

Features

Reference Design

- Half-bridge voltage up to 1kV
- TTL-compatible signal input
- Single 15V to 42V supply
- Shoot-through protection
- Separate input for low and high-side switch for use with different topologies
- Qualified with 65kV/ μ s @ $V_{common\ mode} = 1kV$

RECOM
Reference Design

R-REF01-HB

Description

The Half-Bridge Gate-Drive Power Supply Reference Design (RD) consists of a half-bridge suitable for voltages up to 1kV and a fully-isolated driver stage with isolated power supplies for the low-side and the high-side switching transistors. It is suitable for single gate/drive supply voltages as low as +4V as well as dual gate drive supply voltages as high as +20V / -5V (30V max) with no maximum duty cycle limitations.

Two R12P22005D, R12P21503D, R12P21509D and R12P06S DC/DC modules each are included in the R-REF01-HB design kit.

With these converters the following gate drive voltages can be generated:

- +20V/-5V
- +15V/-3V or +18V*
- +15V/-9V
- +6V

*For single ended +18V please check the [modification instructions which can be found online \(LINK\)](#)

NOTE: transistors sold separately.

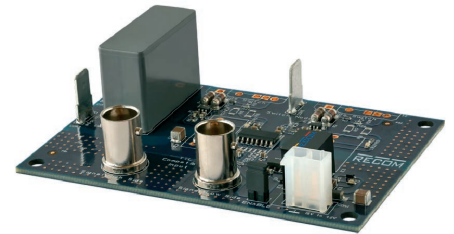
The signal ground is galvanically isolated from the power ground and can be connected to any potential, as long as it is less than 2.5kV with respect to the power potential (high-side and low-side). The limiting element is the gate driver IC specification.

Features:

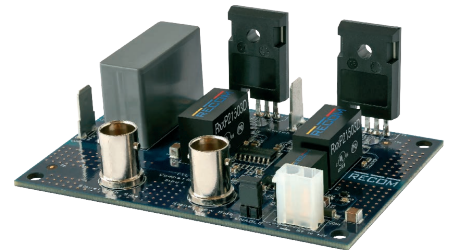
- Optimized for very high switching speed
- 2.5kV continuous input to output isolation
- High gate-drive currents (up to 10A source and sink)
- The RD is fitted with a SI8273 gate driver, but can be used with any pin-compatible gate driver with a PWM input (SI8274) or for gate driver ICs with reinforced isolation, for example the UCC21520 (dual pinout layout on PCB).

This RD can easily be configured for the following topologies (see application suggestions section):

- LLC half-bridge
- Asymmetric duty cycle half-bridge (forward and flyback)
- Active clamp half-bridge (forward and flyback)
- Full-bridge / phase-shifted full-bridge
- 3-phase B6 bridge
- NPC B6 bridge (additional driving circuit for NPC is required)
- Double pulse test
- Synchronous boost converter
- Synchronous buck converter



Delivered Board



fully populated



DANGER!

This board is designed to be used with voltages up to 1kV, only qualified personnel should work with this board. Direct contact with hazardous voltage can cause injury or death!

Never leave the board operating unattended. After removing the high voltage from the board, discharge the capacitors with a suitable discharging resistor to avoid electrical shock!

Caution:

This reference design is built with ESD (electrostatic discharge) sensitive components. Always follow ESD prevention procedures when handling the product to avoid failures!



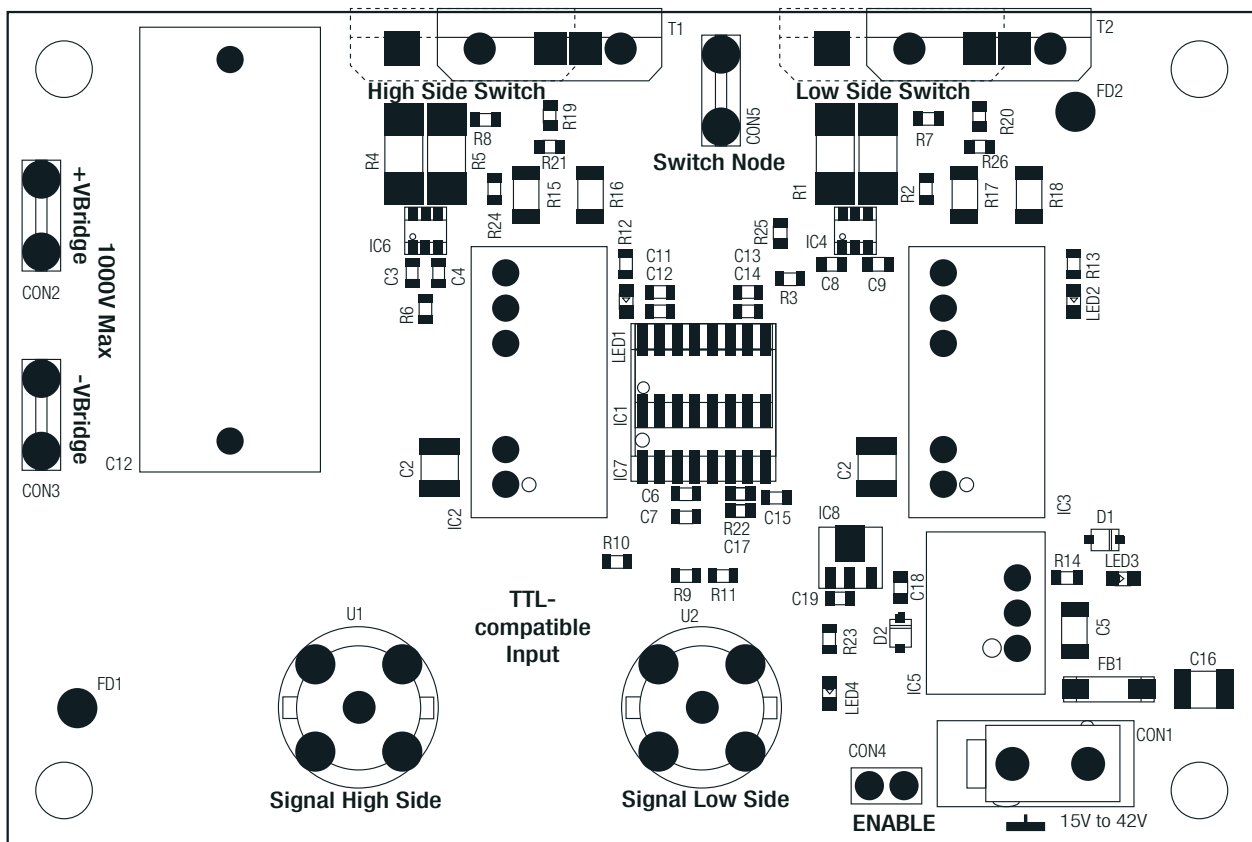
www.recom-power.com/bier

Specifications (measured at Ta= 25°C, 1.5Vin, full load after warm up unless otherwise stated)

BASIC CHARACTERISTICS

| Parameter | Condition | Min. | Typ. | Max. |
|-------------------------------|------------------------------|--|-------|-------|
| Input Voltage Con1 | | 15V | | 42V |
| Input Voltage Con2 -> Con3 | limited by C10 | 0V | | 1000V |
| Digital U1, U2, Enable | | -0.5V | | 5.5V |
| Logic High Input Threshold | | 2V | | |
| Logic Low Input Threshold | | | | 0.8V |
| Input Hysteresis | | 350mV | 400mV | |
| Maximum Ratings | | -0.5V | | 5.5V |
| Driver Section | | | | |
| Source and Sink Current (max) | | | | 10A |
| Total Drive Voltage | positive and negative | +4V | | 30V |
| Propagation Delay | system before gate resistors | 20ns | 40ns | 70ns |
| Rise and Fall Times | | refer to the datasheet of the gate-driver IC | | |
| Isolation | | | | |
| Isolation Voltage | input to output | 2.5kVDC | | |

Component Placement



continued on next page

Specifications (measured at Ta= 25°C, 1.5Vin, full load after warm up unless otherwise stated)

Component List

| Part | Description |
|-------|---|
| IC2 | DC/DC isolated converter for high-side gate-driver. Depending on the transistor type, fit the appropriate DC/DC converter (please refer to pages P-10 to P-12). |
| IC3 | DC/DC isolated converter for low-side gate-driver. Depending on the transistor type, fit the appropriate DC/DC converter (see table 1). |
| T1 | High-side switching transistor (not supplied). Read important notice below. |
| T2 | Low-side switch transistor (not supplied). Read important notice below. |
| Note: | The transistors are placed on the edge of the PCB so that they are easy to mount to a heatsink. They can also be mounted inverted on the bottom side of the PCB. Both TO247-3L and TO247-4L format transistors can be used by using the appropriate hole set. |
| CON1 | Connector for logic and driver supply. Connect a 15V, 18V, 24V or 36V DC supply here. |
| CON2 | +V bridge voltage: connect a positive voltage up to 1kV in respect to power-GND to this connector. |
| CON3 | -V bridge voltage: power-GND |
| CON4 | Enable: a high signal enables the driver signals. Place the jumper on the connector to enable the signals permanently |
| CON5 | Switching node of the half-bridge |
| U1 | Signal high-side: TTL-compatible input for the high-side transistor |
| U2 | Signal low-side: TTL-compatible input for the low-side transistor |

Following DC/DC models are suitable for use with this reference design

| Model | Power [W] | Output Voltage [V] | Application |
|-------------|-----------|--------------------|-------------------|
| R12P22005D* | 2 | +20/-5 | SiC MOSFETs |
| R12P21503D* | 2 | +15/-3 | SiC MOSFETs |
| R12P21509D* | 2 | +15/-9 | IGBTs |
| R12P1509D | 1 | +15/-9 | IGBTs |
| R12P06S* | 1 | +6 | GaN |
| R12P12S | 1 | +12 | Cascode/Si MOSFET |

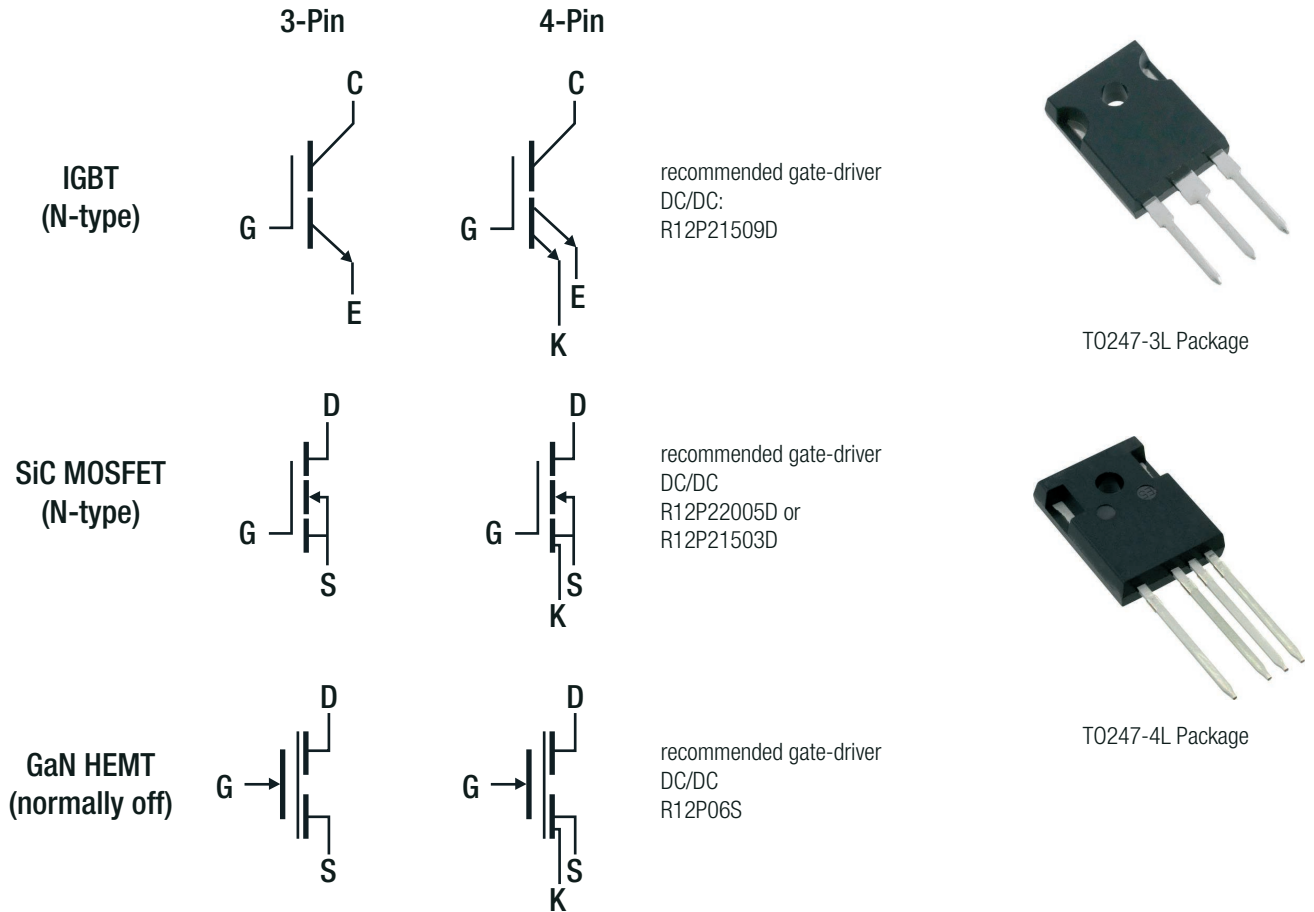
*these models are included in the reference design. Each of them two times

Truth table (with IC1 SI8273 mounted):

| Input | | | Output | | Comment |
|-------|----|--------|----------------|---------------|--------------------|
| U1 | U2 | Enable | High-side Gate | Low-side Gate | |
| L | L | H | L | L | |
| L | H | H | L | H | |
| H | L | H | H | L | |
| H | H | H | L | L | Invalid state |
| X | X | L | L | L | Device is disabled |

Specifications (measured at $T_a = 25^\circ\text{C}$, $1.5V_{in}$, full load after warm up unless otherwise stated)

NOTE: TRANSISTORS SOLD SEPARATELY



Important: using three pin or four pin T0247 packages:

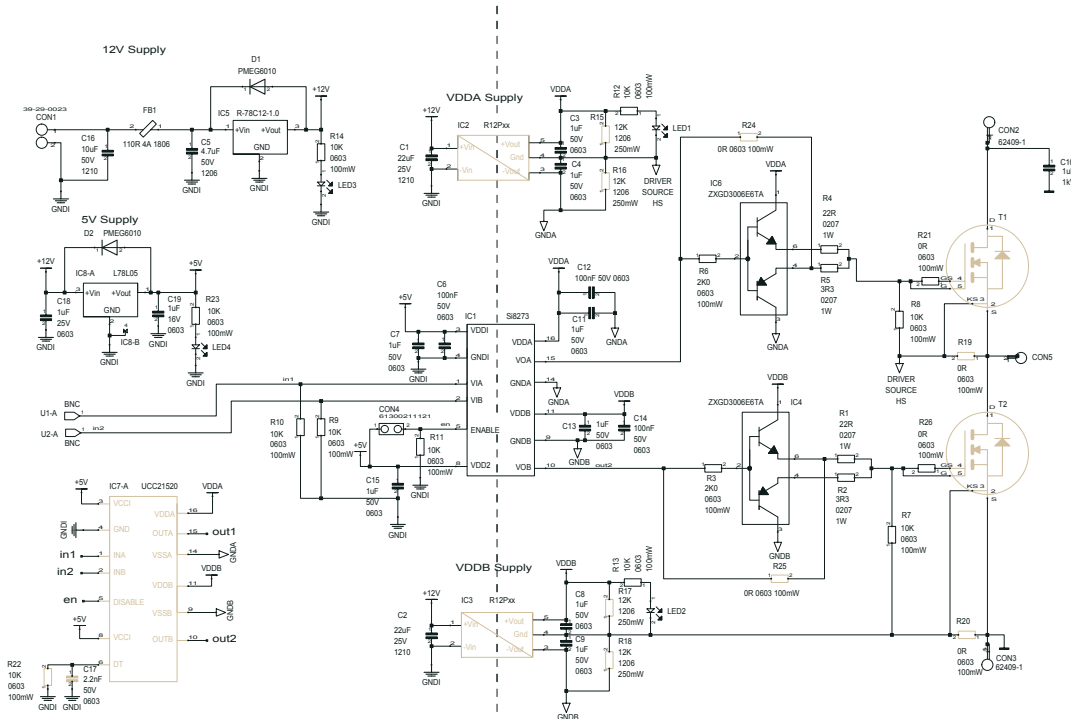
T0247-4L packages can be used without any modification of the PCB. The Kelvin source pin is already connected to the gate-driver ground.

T0247-3L packages however require a minor modification to join the gate-driver ground to the source pin ground. This can be done by soldering 0Ω resistors across R19 and R20 or by making a solder bridge between the source and Kelvin source pads (recommended for lowest gate inductance).



Specifications (measured at Ta= 25°C, 1.5Vin, full load after warm up unless otherwise stated)

Schematic



Description:

The reference design board requires a single supply voltage with a range of 15-42V.

IC5 creates the regulated 12V supply for IC2 and IC3.

IC2 generates the isolated high-side gate-driver supply voltage. Choose the appropriate DC/DC converter from the selection provided.

IC3 generates the isolated low-side gate-driver supply voltage. Choose the appropriate DC/DC converter from the selection provided.

IC8 creates a +Vcc rail required for the gate driver.

IC1 isolates the control signals and level shifts the TTL input to the gate-drive voltages.

IC7 can be mounted instead of IC1 if reinforced isolation is required.

IC4 and IC5 amplify the maximum gate-drive current to ±10A.

R24 and R25 are not fitted. Zero Ω resistors can be mounted if IC4 and IC5 are not required (for example GaN transistors).

The input GND1 is galvanically isolated from the high-side GNDA and the low-side GNDB.

For single-ended designs, it is recommended to connect GND1 to Power-GND (CON3) with a star-earth configuration.

For full-bridge configurations, couple GND1 to Power-GND with Y-Capacitors to avoid generating high potentials caused by common mode currents.

R15, R16, R17 and R18 are not fitted. The positions can be used to add dummy loads for the power supplies if needed, for example, under very light load conditions or low switching frequencies. Alternately R16 and R18 can be used to allow single-output voltage DC/DC converters to be used by connecting -Vout to the gate-driver ground.

| Configuration | R15, R17 | R16, R18 |
|---|--------------|--------------|
| Dual Output DC/DC, Normal Load (standard) | Not required | Not required |
| Dual Output DC/DC, Light Load | 12kΩ | 12kΩ |
| Single Output DC/DC, Normal Load | Not required | Zero Ω |
| Single Output DC/DC, Light Load | 12kΩ | Zero Ω |

R1 and R4 control the turn-on slew rate. 22Ω is fitted as standard.

R2 and R5 control the turn-off slew rate. 3.3Ω is fitted as standard.

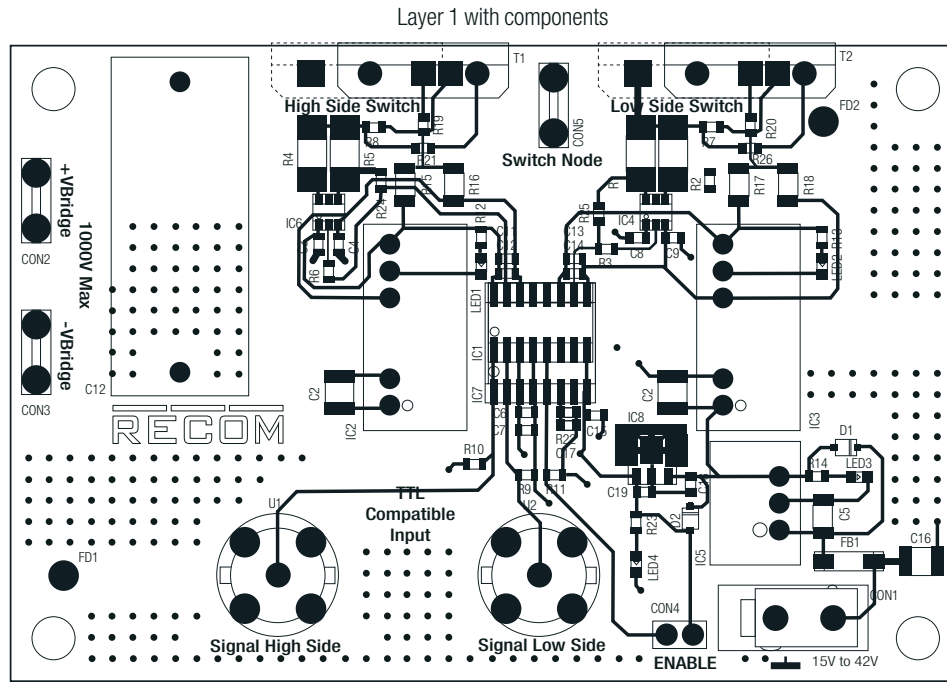
These 0207 package resistors are made to withstand highly pulsed loads. Gate currents up to 10A are possible.

Specifications (measured at Ta= 25°C, 1.5Vin, full load after warm up unless otherwise stated)

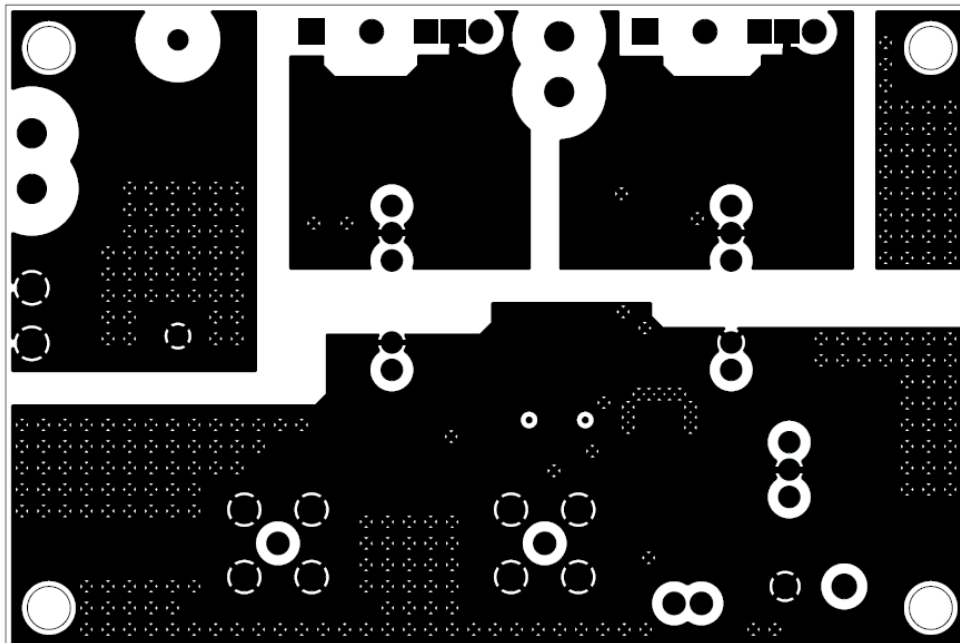
DIMENSION AND PHYSICAL CHARACTERISTICS

| Parameter | Type | Value |
|-------------------|------|----------------------|
| Dimension (LxWxH) | | 90.0 x 60.0 x 51.0mm |
| Weight | | 80.1g typ. |

Layout



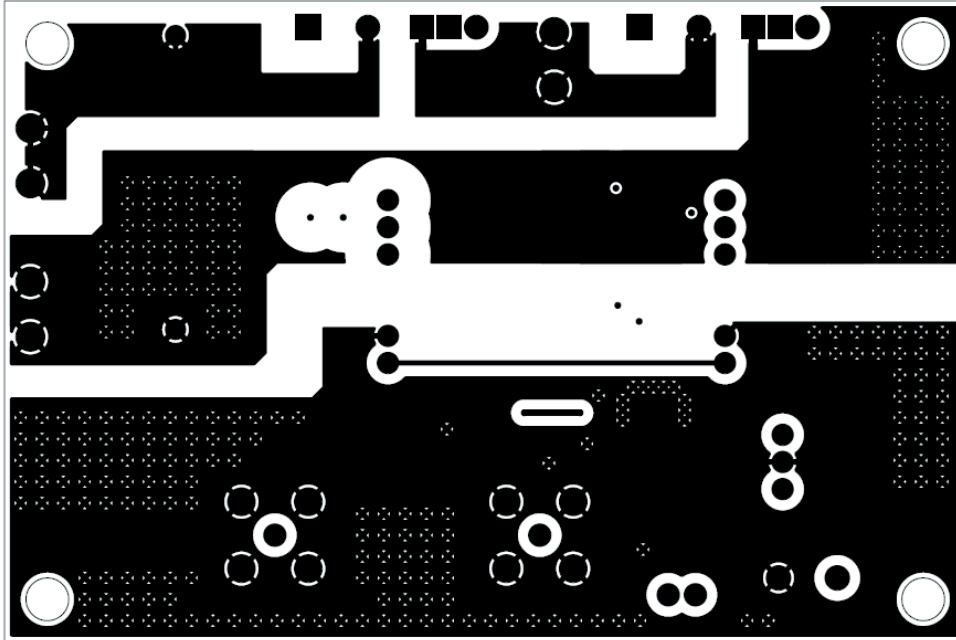
Layer 2



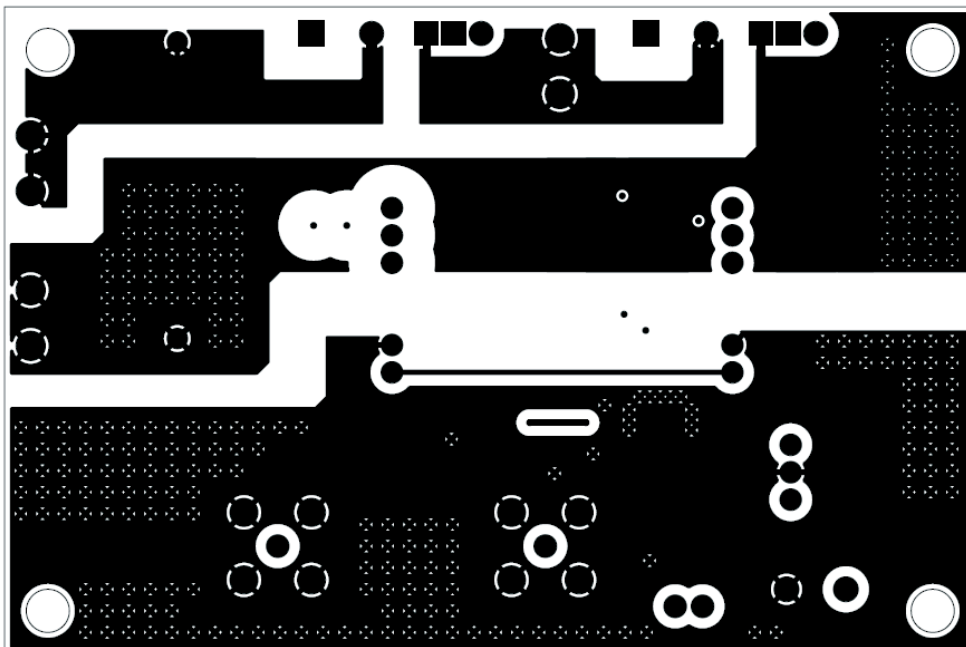
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Specifications (measured at $T_a = 25^\circ\text{C}$, 1.5V_{in} , full load after warm up unless otherwise stated)

Layer 3



Bottom View

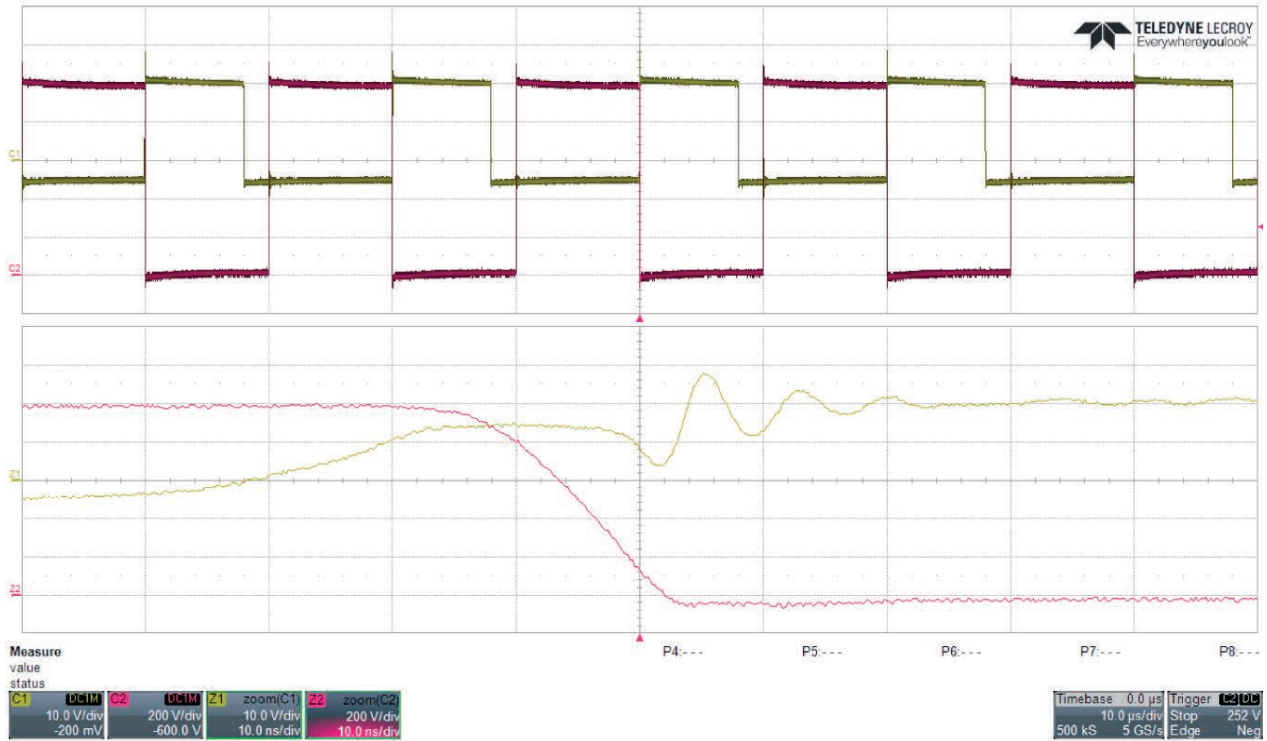


Specifications (measured at Ta= 25°C, 1.5Vin, full load after warm up unless otherwise stated)

| BOM | | | | | |
|-------------------------|---|--------------------------|--------------------------|--------|---|
| Part Name/Number | Description | Manufacturer Part Number | Manufacturer | Qty. | Comps. |
| 74279245 | FERRITE BEAD 110Ω 1806 1LN | 74279245 | Würth | 1 | FB1 |
| BNC_500HM_6.26mm_THD | CONN BNC JACK STR 50Ω PCB | 5-1634503-1 | TE Connectivity | 2 | U1 U2 |
| C1μF-1kV-FOIL-32mmX13mm | CAP FILM 1μF 10% 1kVDC RADIAL | R71QR41004010K | KEMET | 1 | C10 |
| C1μF-0603-16V | CAP CER 1μF 16V X7R 0603 | CC0603KRX7R7BB105 | Yageo | 1 | C19 |
| C1μF-0603-25V | CAP CER 1μF 25V X7R 0603 | TMK107B7105KA-T | Taiyo Yuden | 1 | C18 |
| C1μF-0603-50V | 1μF ±10% 50V X7R MLCC CAPACITOR 0603 | UMK107AB7105KA-T | Taiyo Yuden | 8 | C3 C4 C7 C8 C9 C11 C13 C15 |
| C2.2nF-0603-50V | CAP CER 2200pF 50V X7R 0603 | CC0603KRX7R9BB222 | Yageo | 1 | C17 |
| C3M0120100K-HYBRID | 1000V 120mΩ G3 SIC MOSFET | C3M0120100K | Cree/ WolfSpeed | 2 | T1 T2 |
| C4.7μF-1206-50V | 4.7μF ±10% 50V X7R MLCC CAPACITOR 1206 | UMK316AB7475KL-T | Taiyo Yuden | 1 | C5 |
| C10μF-1210-50V | CAP CER 10μF 50V X7R 1210 | UMK325AB7106KMHT | Taiyo Yuden | 1 | C16 |
| C22μF-1210-25V | CAP CER 22μF 25V X7R 1210 | TMK325B7226KM-PR | Taiyo Yuden | 2 | C1 C2 |
| C100nF-0603-50V | 0.10μF ±20% 50V X7R CERAMIC CAPACITOR SURFACE MOUNT MLCC 0603 | C0603C104M5RACTU | Kemet | 3 | C6 C12 C14 |
| CONNECTOR_2X1_5.5mm | MOLEX MINI-FIT JR | 39-29-0023 | Molex | 1 | CON1 |
| CONNECTOR_6.35mmX0.83mm | FASTON 250 PCB TAB TPBR 6.35 x 0.83mm L=15.8mm | 62409-1 | TE Connectivity | 3 | CON2 CON3 CON5 |
| HEADER_2X2.54mm_WURTH | CONN HEADER 2 POS 2.54 | 61300211121 | Würth | 1 | CON4 |
| L78L05ABUTR | IC REG LINEAR 5V 100mA SOT89-3 | L78L05ABUTR | STMicroelect- ronics | 1 | IC8 |
| LED-0603-GREEN-3.2V | LED GREEN CLEAR 0603 SMD | 150060GS75000 | Würth | 4 | LED1 LED2 LED3 LED4 |
| PMEG6010-SOD323 | DIODE SCHOTTKY 60V 1A SOD323F PMEG6010 | PMEG6010CEJ | NXP | 2 | D1 D2 |
| R0-0603 | RES SMD 0.0Ω JUMPER 1/10W 0603 | RC0603JR-070RL | Yageo | 4 2 | R19 R20 R24 R25 R21 R26 |
| R2K0-0603 | RES SMD 2kΩ 1% 1/10W 0603 | RC0603FR-072KL | Yageo | 2 | R3 R6 |
| R3E3-0207-MELF | RES SMD 3.3Ω 1% 1W 0207 | MMB02070C3308FB200 | Vishay Bey- schlag | 2 | R2 R5 |
| R12P22005D | CONV DC/DC 2W 5VIN +20/-5VOUT | R12P22005D | RECOM | 2 | IC2 IC3 |
| R10K0-0603 | RES SMD 10kΩ 1% 1/10W 0603 | RC0603FR-0710KL | Yageo | 1 9 | R22 R7 R8 R9 R10 R11 R12 R13 R14 R23 |
| R22E0-0207-MELF | RES SMD 22Ω 1% 1W 0207 | MMB02070C2209FB200 | Vishay Bey- schlag | 2 | R1 R4 |
| R47K-1206 | RES SMD 47kΩ 1% 1/4W 1206 | RC1206FR-0747KL | Yageo | 4 | R15 R16 R17 R18 |
| R-78C12-1.0 | CONV DC/DC 1A 12V OUT SIP VERT | R-78C12-1.0 | RECOM | 1 | IC5 |
| SI8273GBD-IS1 | OPTOISO 2.5kV GATE DRVR 16SOIC | SI8273GBD-IS1 | Silicon Labs | 1 | IC1 |
| UCC21520 | OPTOISO 5.7kV GATE DRVR 16SOIC | UCC21520ADW | Texas Instru- ments | 1 | IC7 |
| ZXGD3006E6TA | IC GATE DRVR IGBT/MOSFET SOT26 | ZXGD3006E6TA | Diodes Incor- porated | 2 | IC4 IC6 |

Specifications (measured at Ta= 25°C, 1.5Vin, full load after warm up unless otherwise stated)

Typical Switching Waveforms



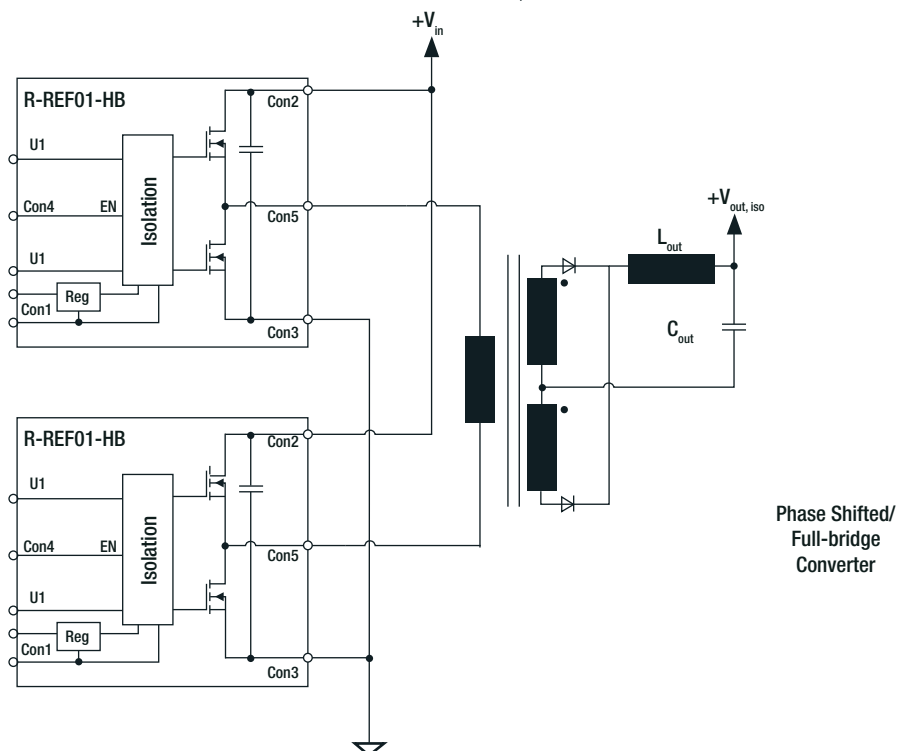
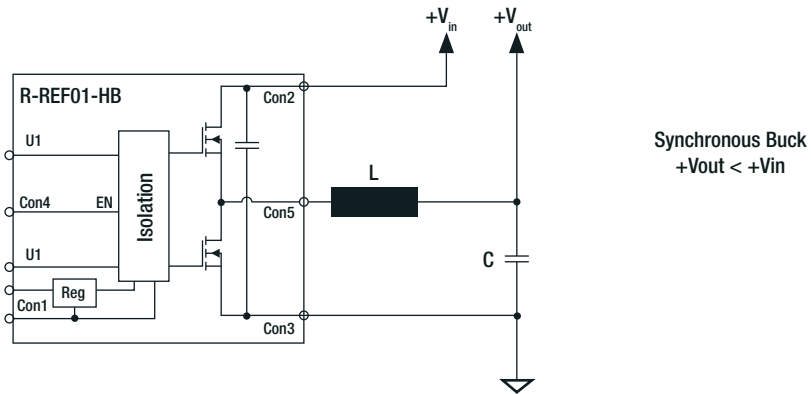
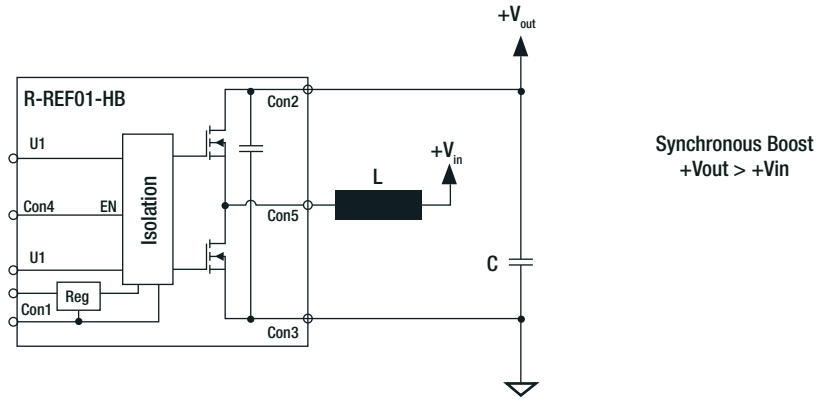
Ch.1: Low-side Gate Source Voltage
Ch.2: Low-side Drain Source Voltage

Switching Voltage: 1000VDC
Transistor: C2M1000170D-ND
IC2/IC3: R12P22005D

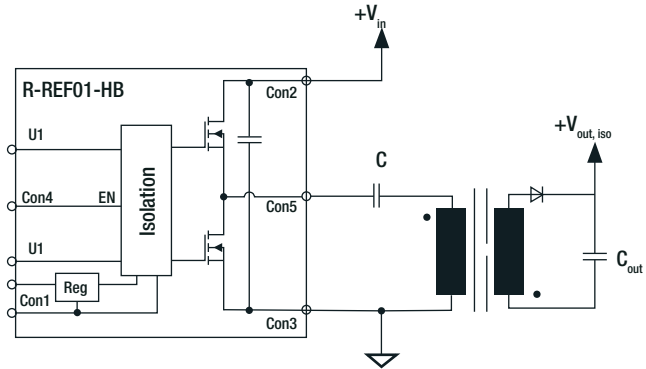
Switching Frequency: 50kHz
Measured Switching Slew Rate: 65kV/μs
Measured Switching Time: 15ns

Specifications (measured at $T_a = 25^\circ\text{C}$, 1.5V_{in}, full load after warm up unless otherwise stated)

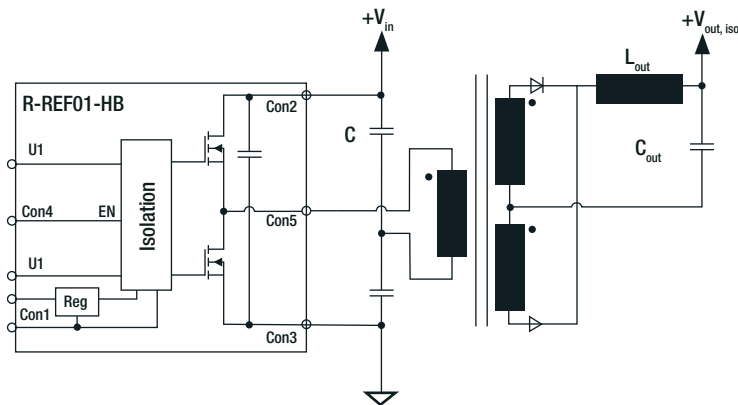
Application Suggestion



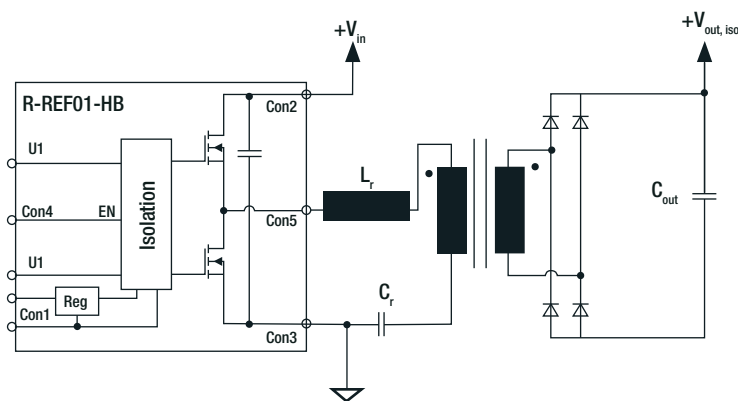
Specifications (measured at $T_a = 25^\circ\text{C}$, 1.5V_{in}, full load after warm up unless otherwise stated)



Half-bridge
Flyback
Converter

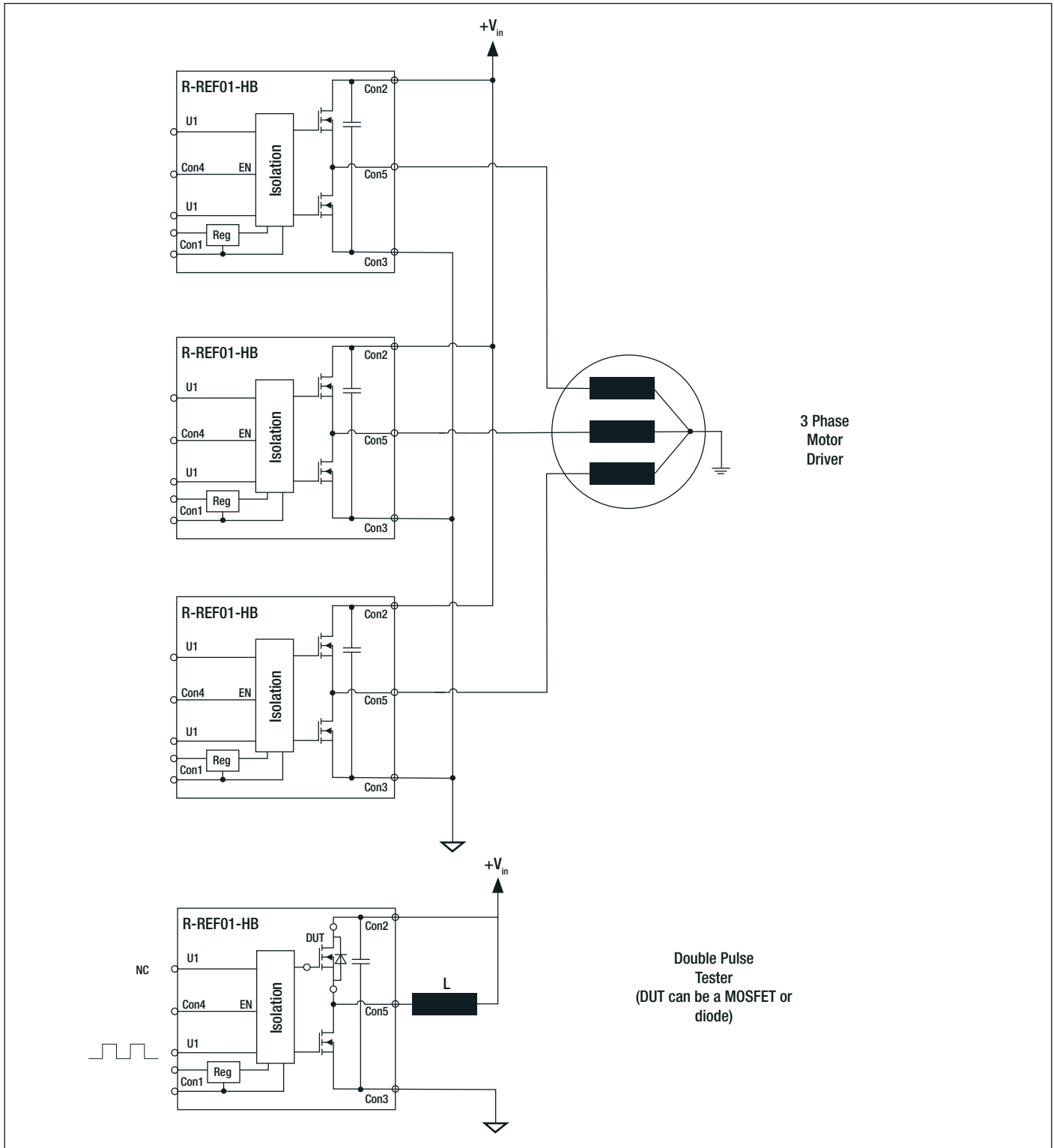


Half-bridge
Forward
Converter



Half-bridge
LLC
Converter

Specifications (measured at $T_a = 25^\circ\text{C}$, 1.5V_{in}, full load after warm up unless otherwise stated)



PACKAGING INFORMATION

| Parameter | Type | Value |
|-----------------------------|--------|------------------------|
| Packaging Dimension (LxWxH) | carton | 200.0 x 135.0 x 68.0mm |
| Packaging Quantity | | 1pcs |

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