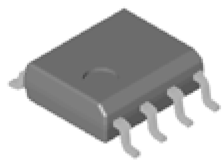
RED2832 0.5% Dimming LED Controller

Features

- Advanced Resonant Controller IC for high efficiency dimmable LED drivers
- Linear dimming down to 0.5% possible
- +/-3% Secondary Side Regulation of LED current with no Flicker
- 50% duty cycle, variable frequency control of resonant half-bridge
- Suitable for use with digital or analogue Dimming control modules
- Protection modes:
  - Short-circuit
  - No-Load
  - Over-temperature current foldback
- No flicker - zero output current ripple



Small SO8 package

Applications

- Linear dimmable LED drivers without flicker
- Low-cost passive PFC LED drivers <80W
- High power universal mains input LED drivers <250W

Order code

Part Number	Package	Packaging
RED2832AD-TR13	SO8	Tape and reel

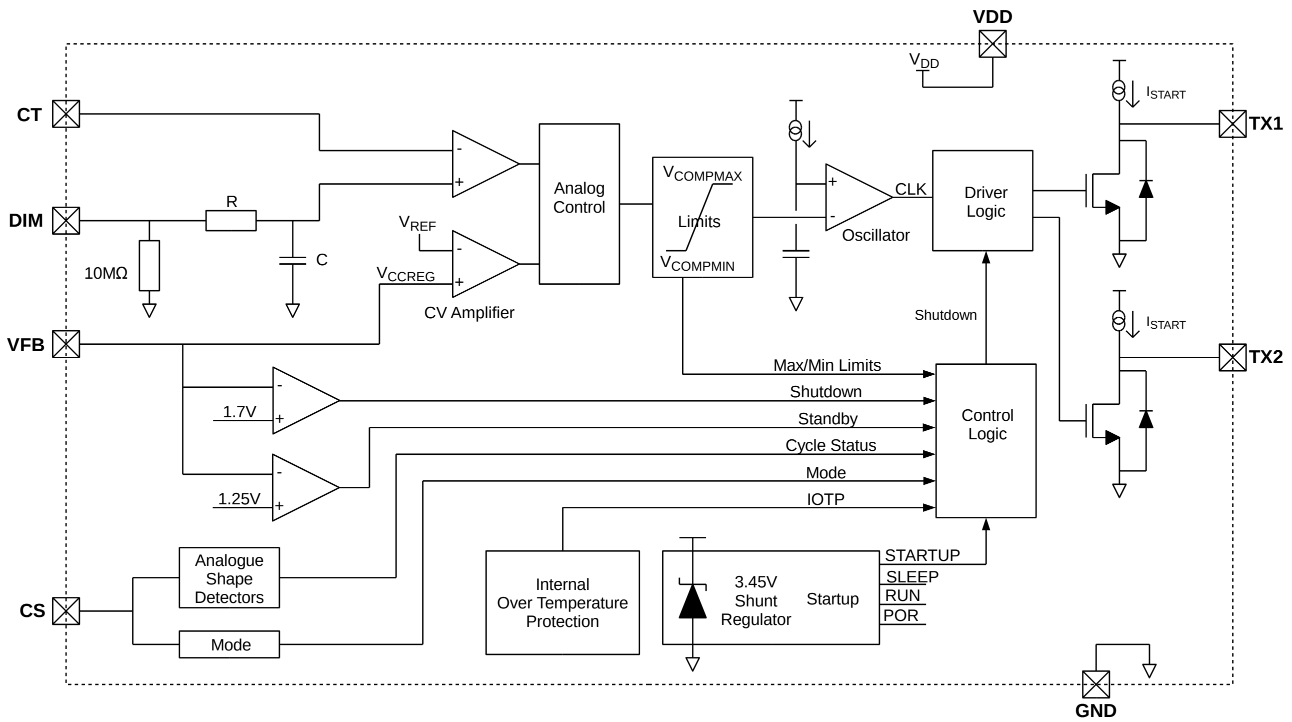


Figure 1: Block diagram

Device Pins

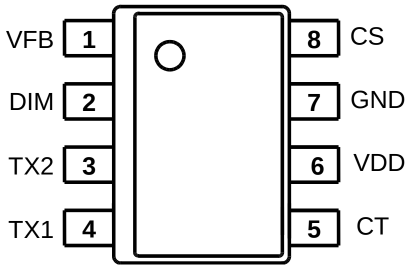


Figure 2: SO8 pin connections (top view)

Pin Functions

Pin #	Name	Function
1	VFB	PSR Feedback input for output voltage regulation. Connect to primary sense winding.
2	DIM	Output current varies linearly from 0% output to 100% output
3	TX2	Output to control transformer
4	TX1	Output to control transformer
5	CT	Input for sensing the DC LED current
6	VDD	IC Power Supply pin – nominally 3.45V
7	GND	Chip ground.
8	CS	Resonant current waveshape detection for protection features such as overcurrent & capacitive mode. The CS pin is connected to the half-bridge current sense resistor.

Typical Application

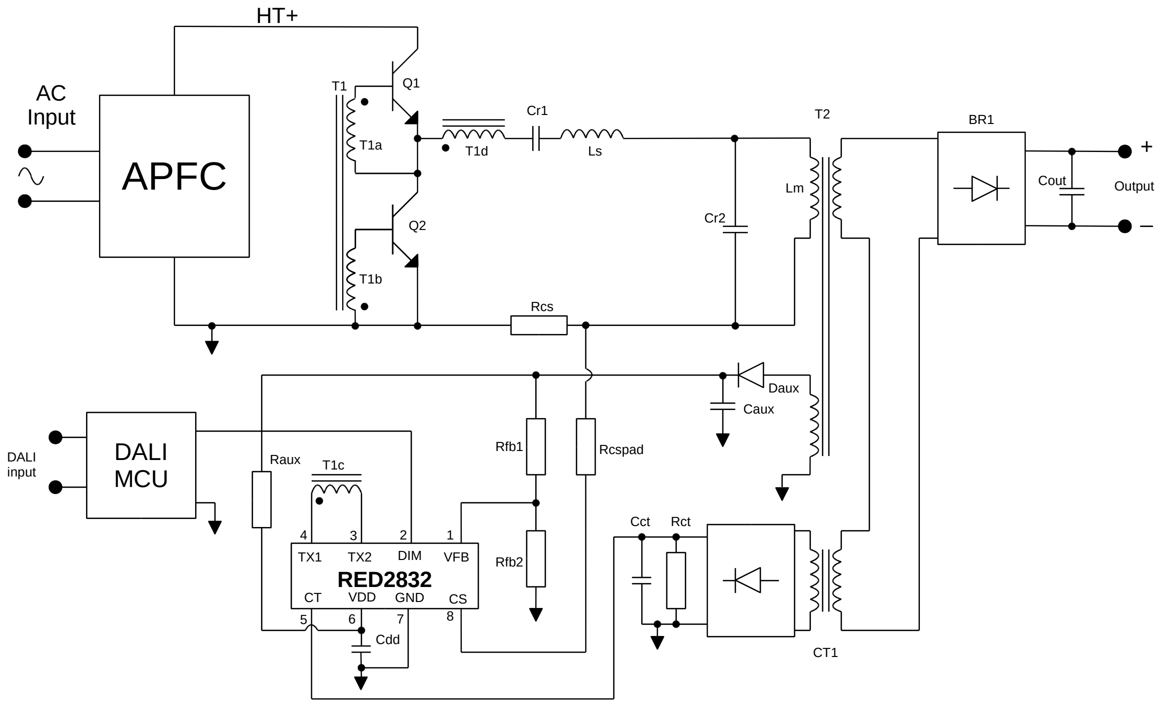


Figure 3: Typical Application:

LED driver using RED2832 *LCC controller with DALI input*

Features

RED2832 is an advanced CMOS control IC for resonant converters. The patented RED2832 Secondary Side Regulation control scheme accurately controls the LED current so that accurate dimming down to 0.5% can be achieved.

RED2832 uses the CSOC (Controlled Self-Oscillating Converter) scheme to drive two low-cost bipolar transistors in a half-bridge configuration. RED2832 is optimized to work with RediSem's patented Passive PFC technology as well as with most APFC controllers.

Please contact RediSem for application design information for LED drivers with passive or active PFC.

Accurate Current Regulation

The RED2832 regulates the LED drive current by keeping the CT pin voltage to be half of the DIM pin voltage. In this way, the accuracy of the dim signal is directly proportional to the accuracy of the output current level.

Voltage Regulation

With a faulty or disconnected LED, the RED2832 controls the maximum output voltage using primary side voltage regulation, overriding the DIM pin. To minimise input power in this condition, the IC should be shut down by pulling the VFB pin high.

Protection Features

The IC is able to detect a number of faults that cause the IC to enter a fault mode:

- Output short circuit
- Resonant inductor shorted
- Over-temperature current foldback

During these fault conditions, the IC will continually attempt to re-start. Between each re-start attempt there will be 16 dummy re-starts when the IC re-starts while the converter is off.

If the output is short-circuit, the IC detects this and runs at fmax. If the fault is removed, the IC will automatically return to the output current set by the DIM input.

The IC also has an instantaneous cycle-by-cycle over-current protection (OCP) level that will terminate any cycle instantaneously should the current exceed a pre-set level.

Over-temperature Foldback

The RED2832 Over-temperature foldback occurs when the IC temperature reaches 125°C. Between 125 & 130°C the IC reduces the output current from the current dim level setting down to 0%.

Automatic Dead-Time Control

An important feature of the Controlled Self Oscillating Converter is that the dead-time is controlled naturally. Unlike MOSFET half-bridge converters, it is not necessary to program the dead-time on RED2832. The bipolar switching transistors are turned on correctly through the self-oscillation of the converter and turned off by RED2832. This greatly simplifies the design process and improves the robustness of the resonant converter.

Capacitive Mode Protection

RED2832 includes a capacitive mode protection feature which prevents the converter from entering capacitive switching mode on a cycle-by-cycle basis by limiting the minimum frequency. This always ensures the Controlled Self Oscillating Converter continues to oscillate correctly.

Oscillator

The RED2832 includes an internal oscillator which is used to control the switching frequency of the converter. The maximum and minimum frequency limits are pre-set inside the IC and have been chosen to suit a low power CSOC converter. The oscillator ramp is compared to an internal control voltage to produce the correct frequency required to regulate the converter.

IC Operation

VDD and GND pins

With a low voltage between VDD and GND the IC is in SLEEP mode. In SLEEP mode the IDD current is approximately 8uA ($I_{DDSLEEP}$). Once VDD reaches 3.7V ($V_{DDSTART}$) the IC wakes up and enters STARTUP mode. During the initial period of approximately 40ms (8192 cycles) VDD is allowed to drop to 2.4V. This gives time for the application to pull up the output voltage. After this the IC enters RUN mode when the controlled Zener clamp inside the IC regulates the VDD voltage to 3.45V (V_{DDREG}). The IC current drawn is approximately 0.7mA (I_{DDREG}) plus any excess current required to clamp VDD to 3.45V. If VDD falls below 3.45V (V_{DDREG}) the Zener clamp turns off and I_{DD} reduces to 0.7mA (I_{DDREG}) only. If VDD falls below 3.0V ($V_{DDSLEEP}$), the IC enters SLEEP mode. In this condition I_{DD} reduces back to 8uA. ($I_{DDSLEEP}$).

Because the IC is shunt regulated, feed power to the IC through a resistor. Connect a capacitor between VDD and GND of at least 100nF. The capacitor should be located close to the pins. To ensure the IC does not turn on after a power-down, add a resistor between VDD and GND. A diagram of the connection circuit can be seen in Figure 4.

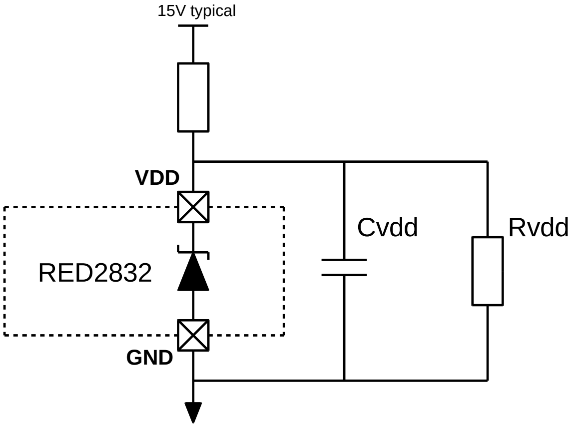


Figure 4: VDD & GND connections

TX pins

A diagram of the output stage can be seen in Figure 5. To start the converter oscillating the RED2832 issues start pulses through the TX pins during the first two cycles. These start pulses are 800ns long ($t_{TXSTART}$) and provide 20mA ($I_{TXSTART}$) current pulses from both TX1 and TX2 pins. After this the converter self-oscillates and no longer needs start pulses to maintain oscillation. A low on-state NMOS transistor is used to turn the bipolar transistors off. It is controlled by the oscillator off-time. The NMOS device is turned to pull TX pin low, which switches off the corresponding bipolar transistor in the power converter half-bridge.

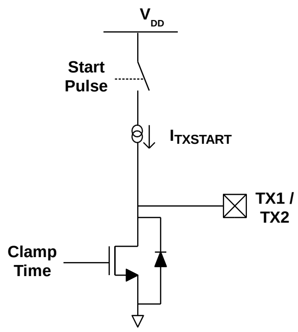


Figure 5: TX pins

VFB pin

RED2832 features an internally compensated CV control loop to control the maximum LED converter output voltage. The VFB input senses the output voltage from an auxiliary winding on the primary side of the transformer. This signal is conditioned in the PSR block and compared to a voltage reference of 1.20V (VREF) inside the IC.

In CV mode the VFB pin is regulated to VREF by adjusting the internal control voltage and therefore the converter operating frequency. If the VFB pin voltage exceeds 1.25V [VFBSTBY], RED2832 will go into STANDBY.

In a constant current LED application the VFB voltage will normally be below the 1.2V regulation point VREF as the CC control loop determines the control voltage. If the LED voltage is too high, or the LED becomes disconnected, the CC loop is not in control and the VFB voltage will exceed 1.2V VREF control voltage.

If the VFB pin is exceeds 1.7V[VFBSDN]. IC will shutdown and reset.

A diagram of the circuit in and around the VFB pin can be seen in figure 6.

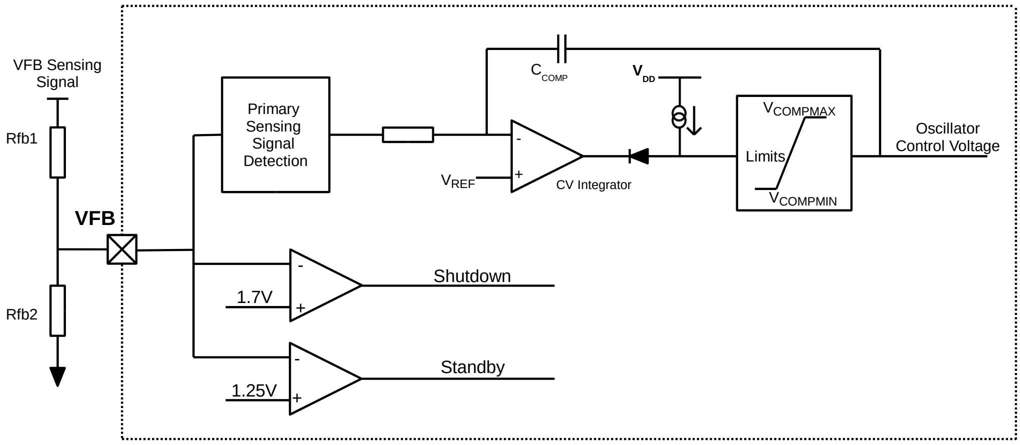


Figure 6: Voltage Error Amplifier Circuit

CT pin

Figure 7 shows the typical connection to the CT pin. The transformed output current of the CT generates a voltage across the sense resistor. This voltage is full-wave rectified by a diode bridge and low-pass filtered to the CT pin. The filter time-constant is optimally in the range 10-20usec to achieve zero ripple performance.

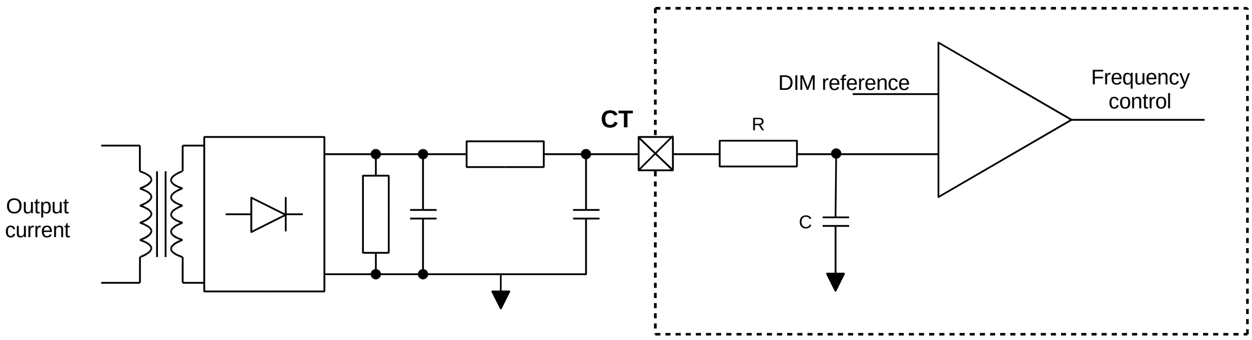


Figure 7: Typical CT pin connection

CS pin

The primary function of the CS pin is to determine the shape of the resonant current. The CS pin is connected to a resistor in the series resonant current path. The resistor value should be chosen to give an average voltage of 158mV [V_{CCREG}] at full output current. The IC gathers information from the waveshape to ensure protection in capacitive mode operation and ensuring correct commutation at low dim levels.

The CS padding resistance (Rcspad) is to determine the operating Mode. If Rcspad ≤100ohm, the chip will enter APFC mode; if 200ohm < Rcspad <300ohm, the chip will enter PPFC mode; if Rcspad >500ohm, the IC will also go off with a dim level < 1%.

The CS pin also includes an instantaneous Over-Current Protection (OCP) by terminating the current oscillator cycle and the transistor on-time. When a peak voltage occurs that exceeds the OCP threshold 700mV [V_{OCPTHR}] the OCP comparator terminates the current oscillator on-time cycle. The oscillator is reset and the off-time begins resulting in the bipolar transistors turning off and the half-bridge commutating. This is repeated in subsequent cycles whenever the CS voltage exceeds the OCP threshold. Note that in a correctly designed converter it should not be possible to trip OCP in normal operation.

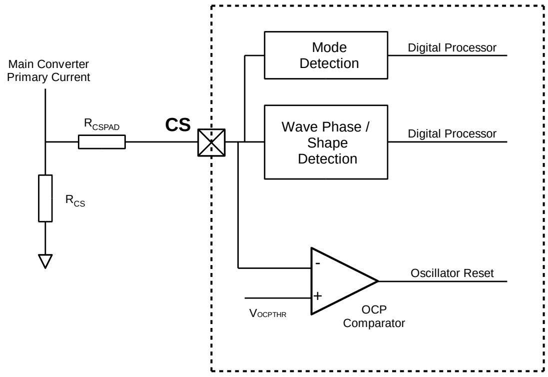


Figure 8*: CS Pin connection*

DIM pin

RED2832 has provision to allow for a DIM level down to 0.5% with good accuracy. This allows a 1% dim driver with the current limited to 50% of maximum output, such as in an Iset driver. A typical maximum input voltage for the DIM pin is 3.3V and the accuracy of this will directly affect the accuracy of the driver output current. A lower maximum voltage can be chosen for the DIM pin, but this will result in worse accuracy, particularly at low dim levels.

The DIM pin is used to control the average level of the voltage on the CT pin. The IC will integrate and regulate the CT pin voltage to be half of the voltage seen on the DIM pin. The output current can be varied from 100% down to nearly 0% as the DIM pin varies from 3.3V (typically) to 0V.

Dim-to-off can be implemented by forcing the VFB pin high. It is recommended that the DIM pin is set to 0V before the VFB pin is pulled high.

A graph showing the relationship between the LED driver output current and the DIM pin voltage is given in figure 10.

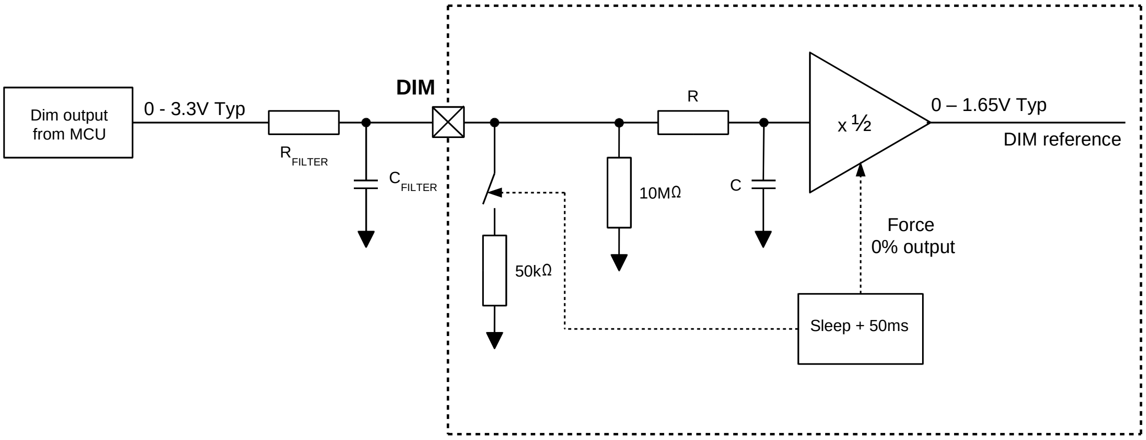


Figure 9*: RED2832 DIM pin circuit*

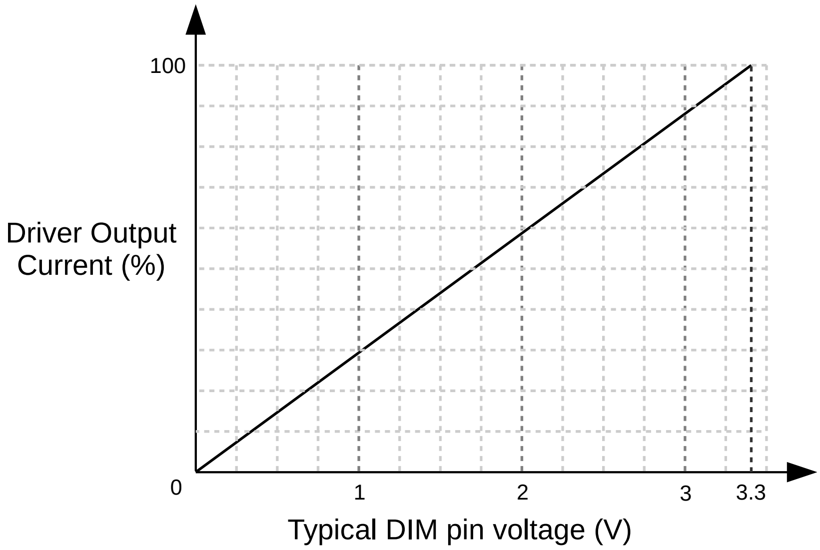


Figure 10*: DIM pin voltage vs output current*

ABSOLUTE MAXIMUM RATINGS

CAUTION: Permanent damage may result if a device is subjected to operating conditions at or in excess of absolute maximum ratings.

Parameter	Symbol	Condition	Min	Max	Unit
Supply voltage	V_{DD}	SLEEP mode: self-limited by IC start-up ($V_{DDSTART}$)	-0.5	4.5	V
Supply voltage	V_{DD}	RUN mode: Self-limited by internal shunt regulator	-0.5	4.0	V
Supply current	I_{DD}		0	10	mA
Input/output voltages	V_{IO}		-0.5	V_{DD} + 0.5	V
Input/output currents	I_{IO}		-10	10	mA
Junction temperature	T_J	T_{J_MAX} limited by OTP (T_{OTPS_MAX})	-25	+135	°C
Storage temperature	T_P		-25	+125	°C
Lead temperature	T_L	Soldering, 10 s		260	°C
ESD withstand		Human body model, JESD22-A114		2	kV
		Capacitive Discharge Model		500	V

NORMAL OPERATING CONDITIONS

Unless otherwise stated, electrical characteristics are defined over the range of normal operating conditions. Functionality and performance is not defined when a device is subjected to conditions outside this range and device reliability may be compromised.

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Minimum supply current	I_{DDMIN}		0.8	1.0	1.2	mA
Junction temperature	T_J		-25	25	125	°C

ELECTRICAL CHARACTERISTICS

Unless otherwise stated:

- Min and Max electrical characteristics apply over normal operating conditions.
- Typical electrical characteristics apply at $T_J = T_{J(TYP)}$ and $I_{DD} = I_{DDREG(TYP)}$.
- The chip is operating in RUN mode.
- Voltages are specified relative to the GND pin.

VDD Pin

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Supply voltage	$V_{DDSTART}$	Enter RUN mode from SLEEP	3.2	3.7	4.2	V
	V_{DDREG}	$I_{DD} < I_{DDSHUNT}$	3.3	3.45	3.6	V
	$V_{DDSLEEP}$	To enter SLEEP mode	2.85	3.0	3.15	V
Supply current	I_{DDREG}	In RUN mode, $VDD < VDD_{REG}$		0.7	0.8	mA
	$I_{DDSLEEP}$	In SLEEP mode		8	12	µA
	$I_{DDSHUNT}$	VDD shunt regulator max current			8	mA

VFB Pin

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Regulation voltage	V_{REF}		1.15	1.20	1.25	V
Standby threshold	V_{FBSTBY}			1.25		V
Shutdown threshold	V_{FBSDN}			1.7		V

CS Pin

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Instantaneous over-current protection threshold	V_{OCPTHR}			700		mV

Oscillator

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Minimum Frequency	F_{MIN}			39		kHz
Maximum Frequency	$F_{MAXAPFC}$	Rcspad ≤100ohm		295		kHz
Maximum Frequency	$F_{MAXPPFC}$	Rcspad >200ohm		240		kHz

CT Pin

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Typical input voltage max	V_{CT}	3.3V on DIM pin for 100% output		1.65		V

DIM Pin

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Typical 100% input voltage	V_{DIMMAX}			3.3		V
Zero input offset				0.5		%
Input Impedance	R_{DIM}			10MΩ		

TX1, TX2 Pins

Parameter	Symbol	Condition	Min	Typ	Max	Unit
On-state resistance	R_{TXON}			1.0	1.5	Ω
TX pin clamp current	$I_{TXCLAMP}$*	TX pin frequency >30kHz			800	mA
Start-pulse output current	$I_{TXSTARTAPFC}$*	TX pin voltage 2V, APFC mode		8		mA
Start-pulse output current	$I_{TXSTARTPPFC}$ *	TX pin voltage 2V, PPFC mode		16		mA
Start-pulse width	$T_{TXSTART}$			800		ns

Over-Temperature Protection (OTP) *

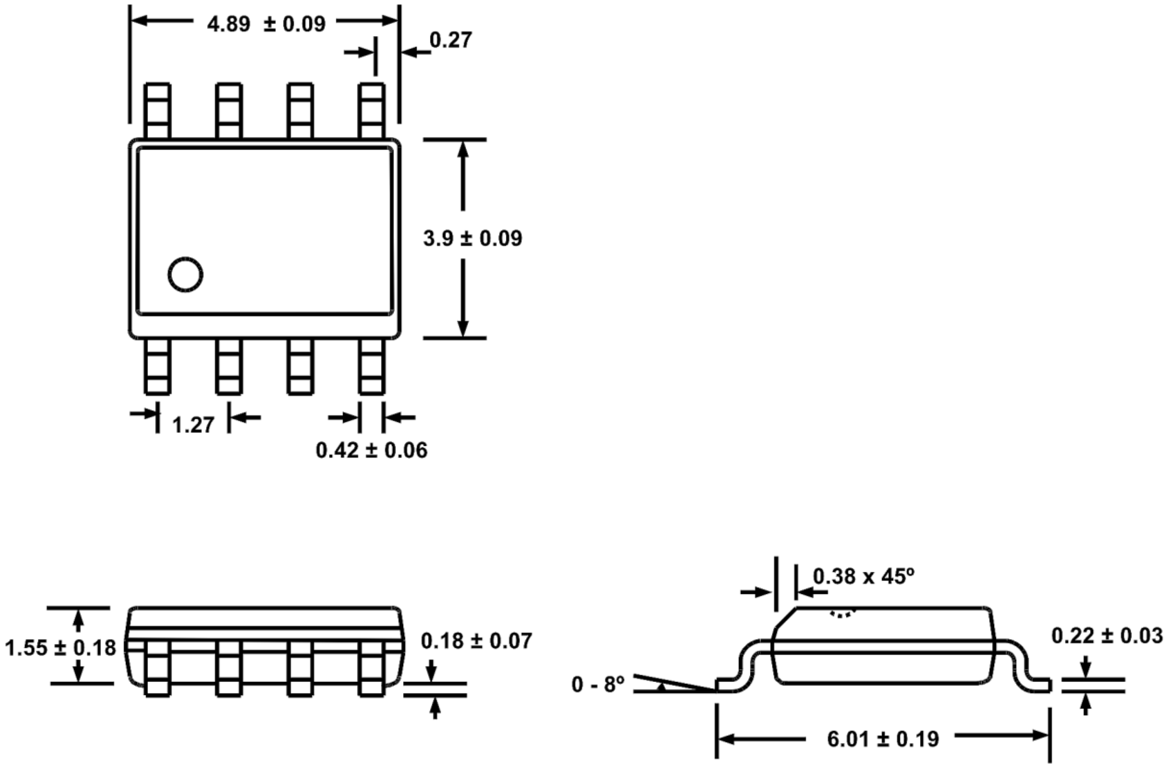
Parameter	Symbol	Condition	Min	Typ	Max	Unit
Over-Temperature Foldback threshold	T_{OTFS}	At silicon junction	115	125	135	°C

*: *not tested in production*

PACKAGE INFORMATION

Package Dimensions

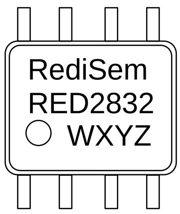
SO8N package dimensions are shown below. All units are in mm.



Available packages

Package type	Part number	Moisture Sensitivity Level (MSL)	Packaging	Thermal Resistances		
SO8	RED2832AD-TR13	3 (JEDEC J-STD-020)	Tape and reel 2500pcs/13” reel	Junction - Lead	θ_{JL}	30°C/W
				Junction - Ambient	θ_{JA}	150°C/W

Package Marking



SO8 top-side marking for RED2832

RED2832= Part Number

WXYZ= Lot Code, e.g. AAAA, AAAB

Status

The status of this Datasheet is shown in the footer.

Datasheet Status	Product Status	Definition
Preview	In development	The Datasheet contains target specifications relating to design and development of the described IC product.
Preliminary	In qualification	The Datasheet contains preliminary specifications relating to functionality and performance of the described IC product.
Production	In production	The Datasheet contains specifications relating to functionality and performance of the described IC product which are supported by testing during development and production.

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