Synchronous Flyback Controller with Integrated Feedback & Digital Isolator

Features

- Wide VIN Range: 5V to 80V
- Integrated Feedback and Digital Isolator
- Internal Startup Regulator
- Integrated Driver for Synchronous Rectifier MOSFET
- ±1.5% Feedback Voltage Reference
- 8V Primary Driver with 1A Source/2A Sink Current Capability
- 9V Secondary Driver with 2A Source/3A Sink Current Capability
- Over 3000V-rms Isolation
- Adjustable Frequency From 100kHz to 700kHz
- Adjustable Soft-Start Time
- Optional Primary Side Bias for Optimized Efficiency
- Built-in Cycle-by-Cycle Current Limit, Input UVLO, Over Current Protection, Short-Circuit Protection, and Thermal Shutdown Protection
- SOP-16 Wide Body (10.3mm x 7.5mm)
- -40°C to 125°C Operating Junction Temperature Range
- Safety Certifications: UL1577

Brief Description

The KTB1095 is a highly integrated isolated synchronous flyback controller with internal feedback and an integrated digital isolator. The internal digital isolator eliminates the need to use an external optocoupler and enables small total solution size. The device operates over a wide input voltage range from 5V to 80V to support a variety of applications.

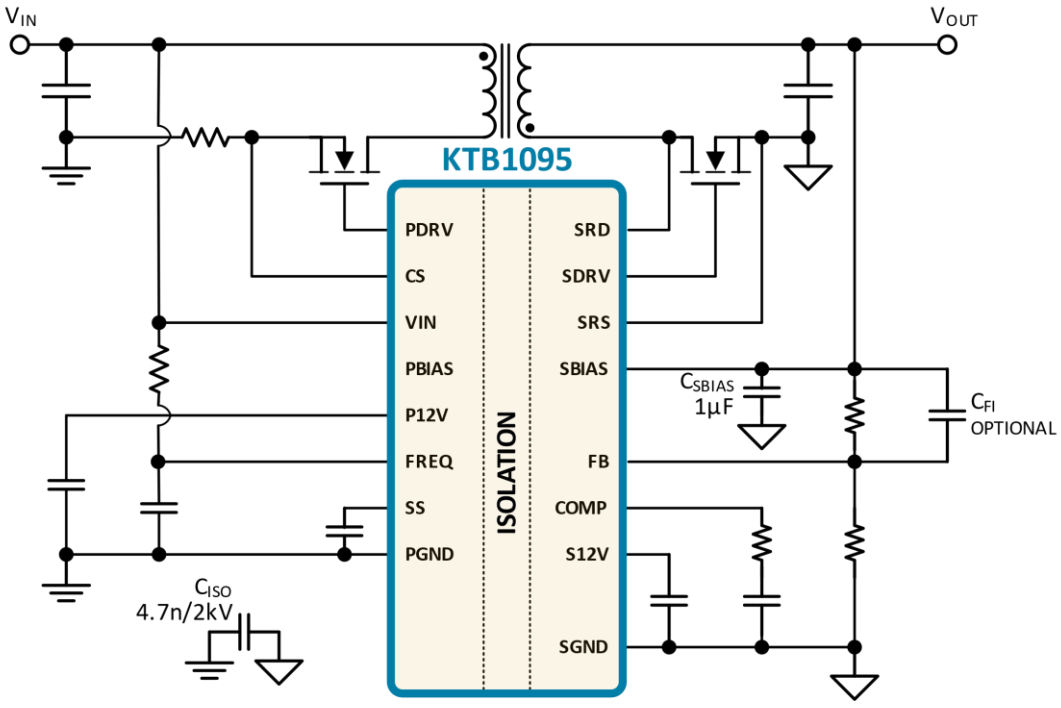
The KTB1095 employs current-mode PWM control with constant on-time (COT) for fast transient response as well as superior output voltage regulation. The device features an adjustable soft-start function to limit inrush current during start-up. The device has built-in protection features including input voltage UVLO, output over-voltage-protection (OVP), cycle-by-cycle current limit, short-circuit protection and thermal shutdown.

The KTB1095 is available in RoHS and Green compliant SOP-16 package.

Applications

- Telecom and Communications Power Systems
- Industrial PLCs, Smart Meters
- Power-Over-Ethernet (PoE)
- Bias supply for isolated DC-DC converters
- Low power isolated power modules
- Battery Management System (BMS) in EVs

Typical Application

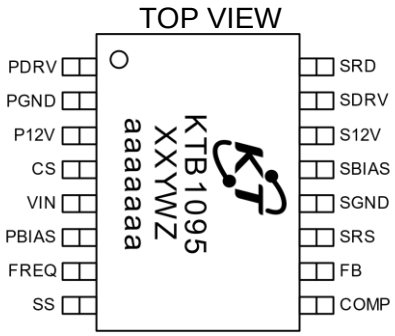


Ordering Information

Part Number	Marking[1]	Operating Temperature	Package
KTB1095EYAA-TE	SS*YWZaaaaaaa*	-40°C to +85°C Ambient	SOP-16

Pinout Diagram

SOP-16



16-pin 10.3mm x 7.5mm x2.65mm

Top Mark: XX = Device ID, YW = Date Code, Z = Serial Number, aaaaaaa = Assembly Lot Tracking Number

Pin Descriptions

Pin #	Name	Function
1	PDRV	Primary output gate drive for the external power MOSFET
2	PGND	Primary Side Ground
3	P12V	Regulated Power Supply for Primary Side Driver, internally produced from Vin input.
4	CS	Primary MOSFET current sense
5	VIN	Input supply voltage with 5V to 80V operating range (100V Absolute Maximum rating).
6	PBIAS	Optional input to produce primary side regulator. Powering PBIAS from an external supply instead of VIN can reduce power loss at high VIN. For PBIAS > 7V, the regulator draws current from PBIAS pin. The PBIAS pin voltage must not exceed 28V.
7	FREQ	Switching frequency programming pin. Refer to the typical application schematic, one external resistor and one capacitor are used to set the switching frequency, where one resistor is connected between VIN pin and FREQ, and a capacitor is connected to FREQ pin and PGND. See Application session for details on how to set the switching frequency.
8	SS	Soft-start programming pin. A capacitor between the SS pin and PGND pin to set soft-start time.
9	COMP	Output of the error amplifier. An external RC compensation network connected between COMP and SGND compensates the converter control loop.
10	FB	Feedback pin for output voltage regulation. Connect a resistor divider network from the output of converter to the FB pin.
11	SRS	Synchronous rectifying MOSFET source voltage sense
12	SGND	Secondary Side Ground
13	SBIAS	Input to produce secondary side regulators.
14	S12V	Regulated Power Supply for Secondary Side Driver. It is produced from SBIAS input.
15	SDRV	Secondary-side output gate drive for the external Synchronous Rectifier MOSFET
16	SRD	Synchronous rectifying MOSFET drain voltage sense

1. SS = Device ID, YW = Date Code, Z = Serial Number, aaaaaaa = Assembly Lot Tracking Number

Absolute Maximum Ratings[2]

Symbol	Description	Value	Units
VIN, FREQ	VIN, FREQ to PGND	-0.3 to 100	V
SRD	SRD to SGND	-0.3 to 120	V
PBIAS	PBIAS to PGND	-0.3 to 48	V
PDRV, P12V	PDRV, P12V to PGND	-0.3 to 16	V
SDRV, S12V	SDRV, S12V to SGND	-0.3 to 16	V
SS, CS	SS, CS to PGND	-0.3 to 6	V
COMP, FB	COMP, FB to SGND	-0.3 to 6	V
SBIAS	SBIAS to SGND	-0.3 to 48	V
SRS	SRS to SGND	-0.3 to 6	V
T_J	Die Junction Operating Temperature Range	-40 to 150	°C
T_S	Storage Temperature Range	-55 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	260	°C

ESD Ratings[3]

Symbol	Description	Value	Units
V_{ESD}	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins	±2000	V
	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins	±500	

Thermal Capabilities[4]

Symbol	Description	Value	Units
Θ_{JA}	Thermal Resistance – Junction to Ambient	87.0	°C/W
Θ_{JC}	Thermal Resistance – Junction to Case	52.0	°C/W
P_D	Maximum Power Dissipation	1.4	W
$\Delta P_D/\Delta T$	Derating Factor above T_A = 25°C	-11.5	mW/°C

Recommended Operating Conditions[5]

Symbol	Parameter	Min.	Typ.[6]	Max.	Units
VIN	Input Power Supply	5	-	80	V
T_A	Ambient Operating Temperature Range	-40	-	+85	°C
T_{J_MAX}	Recommended Maximum Junction Operating Temperature			125	°C

2. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.
3. ESD and Surge Ratings conform to JEDEC and IEC industry standards. Some pins may have higher performance. Surge ratings apply with chip enabled, disabled, or unpowered, unless otherwise noted.
4. Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board.
5. The recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Kinetic does not recommend exceeding them or designing to Absolute Maximum Rating.
6. Typical specification, not 100% tested. Performance guaranteed by design and/or other correlation methods.

Electrical Characteristics[7]

Typical values correspond to T_A = 25°C. Minimum and Maximum specs are applied over the full operation junction temperature range of -40°C to 125°C, unless otherwise noted. V_{IN} = 24V, unless otherwise noted.

Supply and Enable Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IN}	Input Voltage Operating Range		5		80	V
I_{IN}	Non-Switching Operating Current	FB = 2V, PBIAS = 0V		5	7	mA
P12V	P12V Regulator Output Voltage	Powered from VIN pin, V_{IN} = 9V to 75V, P_{BIAS} = open		8		V
		Powered from VIN pin, V_{IN} = 7V to 9V, P_{BIAS} = open		VIN-1.5		V
	P12V Maximum Output Current			30		mA
PBIAS	PBIAS Operating Voltage Range		7		28	V
	P12V Regulator Input Switchover (Powered from VIN to PBIAS) Threshold	V_{IN} = 24V			7	
SBIAS	SBIAS Operating Voltage Range		3.5		48	V
S12V	S12V Regulator Output Voltage	9V<SBIAS <48V		9.0		V
	S12V Regulator Output Voltage	3.5V<SBIAS <9V		SBIAS-0.3		
	S12V Maximum Output Current	SBIAS >12V		30		mA

Primary Side Driver Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{HIGH}	Driver voltage high level	V_{IN} <9V, C_L = 1nF		V_{IN}-1.5		V
		V_{IN} >9V, C_L = 1nF		8		
V_{LOW}	Driver voltage low level	C_L = 1nF		0.2		V
I_{SOURCE}	Source Current Capacity			1.0		A
I_{SINK}	Sink Current Capacity			2.0		A
t_{ON}	FET Minimum On Pulse Duration			250		ns
t_{OFF}	FET Minimum Off Pulse Duration			650		ns
t_r	Driver voltage rise time	C_L = 1nF		20		ns
	Driver voltage fall time			15		

7. Device is guaranteed to meet performance specifications over the -40°C to +125°C operating temperature range by design, characterization, and correlation with statistical process controls.

Electrical Characteristics (continued)[8]

Typical values correspond to T_A = 25°C. Minimum and Maximum specs are applied over the full operation junction temperature range of -40°C to 125°C, unless otherwise noted. V_{IN} = 24V, unless otherwise noted.

Secondary Side Driver Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{HIGH}	Driver voltage high level	SBIAS <9V, C_L = 1nF		SBIAS-0.3		V
		SBIAS >9V, C_L = 1nF		9		
V_{LOW}	Driver voltage low level	C_L = 1nF		0.2		V
I_{SOURCE}	Source Current Capacity			2		A
I_{SINK}	Sink Current Capacity			3		A
t_{ON}	FET Minimum On Pulse Duration			150		ns
t_{OFF}	FET Minimum Off Pulse Duration			350		ns
t_r	Driver voltage rise time	C_L = 1nF		20		ns
	Driver voltage fall time			15		
T_{dead}	Dead time between PDRV falling and SDRV rising			170		ns
	Dead time between SDRV falling and PDRV rising					
SRD	Negative detection for turn on synchronous			-300		mV

Primary Side OCP

Symbol	Description	Conditions	Min	Typ	Max	Units
I_{CC}	Cycle by Cycle Current Limit Threshold			60		mV
N_h	Consecutive Cycles of Cycle-by-Cycle Current Limiting Events before Entering Hiccup Mode			32		-
T_{hic}	Blanking Time in Hiccup Mode	With 64ms, 1s, and shutdown options		256		ms
I_{sh}	Short Current Protection Threshold			80		mV
N_s	Consecutive Cycles of Short Current Protection Events before Entering Hiccup Mode			1		-

Secondary Side Current Sense

Symbol	Description	Conditions	Min	Typ	Max	Units
SRS	CSP Pin Input Bias Current			100		µA
SRD	CSN Pin Input Bias Current			100		µA

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8. Device is guaranteed to meet performance specifications over the -40°C to +125°C operating temperature range by design, characterization, and correlation with statistical process controls.

Electrical Characteristics (continued)[9]

Typical values correspond to T_A = 25°C. Minimum and Maximum specs are applied over the full operation junction temperature range of -40°C to 125°C, unless otherwise noted. V_{IN} = 24V, unless otherwise noted.

Feedback (FB) and Error Amplifier Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{REF}	Feedback Voltage Reference		1.18	1.2	1.22	V
Gm	Error Amplifier Transconductance			300		µS
R_{OUT}	Error Amplifier Output Resistance			10		MΩ
f_{BW}	Unity Gain Bandwidth			2		MHz
I_{FB}	Error Amplifier Input Bias Current			20		nA
I_{COMP}	COMP Sink Current	$V_{FB}=V_{REF}$ + 300 mV		150		µA
		$V_{FB}=V_{REF}$ - 300 mV		150		

Over-Voltage Protection (OVP) Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
OVP	OVP Voltage Threshold with Respect to V_{REF}	V_{FB} Rising	107	112	117	%
	OVP Voltage Hysteresis with Respect to V_{REF}			2		

Frequency and SS Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
f_{SW}	Switching Frequency Range[10]		100		700	kHz
I_{SS}	Soft-start Pull-up Current			6		µA

Thermal Shutdown Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
T_{J_SHDN}	Thermal Shutdown Set Threshold	T_J rising		150		°C
T_{J_hys}	Thermal Shutdown Hysteresis			20		°C

Insulation Specifications

Symbol	Description	Conditions	Min	Typ	Max	Units
V_{ISO}	Isolation Voltage	1 minute duration, AC(RMS)	3			kV

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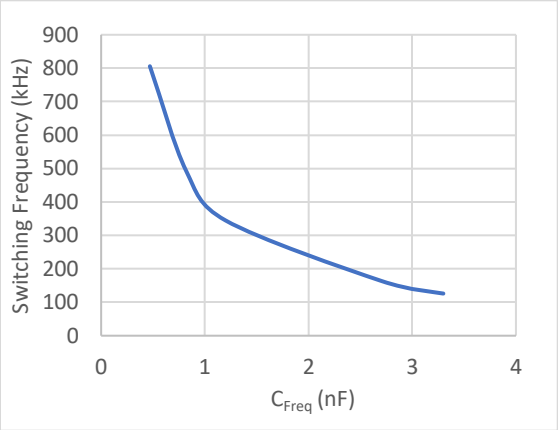
9. Device is guaranteed to meet performance specifications over the -40°C to +125°C operating temperature range by design, characterization and correlation with statistical process controls.

10 Guaranteed by design, characterization and statistical process control methods; not production tested.

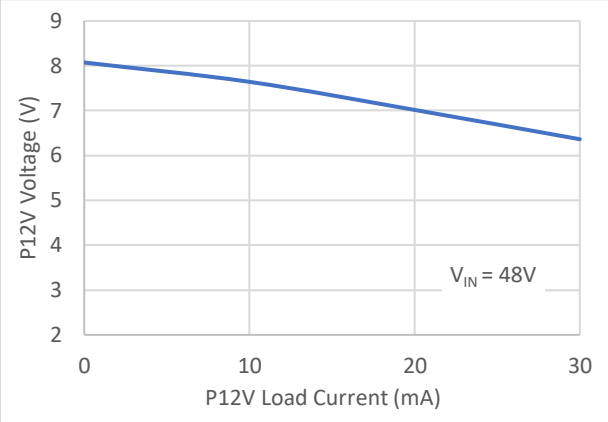
Typical Characteristics

V_{IN} = 48V, R_{FREQ} = 150k, C_{FREQ} =1.2nF unless otherwise specified.

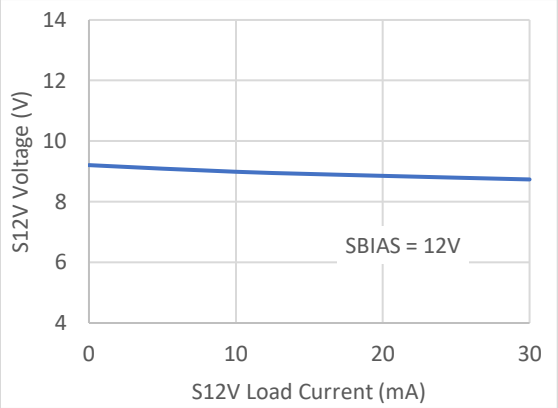
Switching Freq. vs. Programming Capacitor



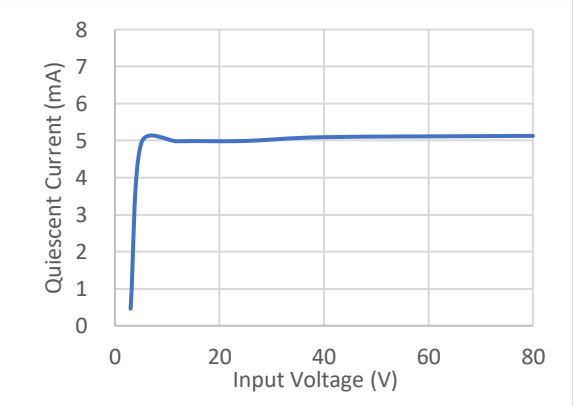
P12V Voltage vs. P12V Load Current



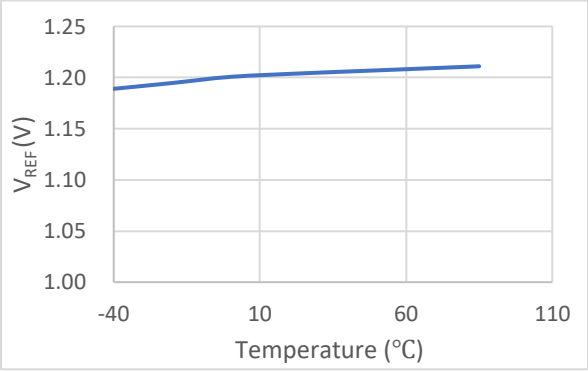
S12V Voltage vs. Load Current



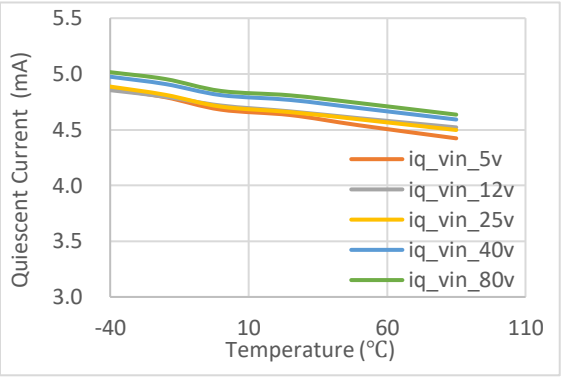
Quiescent Current vs. Input Voltage



Feedback Voltage Reference vs. Temperature



Quiescent Current vs. Temperature



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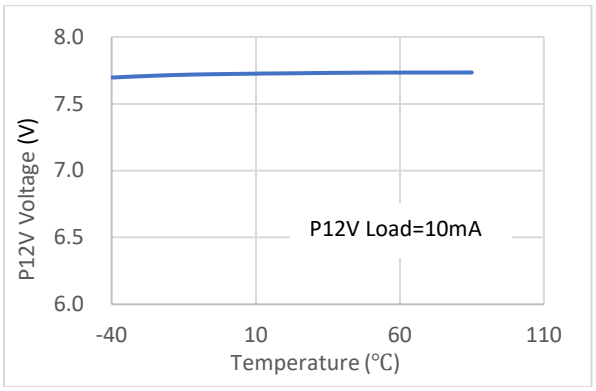
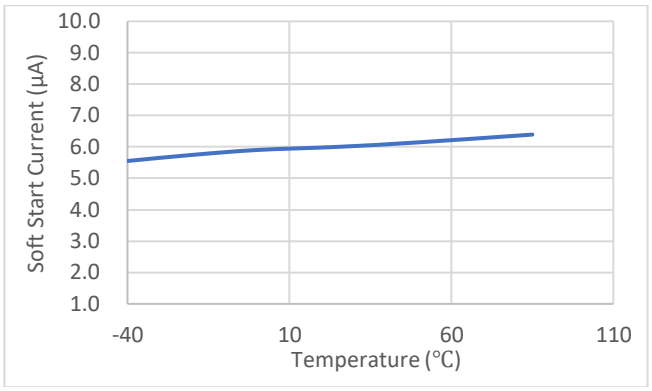
Typical Characteristics (continued)

V_{IN} = 48V, R_{FREQ} = 150k, C_{FREQ} =1.2nF unless otherwise specified.

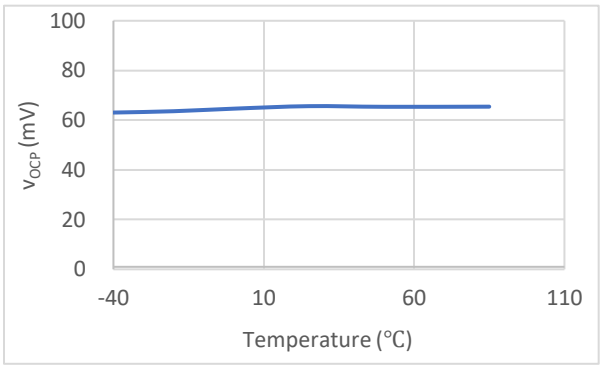
P12V Voltage vs. Temperature



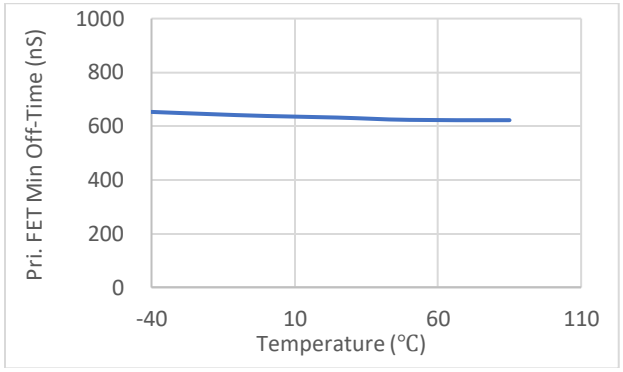
Soft Start Current (I_{SS}) vs. Temperature



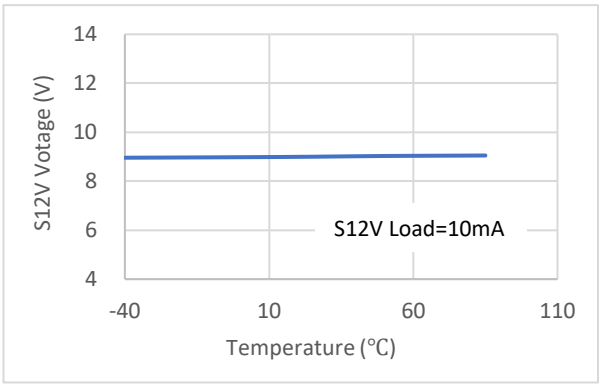
V_{OCP} vs. Temperature



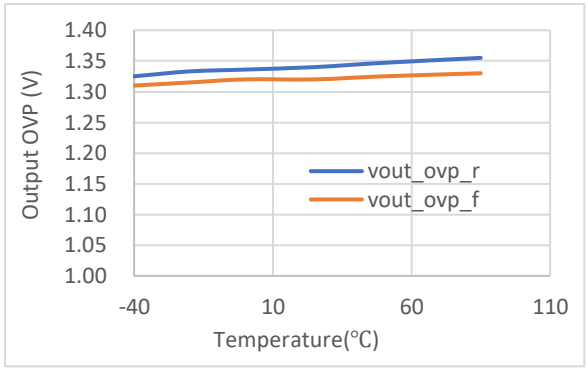
Primary FET Min. Off Time vs. Temp



S12V Voltage vs. Temperature



Output Overvoltage (OVP) vs. Temperature



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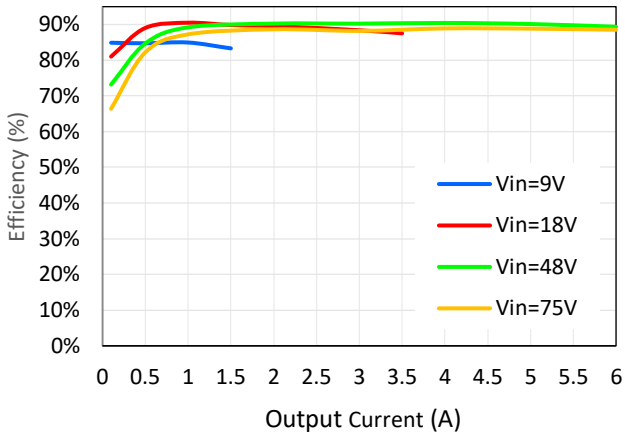
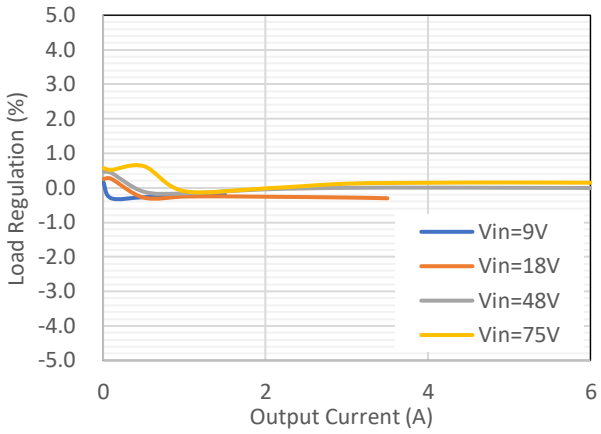
Typical System Performance Characteristics

V_{IN} = 9V-75V, V_{OUT} = 12V, R_{FREQ} = 150k, C_{FREQ} = 1.2nF, Transformer (Np: NS = 2.33:1, Lp = 16µH) unless otherwise specified.

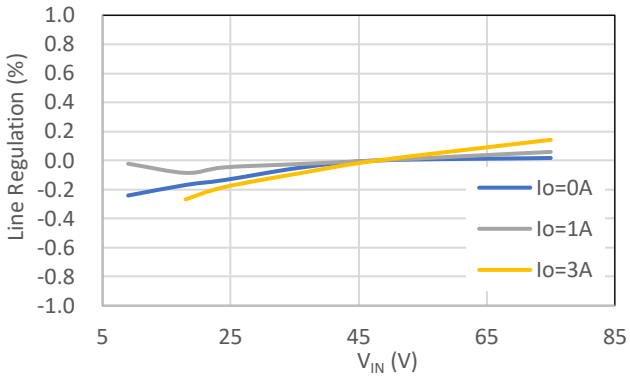
Efficiency vs Load Current



Load Regulation



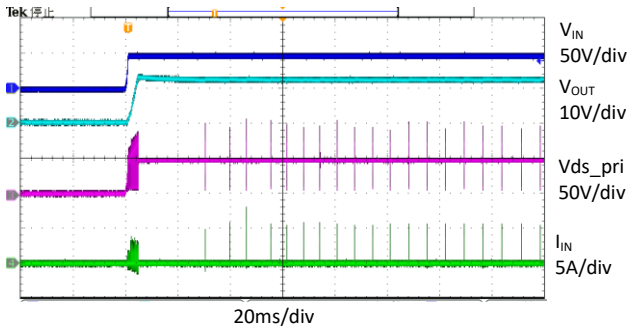
Line Regulation



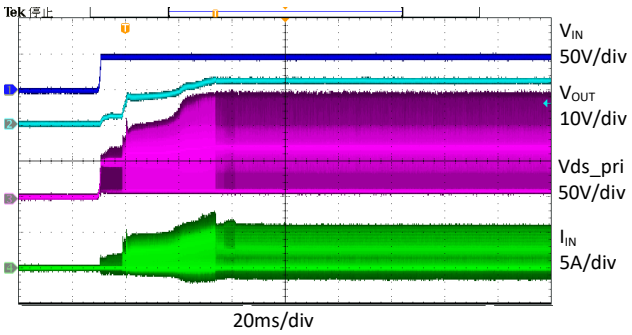
Typical System Performance Characteristics (continued)

V_{IN} = 9V-75V, V_{OUT} = 12V, R_{FREQ} = 150k, C_{FREQ} = 1.2nF, Transformer (Np: NS = 2.33:1, Lp = 16µH) unless otherwise specified.

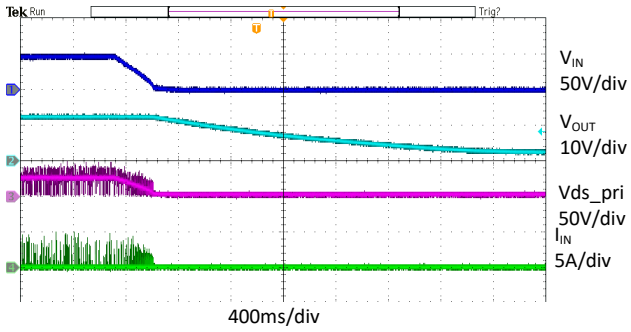
Input Startup
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 0A)



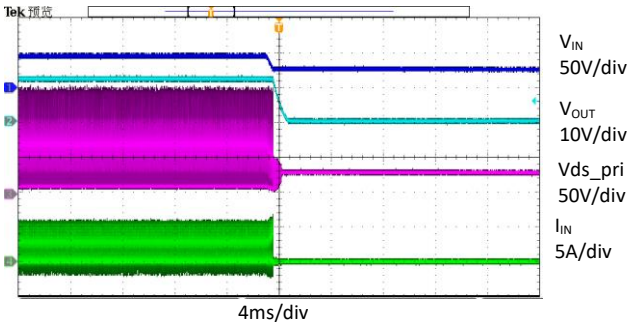
Input Startup
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 6A)



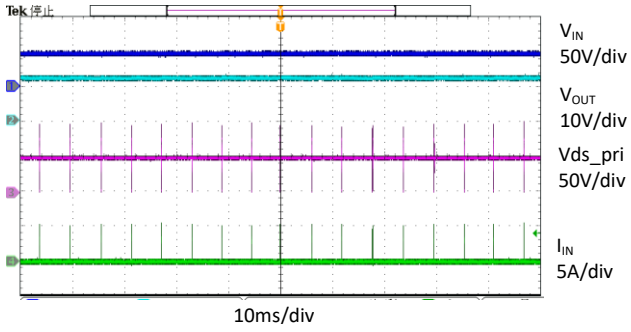
Input Shutdown
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 0A)



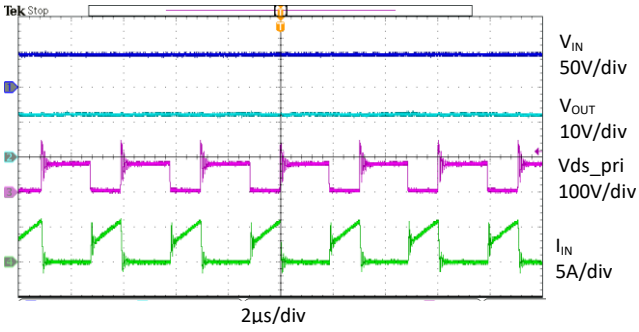
Input Shutdown
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 6A)



Steady State
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 0A)



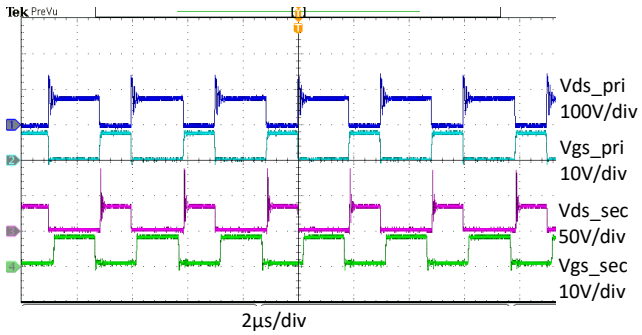
Steady State
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 6A)



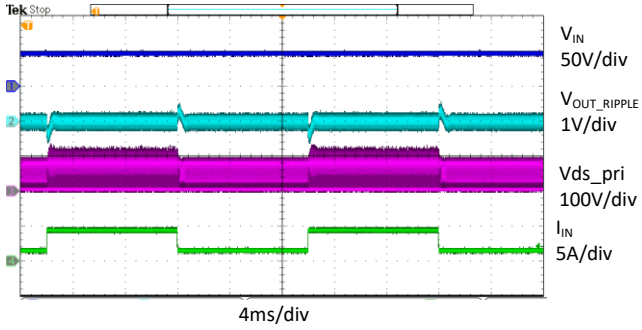
Typical System Performance Characteristics (continued)

V_{IN} = 9V-75V, V_{OUT} = 12V, R_{FREQ} = 150k, C_{FREQ} = 1.2nF, Transformer (Np: NS = 2.33:1, Lp = 16µH) unless otherwise specified.

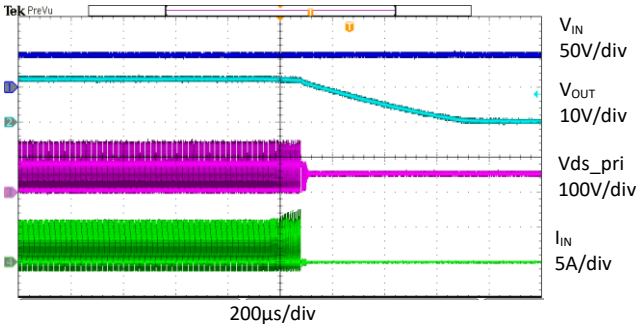
Steady State
($48V_{IN}$, $12V_{OUT}$, I_{OUT} = 6A)



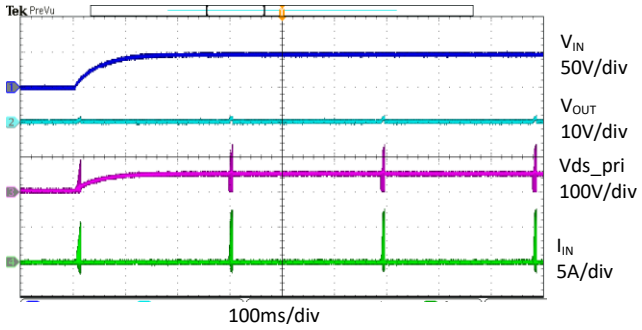
Dynamic Load Performance
($48V_{IN}$, $12V_{OUT}$, Load Step from 1.5A-4.5A-1.5A)



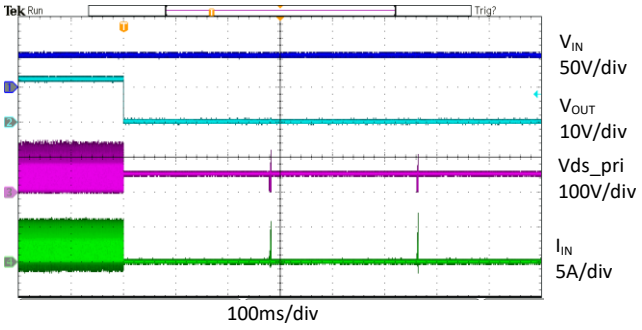
OCP Performance
($48V_{IN}$, $12V_{OUT}$, I_{OUT} from 6A to OCP)



Short Circuit Performance
($48V_{IN}$, $12V_{OUT}$, I_{OUT} from Short to Start)



Short Circuit Performance
($48V_{IN}$, $12V_{OUT}$, I_{OUT} from 6A to Short)



Functional Block Diagram

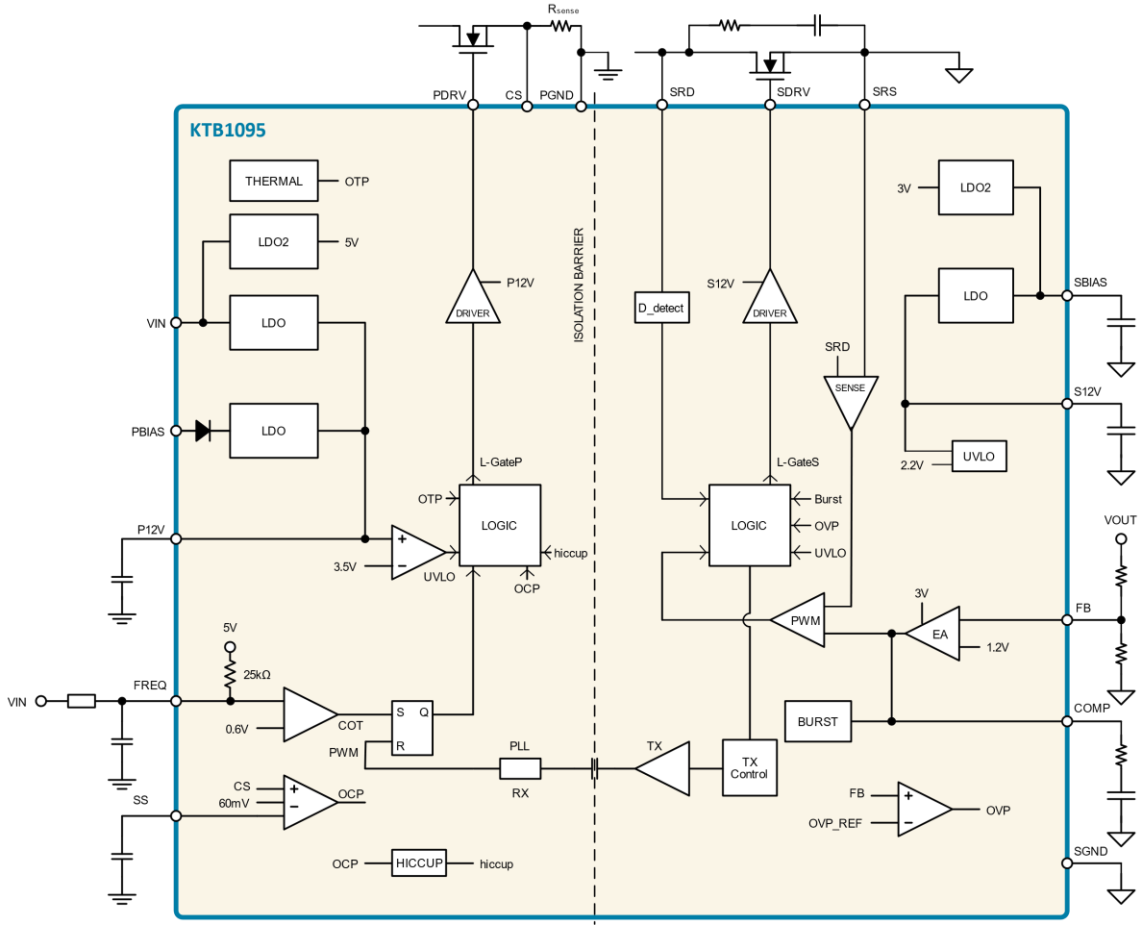


Figure 1. Functional Block Diagram

Functional Description

Overview

The KTB1095 is a highly integrated isolated synchronous flyback controller with digital isolator and secondary feedback circuit. It employs current-mode constant on-time (COT) control. KTB1095 offers a complete solution for an isolated flyback synchronous dc-to-dc power supply by integrating the 3kV digital isolator and secondary feedback circuitry in one package. The device operates over a wide input voltage range from 5V up to 80V (100V absolute maximum) supporting a variety of applications. The output voltage can be set by an external resistive divider, allowing KTB1095 to be used in many applications.

A digital isolator is integrated in the KTB1095 to eliminate the optocoupler that transmits the output voltage condition from secondary to primary. Integrating the digital isolator reduces system design complexity, PCB area, and component count and improves overall system performance and reliability. Traditionally in a flyback converter, a discrete optocoupler is used in the feedback path to transmit the signal from the secondary side to the primary side. However, the current transfer ratio (CTR) of optocouplers can degrade over time and over the temperature range. If it is not considered during the design, it can reduce long-term system reliability. Secondly,

most discrete optocouplers used in telecom or industrial applications have a maximum operation temperature of approximately 100°C to 125°C, potentially limiting the maximum operating temperature of the system.

The KTB1095 eliminates the use of a discrete optocoupler and related feedback components, thereby reducing PCB area and complexity, while improving system reliability and increasing the maximum operating temperature of the system.

The KTB1095 primary side includes a current limit function. When the current exceeds its peak current limit for 32 cycles, the KTB1095 will shut down and enter hiccup mode with a 256ms time interval.

Secondary-side feedback circuitry is integrated in the KTB1095 to eliminate external voltage reference and error amplifier. The integrated voltage reference has high accuracy, and the error amplifier has high gain bandwidth.

The primary-side circuitry in the KTB1095 includes a primary gate driver, high voltage start-up regulators for control and driver, primary current sensing, and protection, optional PBIAS circuit, soft start circuit and PWM generator. The secondary-side circuitry includes the secondary gate driver, SBIAS circuit, error amplifier, an internal voltage reference, secondary regulators, and synchronous rectification MOSFET drain and source sense circuit.

The KTB1095 PWM signal is controlled both by the constant on-time control of the primary side and the valley current-mode control in the secondary side of KTB1095. The output voltage of the converter is sensed by the error amplifier on the secondary side, sending a signal to the primary side via the 3kV integrated digital isolator for a complete control loop solution.

KTB1095 offers features such as input undervoltage lockout (UVLO), over current protection (OCP) and short circuit protection (SCP), output overvoltage protection (OVP), over temperature protection (OTP), and power saving with burst mode in light load conditions.

Primary Side Gate Driver

The KTB1095 has an integrated primary MOSFET driver with 1A (typical) peak source and 2A (typical) sink current capability. The gate driver is powered from the regulated LDO output at P12V pin.

The primary side driver is intended for driving the flyback primary switching MOSFET. The dead time between the primary side driver (PDRV) and secondary side driver (SDRV) is fixed at 170ns (typical). The rising-edge dead time and the falling-edge dead time are the same. Refer to the diagram below.

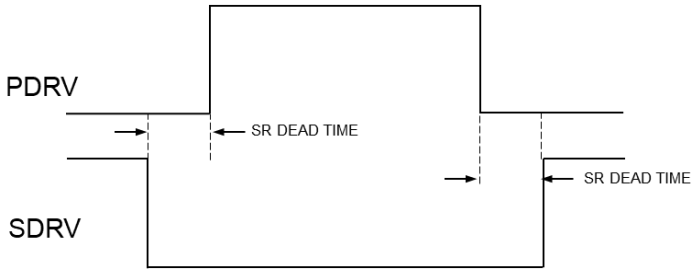


Figure 2. PDRV/SDRV Rising/Falling Dead Times

Primary Side P12V Regulator

A high voltage start-up regulator is connected to VIN and provides a regulated output at P12V. It allows the VIN pin to be connected directly to a wide range of DC line voltages up to 80V (100V absolute maximum). The regulated output voltage is 8V (typical), to power the primary gate driver. Connect a 1µF capacitor from P12V to primary-side ground (PGND).

For high input voltage and high frequency applications, to prevent KTB1095 from dissipating unnecessary heat in its internal start-up regulator, an external regulated voltage supply (9V to 15V) can be applied to the P12V pin directly, refer below figure 5.

Primary Side Over-Current Protection

The CS pin input provides the current signal that is used for primary-side cycle-by-cycle current limit and over-current protection. The current through the external primary switching MOSFET can be sensed through a current-sense resistor that is connected in series with the MOSFET's source. If the sensed voltage at CS pin exceeds 60mV for 32 switching cycles, the over-current protection will trigger and stop the controller. A small RC filter, located near the controller, is recommended for the CS input pin. The blanking time is around 65ns at the start of each main switch cycle to attenuate the leading-edge spike in the current sense signal. After OCP, the KTB1095 will restart after the hiccup time. The hiccup time is 256ms (typical).

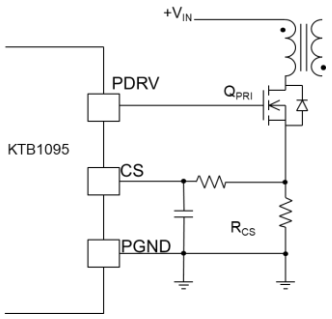


Figure 3. Primary Side Current Sense Circuit

Input Voltage Range

The KTB1095 can operate over a wide input voltage range from 5V up to 80V (100V absolute maximum) that can support a variety of applications. It can be used with various bus voltages such as 12V, 24V, 48V, 60V etc. When working at a low input voltage, maximum duty and transformer turn ratios must be considered to get a target output voltage. The controller starts to work at approximately 4V input voltage with a typical 200mV hysteresis voltage.

Primary Optional PBIAS Supply

There is an optional input to primary side 5V regulator that can be powered from an external supply instead of VIN. This can reduce the power loss at high input voltages. For PBIAS > 7V, the regulator draws current from PBIAS pin. The PBIAS pin voltage is suggested to not exceed 28V (48V absolute maximum) for power savings.

For low input voltage application (for example Vin<36V), when PBIAS pin function is not used, leave it floating (open). For high input voltage applications, it is recommended to use PBIAS function for higher system efficiency when system input voltage is over 36V. An auxiliary primary winding of the transformer is generally used for this PBIAS function. The external voltage at the PBIAS pin is suggested to be greater than 7V and not exceed 28V (48V absolute maximum) for power savings.

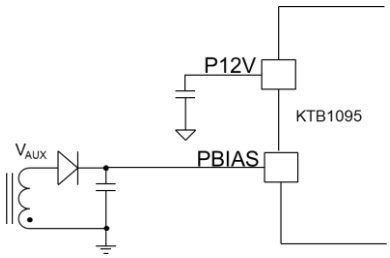


Figure 4. PBIAS Connection for High Vin Application

For high input voltage (for example Vin>36V) and high frequency (for example Fsw>300kHz) applications, to reduce power loss in the internal regulators and keep the KTB1095 internal power dissipation to a minimum, an external voltage supply is suggested to apply to the PBIAS pin and P12V pin together. This external voltage can be an LDO connected to an auxiliary transformer winding, as shown in Figure 5 below. The regulated LDO voltage is suggested to be greater than 9V that can shut off the internal regulator and not exceed 15V to over the maximum rating of the P12V pin.

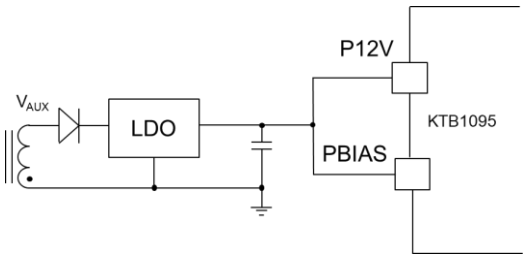


Figure 5. PBIAS Connection for High Vin and High Frequency Application

Frequency

Switching frequency can be programmed by an external resistor, R_{FREQ}, connected between VIN and FREQ and an external capacitor, C_{FREQ}, connected from FREQ to PGND, as shown in the figure below.

The switching frequency during CCM (continuous conduction mode), is constant and reduces during DCM (discontinuous conduction mode). During light load, the regulator will enter burst mode, only switching to replenish the output capacitor to save power and therefore increase the system efficiency.

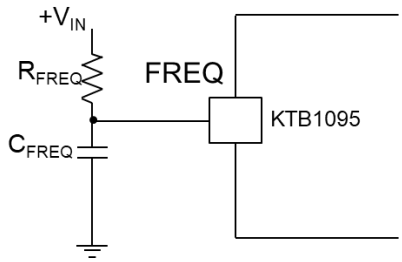


Figure 6. Switching Frequency Programming Circuit

Soft-Start (SS)

To provide a controlled startup, a capacitor is required on the SS pin. At device power on, the SS capacitor is slowly charged by an internal 6μA current source.

Soft-start function makes the startup frequency in a low value and increases step by step before V_{OUT} reaches 2.6V. Once it reaches 2.6V which is high enough to power the secondary side. The secondary will take over the control loop and the frequency will be much higher. During soft start, the peak current limit will be limited by the voltage of SS pin. The soft start is over when SS reaches 0.6V. Users need to make sure the V_{OUT} has already reached the target before soft start finishes. Otherwise OCP will trigger and the IC will restart after 256ms hiccup time.

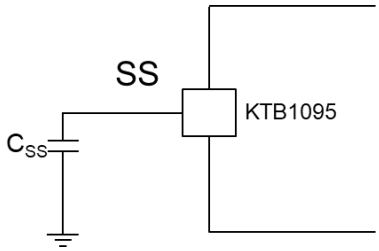


Figure7. Soft-Start Programming Capacitor

Secondary-Side Gate Driver

KTB1095 has an integrated secondary MOSFET driver with 2A (typical) peak source and 3A (typical) sink current capability. The gate driver is powered from the regulated LDO output at S12V pin. The secondary-side driver is intended for driving the secondary synchronous rectifier MOSFET.

Secondary Side S12V Regulator

S12V is one of the output regulators produced from SBIAS pin input. It is the power supply for the secondary-side gate driver. The regulated voltage is typically 9V when SBIAS input range is from 9V to 48V. Connect a 1µF capacitor to secondary ground SGND.

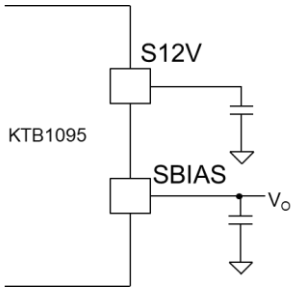


Figure 8. S12V Secondary-Side Regulator Circuit

Secondary SBIAS Supply

SBIAS is the input power for the secondary side 9V regulator for the gate driver and 3V regulator for control circuit. SBIAS is a high voltage input and has a wide input range from 3.5V to 48V. It can be directly connected to the output voltage when the output voltage is between 5V to 24V, refer to figure 9.

For very low output voltage applications (for example V_{OUT} = 3.3V), or very high output voltage applications (for example V_{OUT}>30V), SBIAS pin can be connected to an auxiliary secondary winding of transformer. The typical auxiliary secondary winding voltage is suggested to be in the range of 5V to 28V for internal regulators power loss saving and synchronous rectifier driver.

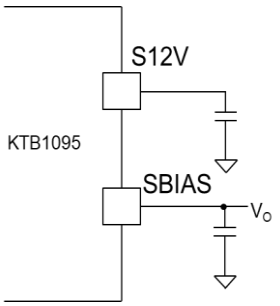


Figure 9. SBIAS Connected to Output Voltage

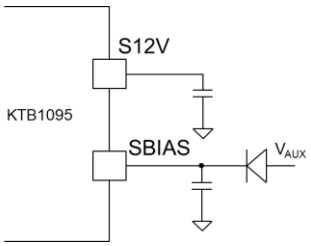


Figure 10. SBIAS Connected to Auxiliary Secondary Winding of a Transformer

Output Voltage Sensing and Feedback

The output voltage of the DC-DC converter is set by a resistive divider to the FB pin. The resistive divider must be set in a manner such that the voltage at the FB pin is 1.2V in steady state. The output voltage must be differentially sensed using the FB pin and the SGND pin.

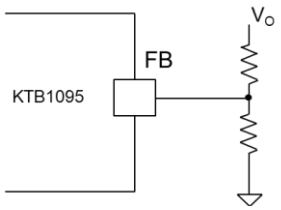


Figure 11. Output Voltage Sensing

Compensation

An external RC compensation network connected between COMP (output of the error amplifier) and SGND compensates the converter control loop to provide system stability.

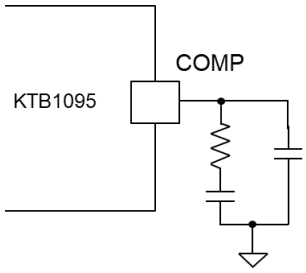


Figure 12. External Compensation Network

Current Sense

The current of the synchronous MOSFET on the secondary side is monitored by SRD and SRS pins. By monitoring the voltage drop of the power MOSFET. The current signal is sensed by a current sensor and the signal is sent to PWM comparator to generate the PWM signal. The SRD pin also monitors the diode drop to synchronize the driver signal between primary side and secondary side.

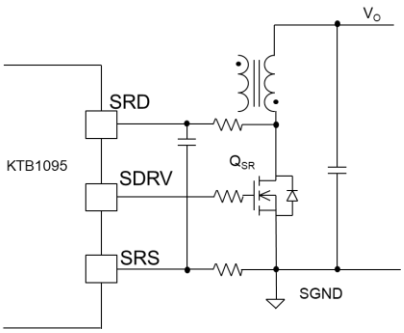


Figure 13. Current Sense

Output Over Voltage Protection (OVP)

The output voltage of the DC-DC converter is sensed by the FB pin through a resistive divider. When the sensed voltage at FB pin exceeds the OVP threshold, the controller immediately shuts off the drivers on both the primary and secondary side. When the voltage at the FB drops below the OV hysteresis level, the controller resumes switching.

Thermal Protection

The KTB1095 provides thermal protection by the continuous monitoring of the die junction temperature. Thermal protection is triggered when the die junction temperature reaches 150°C. When the die junction temperature falls below 130°C, the KTB1095 will be turned on again.

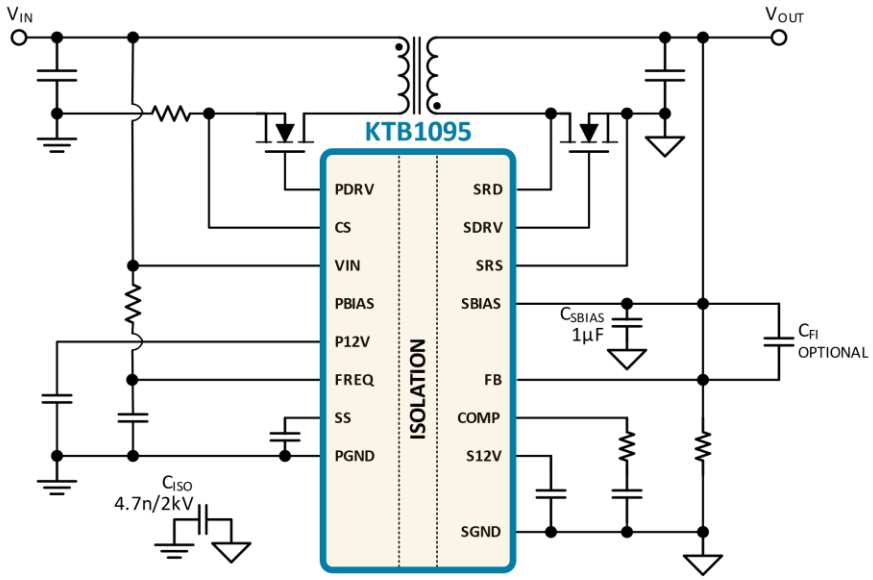
Isolation Voltage

The PWM signal generated on the secondary side is sent to primary side by a digital isolator. The minimum isolation voltage of the isolator is 3kV-RMS.

Applications Information

Typical Application Circuit

Below figure is the typical application circuit of KTB1095. The KTB1095 is a highly integrated isolated synchronous flyback controller with digital isolator and secondary feedback circuit. It can offer a complete solution for an isolated flyback DC/DC power supply. The flyback power supply is typically used to convert a wide input range DC voltage to an isolated DC output voltage. The device can operate over a wide input voltage range from 5V up to 80V (100V absolute maximum) to support a variety of applications. The output voltage can be programmed to a variety of voltages such as 3.3V,5V, 12V, 24V etc. For a typical 48V input bus to 12V output synchronous rectifier flyback converter design by KTB1095, the target output power range is suggested to be within 72W. For all these applications, besides control component design, we need to also select suitable power components such as Primary MOSFET, transformer, output rectification MOSFET and other items. Among these components, the transformer design is the most complex. Below, introduces the key design procedures of the transformer for the application circuits of KTB1095 and frequency setting for KTB1095.



Flyback Transformer Design

The transformer design should consider the input voltage, output voltage and transformer size. The key electrical parameters of the transformer are turns ratio, inductance and saturation current.

For the transform design, we usually design turns ratio first, then we design the inductance of the transformer, finally we design the saturation current of the transformer. Below is reference design procedure for a transformer design, the transformer parameters need a comprehensive consideration through turns ratio, inductance, and saturation current, power MOSFET and diode voltage stress and so on.

The transformer turns ratio is calculated as follows:

$$n = \frac{Vin\_min * Dmax}{(Vo\_max + Vd) * (1 - Dmax)} \qquad \text{Equation (1)}$$

Where,

- n = the turns ratio from primary winding to secondary winding
- V_{in_min} = the min. operating input voltage
- V_{O_max} = the max. output voltage
- V_d = the forward voltage drop of secondary rectifier component
- D_{MAX} = max. duty cycle, (the max. duty cycle of the flyback converter is approx. 70%)

The flyback transformer primary inductance is calculated as follows:

$$Lm = \frac{n * Vin * D * (1 - D)}{Fsw * Io * Kc} \qquad \text{Equation (2)}$$

Where,

- L_m = the primary inductance of flyback transformer
- n = the turns ratio from primary winding to secondary winding
- V_{in} = the operating input voltage
- D = duty cycle.
- F_{SW} = Switching frequency
- I_O = Output current
- K_C = is the ripple current coefficient compared with output current. The value of Kc is normally selected between 0.5 to 1.5.

The primary side peak current is calculated as follows:

$$Ipeak = \frac{Io}{n * (1 - D)} + \frac{Vin * D}{2Fsw * Lm} \qquad \text{Equation (3)}$$

Where,

- I_O = Output current
- n = the turn ratio from primary winding to secondary winding
- D = duty cycle
- V_{IN} = the operating input voltage
- D = duty cycle
- F_{SW} = Switching frequency
- L_m = the primary inductance of flyback transformer

Frequency Setting

The KTB1095 employs current-mode, constant on-time (COT) control for fast transient response as well as superior output voltage regulation. The switching frequency of KTB1095 can be set by the value of R_{FREQ} and C_{FREQ}. To set the frequency, first choose the value of R_{FREQ}, and then set the C_{FREQ} to achieve the target switching frequency, as shown in the following:

$$Rfreq = \frac{n*Vo*Ri}{Vdd} \qquad \text{Equation (4)}$$

$$Fsw = \frac{n*Vo}{Vt*Rfreq*Cfreq} \qquad \text{Equation (5)}$$

Where,

- n = the turns ratio from primary winding to secondary winding
- V_O = the target output voltage
- R_i = the internal resistance of KTB1095, internally fixed at 25kΩ
- Vdd = the internal power supply of KTB1095, internally fixed at 4.8V
- V_t = the internal comparator threshold of KTB1095, internally fixed at 0.6V
- R_{freq} = the frequency set resistor
- C_{freq} = the frequency set capacitor

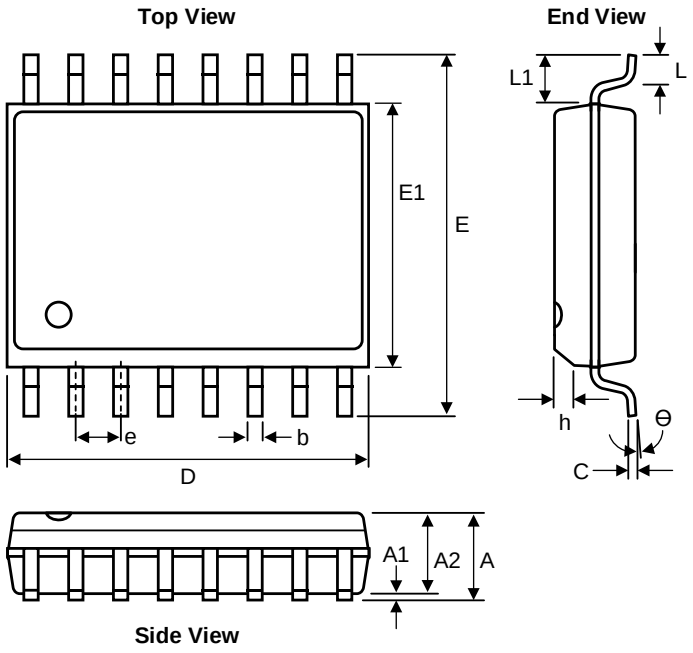
PCB Layout Guidelines

The following guidelines are recommended for optimum performance.

1. Keep below power stage loops area as small as possible for minimal noise and ringing.
    a. Input power loop: Input capacitors, Primary of Transformer, Primary FET, Current sense resistor.
    b. Output power loop: Secondary of Transformer, Output capacitors, Synchronous Rectifier FET.
2. All the primary signal ground tracks should be connected in common near the IC PGND (Pin2), and then a single connection made from the KTB1095 PGND net to the system primary power ground (primary sense resistor ground point).
3. All the secondary signal ground tracks should be connected in common near the IC SGND (Pin12), and then a single connection made from the KTB1095 SGND net to the system secondary power ground (secondary output power capacitor ground point).
4. Ground all the control capacitors to their respective grounds and place the control circuit capacitors close to the IC to decouple noise. Keep the primary and secondary control circuit trace far away from noise sources (such as primary FET switch node and secondary FET switch node).
5. SRD and SRS pins should differentially sense the signal through the sense components. A 100Ω to 1kΩ filter resistor is suggested in series with each SRD and SRS pins. The SRD and SRS traces should not cross any switch nodes.
6. The gate drive outputs of the KTB1095 should have short direct paths to the MOSFETs to minimize inductance in the PCB traces, wider trace is suggested for these gate drive loops.
7. A snubber circuit like RCD should be used to limit peak voltage on the primary and secondary FETs at turn-off. Minimize the loop from the RCD snubber components to the transformer and FETs.
8. The current-sense circuit usually employs a sense resistor. The sense resistor is connected between the Source of primary MOSFET and the power ground terminal of the system. A low inductance resistor should be used. The negative terminal of the input power capacitor, the ground return of the MOSFET, and current-sensing resistor should be close together. The filter network for the current-sense circuit should be located close to the IC.

Packaging Information

SOP-16 (10.30mm x 7.50mm x 2.65mm)



Dimension	mm		
	Min.	Typ.	Max.
A	2.15	–	2.65
A1	0.10	–	0.30
A2	2.05	–	2.55
b	0.31	–	0.51
C	0.10	–	0.33
D	10.10	10.30	10.50
E	9.97	10.30	10.63
E1	7.40	7.50	7.60
e	1.27 BSC		
h	0.25	–	0.75
L	0.40	–	1.27
L1	1.4 BSC		
Θ°	0	–	8

Recommended Footprint