Design Guide: TIDA-050027
Multi-rail TV Power Supply Reference Design With Flexible Partitioning to Maximize Power Savings

Description

The TIDA-050027 reference design is a power-distribution solution for television (TV) platforms. By providing a configuration that emulates common voltage rails and peripherals, this design can be used as a reference design across multiple TV power architecture including LCD and OLED TV. On the input, an eFuse is used for short-circuit protection, while the high-efficiency buck converters provide the necessary power for the core rail, always-on rails, and peripheral rails. There are two voltage supervisors on the 5 V rail from the buck converter and the LDO that monitor the rails and reset on undervoltage conditions. Additionally, low I_Q low-dropout regulators (LDOs) provide clean digital-power for certain peripheral rails. In addition to these power components, load switches control the voltage with controlled slew rates to allow for power sequencing and power savings. Additionally, integrated load switches provide self protection while reducing bill of materials (BOM) count and solution size.

Resources

TIDA-050027	Design Folder
TPS22919, TPS22975	Product Folder
TPS2595, TPS22810	Product Folder
TLV755, TLV62568	Product Folder
TLV62569A, TLV809E	Product Folder
TPS564201, TPS566250	Product Folder

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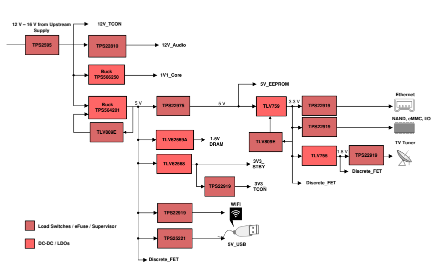
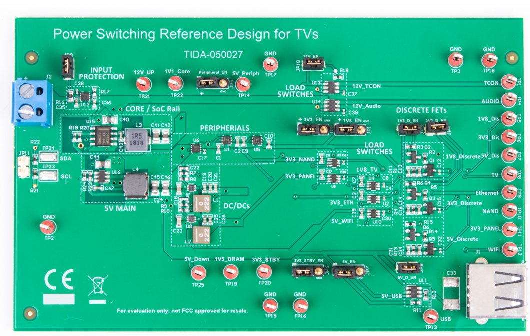
Features

- Fully-featured power tree for common TV rails allow for appropriate selection of load switches, buck converters, and LDOs in system design
- High efficiency buck converters with fast transient response and reduced Bill of Material (BOM) count for smaller solution size
- Integrated protection features improves system reliability and reduces customer returns
- Switching OFF unused loads results in higher system efficiency and lower standby current
- Load switches offer smaller solution size and lower component count when compared to discrete FET solutions
- High accuracy voltage supervisors ensure health of voltage rails and maintain voltage levels

Applications

- HDTV
- UHD 4K OLED TV
- UHD LCD TV





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1 System Description

This reference design showcases a power distribution solution for televisions (TVs). Since many TV architectures require similar core voltage and peripheral rails, this design can be used across multiple TV architectures including OLED and LCD TVs.

This design incorporates four buck converters as well as two LDOs to power the core rails, always-on rails, memory, and peripherals such as USB ports and TV tuner. Each buck converter is chosen to handle specific requirements for each of the rails. For the core rail, the requirements include steady output voltage with very good transient response to avoid affecting performance. The remainder of the rails require high efficiency with good transient response. The LDOs for the peripherals provide a I_Q power supply that also require a clean-power supply such as the TV Tuner.

This design also incorporates nine load switches for peripheral loads commonly found on most TVs including: Panel Power (TCON), Stand-by (STBY) rails, WIFI, NAND, USB, and TV Tuner blocks. All of the load switches have their ON pins connected to external jumpers for quick access to each peripheral rail. An eFuse at the input manages short-circuit and overvoltage events that could potentially damage downstream DC/DC converters and load switches. The reference design also includes common voltage rails found in most TV solutions, including 5 V Peripheral, 3.3 V Standby, 1.5 V DRAM, 3.3 V I/O, and 1.1 V Core rail. Finally, a USB-A header is included at the output of the 5 V USB switch to support USB loads. By using integrated devices, this reference design reduces BOM count, improves system reliability, and enables faster design cycles.

Each main voltage rail (5 V, 3.3 V, and 1.8 V) is accompanied by a discrete FET solution. This allows a direct performance comparison between the integrated load switch and a discrete FET solution. Test points are included at the output of each peripheral and voltage rail, and silkscreen traces outline the size of each solution.

1.1 Key System Specifications

Table 1. Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Input voltage range	V_{IN}	12 V to 16 V

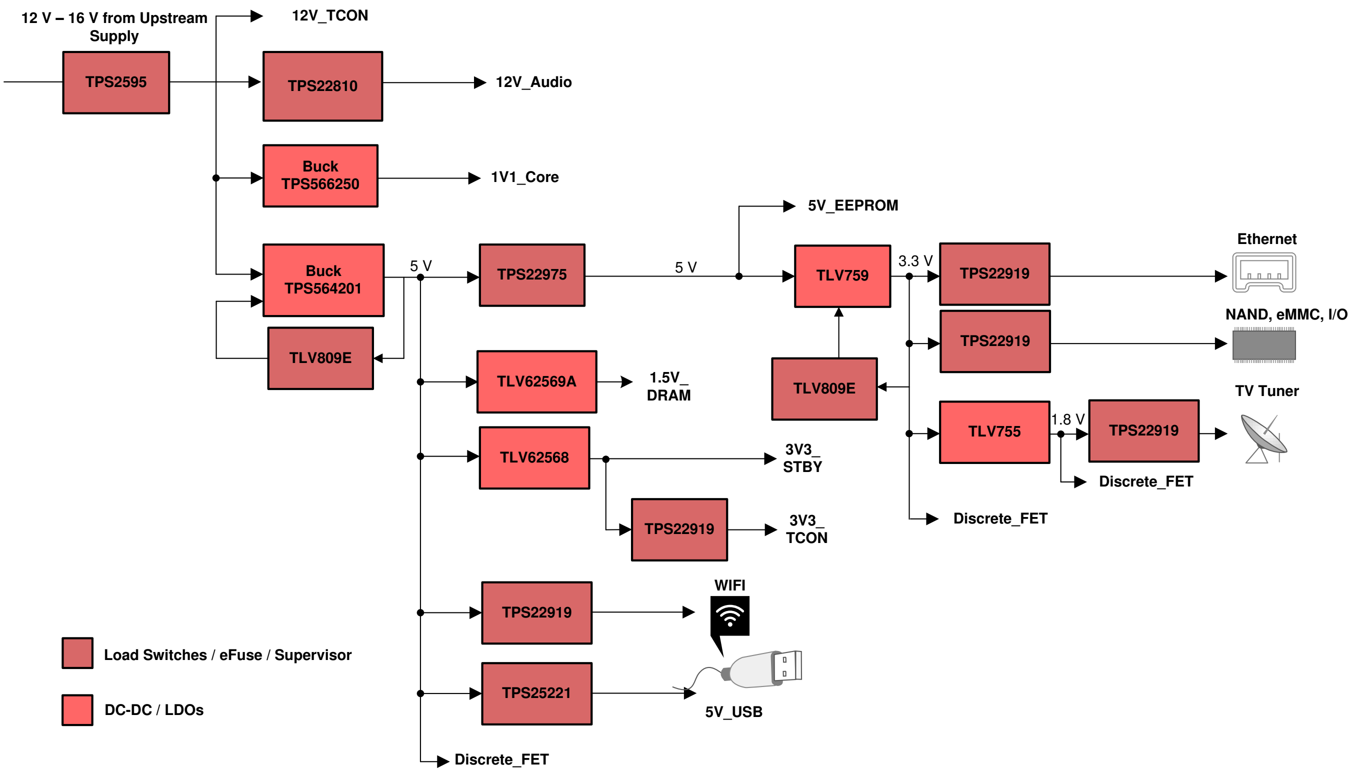
DEVICES	DEVICES	VIN	VOUT	IOUT
DC/DCS	TPS564201	12 V to 16 V	5 V	4 A
	TPS566250	12 V to 16 V	1 V	6 A
	TLV62569A	5 V	1.5 V	2 A
	TLV62568	5 V	3.3 V	1 A
LDOs	TLV759P	5 V	1.8 V	1 A
	TLV75518	3.3 V	1.8 V	400 mA

PARAMETER	DEVICES	VIN	RON	IOUT
eFuse	TPS2595	12 V to 16 V	34 mΩ	4 A
Load Switch	TPS22810	12 V to 16 V	79 mΩ	2 A
	TPS22975	5 V	16 mΩ	6 A
	TPS22919	5 V, 3.3 V, 1.8 V	89 mΩ at 5 V	1.5 A
USB Switch	TPS25221	5 V	70 mΩ	2 A

2 System Overview

2.1 Block Diagram

Figure 1. TIDA-050027 Block Diagram

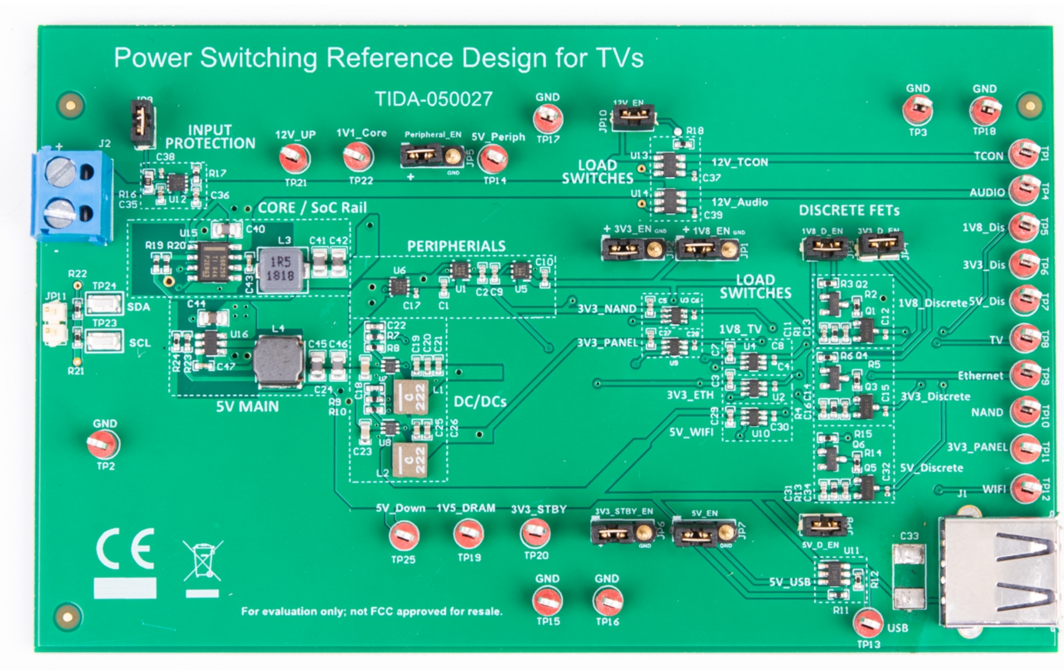


2.2 Design Considerations

2.2.1 Total Solution Size

Referring to Figure 2, the design is laid out in three main stages: Front-end stage, Power Stage, and Peripherals. Using integrated devices simplifies the solution complexity while keeping the PCB space as compact and space-efficient as possible.

Figure 2. TIDA-050027 Reference Board



The front-end stage includes an eFuse at the input alongside two DC/DCs. The TPS2595 eFuse provides short-circuit and overvoltage protection, while the two DC/DCs emulate voltage rails commonly found on televisions: a 1.1 V core (1V1_CORE) and a 5 V rail for downstream components. The core rail is an always-on, high current rail for the TV SoC, while the 5 V rail leads to downstream power components. The total solution size of the front end components is 111mm^2, with 7mm^2 for the eFuse and 104mm^2 for the DC/DC components.

The power stage components consist of additional DC/DCs to power a 3.3 V standby rail (3V3_STBY), as well as a 1.5 V rail for DRAM or SoC Memory modules. The standby rail is useful when the TV enters a low-power mode, such as a sleep or rest state. The 1.5 V rail is another high current rail used for additional SoC modules, such a memory or DRAM. The total solution size of the DC/DC components is 56mm^2. There are also 5 V peripherals connected to the 5 V rail with integrated load switches, including WiFi (5V_WIFI) and USB (5V_USB). A discrete FET implementation is also included to compare performance and size against an integrated solution.

The Peripherals included on this TV reference design emulate common rails and outputs found on TV power designs. A TPS22975 load switch is included at the input of the 5 V peripheral rail, allowing easy access to power down all of the peripherals, for example during standby mode. An LDO converts the 5 V rail into a 3.3 V rail for peripherals including Ethernet, NAND, eMMC, and I/O. Another LDO branches off the 3.3 V down to 1.8 V, providing access to 1.8 V loads such as TV tuners and digital voltage rails required by the SoC. Finally, load switches are included on the front end 12 V line for 12 V rails such as audio and TCON.

Table 2. Solution Area Size

Name of Box	Included Components	Total Solution Size
Input Protection	TPS2595	7mm^2
Core / SoC Rail	TPS566250	57mm^2
5 V Main	TPS564201	47mm^2
DC/DCs	TLV62568, TLV62569A	56mm^2
Peripherals	TPS22975, TLV757	14.18mm^2

2.2.2 Power Switching Complexity and Size

As televisions push for higher resolution and greater complexity, their power designs are also getting larger and more complex. As the number of power rails and peripherals increases, additional devices and passive components need to be selected and integrated into the system. As the BOM complexity increases, the number of design considerations increase: including design and layout cycles, PCB space, and points of failure/visual inspection.

A discrete switching circuit contains several components to control the turnon and turnoff behavior of a discrete power MOSFET. Figure 3 shows a common discrete FET implementation, which is used on the reference design. In comparison, Figure 4 shows a TPS22919 integrated load switch that can also be used to turn on and or off the corresponding load. Compared to a discrete solution, integrated load switches reduce the BOM count, which helps to reduce the total solution complexity and size.

Figure 3. Discrete FET Solution

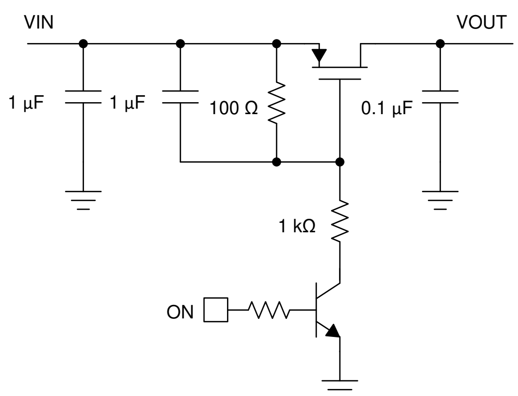
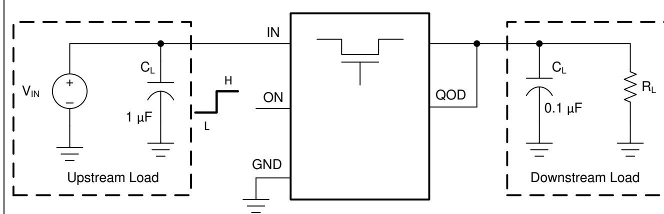


Figure 4. TPS22919 Solution



The TPS22919 also contains additional features that are difficult or not possible to implement discretely. Features such as self-protection and recovery from short circuits, controlled slew rate, thermal shutdown, and quick output discharge (QOD), would require additional components or oversized FETs to be done discretely. With an integrated load switch, this can be accomplished using a single device. Section 3.2.2 will demonstrate and compare the discrete circuit and the TPS22919 in-depth, providing power on and or off waveforms, thermal images, and transient event waveforms. For more information regarding the drawbacks and limitations of a discrete switching solution, please refer to Integrated Load Switches versus Discrete MOSFETs app note.

Table 3. Discrete FET vs. TPS22919 Load Switch Comparison

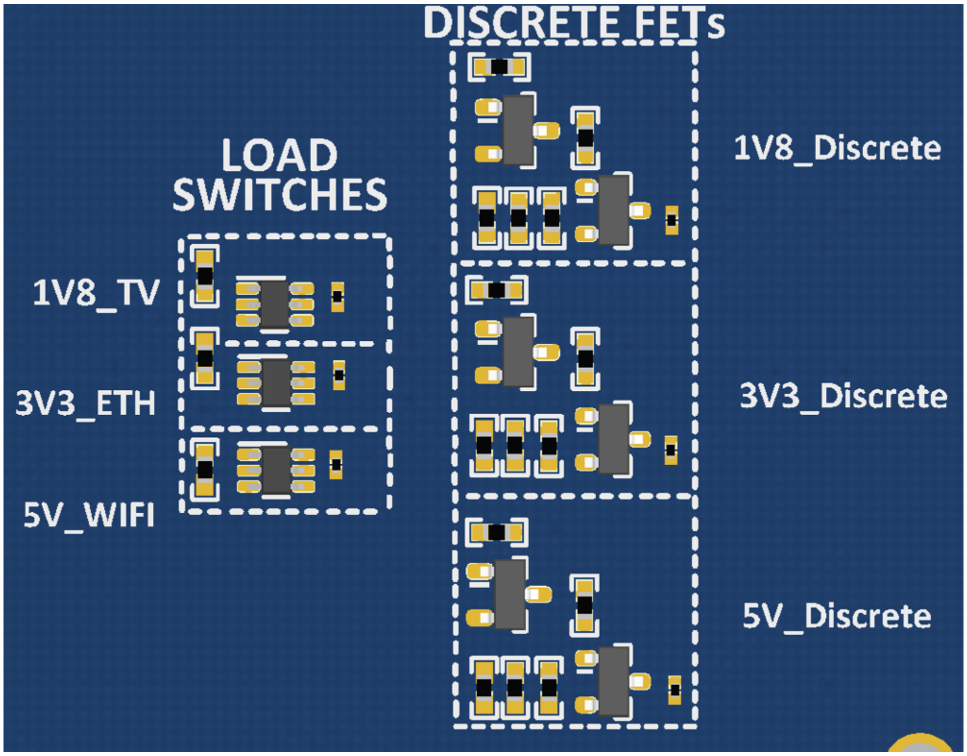
	Discrete Solution	TPS22919
BOM Count	6 components	1 component
Solution Size	17.08mm^2	4.1mm^2
Rise Time	RC Based	Linear, ~1 ms
Thermal Shutdown		✓
Short Circuit Protection		✓
Quick Output Discharge (QOD)	Implemented using External Components	✓

Figure 5 compares the solution size of both switching solutions. The three discrete FETs, (1V8_DIS, 3V3_DIS, 5V_DIS), consists of 18 components with a total solution size of 275mm^2. In comparison, the three integrated rails consists of three TPS22919 load switches, with a 76 percent reduction in solution size.

Table 4. Discrete vs. Integrated Solution Size

Solution	Included Components	Number of Components	Total Solution Size
3 Load Switches	3* TPS22919 (1V8_TV, 3V3_ETH, 5V_WIFI)	3	12.3mm^2
3 Discrete FETs	3* PMOS FET 3* BJT 9*Resistors 3*Gate Capacitor	18	51.24mm^2

Figure 5. Discrete vs. Integrated Solution Size



2.2.3 Protection Features

Protection features allows for safer and more reliable systems, reducing system failures and customer returns. In television power architectures, features such as inrush current protection, short circuit protection, thermal shutdown, and power sequencing ensure that the system remains robust, while preventing damage to sensitive components.

During startup, inrush current is controlled to protect the MOSFET, PCB traces, and prevent voltage dip that could leave the system in an undesired state. When power is initially applied to the system, capacitor charging can result in a spike of inrush current, which can exceed the nominal load current. The TPS2595 eFuse at the input manages inrush current to the downstream voltage rails, while the TPS22919 manages inrush current to the various peripheral loads. By increasing the rise time of each voltage rail using slew rate control, this minimizes the inrush current while protecting the downstream load. To implement this configuration using discrete components, additional passive components such as a gate resistor and capacitors need to be included, which increases BOM count, solution size, and timing complexity.

The eFuse and integrated load switches also provide short circuit protection and thermal shutdown. The eFuse at the input prevents damage to downstream components in case of an overvoltage/overcurrent or fault condition, while the TPS22919 offers self protection, meaning that it will protect itself from short circuit events on the peripheral rails. The TPS22919 also has thermal shutdown to prevent damage to the device from overheating, which could occur during startup into a capacitive load or a high-current fault condition.

The voltage supervisor allows for monitoring of the buck converter and LDO for undervoltage conditions and turn off appropriately when they reach below the voltage thresholds for each device. When the voltage at the output of these devices falls below the set voltage thresholds for the voltage supervisors, they will output an active-low signal from the $\overline{\text{RESET}}$ pin to disable the devices.

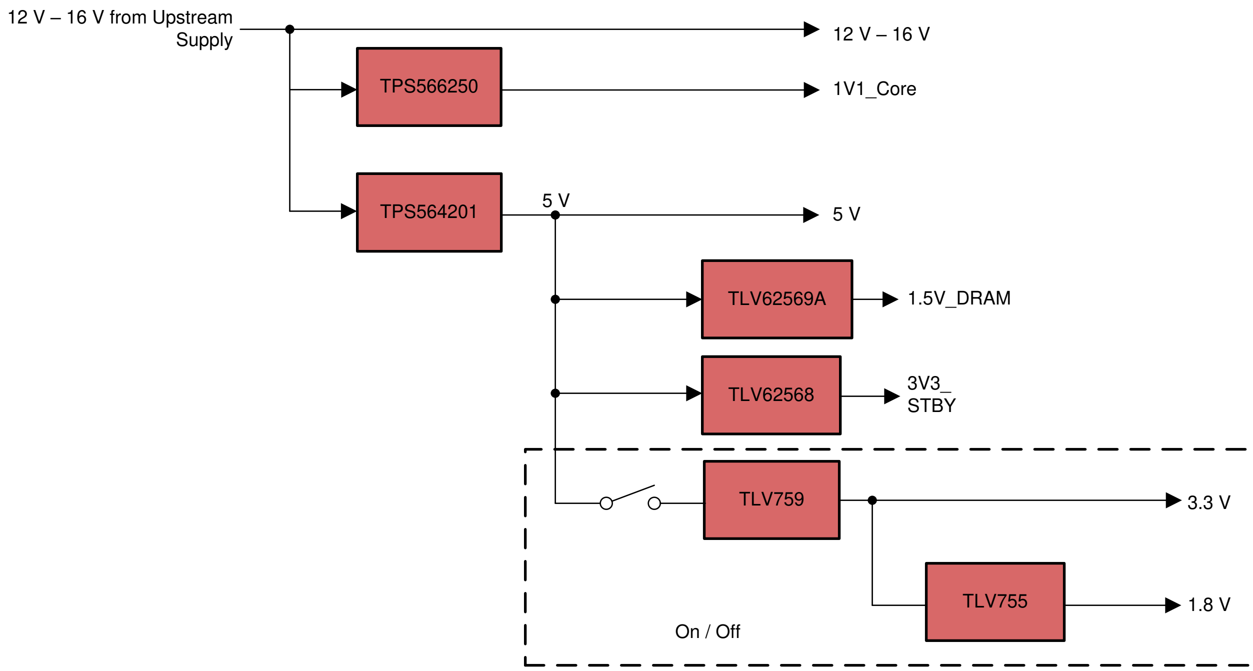
2.2.4 Power Consumption

To reduce standby power for the system, this reference design reduces power consumption by choosing high efficiency and low I_Q power components and by disconnecting loads and peripherals from DC/DC converters when not in use, which is common practice in standby mode.

In this design, load switches are used to emulate various peripheral rails, which can be turned on or off when not in use. If the TV requires all the peripherals to be off in a certain mode, such as standby mode, the TPS22975 can also be used to turn off all the various peripheral rails. The switches can also be used for power sequencing. Power Sequencing is critical for voltage rails that must turn on in a specific order to ensure operation safety and reliability. Sequencing the rails also staggers the inrush current during startup, which reduces system stress and prevents unexpected reverse bias conditions. On this TV power design, the load switches can be sequenced to ensure that the core rails (1V1_CORE, DRAM, Panel), are up before the peripheral rails are operational.

Televisions also contain always-on rails to power critical system components such as core SoC rails, standby rails, and DRAM power. These rails must remain on throughout all operation modes. Therefore, all of the four DC/DC converters remain enabled to emulate powering always-on loads.

Figure 6. Power Tree



2.3 *Highlighted Products*

2.3.1 TPS22919

The TPS22919 device is a small, single channel load switch with controlled slew rate. When power is first applied, a Smart Pull Down is used to keep the ON pin from floating until system sequencing is complete. When the pin is deliberately driven High (>VIH), the Smart Pull Down is disconnected to prevent unnecessary power loss. The TPS22919 load switch is also self-protected, meaning that it will protect itself from short circuit events on the output of the device. It also has thermal shutdown to prevent any damage from overheating.

2.3.2 TPS22810

The TPS22810 is a single channel load switch with configurable rise time and with an integrated quick output discharge (QOD). In addition, the device features thermal shutdown to protect the device against high junction temperature. Because of this, safe operating area of the device is inherently ensured. The device contains an N-channel MOSFET that can operate over an input voltage range of 2.7 V to 18 V.

2.3.3 TPS22975

The TPS22975 is a single-channel load switch that provides a configurable rise time to minimize inrush current. TPS22975 has an optional 230-Ω on-chip load resistor for quick output discharge when switch is turned off. The TPS22975 is available in a small, space-saving 2-mm × 2-mm 8-pin SON package (DSG) with integrated thermal pad allowing for high power dissipation.

2.3.4 TPS2595

The TPS2595 eFuse (integrated FET hot swap devices) is a highly integrated circuit protection and power management solution in a small package. The device provides multiple protection modes using very few external components and are a robust defense against overloads, short circuits, voltage surges, and excessive inrush current.

2.3.5 TPS566260

The TPS566250 is a 18 V, 6A synchronous step-down (buck) converter with dynamic voltage scaling (DVS) capability through I^2c . It operates using D-CAP2™ control mode which provides very fast transient response, and reduces the required output capacitance required to meet a specific level of performance. This device also would not require external compensation which reduces the total size and cost of implementation. The output voltage of the device can be set by either FB with resistor divider or it can be dynamically set from 0.6 V ~ 1.87 V through I^2C compatible interface.

2.3.6 TPS564201A

The TPS564201 is a simple, easy-to-use, 4-A synchronous step-down converter in SOT-23 package. The device is optimized to operate with minimum external component count and also optimized to achieve high efficiency at both normal and light load conditions. This solution is a part of a pin-to-pin compatible family of devices (TPS56x201) which would support from 1A ~5A current loads.

2.3.7 TLV65268

The TLV62568 device is a synchronous step-down buck DC-DC converter optimized for high efficiency and compact solution size. The device integrates switches capable of delivering an output current up to 1A. In order to provide the lowest power consumption for an always on rail, the device enters power save mode at light loads. If lower ripple is required, the TLV62568A can be used instead. In shutdown, the current consumption is reduced to less than 2 μA.

2.3.8 TLV65269A

The TLV62569A device is a synchronous step-down buck DC-DC converter optimized for high efficiency and compact solution size. The device integrates switches capable of delivering an output current up to 2 A. In order to provide the lowest ripple and best transient response for powering the DRAM rail, the device operates only in pulse width modulation (PWM) mode without a power saving mode. If light load efficiency is important, the TLV62569 can be used instead. In shutdown, the current consumption is reduced to less than 2 μA.

2.3.9 TLV755/7P

The TLV755P is an ultra-small, low quiescent current, low-dropout regulator (LDO) that sources 500mA and 1 A for the TLV757P, with good line and load transient performance. The TLV755P is optimized for a wider variety of applications by supporting an input voltage range from 1.45 V to 5.5 V. To minimize cost and solution size, the device is offered in fixed output voltages ranging from 0.6 V to 5 V to support the lower core voltages of modern microcontrollers (MCUs). Additionally, the TLV755P has a low I_Q with enable functionality to minimize stand-by power. When shutdown, the device actively pulls down the output to quickly discharge the outputs and ensure a known start-up state.

2.3.10 TLV758/9P

The TLV759P low-dropout regulator (LDO) is an adjustable output, ultra-small, low quiescent current LDO that sources 1 A and 500mA for the TLV758P, with good line and load transient performance. The TLV759P is optimized for a wide variety of applications by supporting an input voltage range from 1.45 V to 5.5 V. Additionally, the TLV759P has a low I_Q with enable functionality to minimize standby power. When shutdown, the device actively pulls down the output to quickly discharge the outputs and ensure a known start-up state. Furthermore, the TLV759P supports adjustable output via resistor divider for voltage options not supported by the TLV755/7.

2.3.11 TLV809E

The TLV809E voltage supervisor is a low current (250 nA typical, 2 µA max) circuit (reset IC) that monitors a V_{DD} voltage level. This device initiates a reset signal whenever supply voltage drops below the factory programmed threshold voltage, V_{IT-}. The reset output remains low for a fixed reset time delay t_D after the V_{DD} voltage rises above the threshold voltage and hysteresis.

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware

3.1.1 System Overview

The TIDA-050027 TV Reference Design power rails can be sequenced depending on the downstream loads and peripherals. Table 5 provides an overview of the jumpers and test points on the TI Design.

Table 5. Jumper/Connector Summary

Stage	Connector	Label	Description
Input	J2	-	Input Power, connector for 12 - 16 V
	JP9	-	Enable for TPS2595 (U12)
	TP21	12V_UP	Test Point for eFuse output
CORE / SoC Rail	JP11, TP23, TP24	SDA / SCL	Test Points for TPS566250 communication
	TP22	1V1_Core	Test Point for DC/DC output
5 V Main	TP25	5V_Down	Test Point for DC/DC output
DC/DCs	TP19	1V5_DRAM	Test Point for DC/DC output
	TP20	3V3_STBY	Test Point for DC/DC output
Peripherals	JP5	Peripheral_EN	Enable for TPS22975
	TP14	5V_Periph	Output of 5 V Peripheral Rail
Load Switches	JP10	12V_EN	Enable for TPS22810
	JP2	3V3_EN	Enable for TPS22919
	JP1	1V8_EN	Enable for TPS22919
	JP7	5V_EN	Enable for TPS22919
	TP8	TV	Output of 1.8 V Peripheral Rail
	TP1	TCON	Output 12 V Rail
	TP4	Audio	Output 12 V Rail
	TP9	Ethernet	Output of 3.3 V Peripheral Rail
	TP10	NAND	Output of 3.3 V Peripheral Rail
	TP11	3V3_Panel	Output of 3.3 V Standby Rail
	TP12	WIFI	Output of 5 V Peripheral Rail
Discrete FETs	JP3	1V8_D_EN	Enable for Discrete FET
	JP4	3V3_D_EN	Enable for Discrete FET
	JP8	5V_D_EN	Enable for Discrete FET
	TP5	1V8_Dis	Output of 1.8 V Discrete Rail
	TP6	3V3_Dis	Output of 3.3 V Discrete Rail
	TP7	5V_Dis	Output of 5 V Discrete Rail

3.2 Testing and Results

3.2.1 Test Setup

To configure the reference design for operation, connect the jumpers as shown in Figure 7.

Figure 7. TIDA-050027 Test Configuration

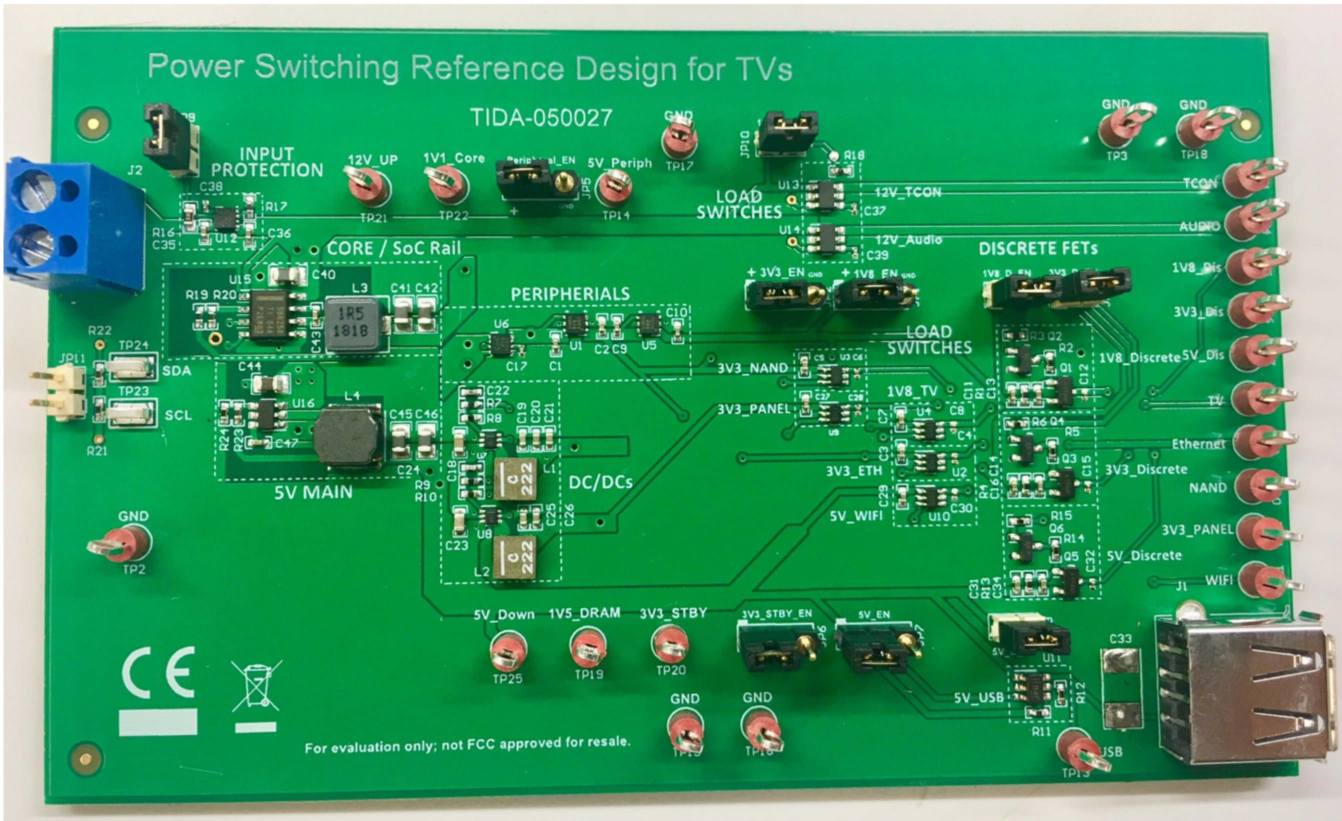


Table 6. TV Configuration Setup

Description	Jumper / Connector	Value
Input Power, connector for 12 - 16 V	J2	Connect pins 1 and 2
12 V Load Switch enable	JP5, JP10	Connect pins 1 and 2
5 V, 3.3 V, 1.8 V Load Switch enable	JP1, JP2, JP6, JP7	Connect pins 1 and 2
Discrete FET Enable	JP3, JP4, JP8	Connect pins 1 and 2

3.2.2 Test Results

3.2.2.1 Power Sequencing Demonstration

Power Sequencing is critical on voltage rails that must turn on in a specific order to ensure operational safety and reliability. For example, core rails for downstream SoCs and microcontrollers need to be powered before WIFI and other peripherals are turned on. Sequencing the rails also helps stagger the inrush current during power-up, which reduces system stress and prevents unexpected reverse bias conditions.

The TV Reference Design’s voltage rails are sequenced to emulate the power-on of a television system. After the system is initially turned on, the 12 -16 V input passes downstream and turns on the two critical rails, 1V1_Core and 5 V Main. Once both of these rails are high, the 5 V Peripherals are turned on followed by the 3.3 V and 1.8 V Peripherals. Figure 8 and Figure 9 demonstrate the power-on sequence.

Figure 8. Power Sequencing 5 V Main

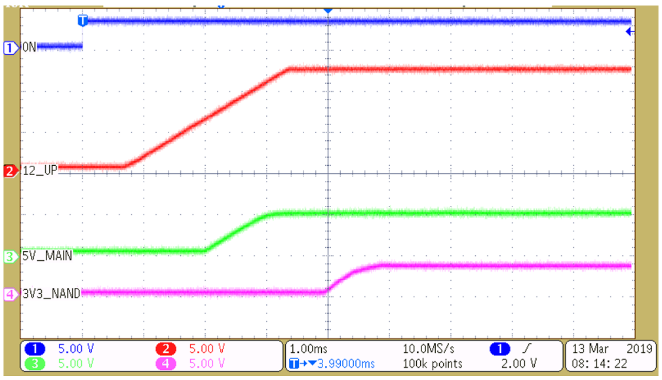
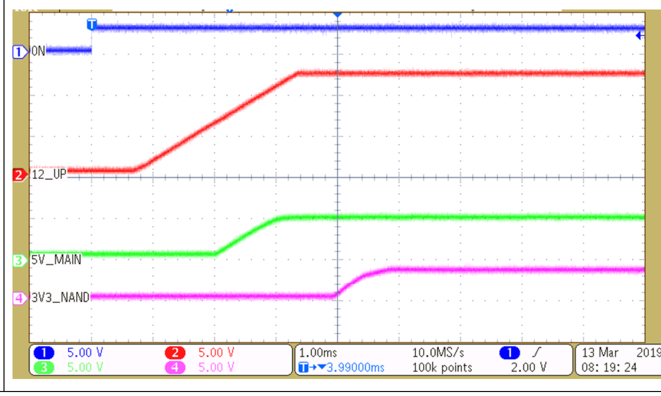


Figure 9. Power Sequencing 1 V1 Core



3.2.2.2 Standby Power Demonstration

The system standby current measurements were taken in various on/off modes. In standby mode, the measured input current was 1.256mA. This includes all of the necessary “always-on” core rails, including 1V1_Core and 3V3_STBY. With all of the peripherals and load switches enabled, the design was drawing roughly 1.5mA of quiescent current. This accounts for all of the LDOs and peripheral load switches, which drew an additional 220 µA current when enabled. In comparison, three discrete FETs drew roughly 500µA when enabled.

Table 7. Measured Input Current

Mode of Operation	Devices Enabled	Measured Input Current
Standby Mode	TPS2595, TPS566250, TPS564201, TLV62569A, TLV62568	1.256mA
Everything on except Discrete FETs	TPS2595, TPS566250, TPS564201, TLV62569A, TLV62568, TPS22975, TLV757, TPS22919	1.478mA
All Devices Enabled	TPS2595, TPS566250, TPS564201, TLV62569A, TLV62568, TPS22975, TLV757, TPS22919, 1V8_Dis, 3V3_Dis, 5V_Dis	1.923mA

3.2.2.3 Discrete FET vs. Integrated Load Switch Comparison

Table 8. Turn On/Off Summary Table

Voltage	Parameter	Description	Section
1.8 V	1.8 V Capacitive Load	100uF	Figure 10
	1.8 V Load	100uF, 3.6Ω (500mA)	Figure 11
3.3 V	3.3 V Capacitive Load	100uF	Figure 12
	3.3 V Load	100uF, 5.5Ω (600mA)	Figure 13
5 V	5 V Capacitive Load	100uF	Figure 14
	5 V Load	100uF, 1Ω (1A)	Figure 15

3.2.2.3.1 1.8V Load Demonstration

As shown in Figure 4 the discrete solution contains an NPN BJT is connected to the gate of the PMOS "pass FET." When the NPN BJT is enabled, it pulls down the gate of the PMOS and allows for power to flow from VIN to VOUT. However, compared to a TPS22919 solution, the discrete solution comes with a set of limitations. During power on and or off sequences, the discrete solution will have a nonlinear (RC) turn-on behavior, which can lead to a large spike of inrush current. The following waveforms will compare/contrast the turnon behaviors overlaid on one another. In the first waveform, Figure 10, both switching solutions are starting into a 100uF capacitive load. The TPS22919 exhibits a linear turn on behavior, limiting the inrush current to roughly 200mA. In comparison, the discrete solution experiences a peak of over 400mA of inrush current. In Figure 11, both solutions are starting into a 500mA / 100uF load. The TPS22919 helps to manage the inrush current with the controlled slew rate, while the discrete solution peaks at 700mA of inrush current.

Figure 10. 1V8_Dis vs. TPS22919 into 100uF Load

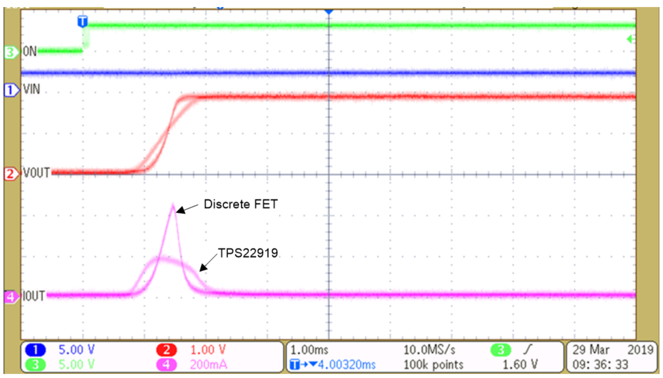
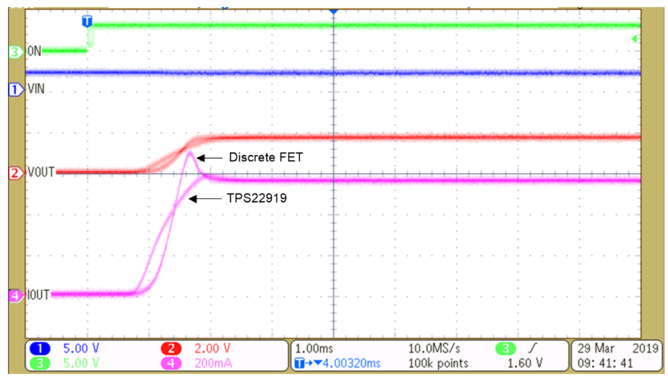


Figure 11. 1V8_Dis vs. TPS22919



3.2.2.3.2 3.3V Load Demonstration

Figure 12 and Figure 13 provide a comparison between the discrete solution and the TPS22919 at 3.3 V. When starting into a capacitive load, the TPS22919 limits the inrush current to 250mA while the inrush current on the discrete solution jumps to 700mA. When starting into a 1A load with 100uF of capacitance, the TPS22919 limits the inrush current while the discrete FET peaks to 1A.

Figure 12. 3V3_Dis vs TPS22919 into 100uF Load

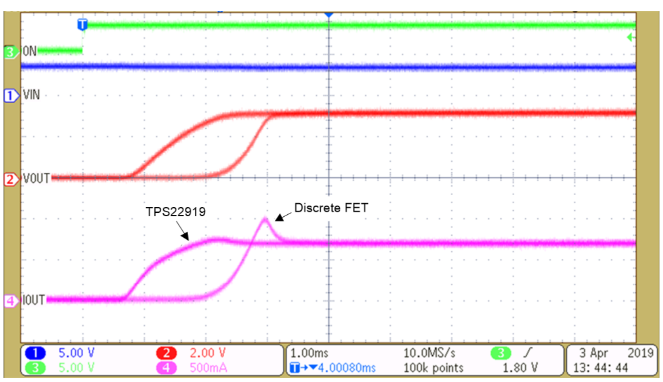
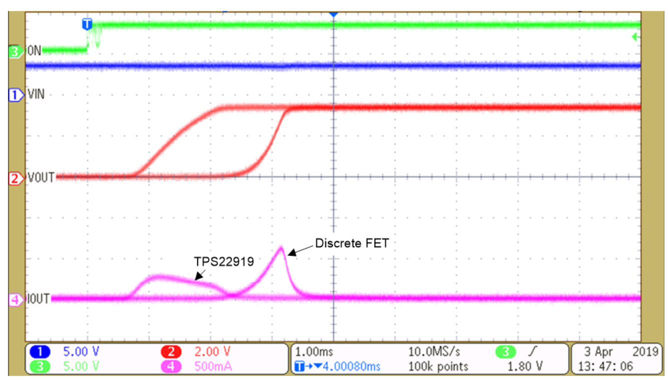


Figure 13. 3V3_Dis vs. TPS22919



3.2.2.3.3 5 V Load Demonstration

Figure 14 and Figure 15 provide a comparison between the discrete solution and the TPS22919 at 5 V. When starting into a capacitive load, the TPS22919 limits the inrush current to 250mA while the inrush current on the discrete solution jumps to 1.3A. When starting into a 1A load with 100uF of capacitance, the TPS22919 limits the inrush current while the discrete FET peaks at over 1.75A.

Figure 14. 5V_Dis vs. TPS22919 into 100uF Load

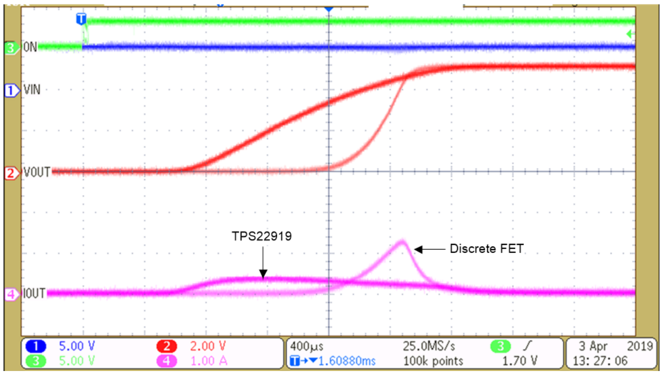
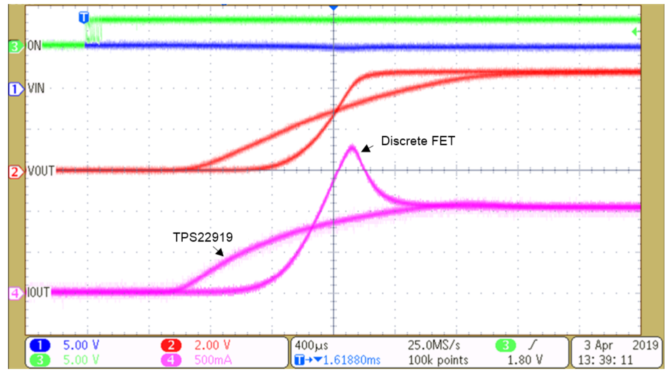


Figure 15. 5 V_Dis vs. TPS22919



3.2.2.3.4 Thermal Protection

Thermal shutdown protects the device from failure when the device junction temperature exceeds its safe limit. During operation, the junction temperature can rise due to many factors, including a high current load, large inrush current during startup, or during a fault condition. Thermal protection turns off the switch to protect itself by reducing the power dissipation, also potentially avoiding damage to upstream and downstream components. In comparison, a discrete FET cannot protect itself if it exceeds it's thermal junction temperature. In this case, the FET could potentially break, causing a short and damaging the downstream load or peripheral.

Figure 16 and Figure 17 provide a thermal image of the TPS22919 with a high current load at 25C. In this scenario, a 3A load is connected to 3V3_Eth, causing the thermal junction temperature to rise. As the temperature increases past 144C, the TPS22919 turns off and thermal cycles, bringing the board temperature back down to roughly 85C.

Figure 16. TPS22919 Thermal Image after Initial Turn-on

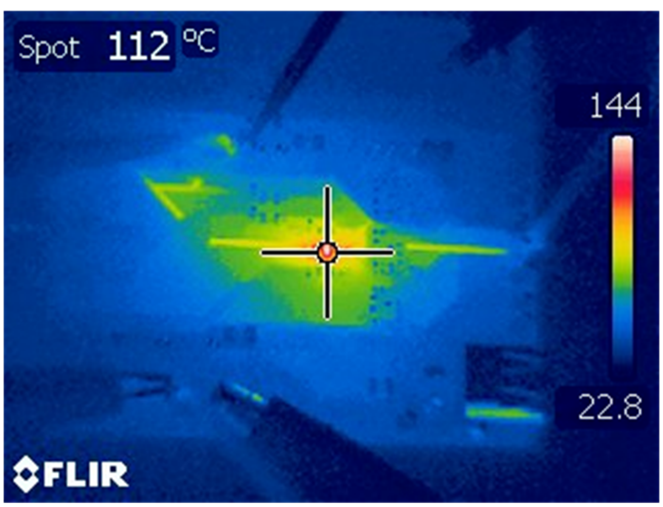
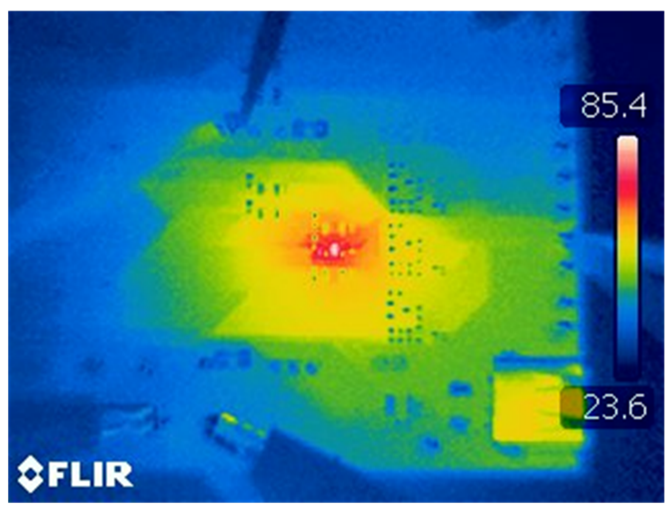
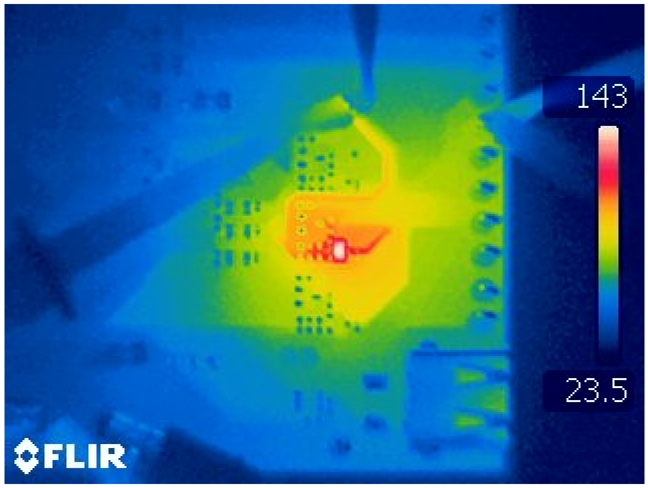


Figure 17. TPS22919 Thermal Image after Thermal Cycling



In comparison, Figure 18 shows the package temperature of the discrete FET at 25C under the same 3A load. The 3.3 V discrete FET will continue to power the downstream load until it fails. Unlike the TPS22919, the discrete FET does not have thermal shutdown, and will continue to be thermally stressed until the load is removed. If the FET is stressed beyond its absolute maximum rating, the device could also potentially be damaged. At higher ambient temperatures, the discrete FET will continue to be stressed beyond 143C, whereas the TPS22919 will continue to protect itself and thermally cycle.

Figure 18. Discrete FET Thermal Image



3.2.2.3.5 *Transient Protection Features*

TV Power Architectures can be stressed during startup and fault conditions. During these conditions, discrete FETs can dissipate more power that exceeds the physical and thermal limits of the MOSFET. If proper tests aren't taken into consideration, the system can fail due to overstressing these components. Additionally, some of these fault conditions, such as short circuit protection and hot plug protection, are often difficult to implement discretely and require additional components and design complexity. By using integrated devices on the TIDA-050027, these additional protection features can make the design more robust while simplifying the design.

The first major transient event that could severely damage the system is *Power Into Short*. In this condition, the output of the FET / IC is shorted to ground before the switch is turned on. As the FET is turned on, VOUT remains grounded at 0V. Therefore, the stress across the FET is equal to VIN. The power dissipated into the FET is equal to VIN * IOUT. Done discretely, as shown in Figure 19, the FET doesn't limit the current in the transient event and passes 10A of current downstream. Since the junction temperature of the FET exceeds its thermal limit during this event, the FET is damaged and sends 10A of continuous current to the downstream component.

In comparison, the TPS22919 integrated load switch is self-protecting and prevents damaging itself during the power into short event. When the short occurs, the large VIN to VOUT voltage drop causes the switch to limit the output current (Isc). Since the output voltage starts at 0 V, a lower limit is used to minimize the power dissipation until the fault is removed. In this case, as shown in Figure 20, the TPS22919 limits the output current to 0.5A while protecting itself from damage.

Figure 19. Discrete FET: Power into Short (Damages Discrete FET)

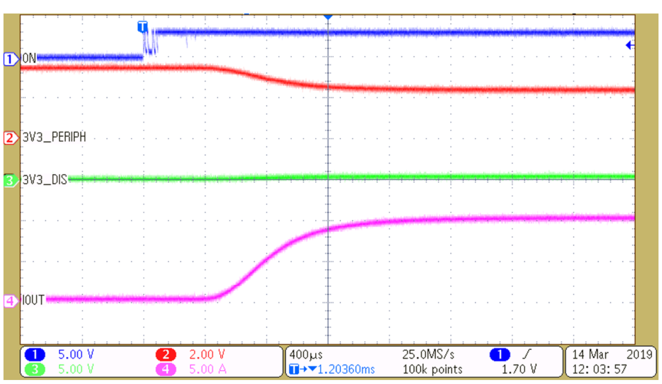
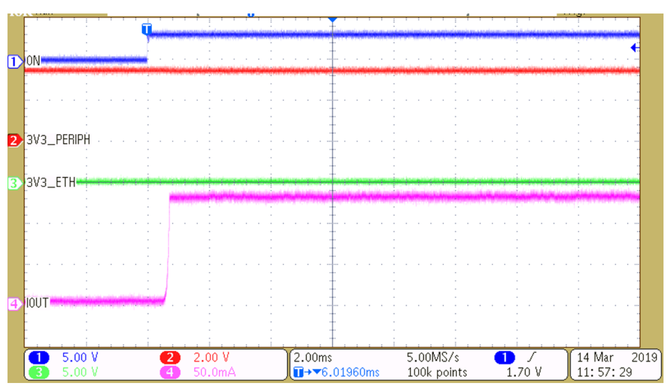


Figure 20. TPS22919: Power into Short (Limits to 150mA)



The other major transient event that could severely damage the system is *Hot Short*. In this condition, the output of the FET / IC is shorted to ground when the device is already turned on. This event is considered the more stressful event since the switch usually starts out hotter due to the pre-existing load current. The power dissipated into the switch is equal to VIN * IOUT. Figure 21 demonstrates a discrete implementation. Since the discrete FET doesn't limit the current in the transient, more than 10A passes downstream and the FET fails.

In comparison, the TPS22919 integrated load switch measures the voltage drop across the device and limits the output current within t_{sc}. The device continues to limit the current until it reaches the thermal shutdown temperature. At this point, the device turns off until the junction temperature has lowered. As shown in Figure 22 the TPS22919 limits the output current and turns off, dropping the output voltage to 0 V and protecting itself from damage.

Figure 21. Discrete FET: Hot Short (Damages Discrete FET)

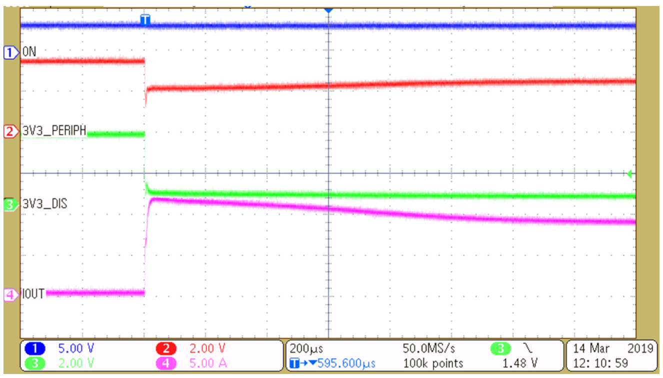
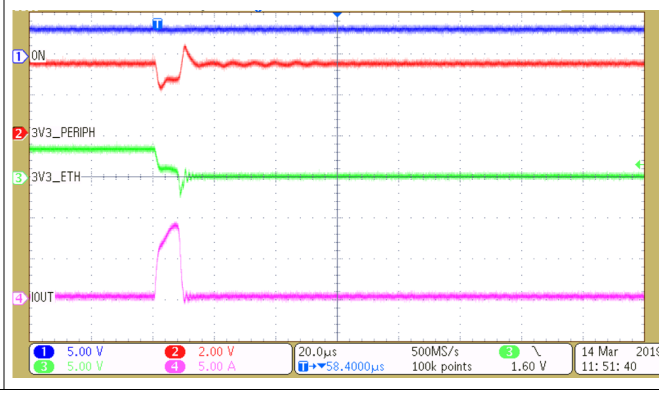


Figure 22. TPS22919: Hot Short



3.2.2.4 DC/DC Efficiency and Transient Testing Results

Figure 23, Figure 24, Figure 25, and Figure 26 provides the TIDA-050027 DC/DC efficiency results. Figure 27, Figure 28, Figure 29, Figure 30, Figure 31, and Figure 32 provides the TIDA-050027 DC/DC transient responses.

Figure 23. TLV62568 Efficiency vs. Output Current

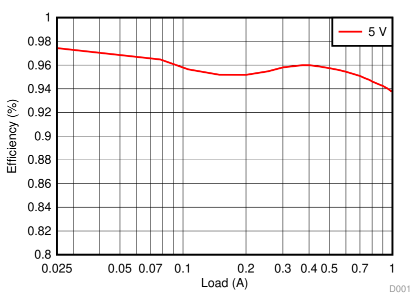


Figure 24. TLV62569A Efficiency vs. Output Current

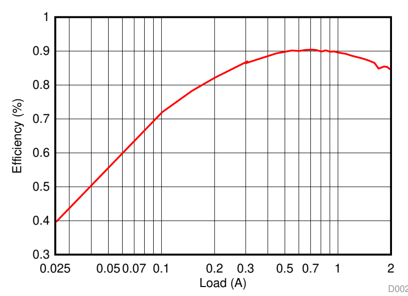


Figure 25. TPS566250 Efficiency vs. Output Current

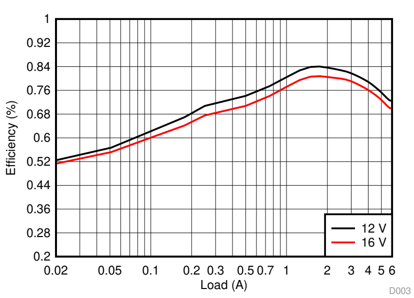


Figure 26. TPS564201 Efficiency vs. Output Current

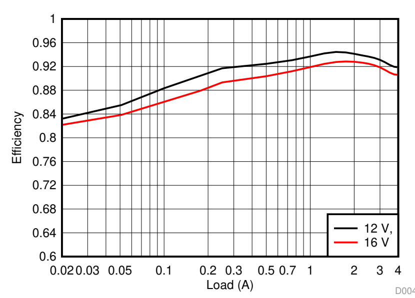


Figure 27. TLV62568 Transient Response

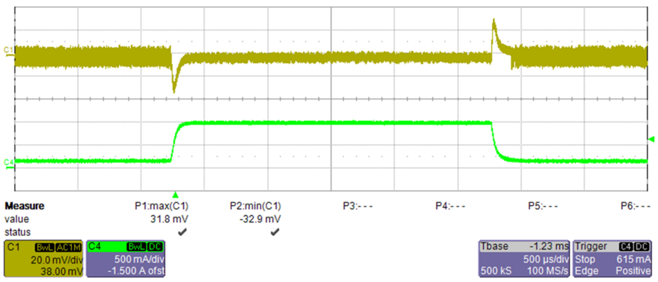


Figure 28. TLV62569A Transient Response

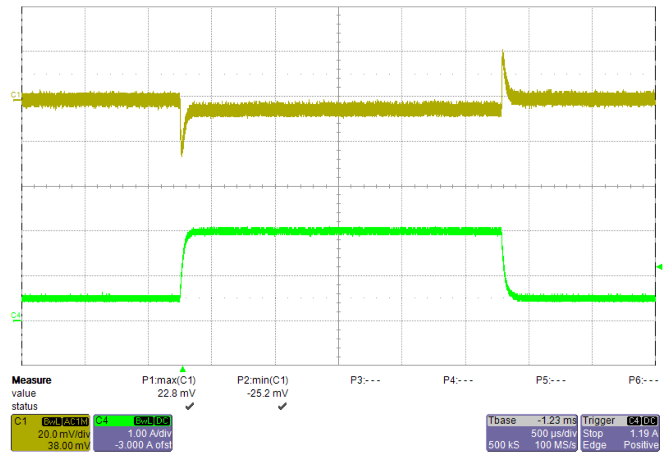


Figure 29. TPS564201 12V Transient Response

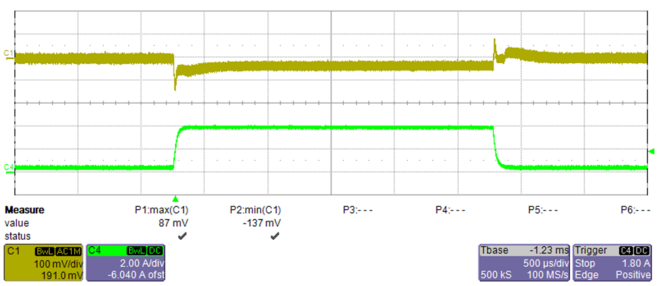


Figure 30. TPS564201 16V Transient Response

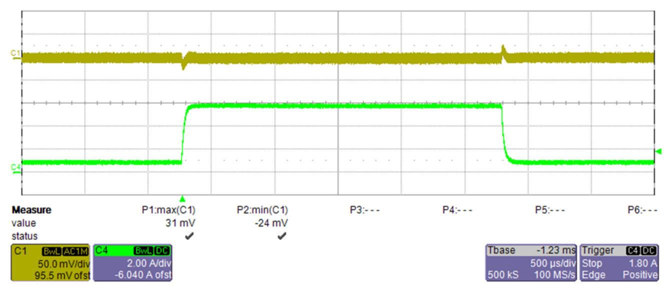


Figure 31. TPS566250 12V Transient Response

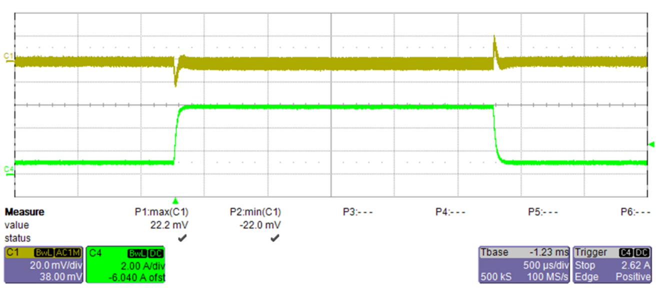
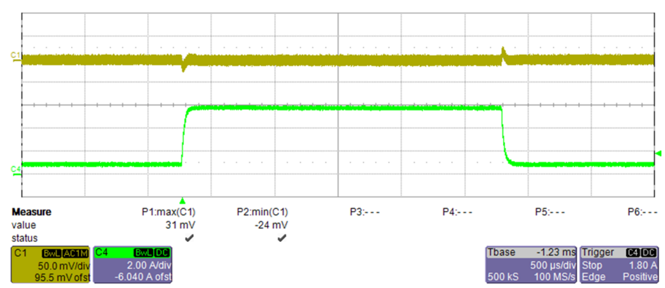


Figure 32. TPS566250 16V Transient Response



4 Design Files

4.1 Altium Project

To download the Altium Designer® project files, see the design files at TIDA-050027.

4.2 Schematics

To download the schematics, see the design files at TIDA-050027.

4.3 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-050027.

4.4 PCB Layout Recommendations

4.4.1 Layout Prints

To download the layer plots, see the design files at TIDA-050027.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-050027.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-050027.

5 Software Files

To download the software files, see the design files at TIDA-050027.

6 Related Documentation

1. *Integrated Load Switches versus Discrete MOSFETs* app report
2. *Basics of Power Switches* app report

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Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (May 2019) to B Revision	Page
• Added There are two voltage supervisors on the 5 V rail from the buck converter and the LDO that monitor the rails and reset on undervoltage conditions.	1
• Added product folder	1
• Added info on voltage supervisors.	1
• Changed diagram to include TLV809E.	1
• Added TLV809E to block diagram.	4
• Added section on voltage supervisors.	8
• Added new section on TLV809E.	10

Changes from Original (May 2019) to A Revision	Page
• Changed title from *Power Switching Reference Design for TVs* to *Multi-rail TV Power Supply Reference Design With Flexible Partitioning to Maximize Power Savings*	1

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