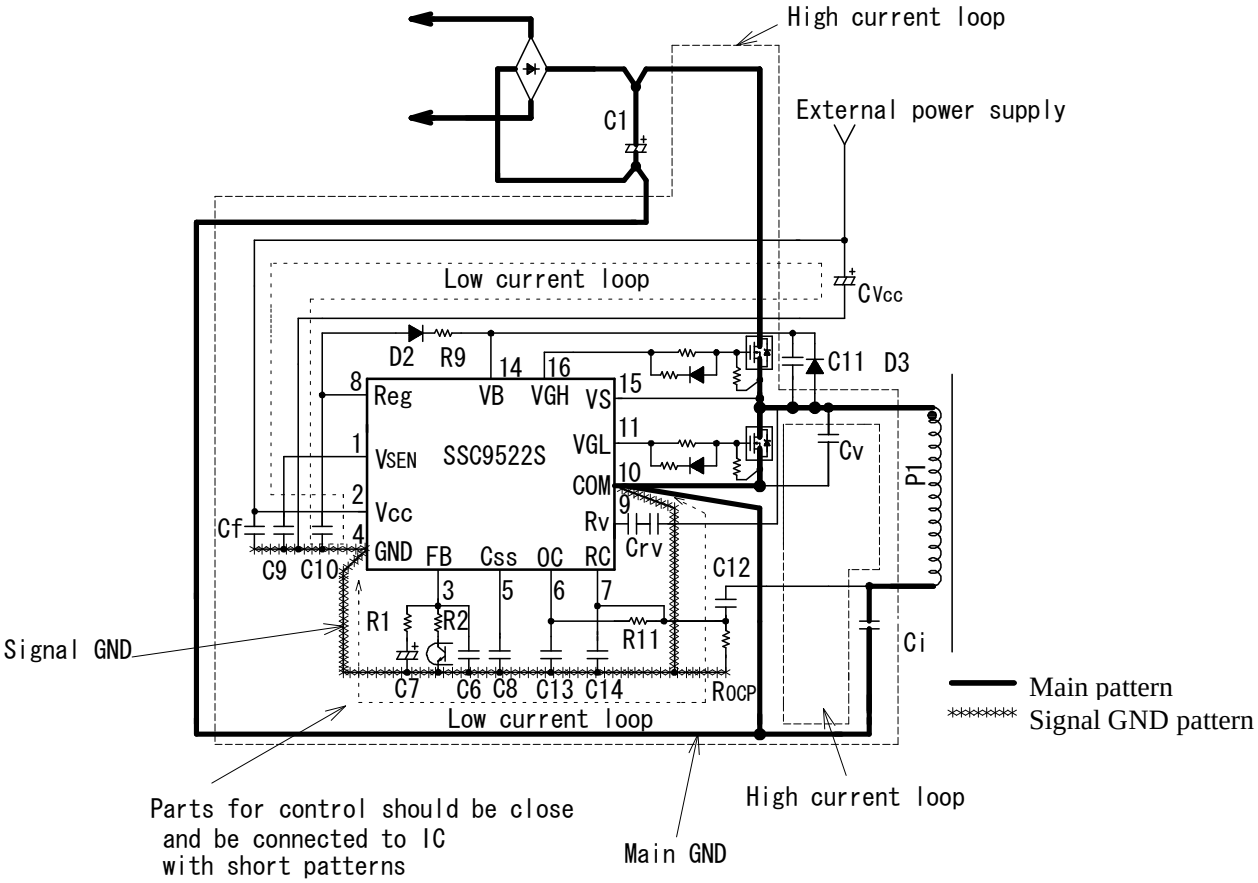


Figure 8-4 Layout design example

Figure 8-4 shows a circuit layout design example.

- Separate signal GND patterns from main current GND patterns because of reducing common impedance, and connect them at COM terminal (No.10 pin). Especially, connect GND (No.4) terminal to COM (No.10) terminal with the shortest pattern possible to prevent main resonant circuit current from flowing into the patterns for control.
- Place a C_f (film capacitor of about 0.1μF) close to the IC to prevent malfunctions caused by noise, when the distance between C_{VCC} and V_{CC} terminal becomes long.
- Connect control parts for the IC close to the IC with the shortest patterns possible.

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