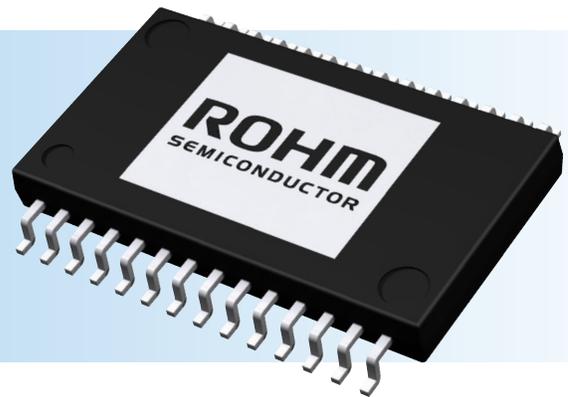




Innovations Embedded

Gate Drivers



Selection Guide

Overview

Selecting a Gate Driver requires consideration of a number of factors. This guide will attempt to present the various options somewhat in order of importance, since for example if the driver does not meet the isolation voltage requirements it will not matter what temperature range it covers, or if it doesn't meet the temperature range needed it won't matter what level of output current can be delivered and so forth.

The 'Isolated DC / DC Power Supply' is responsible for providing the secondary voltage(s) used to drive the gate of the MOSFET. The isolation voltage rating of this supply needs to be appropriate for the application. In addition, it should have very low capacitance from primary to secondary. The power needed for this supply is dependent on the operating frequency of the Gate Driver and the input capacitance of the

MOSFET. For a single MOSFET as shown below anything over 1.5 W is sufficient. However, when driving a Power Module (such as the BSM120D12P2C005) at 100 kHz approximately 3W is needed. If you decide to use an 'off-the-shelf' supply choose one with low-capacitance between primary and secondary. Some manufacturers offer DC / DC converters made specifically for Gate Drive applications.

For those waiting to build their own isolated supply, ROHM offers Gate Drivers with built-in controllers (BM60051FV, 52FV, 54FV) and a Power Supply IC with integrated MOSFET (BD7F100HFN) which may be helpful. The isolation transformer needs to have low capacitance between primary and secondary (5 pF or so). Also keep in mind that agency approvals of a custom isolation transformer may take months.

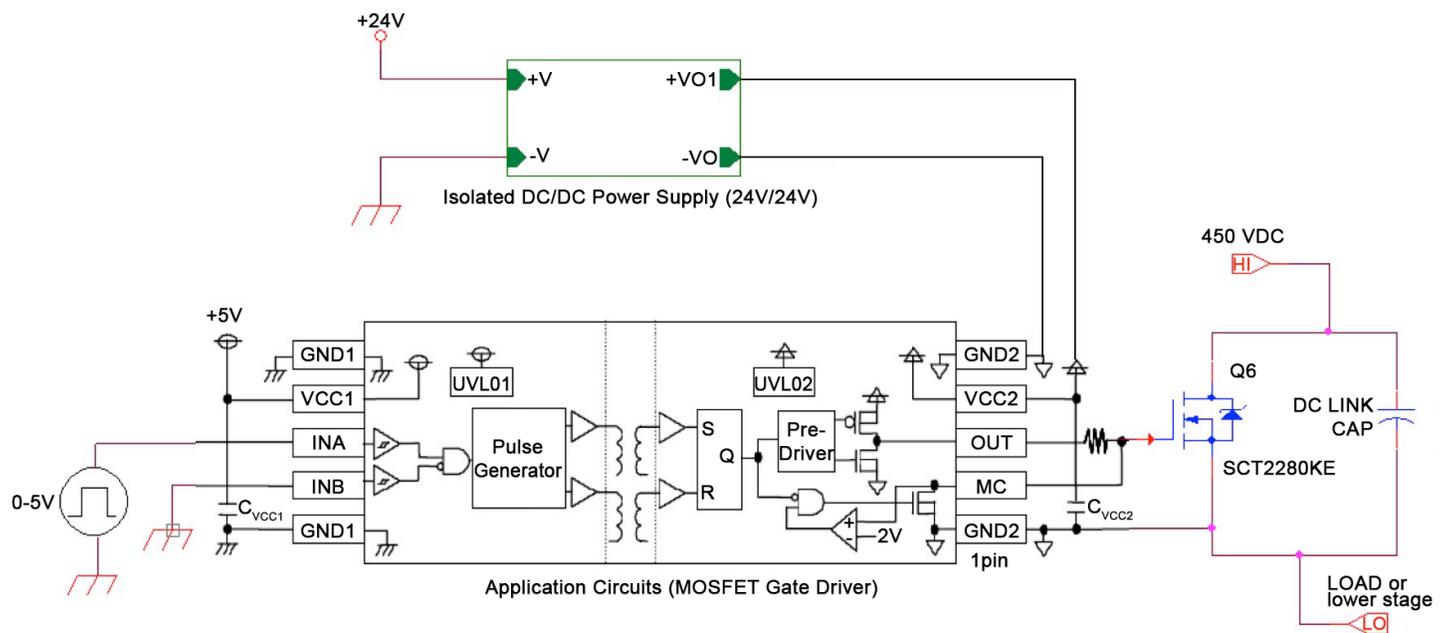


Figure 1. Typical Gate Driver (BM60015FV) and Support Circuitry

Key Gate Driver Characteristics:

Isolation Voltage:

At the present time ROHM Gate Drivers are available in 2500 Vrms or 3750 Vrms ratings. What this means is that the devices **have been tested in accordance with UL 1577** at either 2500 Vrms or 3750 Vrms for 60 seconds without failure. The insulation system is classified as BASIC INSULATION, recognized under UL File Number E181974.

100% of production parts rated at 2500 Vrms are **tested at 3000 Vrms** for 1 second. 100% of production parts rated for 3750 Vrms are **tested at 4500 Vrms** for 1 second.

Creepage and Clearance:

Creepage is defined as the shortest distance along the surface of the insulating material between two conductive surfaces. For ROHM parts rated at 2500 Vrms the creepage distance is 6.2 mm. For parts rated at 3750 Vrms the creepage distance is 8.2 mm. Clearance distance will normally be the same as creepage unless something in the PCB layout is compromised. Dirty environments require more creepage.

The 'Working Voltage' between the primary side (left) and secondary side (right) is significantly less than the rated voltage. The allowable working voltage is highly dependent on the "Pollution Degree" of the environment, or in other words how dirty of an environment the product is expected to see. Figure 2 shows definitions in accordance with IEC 60664-1:

Pollution Degree Categories

- **Pollution Degree 1**
No pollution or only dry, non-conductive pollution occurs. The pollution has no effect.
- **Pollution Degree 2**
Normally only non-conductive pollution occurs, except that occasionally temporary conductivity caused by condensation can be expected.
- **Pollution Degree 3**
Conductive pollution or dry non-conductive pollution that becomes conductive due to condensation occurs.
- **Pollution Degree 4**
Persistent conductivity occurs due to conductive dust, rain, or snow.

* Source: IEC 60664-1, Ed. 1.2, Clause 2.5.1

Figure 2

As a general guideline (for clean environments categorized as Pollution Degrees 1 or 2) from DIN EN 60747-5-2, if the DC Link (DC Bus) voltage is expected to be 566 VDC or less 2500 Vrms rated parts can be used. And for DC Link voltages greater than 566 V but less than 891 V 3750 Vrms rated parts are recommended. Currently we cannot support applications with a DC Link voltage greater than 891 VDC.

Temperature Range:

Most ROHM Gate Drivers are rated for operation at ambient temperatures from -40°C to 125°C . A few (such as the BM6105FW and BM60015FV) are rated from -40°C to 105°C . The maximum junction temperature for all our Gate Drivers is $+150^{\circ}\text{C}$.

Output Current:

ROHM Gate Drivers provide peak output currents from 1A to 5A. The amount of current required is directly related to the required Gate Charge (Qg) and operating speed. Power Modules (with multiple devices inside) will almost certainly require adding a high current buffer stage following the Gate Driver. This is generally accomplished with a pair of bipolar transistors and a few resistors. A good article regarding gate charge information can be found [here](#).

Input-Output Delay Time:

All drivers regardless of isolation technology introduce some delay time from the logic input to the output. Ideally this delay is the same whether the device is turned ON or OFF. It is also good to have the delay remain constant over temperature. ROHM offers drivers with delays ranging from 90 nanoseconds to 350 nanoseconds. In general the highest operating frequencies are achieved in drivers with the smallest delay. The datasheet for each device specifies the delay and the minimum input pulse width that may be applied.

Temperature Monitor:

Several ROHM gate drivers integrate temperature monitoring. For example, the BM6101FV has a simple comparator circuit which is able to stop operation and send a "Fault" signal to the primary side, while the BM60051FV Driver includes circuitry which can be used with either 10k NTC Thermistors or diode temperature sensors, and a signal is fed back across the isolation barrier to the primary side as a pulse-width modulated signal. The pulse width is proportional to the measured temperature. Many IGBT Power modules also incorporate an internal temperature sensor fastened to the baseplate. Under certain IGBT failure modes the internal temperature sensors pins may come into contact with DC link voltages, making it necessary to isolate the sensor signal from the primary circuitry.

Miller Clamp:

Most power applications involve half-bridge, full-bridge, or three half-bridge topologies. When the upper transistor is switched ON the drain of the lower transistor experiences a very rapid dV/dT transition. Capacitance between the lower transistor's gate and drain tends to turn ON the lower device when it is supposed to be OFF. Likewise, when the upper transistor is switched OFF and the lower transistor is switched ON if the upper turns on the result can be catastrophic.

One way to prevent this from happening is by clamping the device's gate to source with a low impedance clamp (called a Miller Clamp). This can be achieved using a small external MOSFET. Some of ROHM's drivers such as the BM6105FW and BM60051FV series include a built-in MOSFET Miller Clamps pass current if a positive voltage tries to appear at the gate of the power device - when it is supposed to be off. The Miller Clamp can also be used with a negative gate supply, where it will shut off once the gate voltage is low enough.

Negative Power Supply:

Another way to guarantee that the Power MOSFET stays OFF in the presence of large noise is by using a negative voltage at the gate. Currently, ROHM's SiC MOSFETs can be used with -5V applied to the gate to guarantee they stay OFF when they are supposed to be OFF. Most of our drivers can accommodate a negative supply for this purpose. Other drivers include an application circuit showing how to effectively use a negative voltage with just a few external components.

Separated Output:

Sometimes customers may want to asymmetrically drive their power devices, mostly to achieve faster turn-off than turn-on in order to guarantee no "shoot-through". (Shoot-through is a condition where BOTH the upper and associated lower power device are turned on simultaneously). Some ROHM drivers bring out the positive-going and negative-going edges on separate pins. This makes it easy to use different value resistors to achieve different value turn-on and turn-off times. Simple drivers typically have a single output pin and require additional components to achieve this function.

Safety Features:

All ROHM Gate Drivers include Under Voltage Lockout (UVLO) detection for both the Primary and Secondary sides. This prevents activation of the Driver when either of the supply voltages are too low for proper operation. Our more advanced drivers feature a 'Fault Output' pin on the Primary side which can be detected by a microcontroller to give information about problems such as under voltage or over temperature conditions.

Fault Output:

Some drivers include a 'Fault Output' pin on the Primary side. This is an open-drain output pin which is driven LOW to indicate a problem. Depending on the features of the Driver you select, the pin may indicate an under-voltage lock out, an over temperature condition, or that the 'Short-Circuit Protection' function (SCP) has been activated. All error conditions share the same pin.

Output State Feed Back (OSFB):

This is also an open-drain output pin on the Primary side. During normal operation if input logic is set up to drive the gate of the Power MOSFET HIGH, but the gate is observed to be LOW, the OSFB pin will go LOW to indicate that there is a problem. Likewise, if logic inputs are set up to drive the gate LOW and the gate is observed to be HIGH the OSFB pin will go LOW to indicate a problem (the PROOUT bi-directional pin is used as an input to monitor the gate voltage).

Exclusive OR Inputs:

Some of our Gate Drivers include a feature to protect against a logic or microcontroller fault which would try to simultaneously turn on both the upper and lower power devices. This type of logic, called Exclusive-OR, is connected to the INA and INB input pins, which are normally at opposite logic levels. The gate will not be driven HIGH unless BOTH inputs are at the proper logic levels. However, this does require that both upper and lower device drive signals be wired to the upper and lower drivers.

Desat:

Some abnormal situations (such as a shorted motor winding) can cause so much current to flow that the power device will come out of saturation and be in danger of burning up. In order to prevent this, some drivers have a feature called Desat(uration) detection basically involves monitoring the voltage drop across the power device and turning the power OFF if the voltage drop exceeds a certain value when the device is ON, preventing excessive current flow.

If the device is turned OFF at normal speed a larger than normal current may produce a dangerous voltage spike, which is likely to destroy the power device. Therefore, a gentler turn-off is required. Soft turn off is achieved by using the PROOUT pin as an output to drive the gate, through a resistor with significantly higher resistance than a normal gate drive resistor. This will result in an exponentially decaying gate drive voltage, which will gently turn off the power device preventing damage from an overshoot spike on the drain.

Flyback Controller:

The BM6005xV family includes a built-in flyback controller that makes it easier to configure an isolated power supply. All that's required is an external power device (typically a MOSFET) an isolation transformer, and a handful of resistors and capacitors.

Product Lineups

These product tables can be used to quickly evaluate and search for the required characteristics. 'Simple Drivers' are those that provide only a 'one way' transfer of information from primary side to secondary side. They do not offer a 'Fault' output for monitoring secondary side failures.

Simple Drivers

Part No.	Standard				Features					
	AEQ-100	UL1577 (Basic ISO)	UL1577 (Double ISO)	VDE0884-10 (Reinforced ISO)	No. of Channels	Package	Isolation [kVrms]	Delay Time [ns] (max)	Miller Clamp	Negative Power Supply
BM60014FV-C	✓	✓	—	—	1ch	SSOP-B20W	2.5	120	I	—
BM60015FV-LB	—	—	P	P	1ch	SSOP-B10W	3.75	75	I	—
BM60016FV-C	✓	TBD	TBD	—	1ch	SSOP-B10W	2.5	75	I	—
BM60210FV-C	✓	—	—	—	Half Bridge	SSOP-B20W	High: 1.2kVDC Low: Not Isolated	75	I	—

P: Pending | I: Integrated

Complex Drivers

Part No.	Standards		Features											
	AEQ-100	UL1577 (Basic ISO)	Package	Isolation [kVrms]	Delay Time [ns] (max)	Negative Power Supply	Miller Clamp	DESAT	Short Current	Temp S/M	Output State Feedback	RDY Output	Flyback Controller	Soft Turn OFF
BM6101FV-C	✓	✓	SSOP-B20W	2.5	350	✓	E	✓	✓	S	—	—	—	✓
BM6102FV-C	✓	✓	SSOP-B20W	2.5	200	—	E	✓	✓	S	—	—	—	✓
BM6104FV-C	✓	✓	SSOP-B20W	2.5	150	✓	E	✓	✓	—	✓	—	—	✓
BM6108FV-LB	—	—	SSOP-B20W	2.5	150	✓	E	✓	✓	—	✓	—	—	✓
BM6105FW-LB	—	P	SOP16WM	2.5	95	✓	I	✓	—	—	—	✓	—	—
BM60051FV-C	✓	✓	SSOP-B28W	2.5	260	—	I	—	✓	M	✓	—	✓	✓
BM60052FV-C	✓	✓	SSOP-B28W	2.5	110	✓	I	✓	—	S	✓	✓	✓	✓
BM60054FV-C	✓	✓	SSOP-B28W	2.5	110	✓	I	✓	✓	S	✓	✓	✓	✓

P: Pending | E: External Nch MOSFET | S: Shut down | M: Monitor output | I: Integrated

Selection Guide tables adapted from "Gate drivers for high power applications" by Daiki Yanagishima.



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