Transformer Driver for Isolated Power Supplies

1. FEATURES

- Push-pull driver for small transformers
- Single 3.3V or 5V supply
- High primary-side current drive:
  - 5V supply: 500mA (max)
  - 3.3V supply: 500mA (max)
- Low ripple on rectified output permits small output capacitors
- V_{CC} undervoltage detect
- Spread spectrum clocking for EMI
- Thermal shutdown protection
- Small SOT23-5 package

2. APPLICATIONS

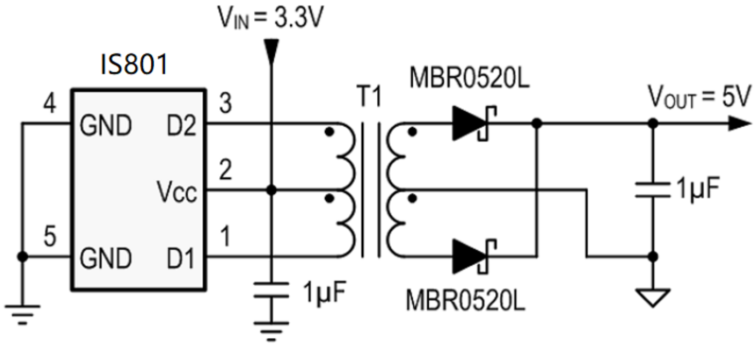
- Isolated interface power supply for CAN, RS-485, RS-422, RS-232, SPI, I²C, Low-Power LAN
- Industrial automation
- Process control
- Medical equipment

3. DESCRIPTION

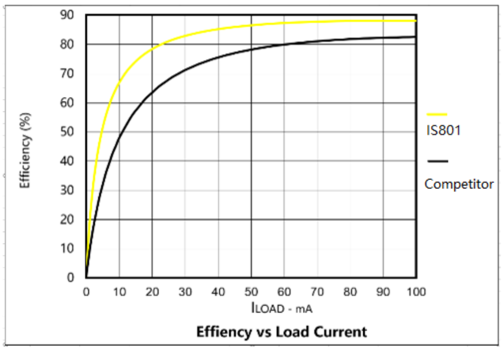
The IS801 is a monolithic oscillator/power-driver, which is designed for small form factor, isolated power supplies in isolated interface applications. A low-profile, center-tapped transformer primary from a 3.3V or 5V DC power supply can be driven by IS801 while the secondary can be wound to provide any isolated voltage based on transformer turns ratio.

The IS801 provides the complementary output signals to drive the ground referenced N-channel power switches. In addition to internal break-before-make logic between two switches, the IS801 is also integrated with V_{CC} undervoltage protection and thermal shutdown protection. The added spread spectrum clocking can help pass the system EMI test.

The IS801 is available in a small SOT23-5 package, and is specified for operation at temperatures from –40°C to 125°C.



Simplified Schematic



Effiency vs Load Current

Table 1 lists the order information.

Table 1. Order Information

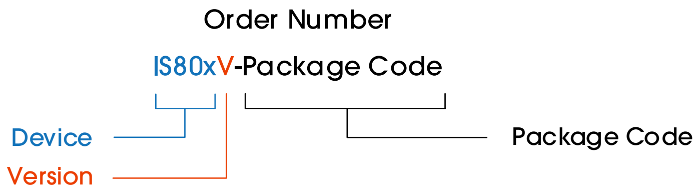
ORDER NUMBER (1)	CH (#)	PKG.	BODY SIZE (MM)	MARKING	HIGH PRIMARY-SIDE MAX CURRENT DRIVE	EN & EXT CLOCK	SPREAD SPECTRUM	OP. TEMP (°C)	PKG. OPTION
IS801ASOT235	1	SOT23-5	2.90 × 1.60	IS801	500	No	Yes	-40-125	T/R-4000

Table 2. Family Selection Guide

ORDER NUMBER (1)	CH (#)	PKG.	BODY SIZE (MM)	MARKING	HIGH PRIMARY-SIDE MAX CURRENT DRIVE	EN & EXT CLOCK	SPREAD SPECTRUM	OP. TEMP (°C)	PKG. OPTION
IS802ASOT236	1	SOT23-6	2.90 × 1.60	IS802	500	Yes	Yes	-40-125	T/R-4000

Devices can be ordered via the following two ways:
1. Place orders directly on our website (www.analogysemi.com), or;
2. Contact our sales team by mailing to sales@analogysemi.com.

Note:



4. PIN CONFIGURATION AND FUNCTIONS

Figure 1 illustrates the pin configuration.

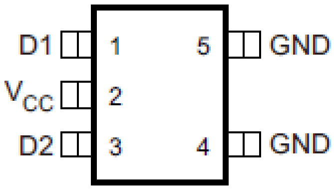


Figure 1. Pin Configuration

Table 3 lists the pin functions.

Table 3. Pin Functions

POSITION	NAME	TYPE	DESCRIPTION
1	D1	OD	Open drain output 1. Connect this pin to one end of the transformer primary side.
2	V_{CC}	P	Supply voltage input. Connect this pin to the center-tap of the transformer primary side. Buffer this voltage with a 1μF to 10μF ceramic capacitor.
3	D2	OD	Open drain output 2. Connect this pin to the other end of the transformer primary side.
4, 5	GND	P	Device ground. Connect this pin to board ground.

5. SPECIFICATIONS

5.1 ABSOLUTE MAXIMUM RATINGS

Table 4 lists the absolute maximum ratings of the IS801. Over operating free-air temperature range, unless otherwise noted.

Table 4. Absolute Maximum Ratings

PARAMETER	DESCRIPTION	MIN	MAX	UNITS
Voltage	Supply, V_{CC}	-0.3	6	V
	Output switch, V_{D1}, V_{D2}		14	
Current	Peak output switch, I_{D1P}, I_{D2P}		500	mA
Power	Continuous power dissipation, P_{TOT}		250	mW
Temperature	Junction, T_J	-40	180	°C
	Storage, T_{stg}	-65	150	

Note: Stresses beyond those listed under Table 4 may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Table 6. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

5.2 RECOMMENDED OPERATING CONDITIONS

Table 6 lists the recommended operating conditions for the IS801.

Table 5. Recommended Operating Conditions

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}			2.5	3.3	5.5	V
Output Switch Voltage	V_{D1}, V_{D2}	V_{CC} = 5V ± 10%	When connected to Transformer with primary winding center-tapped	0		11	V
		V_{CC} = 3.3V ± 10%		0		7.2	
D1 and D2 Output Switch Current (Primary-Side)	I_{D1}, I_{D2}	V_{CC} = 5V ± 10%	V_{D1}, V_{D2} swing ≥ 3.8V			500	mA
		V_{CC} = 3.3V ± 10%	V_{D1}, V_{D2} swing ≥ 2.5V for typical characteristics			500	
Ambient Temperature	T_A			-40		125	°C

5.3 THERMAL INFORMATION

Table 7 lists the thermal information for the IS801.

Table 6. Thermal Information

PARAMETER	SYMBOL	SOT23-5	UNITS
Junction-to-Ambient Thermal Resistance	$R_{\theta JA}$	TBD	°C/W
Junction-to-Case (Top) Thermal Resistance	$R_{\theta JC (top)}$	TBD	°C/W
Junction-to-Board Thermal Resistance	$R_{\theta JB}$	TBD	°C/W
Junction-to-Top Characterization Parameter	ψ_{JT}	TBD	°C/W
Junction-to-Board Characterization Parameter	ψ_{JB}	TBD	°C/W
Junction-to-Case (Bottom) Thermal Resistance	$R_{\theta JC (bot)}$	—	°C/W

5.4 ELECTRICAL CHARACTERISTICS

Table 8 lists the electrical characteristics of the IS801. Over full-range of recommended operating conditions, unless otherwise noted.

Table 7. Electrical Characteristics

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Switch-On Resistance	R_{ON}	V_{CC} = 3.3V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		0.34	0.6	Ω
		V_{CC} = 5V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		0.36	0.52	
Average Supply Current (1)	I_{CC}	V_{CC} = 3.3V ± 10%, no load		201		μA
		V_{CC} = 5V ± 10%, no load		380		
D1, D2 Switching Frequency	f_{SW}	V_{CC} = 3.3V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.	300	390	550	kHz
Internal Frequency Dither Range	FREQ_DITH	MODE = V_{DD}, CLK_RS unconnected, (IS801 only)	−4		4	%
Internal Frequency Dither Step	FREQ_DITH_STEP	MODE = V_{DD}, CLK_RS unconnected, (IS801 only)		0.6		%
Max Peak Current of Internal Powerfet during Soft-Start	ISS	V_{DD} = 3.3V	150	240		mA
Soft-Start Time, Max Peak Current is About 150mA during Soft-Start Time	T_SS	MODE = V_{DD}, CLK_RS unconnected		1.5		ms
Thermal Shutdown Temperature	TSD		150	165	180	°C
Hysteresis of TSD	TSD_HYS		130	150	170	°C
Thermal Shutdown Hiccup Time	T_TSD_HICP			64		ms
V_{CC} under Voltage Lock Out Rising Threshold	V_{CC}_UVLO			2.1	2.5	V
V_{CC} under Voltage Lock Out Falling Threshold				2		V

Note: Average supply current is the current used by IS801 only. It does not include load current.

5.5 SWITCHING CHARACTERISTICS

Table 9 lists the switching characteristics of the IS801. Over operating free-air temperature range, unless otherwise noted.

Table 8. Switching Characteristics

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
D1, D2 Output Rise Time	$t_{r\text{-}D}$	V_{CC} = 3.3V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		96		ns
		V_{CC} = 5V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		99		
D1, D2 Output Fall Time	$t_{f\text{-}D}$	V_{CC} = 3.3V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		126		ns
		V_{CC} = 5V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		71.8		
Break-Before-Make Time	t_{BBM}	V_{CC} = 3.3V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		192		ns
		V_{CC} = 5V ± 10%, R_L = 50Ω to V_{DD}, 15pF capacitor to GND.		136		

5.6 TYPICAL CHARACTERISTICS

TP1 curves are measured with the circuit in Figure 32; whereas, TP1 and TP2 curves are measured with circuit in Figure 34 (T_A = 25°C unless otherwise noted). See Table 12 for transformer specifications.

TBD

Figure 2. Output Voltage vs. Load Current (3.3V-3.3V)

Figure 3. Efficiency vs. Load Current (3.3V-3.3V)

TBD

Figure 4. Output Voltage vs.. Load Current (5V-5V)

TBD

Figure 5. Efficiency vs. Load Current (5V-5V)

TBD

Figure 6. Output Voltage vs. Load Current (3.3V–5V)

TBD

Figure 7. Efficiency vs. Load Current (3.3V–5V)

5.7 TYPICAL CHARACTERISTICS (CONTINUED)

TP1 curves are measured with the circuit in Figure 32; whereas, TP1 and TP2 curves are measured with circuit in Figure 34 (T_A = 25°C unless otherwise noted). See Table 12 for transformer specifications.

TBD

Figure 8. Output Voltage vs. Load Current

TBD

Figure 9. Efficiency vs. Load Current

TBD

Figure 10. Output Voltage vs. Load Current

TBD

Figure 11. Efficiency vs. Load Current

TBD

Figure 12. Output Voltage vs. Load Current

TBD

Figure 13. Efficiency vs. Load Current

TBD

Figure 14. Output Voltage vs. Load Current

TBD

Figure 15. Efficiency vs. Load Current

5.8 TYPICAL CHARACTERISTICS (CONTINUED)

TP1 curves are measured with the circuit in Figure 32; whereas, TP1 and TP2 curves are measured with circuit in Figure 34 (T_A = 25°C unless otherwise noted). See Table 12 for transformer specifications.

TBD

Figure 16. Output Voltage vs. Load Current

TBD

Figure 17. Efficiency vs. Load Current

TBD

Figure 18. Output Voltage vs. Load Current

TBD

Figure 19. Efficiency vs. Load Current

TBD

Figure 20. Output Voltage vs. Load Current

TBD

Figure 21. Efficiency vs. Load Current

TBD

Figure 22. Output Voltage vs. Load Current

TBD

Figure 23. Efficiency vs. Load Current

5.9 TYPICAL CHARACTERISTICS (CONTINUED)

TP1 curves are measured with the circuit in Figure 32; whereas, TP1 and TP2 curves are measured with circuit in Figure 34 (T_A = 25°C unless otherwise noted). See Table 12 for transformer specifications.

TBD

Figure 24. Output Voltage vs. Load Current

TBD

Figure 25. Efficiency vs. Load Current

TBD

Figure 26. Output Voltage vs. Load Current

TBD

Figure 27. Efficiency vs. Load Current

TBD

Figure 28. Output Voltage vs. Load Current

TBD

Figure 29. Efficiency vs. Load Current

TBD

Figure 30. Average Supply Current vs. Free-Air Temperature

TBD

Figure 31. D1, D2 Switching Frequency vs. Free-Air Temperature

6. PARAMETER MEASUREMENT INFORMATION

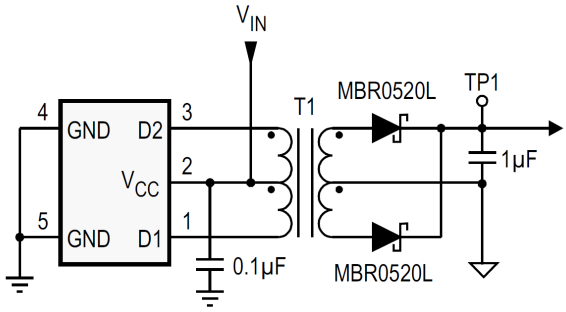


Figure 32. Measurement Circuit for Unregulated Output (TP1)

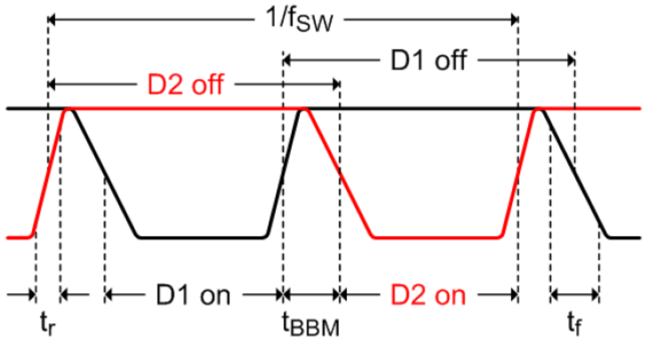


Figure 33. Timing Diagram

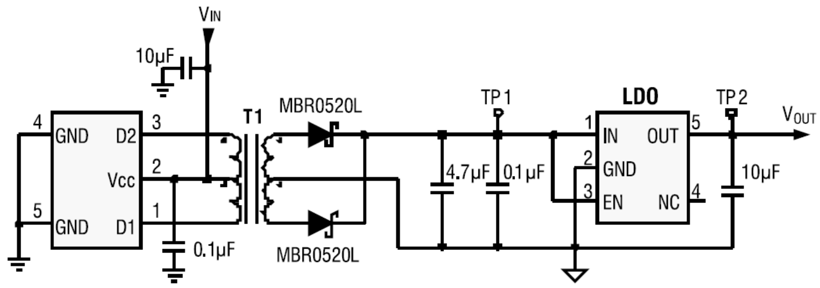


Figure 34. Measurement Circuit for Regulated Output (TP1 and TP2)

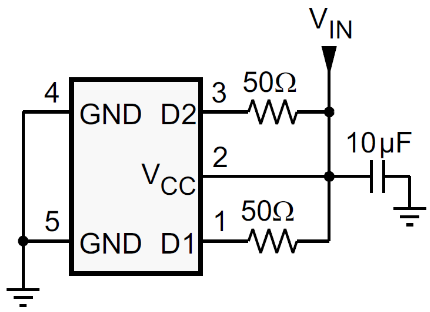


Figure 35. Test Circuit For R_{ON}, F_{SW}, F_{St}, $T_{r\text{-}D}$, $T_{f\text{-}D}$, T_{BBM}

7. DETAILED DESCRIPTION

7.1 OVERVIEW

The IS801 is a transformer driver designed for low-cost, small form-factor, isolated DC-DC converters utilizing the push-pull topology. The device consists of an oscillator followed by the gate driver that includes a frequency divider and a break-before-make (BBM) logic, provides two complementary output signals which alternately turn the two output transistors on and off.

The oscillator's output frequency is divided down by an asynchronous divider that can output two complementary, 50% duty cycle output signals. The break-before-make logic is implanted by injecting a dead-time between the high-pules of the two output signals. As shown in the functional block diagram, either of the two gates can output logic high, hence a short time period is a must when both signals are low and both transistors are high-impedance. This short time period is known as break-before-make time, which can avoid shorting out both ends of the primary. To make it easier to pass system EMI tests, the spread spectrum scheme is also added in oscillator of IS801.

In addition, the IS801 is integrated with V_{CC} undervoltage fault and the thermal shutdown modules.

7.2 FUNCTIONAL BLOCK DIAGRAM

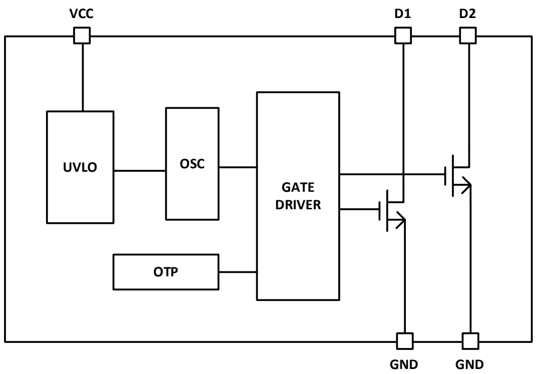


Figure 36. Functional Block Diagram

7.3 FEATURE DESCRIPTION

Push-pull converters require transformers with center-taps to transfer power from the primary to the secondary (see Figure 37).

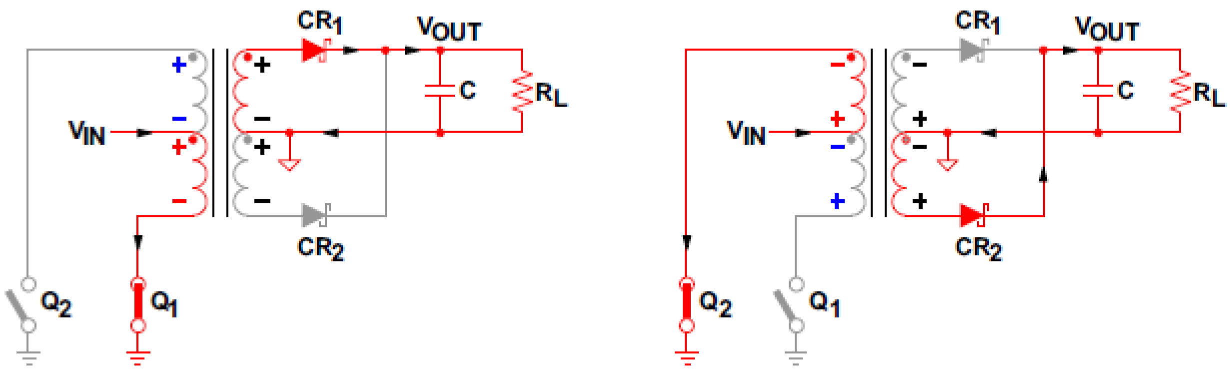


Figure 37. Switching Cycles of a Push-Pull Converter

When Q_1 conducts, V_{IN} drives a current through the lower half of the primary to ground, thus creating a negative voltage potential at the lower primary end with regard to the V_{IN} potential at the center-tap.

At the same time, the voltage across the upper half of the primary is such that the upper primary end is positive with regard to the center-tap in order to maintain the previously established current flow through Q_2, which now has turned high-impedance. The two voltage sources, each of which equaling V_{IN}, appear in series and cause a voltage potential at the open end of the primary of $2 \times V_{IN}$ with regard to ground.

Per dot convention, the same voltage polarities that occur at the primary also occur at the secondary. The positive potential of the upper secondary end therefore forward biases diode CR_1. The secondary current starting from the upper secondary end flows through CR_1, charges capacitor C, and returns through the load impedance R_L back to the center-tap.

When Q_2 conducts, Q_1 goes high-impedance and the voltage polarities at the primary and secondary reverse. Now the lower end of the primary presents the open end with a $2 \times V_{IN}$ potential against ground. In this case, CR_2 is forward biased while CR_1 is reverse biased and current flows from the lower secondary end through CR_2, charging the capacitor and returning through the load to the center-tap.

7.4 DEVICE FUNCTIONAL MODES

The functional modes of the IS801 are divided into start-up, operating, and off-mode.

7.4.1 START-UP MODE

When the supply voltage V_{CC} ramps up to 2V typical, the internal oscillator starts operating. The output stage begins switching, but the amplitude of the drain signals at D1 and D2 has not reached its full maximum yet.

7.4.2 OPERATING MODE

When the power supply voltage at V_{CC} is stable at the normal value, the device is fully operating. But variations on the supply voltage and ambient temperature varies the switching frequencies at D1 and D2. After adding the spread spectrum scheme, the range can be 300kHz to 550kHz.

7.4.3 OFF-MODE

In this state, both drain outputs, D1 and D2, are high-impedance.

7.4.4 SPREAD SPECTRUM CLOCKING

The IS801 adopts spread spectrum clocking technology by modulating its internal clock in such a way that the emitting energy is spread over multiple frequency bands. This Spread Spectrum clocking feature greatly improves the emissions performance of the entire power supply block and hence relieves the system designer from one major concern in isolated power supply design.

7.4.5 THERMAL SHUTDOWN

If the die temperature exceeds the TSD temperature, the device will stop switching for protection. After the die temperature falls below (TSD – hysteresis) temperature, device operation automatically resumes after 64ms hiccup time.

8. APPLICATION AND IMPLEMENTATION

NOTE

The information provided in this section is not part of the AnalogySemi component specification. Hence, AnalogySemi does not warrant its completeness or accuracy. Customers are responsible for determining suitability of components and system functionality for their applications. Validation and testing should be performed prior to design implementation.

8.1 APPLICATION INFORMATION

The IS801 is a transformer driver designed for low-cost, small form-factor, isolated DC-DC converters utilizing the push-pull topology. The device consists of an oscillator followed by the gate driver that includes a frequency divider and a break-before-make (BBM) logic, providing two complementary output signals which alternately turn the two output transistors on and off.

In addition, the IS801 is integrated with V_{CC} undervoltage fault and the thermal shutdown modules.

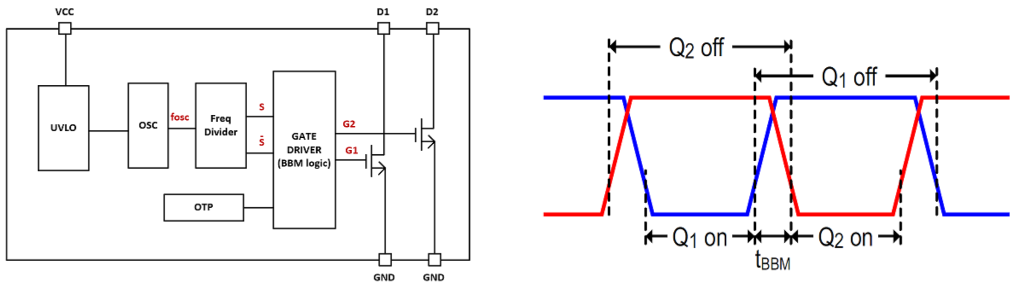


Figure 38. IS801 Block Diagram and Output Timing with Break-Before-Make Action

The oscillator's output frequency is divided down by an asynchronous divider that can output two complementary, 50% duty cycle output signals S and $\bar{S}$. The break-before-make logic is implanted by injecting a dead-time between the high pulses of the two output signals G_1 and G_2, present the gate-drive signals for the output transistors Q_1 and Q_2. As shown in Figure 39, either of the two gates can output logic high, hence a short time period is a must when both signals are low and both transistors are high-impedance. This short time period is known as break-before-make time, which can avoid shorting out both ends of the primary.

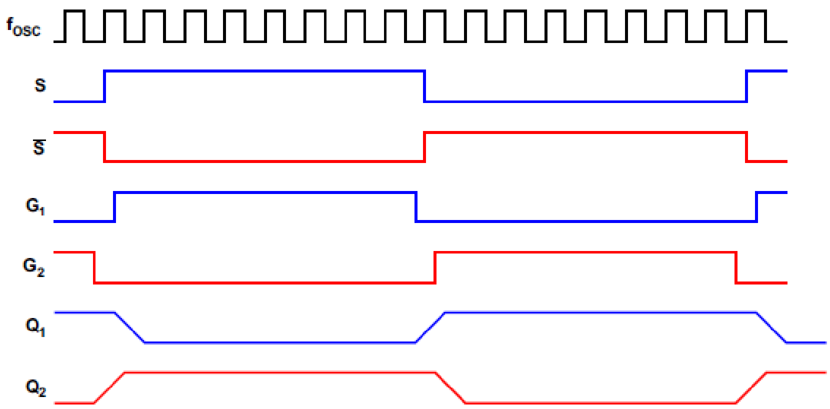


Figure 39. Detailed Output Signal Waveforms

8.2 TYPICAL APPLICATION

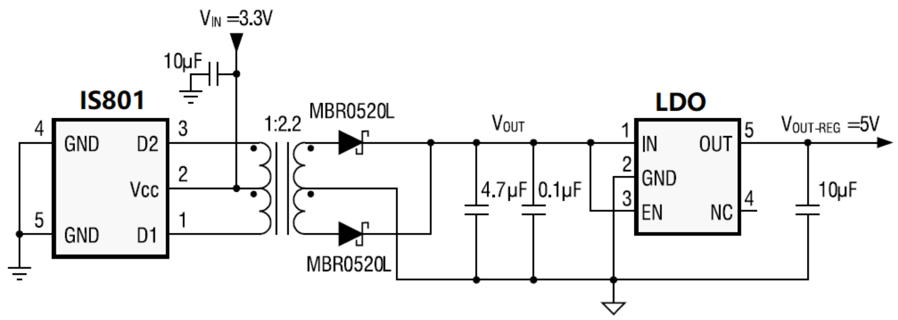


Figure 40. Typical Application Schematic (IS801)

8.2.1 DESIGN REQUIREMENTS

For this design example, use the parameters listed in Table 10 as design parameters.

Table 9. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	3.3V ± 3%
Output Voltage	5V
Maximum Load Current	100mA

8.2.2 DETAILED DESIGN PROCEDURE

The coming contents focus on the design of an efficient push-pull conversion with high-current drive capability. To obtain a stable, load independent supply and efficient design, an LDO is strongly recommended.

8.2.2.1 IS801 DRIVE CAPABILITY

In the design of 3.3V input and 5V output, output voltage could be higher if the turn ratios are implemented. But it could also lead to higher primary currents that should always be limited below the specification.

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8.2.2.2 LDO SELECTION

The minimum requirements for an LDO are:

- LDO's drive capability should slightly exceed the designed load current. For example, 100mA designed load current can select an LDO with 100mA to 150mA load current. But higher load current usually indicates larger dropout voltage, which reduces the efficiency. Hence, a trade-off is needed here.
- The internal dropout voltage, V_{DO}, at the specified load current should be as low as possible to maintain efficiency. Temperature drift of V_{DO} should be considered.
- The required minimum input voltage preventing the regulator from dropping out of line regulation is given with:

$$V_{I\text{-}min} = V_{DO\text{-}max} + V_{O\text{-}max} \quad (1)$$

  Note that the output voltage of the push-pull rectifier at the specified load current is equal or higher than $V_{I\text{-}min}$. If it is not, the LDO will lose line-regulation and any variations at the input will pass straight through to the output.
- The maximum regulator input voltage must be higher than the rectifier output under no-load. At this point, the secondary reaches its maximum voltage of

$$V_{S\text{-}max} = V_{IN\text{-}max} \times n \quad (2)$$

with $V_{IN\text{-}max}$ as the maximum converter input voltage and n as the transformer turns ratio. Thus, to prevent the LDO from damage, the maximum regulator input voltage must be higher than $V_{S\text{-}max}$. Table 11 lists the maximum secondary voltages for various turns ratios commonly applied in push-pull converters with 100mA output drive.

Table 10. Required Maximum LDO Input Voltages for Various Push-Pull Configurations

PUSH-PULL CONVERTER				LDO
CONFIGURATION	$V_{IN\text{-}max}$ (V)	TURNS-RATIO	$V_{S\text{-}max}$ (V)	$V_{I\text{-}max}$ (V)
3.3 V_{IN} to 3.3 V_{OUT}	3.6	1.5 ± 3%	5.6	6 to 10
3.3 V_{IN} to 5 V_{OUT}	3.6	2.2 ± 3%	8.2	10
5 V_{IN} to 5 V_{OUT}	5.5	1.5 ± 3%	8.5	10

8.2.2.3 Diode Selection

Schottky diodes meet both low-forward voltage and short recovery time requirements, therefore it is strongly recommended in push-pull converter designs.

A good choice for low-volt applications and ambient temperatures of up to 85°C is the low-cost Schottky rectifier MBR0520L with a typical forward voltage of 275mV at 100mA forward current. For higher output voltages such as ±10V and above, use the MBR0530 which provides a higher DC blocking voltage of 30V.

Lab measurements have shown that at temperatures higher than 100°C the leakage currents of the above Schottky diodes increase significantly. This can cause thermal runaway leading to the collapse of the rectifier output voltage. Therefore, for ambient temperatures higher than 85°C, use low-leakage Schottky diodes, such as RB168M-40.

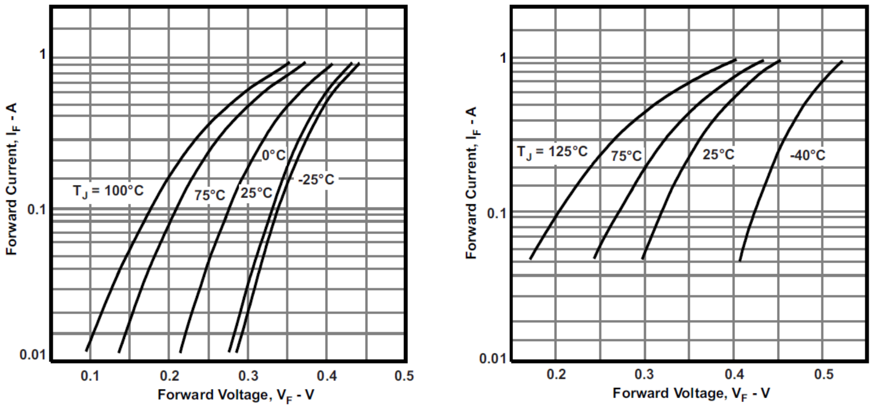

Figure 41. Diode Forward Characteristics for MBR0520L (Left) and MBR0530 (Right)

8.2.2.4 Capacitor Selection

As with all high-speed CMOS ICs, the IS801 requires a bypass multi-layer ceramic chip (MLCC) capacitor in the range of 10nF to 100nF.

The input bulk capacitor at the center-tap of the primary supports large currents into the primary during the fast switching transients. For minimum ripple, make this capacitor 1µF to 10µF.

In a 2-layer PCB design with a dedicated ground plane, place this capacitor close to the primary center-tap to minimize trace inductance. In a 4-layer board design with low-inductance reference planes for ground and V_{IN}, the capacitor can be placed at the supply entrance of the board. To ensure low-inductance paths, use two vias in parallel for each connection to a reference plane or to the primary center-tap.

The bulk capacitor at the rectifier output smoothest the output voltage. Make this capacitor 1µF to 10µF.

The small capacitor at the regulator input is not necessarily required. However, good analog design practice suggests, using a small value of 47nF to 100nF improves the regulator's transient response and noise rejection.

The LDO output capacitor buffers the regulated output for the subsequent isolator and transceiver circuitry. The choice of output capacitor depends on the LDO stability requirements specified in the datasheet. However, in most cases, a low-ESR ceramic capacitor in the range of 4.7µF to 10µF will satisfy these requirements.

8.2.2.5 TRANSFORMER SELECTION

8.2.2.5.1 V-T PRODUCT CALCULATION

To prevent a transformer from saturation, its V-t product must be greater than the maximum V-t product applied by the IS801. The maximum voltage delivered by the IS801 is 1.1 times of the nominal converter input. The maximum time this voltage is applied to the primary is half the period of the lowest frequency at the specified input voltage. Therefore, the transformer's minimum V-t product is determined through:

$$Vt_{min} \geq V_{IN\text{-}max} \times \frac{T_{max}}{2} = \frac{V_{IN\text{-}max}}{2 \times f_{min}} \quad (3)$$

Inserting the numeric values from the datasheet into the equation above yields the minimum V-t products of

$$Vt_{min} \geq \frac{3.6V}{2 \times 250kHz} = 7.2V\mu s \text{ for 3.3V, and}$$

$$Vt_{min} \geq \frac{5.5V}{2 \times 300kHz} = 9.1V\mu s \text{ for 5V applications.} \quad (4)$$

Common V-t values for low-power center-tapped transformers range from 22Vμs to 150Vμs with typical footprints of 10mm x 12mm. However, transformers specifically designed for PCMCIA applications provide as little as 11Vμs and come with a significantly reduced footprint of 6mm x 6mm only.

While Vt-wise all of these transformers can be driven by the IS801, other important factors such as isolation voltage, transformer wattage, and turns ratio must be considered before making the final decision.

8.2.2.5.2 TURNS RATIO ESTIMATE

Assume the rectifier diodes and linear regulator has been selected. Also, it has been determined that the transformer chosen must have a V-t product of at least 11Vμs. However, before searching the manufacturer websites for a suitable transformer, the user still needs to know its minimum turns ratio that allows the push-pull converter to operate flawlessly over the specified current and temperature range. This minimum transformation ratio is expressed through the ratio of minimum secondary to minimum primary voltage multiplied by a correction factor that takes the transformer's typical efficiency of 97% into account:

$V_{S\text{-}min}$ must be large enough to allow for a maximum voltage drop, $V_{F\text{-}max}$, across the rectifier diode and still provide sufficient input voltage for the regulator to remain in regulation. From the LDO SELECTION section, this minimum input voltage is known and by adding $V_{F\text{-}max}$ gives the minimum secondary voltage with:

$$V_{S\text{-}min} = V_{F\text{-}max} + V_{DO\text{-}max} + V_{O\text{-}max} \quad (5)$$

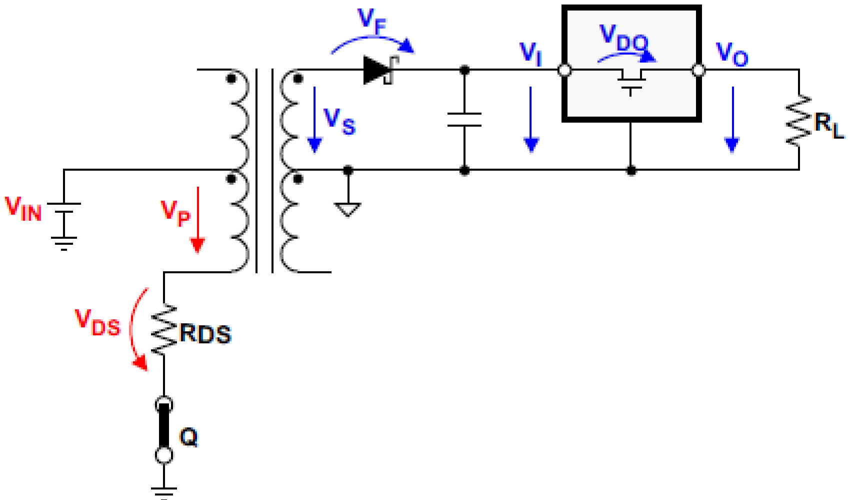

Figure 42. Establishing the Required Minimum Turns Ratio Through $N_{min} = 1.031 \times V_{S\text{-}min} / V_{P\text{-}min}$

Then calculating the available minimum primary voltage, $V_{P\text{-}min}$, involves subtracting the maximum possible drain-source voltage of the IS801, $V_{DS\text{-}max}$, from the minimum converter input voltage $V_{IN\text{-}min}$:

$$V_{P\text{-}min} = V_{IN\text{-}min} - V_{DS\text{-}max} \quad (6)$$

$V_{DS\text{-}max}$, however, is the product of the maximum $R_{DS\,(on)}$ and I_D values for a given supply specified in the (IS801 datasheet:

$$V_{DS\text{-}max} = R_{DS\text{-}max} \times I_{Dmax} \quad (7)$$

Then inserting Equation 7 into Equation 6 yields:

$$V_{P\text{-}min} = V_{IN\text{-}min} - R_{DS\text{-}max} \times I_{Dmax} \quad (8)$$

and inserting Equation 8 and Equation 5 into Equation 9 provides the minimum turns ration with:

$$n_{min} = 1.031 \times \frac{V_{F\text{-}max} + V_{DO\text{-}max} + V_{O\text{-}max}}{V_{IN\text{-}min} - R_{DS\text{-}max} + I_{D\text{-}max}} \quad (9)$$

Example:

For a 3.3 V_{IN} to 5 V_{OUT} converter using the rectifier diode MBR0520L and the 5V LDO TPS76350, the datasheet values taken for a load current of 100mA and a maximum temperature of 85°C are $V_{F\text{-}max}$ = 0.2V, $V_{DO\text{-}max}$ = 0.2V, and $V_{O\text{-}max}$ = 5.175V.

Then assuming that the converter input voltage is taken from a 3.3V controller supply with a maximum ±2% accuracy makes $V_{IN\text{-}min}$ = 3.234V. Finally, the maximum values for drain-source resistance and drain current at 3.3V are taken from the IS801 datasheet with $R_{DS\text{-}max}$ = 0.34Ω and $I_{D\text{-}max}$ = 500mA.

Inserting the values above into Equation 9 yields a minimum turns ratio of:

$$n_{min} = 1.031 \times \frac{0.2V + 0.2V + 5.175V}{3.234V - 0.34\Omega \times 500mA} = 1.82 \quad (10)$$

Most commercially available transformers for 3-to-5V push-pull converters offer turns ratios between 1.82 and 2.3 with a common tolerance of ±3%.

8.2.2.5.3 RECOMMENDED TRANSFORMERS

Depending on the application, use the minimum configuration in Figure 43 or standard configuration in Figure 44.

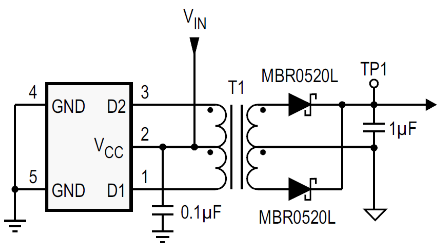

Figure 43. Unregulated Output for Low-Current Loads with Wide Supply Range

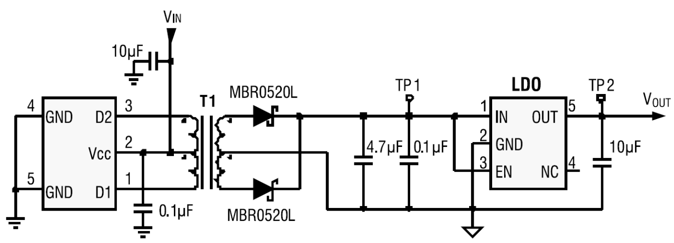

Figure 44. Regulated Output for Stable Supplies and High Current Loads

The Wurth Electronics Midcom isolation transformers in Table 12 are optimized designs for the IS801, providing high efficiency and small form factor at low cost.

The 1:1.1 and 1:1.7 turns-ratios are designed for logic applications with wide supply rails and low load currents. These applications operate without LDO, thus achieving further cost reduction.

Table 11. Recommended Isolation Transformers Optimized for IS801

TURNS RATIO	V × T ($V_{\mu s}$)	ISOLATION (V_{RMS})	DIMENSIONS (mm)	APPLICATION	LDO	FIGURES	ORDER NO.	MANUFACTURER
1:1.1 ± 2%	7	2500	6.73 ×10.05 × 4.19	3.3V to 3.3V	No	Figure 2 Figure 3	760390011	Wurth Electronics/ Midcom
1:1.1 ± 2%	11			5V to 5V		Figure 4 Figure 5	760390012	
1:1.7 ± 2%				3.3V to 5V		Figure 6 Figure 7	760390013	
1:1.3 ± 2%				3.3V to 3.3V 5V to 5V	Yes	Figure 8 Figure 9 Figure 10 Figure 11	760390014	
1:2.1 ± 2%				3.3V to 5V		Figure 12 Figure 13	760390015	
1.23:1 ± 2%				5V to 3.3V		Figure 14 Figure 15	750313710	
1:1.1 ± 2%	11	5000	9.14 × 12.7 × 7.37	3.3V to 3.3V	No	Figure 16 Figure 17	750313734	
1:1.1 ± 2%				5V to 5V		Figure 18 Figure 19	750313734	
1:1.7 ± 2%				3.3V to 5V		Figure 20 Figure 21	750313769	
1:1.3 ± 2%				3.3V to 3.3V 5V to 5V	Yes	Figure 22 Figure 23 Figure 24 Figure 25	750313638	
1:2.1 ± 2%				3.3V to 5V		Figure 26 Figure 27	750313626	
1.3:1 ± 2%				5V to 3.3V		Figure 28 Figure 29	750313638	
1:1.3 ± 3%	11	5000	10.4 × 12.2 × 6.1	3.3V to 3.3V 5V to 5V	No	N/A	HCT-SM-1.3-8-2	Bourns
1:1.1 ± 2%	9.2	2500	7.01 × 11 × 4.19	3.3V to 3.3V 5V to 5V	No	N/A	EPC3668G-LF	PCA Electronics
1:1.5 ± 3%	34.4	2500	10 × 12.07 × 5.97	3.3V to 3.3V 5V to 5V	Yes	N/A	DA2303-AL	Coilcraft
1:2.2 ± 3%	21.5	2500	10 × 12.07 × 5.97	3.3V to 5V			DA2304-AL	

8.2.3 APPLICATION CURVE

See Table 12 for application curves.

8.2.4 HIGHER OUTPUT VOLTAGE DESIGNS

The IS801 can drive push-pull converters that provide high output voltages of up to 30V, or bipolar outputs of up to ±15V. Using commercially available center-tapped transformers, with their rather low turns ratios of 0.8 to 5, requires different rectifier topologies to achieve high output voltages. Figure 45 to Figure 48 show some of these topologies together with their respective open-circuit output voltages.

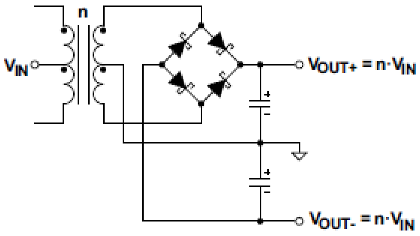

Figure 45. Bridge Rectifier with Center-Tapped Secondary Enables Bipolar Outputs

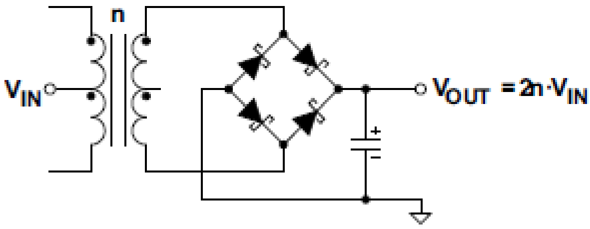

Figure 46. Bridge Rectifier without Center-Tapped Secondary Performs Voltage Doubling

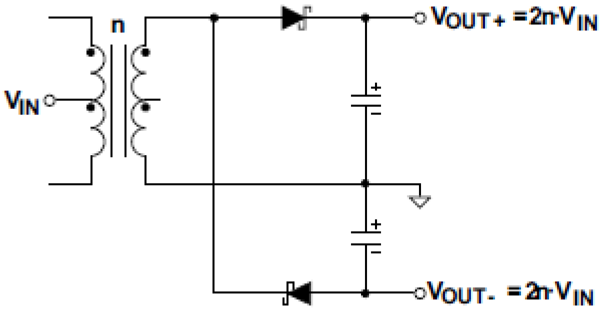

Figure 47. Half-Wave Rectifier without Center-Tapped Secondary Performs Voltage Doubling, Centered Ground Provides Bipolar Outputs

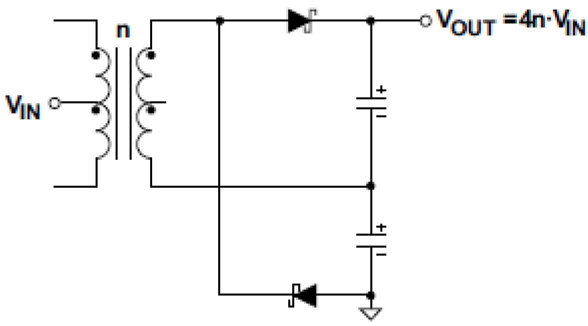

Figure 48. Half-Wave Rectifier without Centered Ground and Center-Tapped Secondary Performs Voltage Doubling Twice, Hence Quadrupling V_{IN}

8.2.5 APPLICATION CIRCUITS

The following application circuits are shown for a 3.3V input supply commonly taken from the local, regulated micro-controller supply. For 5V input voltages requiring different turn ratios, refer to the transformer manufacturers and their websites listed in Table 13.

Table 12. Transformer Manufacturers

Coilcraft Inc.	http://www.coilcraft.com
Halo-Electronics Inc.	http://www.haloelectronics.com
Murata Power Solutions	http://www.murata-ps.com
Wurth Electronics Midcom Inc	http://www.midcom-inc.com

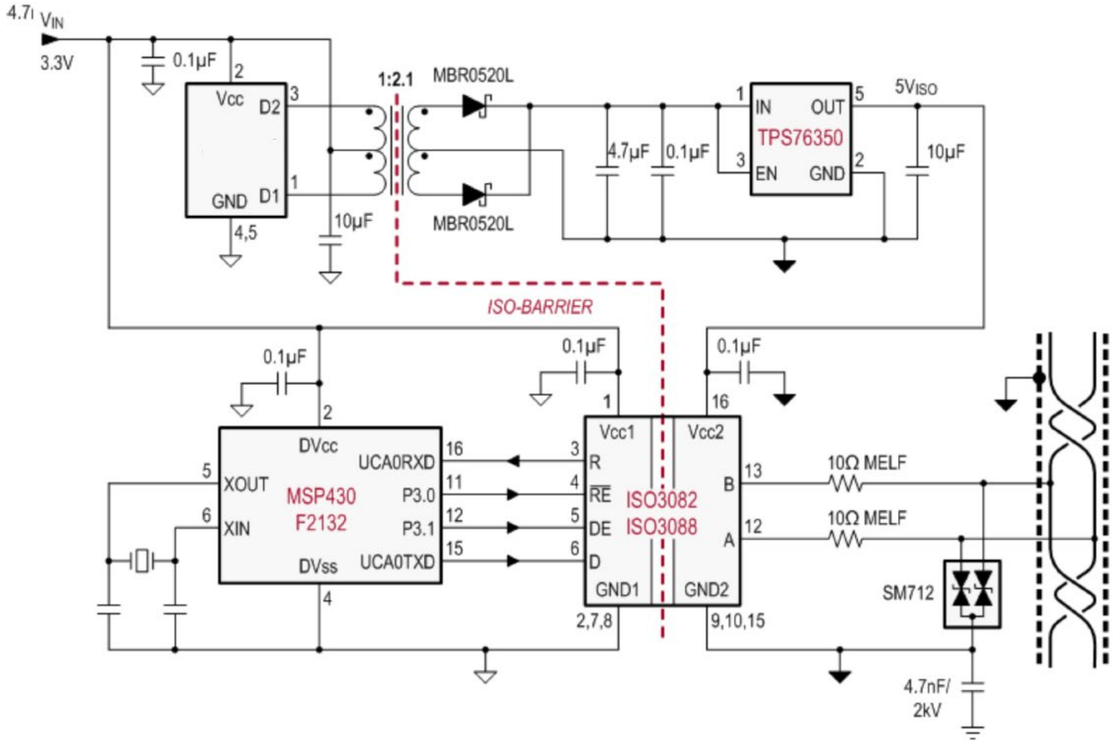

Figure 49. Isolated RS-485 Interface

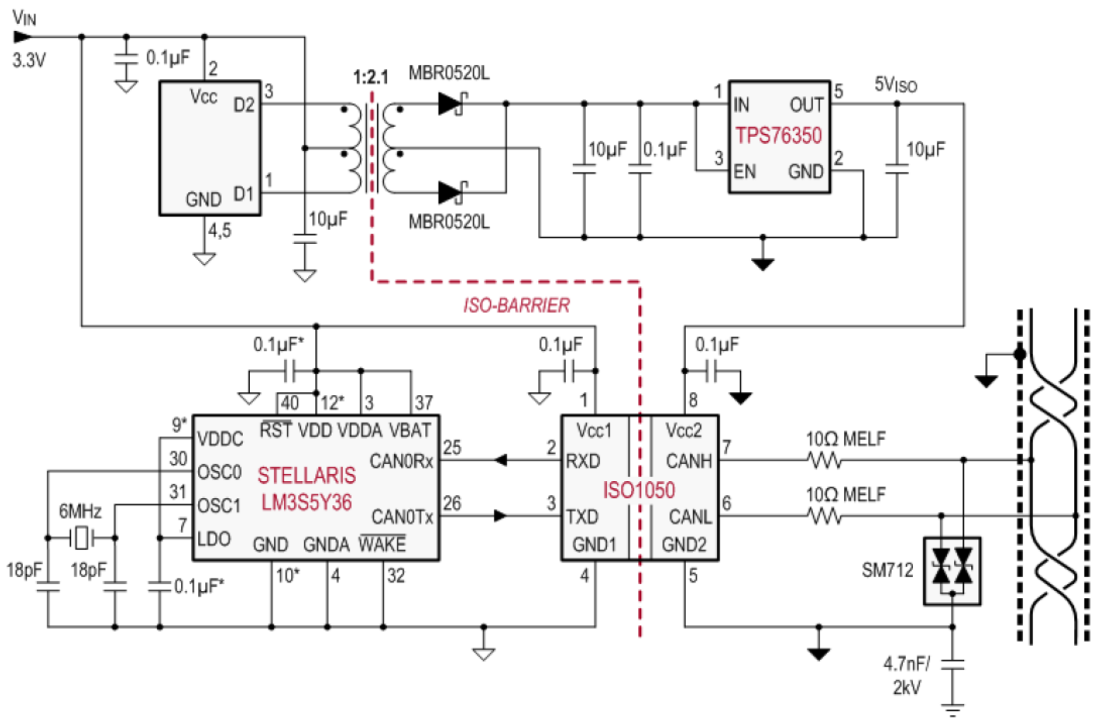

Figure 50. Isolated Can Interface

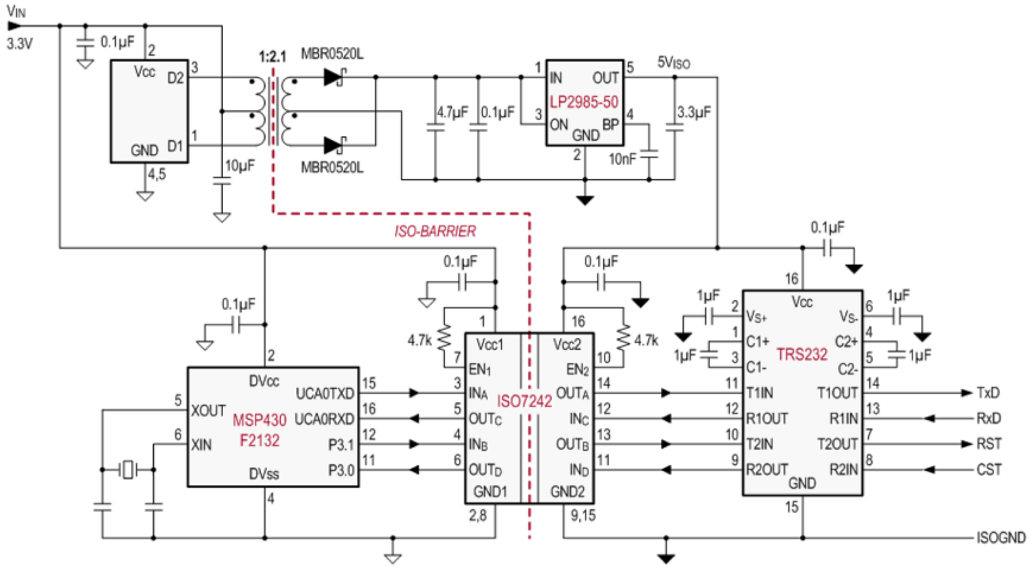

Figure 51. Isolated RS-232 Interface

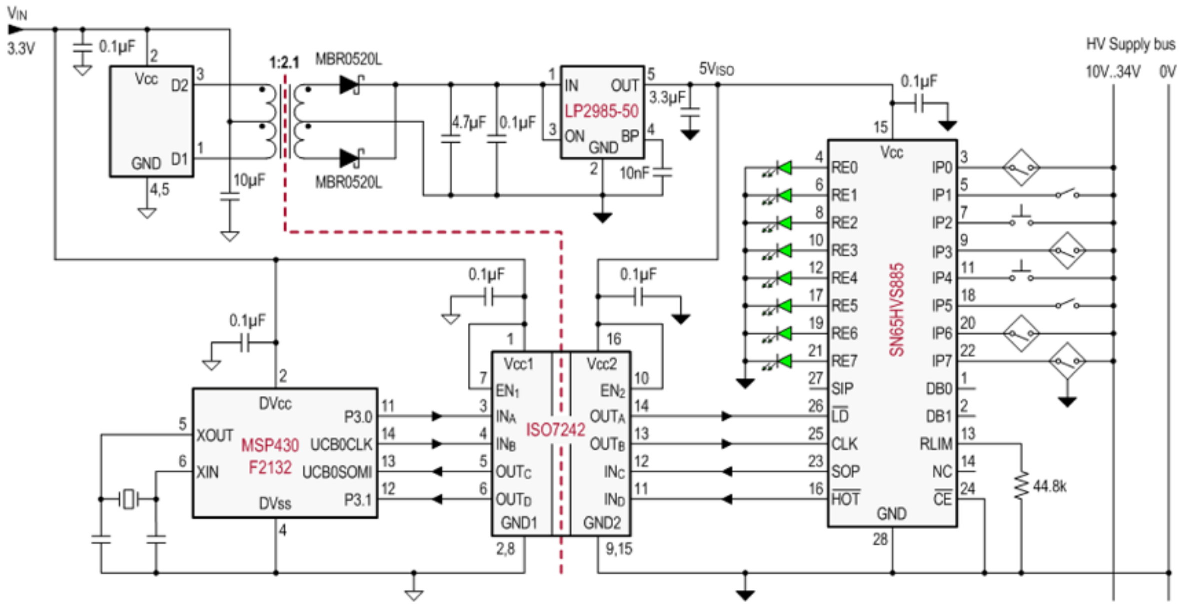

Figure 52. Isolated Digital Input Module

9. POWER SUPPLY RECOMMENDATIONS

The device is designed to operate from an input voltage supply range between 3.3V and 5V nominal. This input supply must be regulated within ±10%. If the input supply is located more than a few inches from the IS801, a 0.1µF bypass capacitor should be connected as possible to the device V_{CC} pin, and a 10µF capacitor should be connected close to the transformer center-tap pin.

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10. LAYOUT

10.1 LAYOUT GUIDELINES

- The V_{IN} pin must be buffered to ground with a low-ESR ceramic bypass-capacitor. The recommended capacitor value can range from 1μF to 10μF. The capacitor must have a voltage rating of 10V minimum and a X5R or X7R dielectric.
- The optimum placement is closest to the V_{IN} and GND pins at the board entrance to minimize the loop area formed by the bypass-capacitor connection, the V_{IN} terminal, and the GND pin. See Figure 53 for a PCB layout example.
- The connections between the device D1 and D2 pins and the transformer primary endings, and the connection of the device V_{CC} pin and the transformer center-tap must be as close as possible for minimum trace inductance.
- The connection of the device V_{CC} pin and the transformer center-tap must be buffered to ground with a low-ESR ceramic bypass-capacitor. The recommended capacitor value can range from 1μF to 10μF. The capacitor must have a voltage rating of 16V minimum and a X5R or X7R dielectric.
- The device GND pins must be tied to the PCB ground plane using two vias for minimum inductance.
- The ground connections of the capacitors and the ground plane should use two vias for minimum inductance.
- The rectifier diodes should be Schottky diodes with low forward voltage in the 10mA to 100mA current range to maximize efficiency.
- The V_{OUT} pin must be buffered to ISO-Ground with a low-ESR ceramic bypass-capacitor. The recommended capacitor value can range from 1μF to 10μF. The capacitor must have a voltage rating of 16V minimum and a X5R or X7R dielectric.

10.2 LAYOUT EXAMPLE

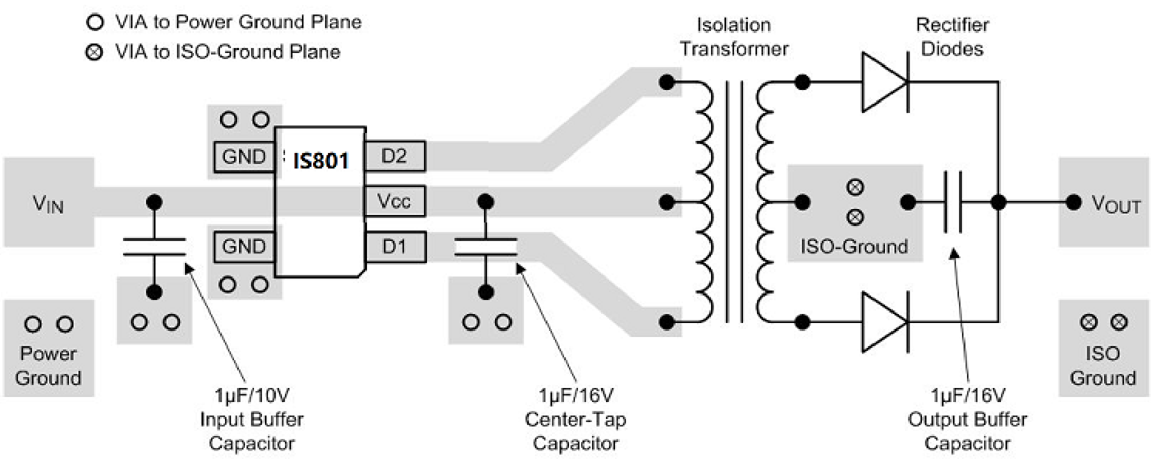


Figure 53. Layout Example of a 2-Layer Board (IS801)

11. PACKAGE INFORMATION

Figure 54 shows the SOT23-5 package view.

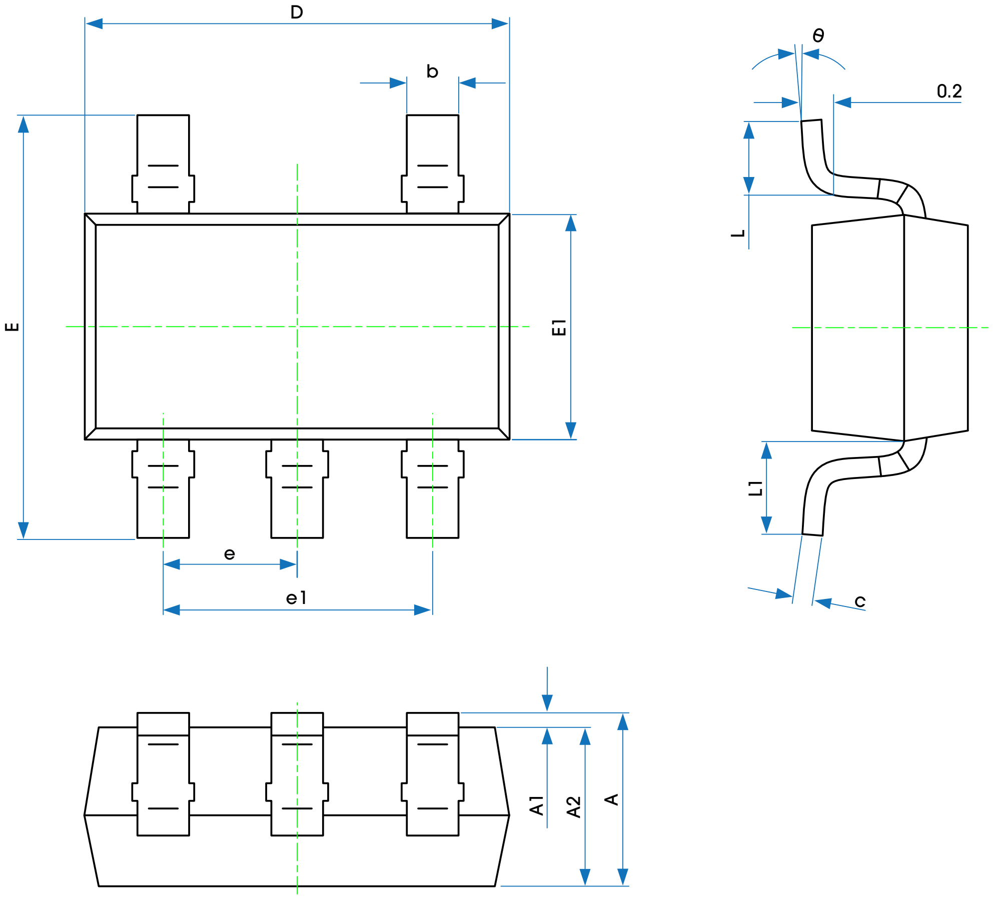


Figure 54. SOT23-5 Package View

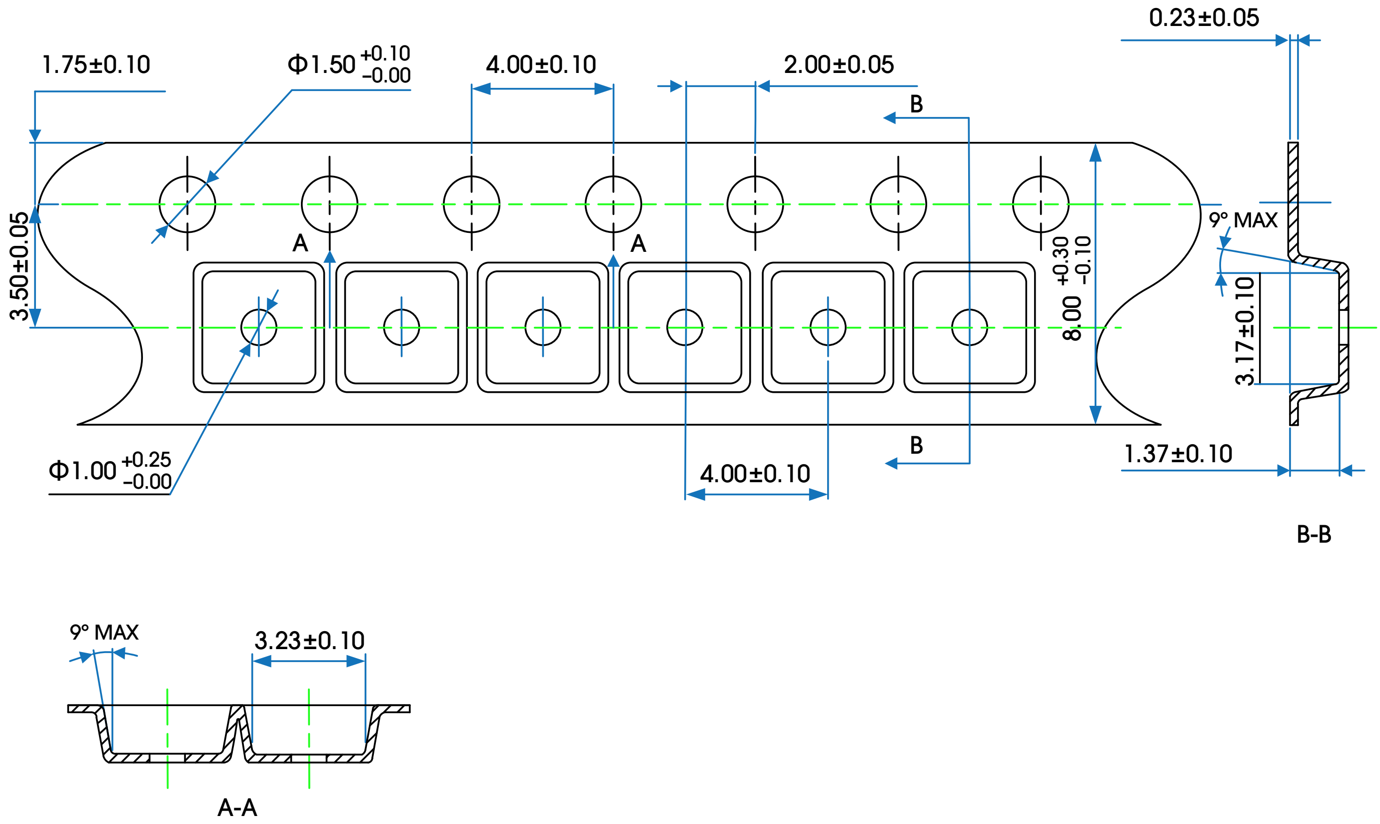
Table 14 provides detailed information about the dimensions of the SOT23-5 package.

Table 13. Dimensions of the SOT23-5 Package

SYMBOL	DIMENSIONS IN MILLIMETERS		DIMENSIONS IN INCHES	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	2.650	2.950	0.104	0.116
E1	1.500	1.700	0.059	0.067
e	0.950 (BSC)		0.037 (BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
L1	0.600 REF.		0.024 REF.	
θ	0°	8°	0°	8°

12. TAPE AND REEL INFORMATION

Figure 55 illustrates the carrier tape.



Notes:
1. Cover tape width: 5.50 ± 0.10.
2. Cumulative tolerance of 10 sprocket hole pitch: ±0.20 (max).
3. Camber: not to exceed 2mm in 250mm.
4. Mold#: SOT23-5.
5. All dimensions: mm.
6. Direction of view:

Figure 55. Carrier Tape Drawing

Table 15 provides information about tape and reel.

Table 14. Tape and Reel Information

PACKAGE TYPE	REEL	QTY/REEL	REEL/ INNER BOX	INNER BOX/ CARTON	QTY/CARTON	INNER BOX SIZE (MM)	CARTON SIZE (MM)
SOT23-5	7''	3000	10	4	120000	210*208*203	440*440*230

Figure 56 shows the product loading orientation—pin 1 is assigned on the lower left corner.

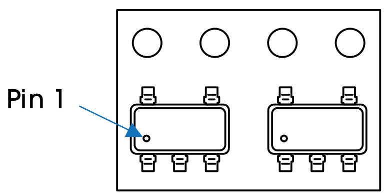


Figure 56. Product Loading Orientation

REVISION HISTORY

REVISION	DATE	DESCRIPTION
Rel 0.1	05 January 2022	DRAFT.
Rel 0.8	20 January 2022	1. Updated Table 3. 2. Updated Table 5. 3. Updated Table 7. 4. Updated Table 8.
Rel 1.0	21 January 2022	1. Updated Table 3. 2. Updated Table 5. 3. Updated Table 7.
Rel 1.1	07 May 2022	1. Updated the FEATURES and DESCRIPTION section. 2. Updated the diagram in Page 1. 3. Updated the order information. 4. Updated Table 5, Table 7, and Table 8. 5. Updated Section 5.7. 6. Removed Section 5.11. 7. Updated Section 7, Section 8.1, Section 8.2.2. 8. Updated the package and tape & reel information.