Ideal Diode Controller with Reverse-Current Protection

- 4.8V to 65V Operating Range
- –65V Reverse voltage rating
- Charge pump for external N-Channel MOSFET
- 20mV ANODE to CATHODE forward voltage drop regulation
- 12V Gate Drive Voltage
- With Enable Input
- Drive High Side External N-Channel MOSFET
- 1μA Shutdown current (EN=Low)
- 60μA Operating quiescent current (EN=High)
- 2.3-A Peak gate turnoff current
- Fast reverse current turn-off within 0.75us
- Meets automotive ISO7637 transient requirements with a suitable TVS Diode
- Available in an TSOT23-6L Package

- Automotive Battery Protection
- Redundant Power Supplies
- Industrial Factory Automation
- Enterprise Power Supplies
- Network Telecom Power Systems
- Servers

The SCT53600 is an ideal diode controller which paired with an external N-channel MOSFET as an ideal diode rectifier for low loss reverse polarity protection to replace a Schottky Diode. The SCT53600 operates over a wide supply voltage range of 4.7V to 65V. The device can withstand and protect the load against damaging from negative supply voltages down to –65 V and blocks reverse current flow helping to simplify the system designs for automotive ISO7637 protection.

The SCT53600 controller provides a charge pump gate drive for an external N-channel MOSFET. The device regulates the forward voltage drop across the external MOSFET to 20mV allowing smooth, ring-free operation with providing very fast turn-off(< 0.75 μs) of the MOSFET during a reverse event to minimize reverse current if power source fails or input micro-short conditions. The fast response to Reverse Current Blocking makes the device suitable for systems with output voltage holdup requirements during ISO7637 pulse testing.

The SCT53600 consumes only 1μA of current during shutdown mode with the enable pin low to extend battery life. The device is available in an TSOT23-6 package.

Typical Application

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NOTE: Page numbers for previous revisions may differ from page numbers in the current version.
Revision 1.0: Released to Production.
Revision 1.1: Update V_{ESD} CDM to 1kV and Update $I_{Q\_Charge\ On}$ MAX and MIN.
Revision 1.2: Update VCAP falling threshold.
Revision 1.3: Update packaging information
Revision 1.4: Update Device Order Information

SCT53600TVBR	Tape & Reel				

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Over operating free-air temperature range unless otherwise noted

$V_{(ANODE)}$	ANODE to GND	-60	60	V
$V_{(CATHODE)}$	CATHODE to GND		60	V
V_{EN}	EN to GND	-60	60	V
$V_{(ANODE)}$ -$V_{(CATHODE)}$	ANODE to CATHODE	-70		V
T_J	Operating junction temperature	-40	150	°C

V_{ESD}	Human Body Model(HBM), per ANSI-JEDEC-JS-001-2014 specification, all pin[1]	-3	3	kV
	Charged Device Model(CDM), per ANSI-JEDEC-JS-002-2014 specification, all pins[2]	-1	+1	kV

(1) JEDEC document JEP155 states that 500V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250V CDM allows safe manufacturing with a standard ESD control process.

	Junction-to-ambient thermal resistance (standard board)	102	°C/W
	Junction-to-case (top) thermal resistance	36.9	

(1) SCT provides $R_{\theta JA}$ and $R_{\theta JC}$ numbers only as reference to estimate junction temperatures of the devices. $R_{\theta JA}$ and $R_{\theta JC}$ are not a characteristic of package itself, but of many other system level characteristics such as the design and layout of the printed circuit board (PCB) on which the SCT2601 is mounted, thermal pad size, and external environmental factors. The PCB board is a heat sink that is soldered to the leads and thermal pad of the SCT2600. Changing the design or configuration of the PCB board changes the efficiency of the heat sink and therefore the actual $R_{\theta JA}$ and $R_{\theta JC}$.

T_J=-40°C~125°C, typical value is tested under 25°C.

$V_{(ANODE)}$	Operating input voltage		4.8		60	V
$V_{(ANODE\ POR)}$	VANODE POR Rising threshold			4.3	4.75	V
	VANODE POR Falling threshold			3.7		V
I_{SHDN}	Shutdown current	V_{EN}= 0V		0.3	1.5	μA
$I_{Q\_Charge\ Off}$	Quiescent current	Vcap-ANODE=14V		60	130	uA
$I_{Q\_Charge\ On}$	Quiescent current	Vcap-ANODE Floating	180	285	650	
ENABLE						
V_{EN_H}	Enable input high threshold			2.15		V
V_{EN_L}	Enable input low threshold			1.48		V
V_{EN_HYS}	Enable Hysteresis			0.65		V

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Figure 2. Shutdown Supply Current vs Supply Voltage

Figure 3. Charge Pump Current vs V_{ANODE}

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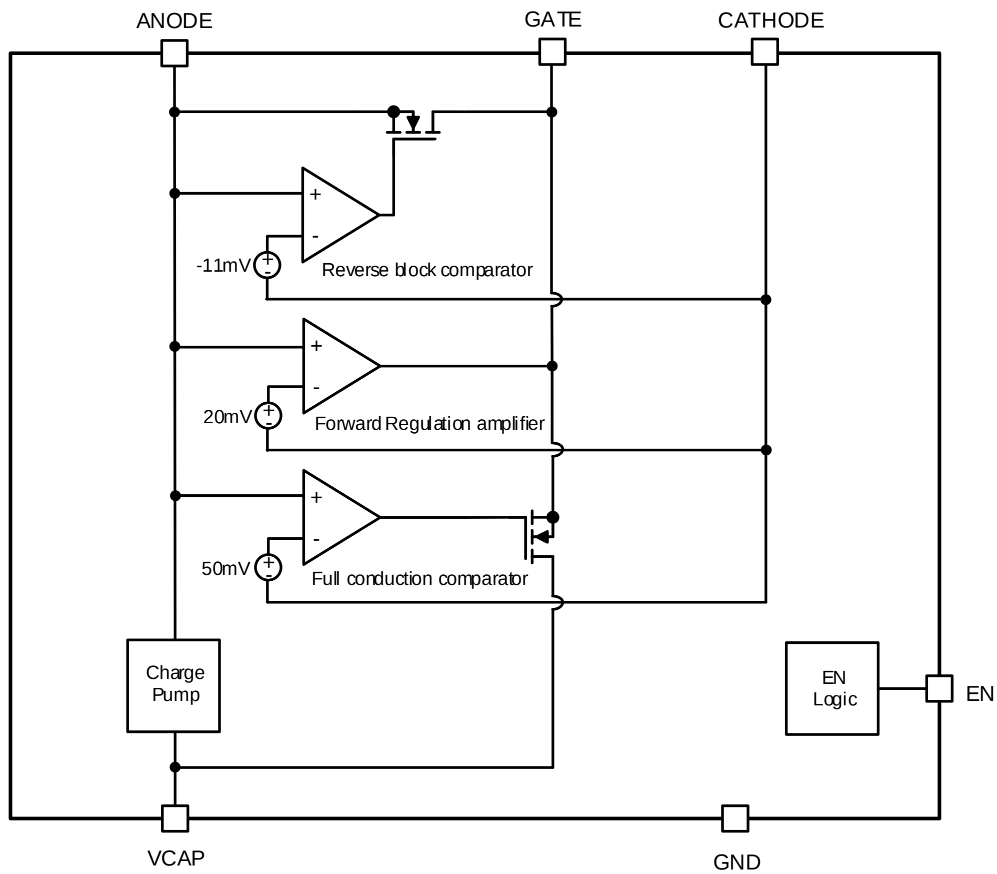

Figure 8. Functional Block Diagram

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Overview

The SCT53600 is a high-voltage, ideal diode controller that provides system protection against reverse voltage, reverse-current flow, and destructive automotive transient voltages to implement an efficient and fast reverse polarity protection circuit or be used in a redundant power system. This easy to use ideal diode controller operates in conjunction with an external N-channel MOSFET to replace other reverse polarity schemes such as a P-channel MOSFET or a Schottky diode.

The SCT53600 controller provides a charge pump gate drive for an external N-channel MOSFET. The voltage drop across the MOSFET is continuously monitored between the ANODE and CATHODE pins, and the GATE to ANODE voltage is adjusted as needed to regulate the forward voltage drop at 20 mV. This closed loop regulation scheme enables graceful turn off of the MOSFET during a reverse current event and ensures zero DC reverse current flow. A fast reverse current condition is detected when the voltage across ANODE and CATHODE pins reduces below –11 mV, resulting in the GATE pin being internally connected to the ANODE pin turning off the external N-channel MOSFET, and using the body diode to block any of the reverse current. The fast response to Reverse Current Blocking makes the device suitable for systems with output voltage holdup requirements during ISO7637 pulse testing.

The SCT53600 consumes only 0.3μA of current during shutdown mode with the enable pin low to extend battery life. The device is available in an SOT23-6 package.

Input Voltage

The ANODE pin is the power supply input for internal circuitry, typically drawing 60 μA when enabled and 0.3 μA when disabled. The SCT53600 operates if the ANODE pin voltage is greater than the POR Rising threshold with EN pin above the specified input high threshold V_{EN_H}. The voltage from ANODE to GND is designed to vary from 65 V to –65 V, allowing the SCT53600 to withstand negative voltage transients.

Enable

A logic input EN pin allows for the gate driver to be either enabled or disabled by an external signal. The EN pin can withstand a voltage as large as 65 V and as low at –65 V. This allows for the EN pin to be connected directly to the ANODE pin if enable functionality is not needed. EN has an internal 2uA sink current which means EN pin cannot be left floating for normal operation.

The SCT53600 enters shutdown mode when the EN pin voltage is below the specified input low threshold VEN_L. Both the gate driver and the charge pump are disabled in shutdown mode. During shutdown mode the SCT53600 enters low IQ operation with the ANODE pin only sinking 0.3μA. When the SCT53600 is in shutdown mode, forward current flow through the external MOSFET is not interrupted but is conducted through the MOSFET's body diode.

Charge Pump

The SCT53600 uses a charge pump to generate the gate drive with respect to ANODE voltage. The charge pump supplies the voltage necessary to drive the external N-channel MOSFET. An external charge pump capacitor is placed between VCAP and ANODE pins to provide energy to turn on the external MOSFET.

The charge pump starts working and sources a charging current of 300 μA typical if EN pin voltage exceeds 2V. If EN pins is pulled low then the charge pump remains disabled. To ensure that the external MOSFET can be driven above its specified threshold voltage, the VCAP to ANODE voltage has the under voltage lockout threshold at typically 5.86 V.

Gate Driver and Conduction Mode

The gate driver is used to control the external N-Channel MOSFET. There are three defined modes of operation that the gate driver operates under forward regulation, full conduction mode and reverse current protection, according to the ANODE to CATHODE voltage.

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The SCT53600 operate in if the current from source to drain of the external MOSFET be large enough to result in an ANODE to CATHODE voltage drop of greater than 50 mV typical. The GATE pin is internally connected to the VCAP pin resulting in the GATE to ANODE voltage being approximately the same as the VCAP to ANODE voltage. By connecting VCAP to GATE the external MOSFET's RDS(ON) is minimized reducing the power loss of the external MOSFET when forward currents are large.

The SCT53600 operate in if the ANODE to CATHODE voltage is typically less than –11

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MOSFET selection is critical to designing a proper protection circuit. Several factors must be considered: gate capacitance, maximum continuous drain current I_D, maximum drain-to-source voltage rating, on-resistance $R_{DS(ON)}$, maximum source current through body diode, peak power dissipation capability and the average power dissipation limit. Gate capacitance is not as critical, but it does determine the length of turn-on and turn-off times. MOSFETs with more gate capacitance tend to respond more slowly.

The maximum continuous drain current, I_D, rating must exceed the maximum continuous load current. The maximum drain-to-source voltage, $V_{DS(MAX)}$, must be high enough to withstand the highest differential voltage seen in the application. It is recommended to use MOSFETs with voltage rating up to 60 V maximum with the SCT53600 [redacted]. The maximum V_{GS} SCT53600 can drive is 13 V

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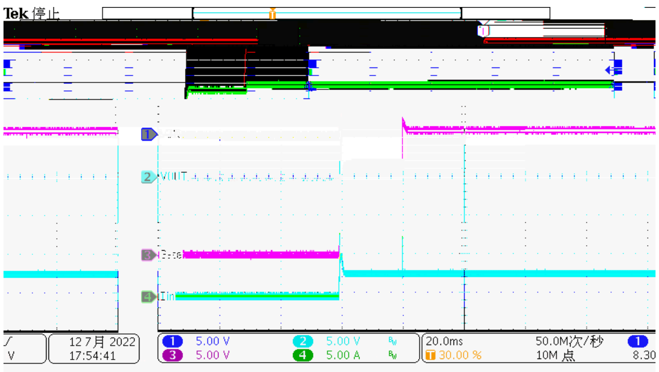

Figure 10. Start up with 3A load

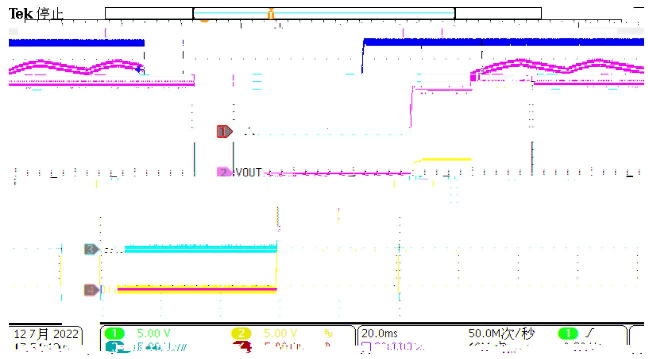

Figure 11. Start up with 5.8A load

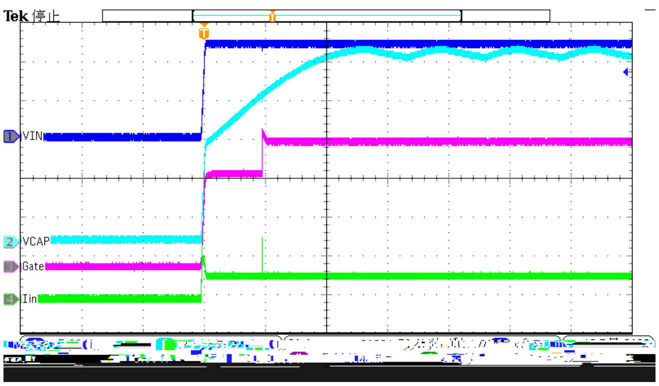

Figure 12. VCAP during startup at 3A load

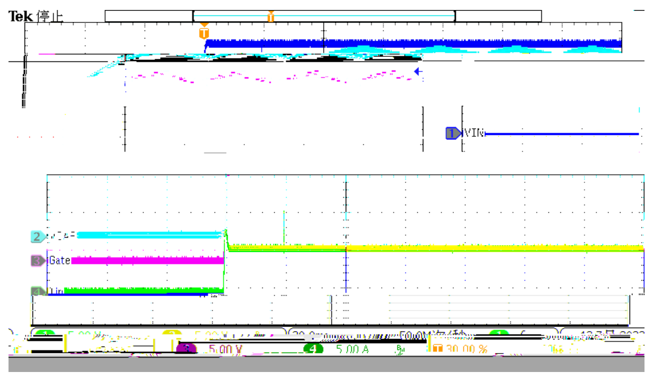

Figure 13. VCAP during startup at 5.8A load

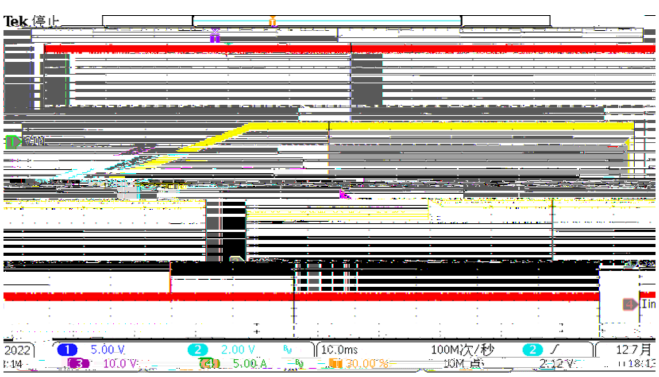

Figure 14. Enable Threshold

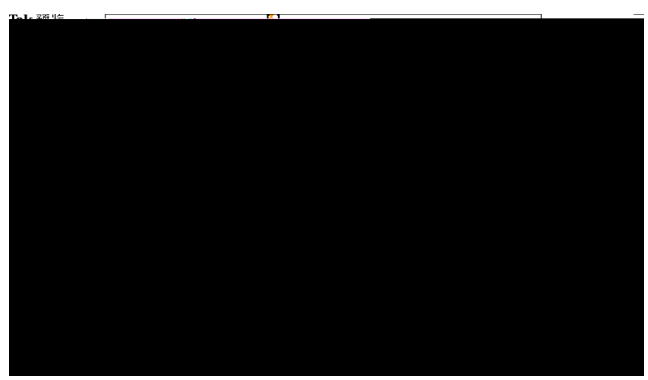

Figure 15. Enable turn on delay

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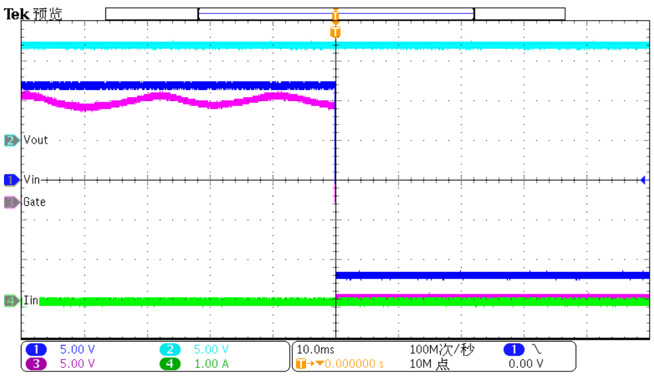

Figure 16. Static Reverse Polarity

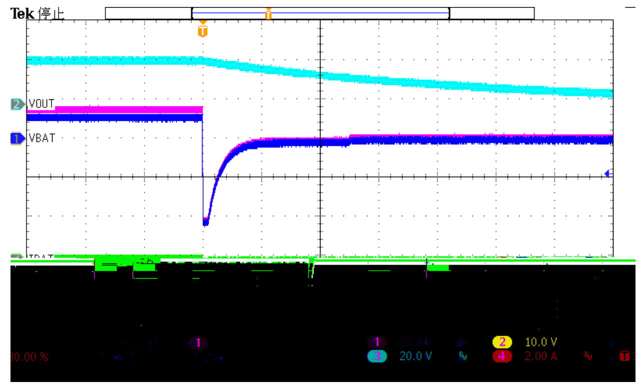

Figure 17. Dynamic Reverse Polarity(ISO 7637-2 Pulse 1)

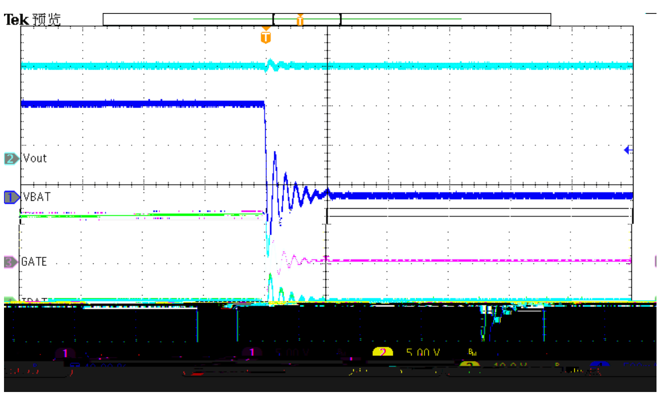

Figure 18. Input Short Response

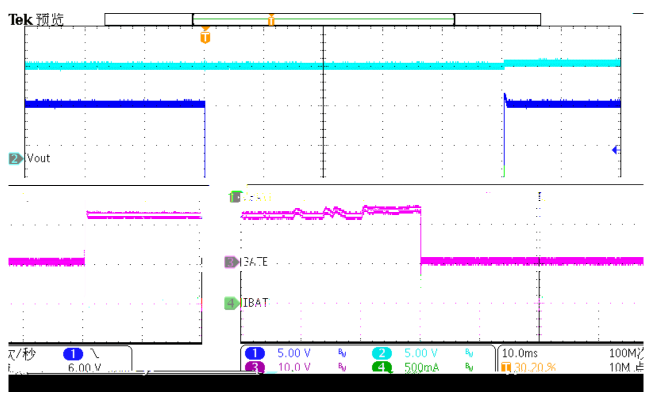

Figure 19. Input Micro-Short

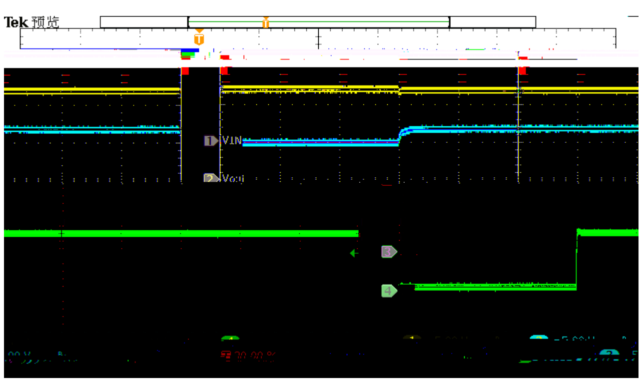

Figure 21. Load Transient Response, 0.1A->3A

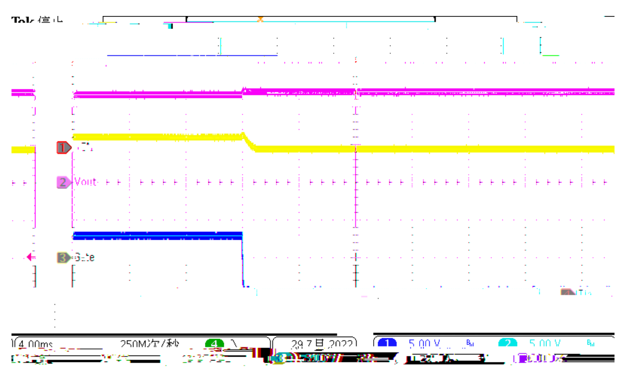

Figure 21. Load Transient Response, 3A->0.1A

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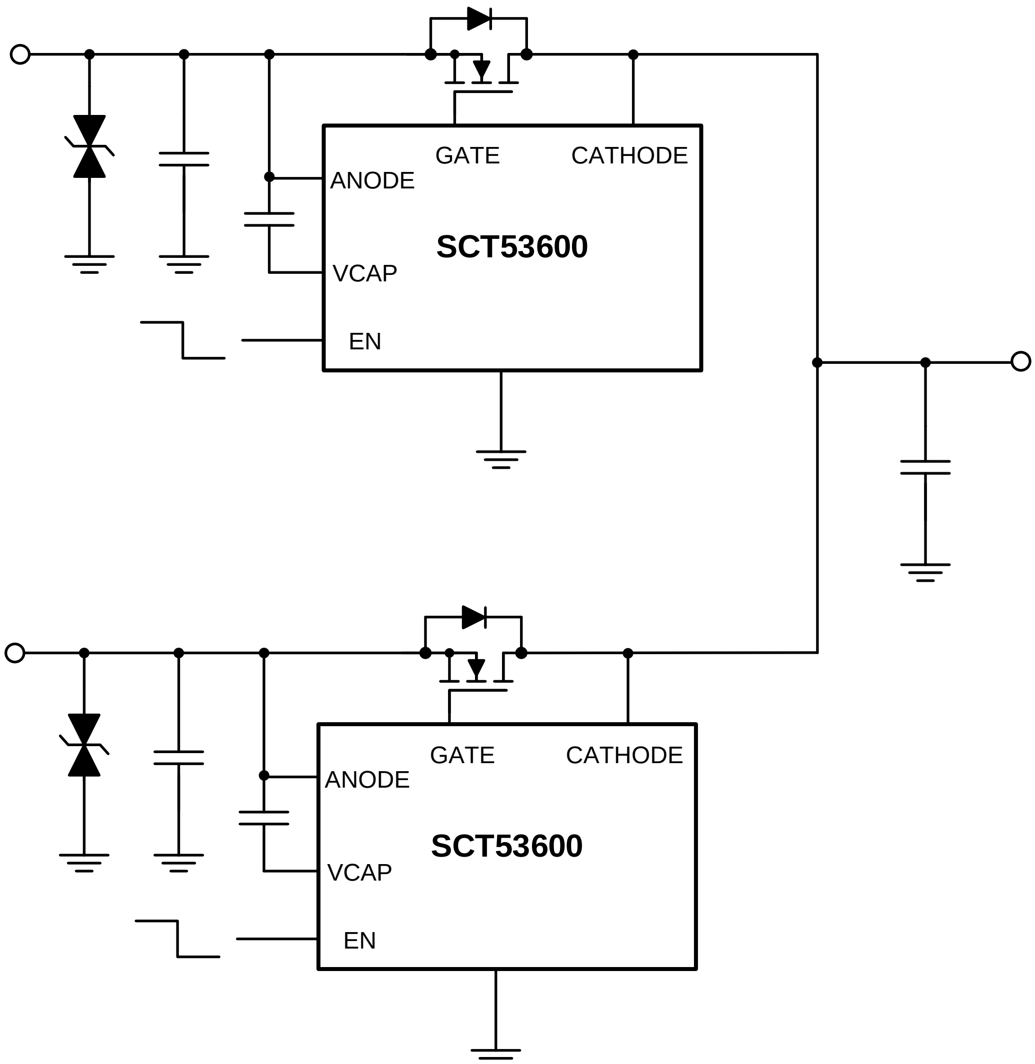
Typical Application- Redundant Power



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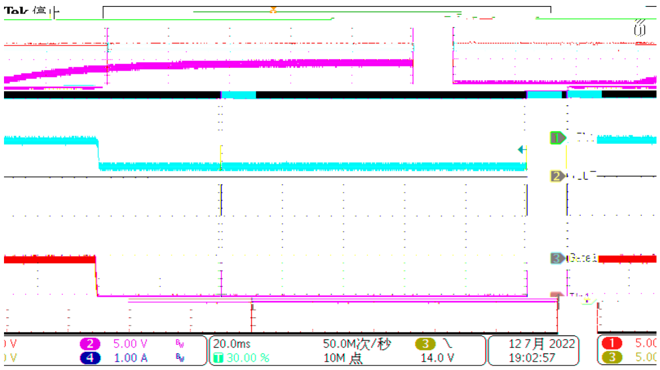

Figure 23. V_{IN1}(12V) to V_{IN2}(15V) Switch Over

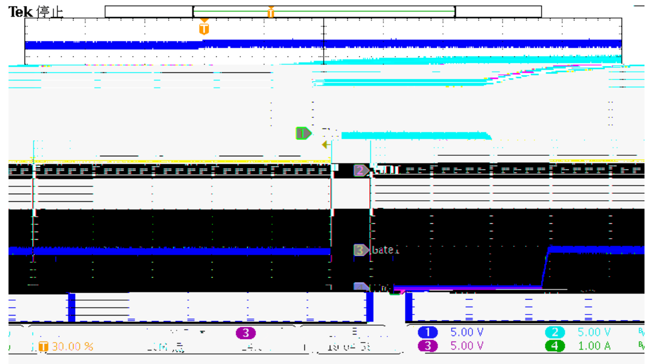

Figure 24. V_{IN1}(12V) to V_{IN2}(15V) Switch Over

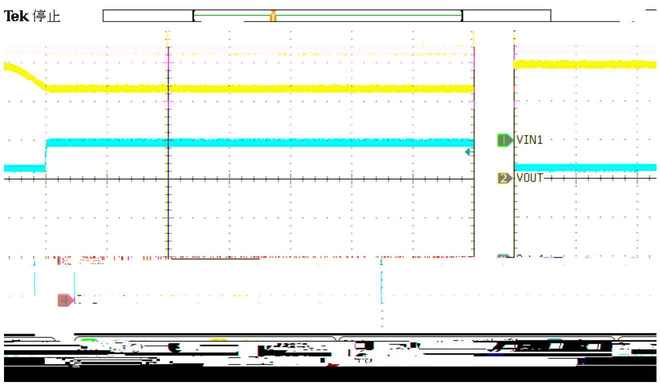

Figure 25. V_{IN2}(15V) to V_{IN1}(12V) Switch Over

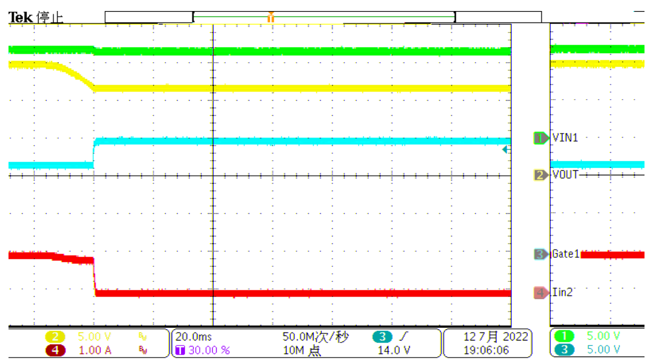

Figure 26. V_{IN2}(15V) to V_{IN1}(12V) Switch Over

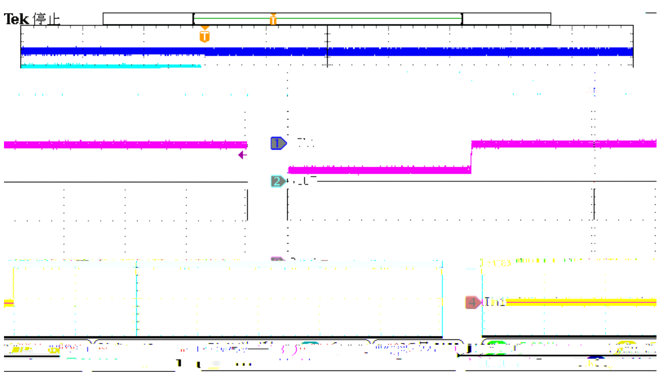

Figure 27. V_{IN2} Fail and Switch Over to V_{IN1}

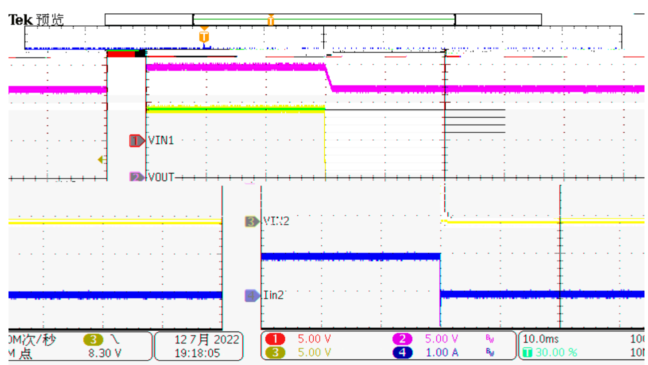

Figure 28. V_{IN2} Fail and Switch Over to V_{IN1}

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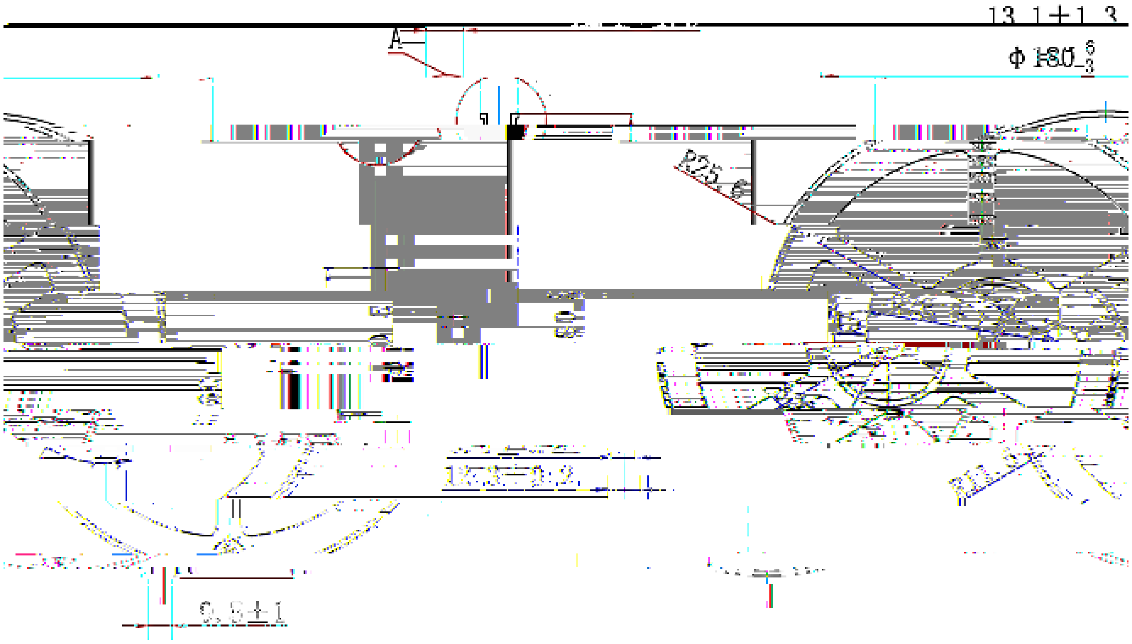
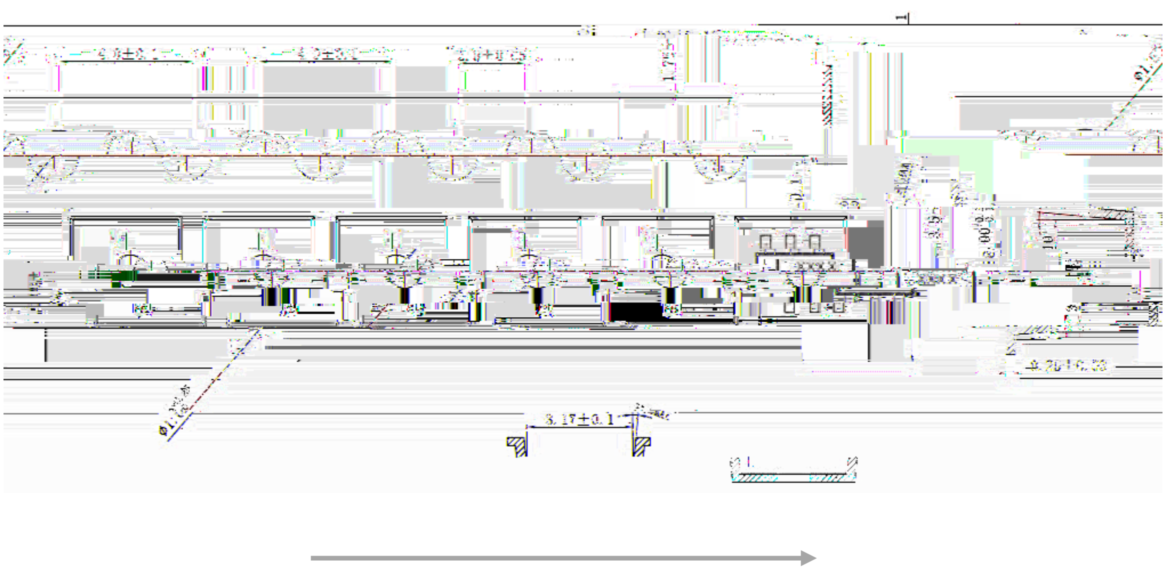

13.1±1.3
Φ 180
R25.6
12.8±0.2
0.5±1


3.17±0.1