

Main Applications and Selection of Gate Driver Optocouplers



Application Note 1335

Introduction

IGBTs are now commonly used as switching components in both inverter and converter circuits used in power control and motor drive applications. A typical power control and motor drive system, as shown in Figure 1, requires isolation between the high voltage devices (IGBT/MOSFET) and the low voltage devices (micro-controller). In addition to meeting the severe requirements for the isolation function, Avago Technologies’ optocouplers provide customized functionality such as direct gate drive for IGBTs or power MOSFETs. This application note focuses on the use of Avago Technologies’ Gate Drive Optocouplers.

Advantages of Using Optocouplers as Gate Drivers for IGBT/MOSFET

- Low system solution cost
- High reliability and long life
- Variable speed/frequency capability
- Ease and simplicity of design
- Small size and footprint area
- Low power dissipation
- Safe optical isolation (galvanic isolation)
- Regulatory and safety agency approvals

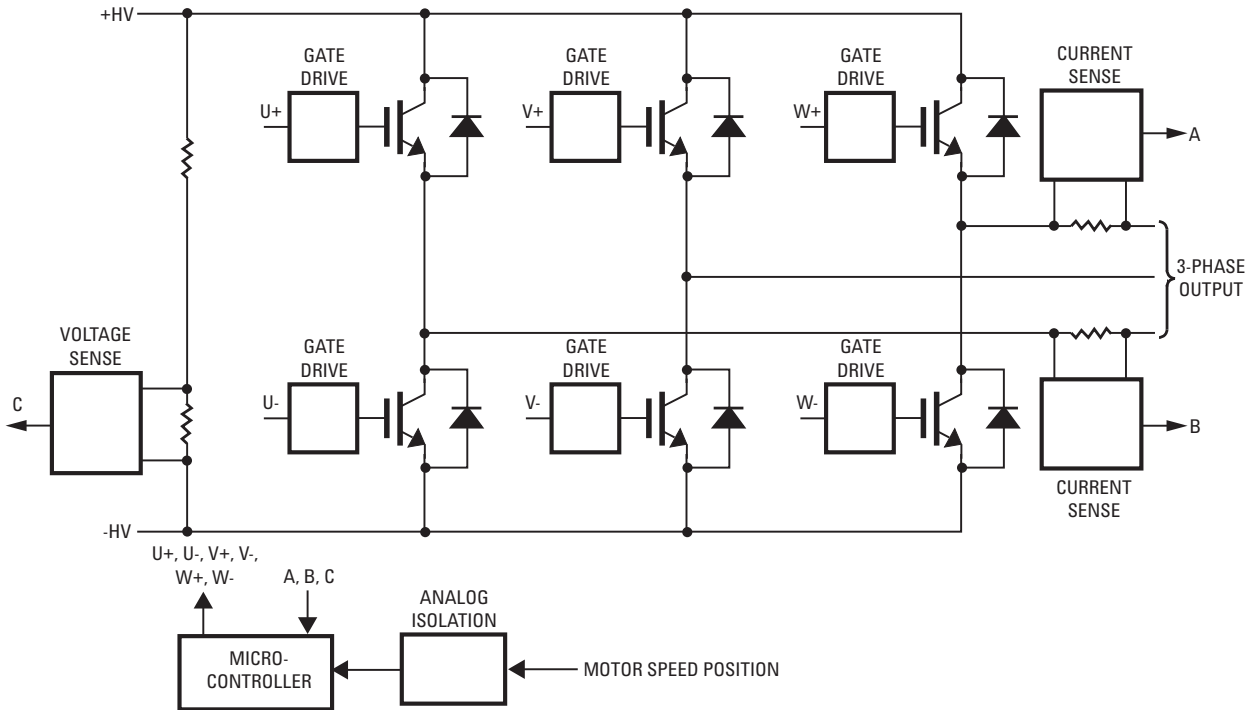


Figure 1. Isolation Circuits for Power Control – System Overview

Block Diagrams of Main Applications of Gate Drive Optocouplers

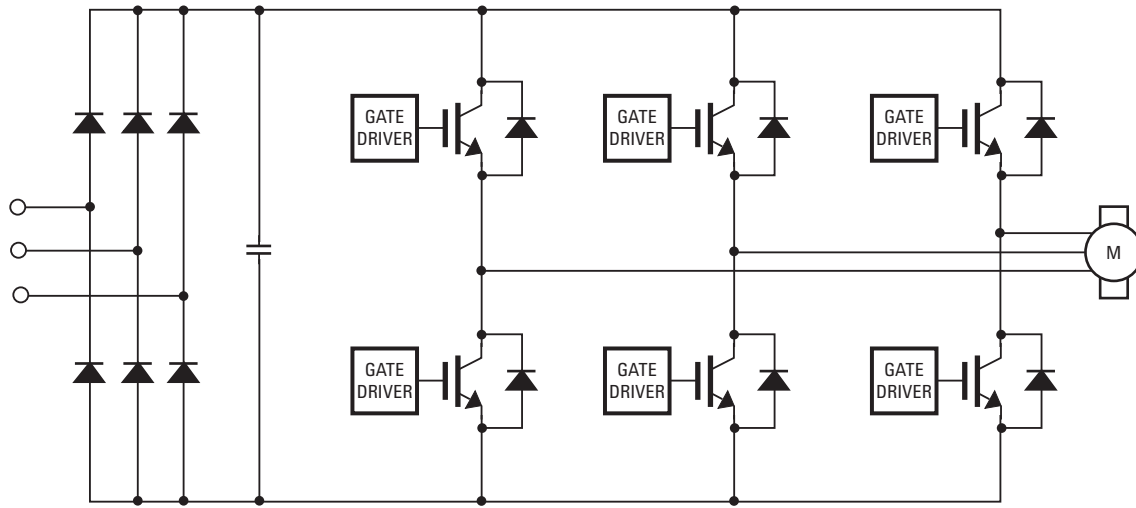


Figure 2. VVVF Inverter (PWM)

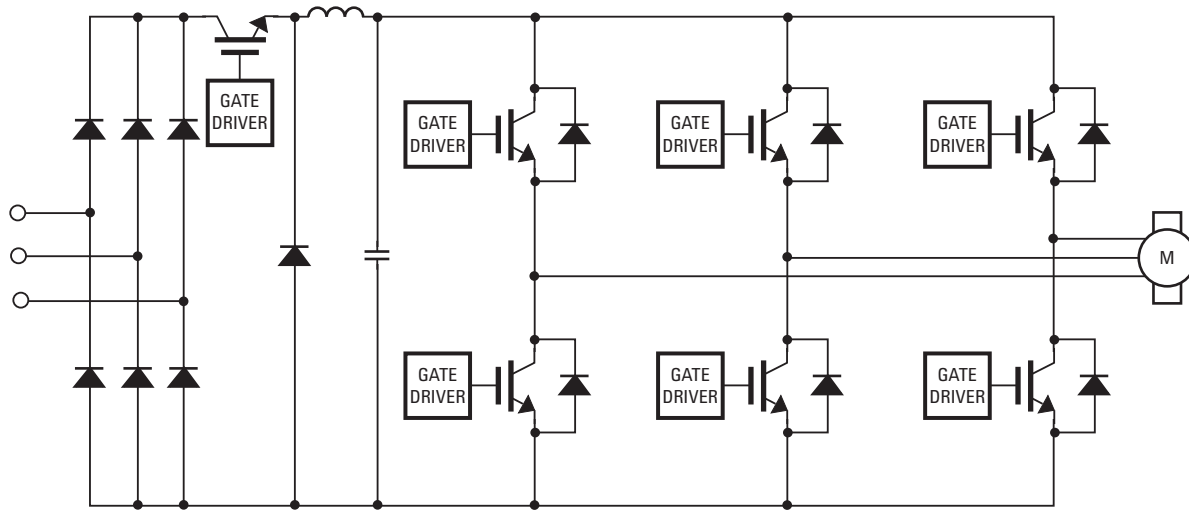


Figure 3. VVVF Inverter (PAM)

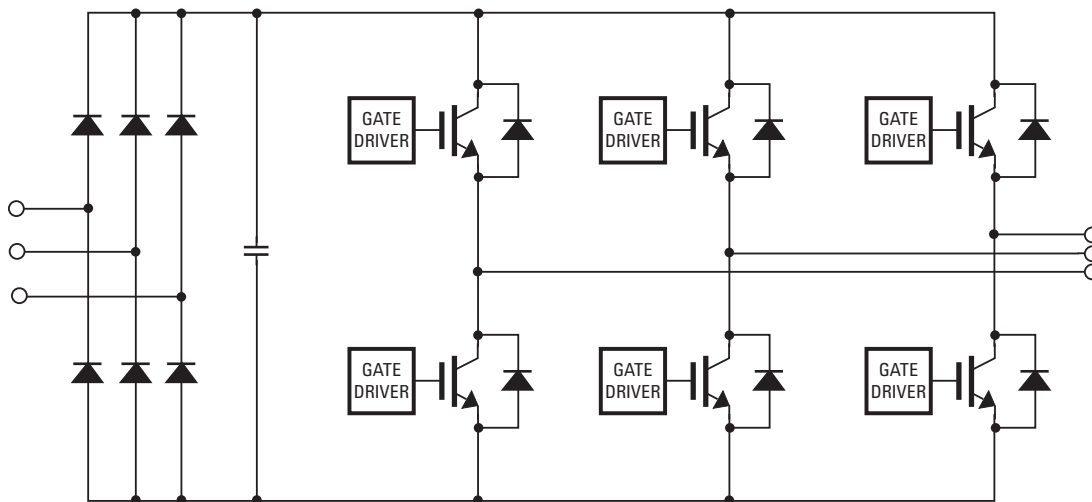


Figure 4. CVCF Inverter (UPS)

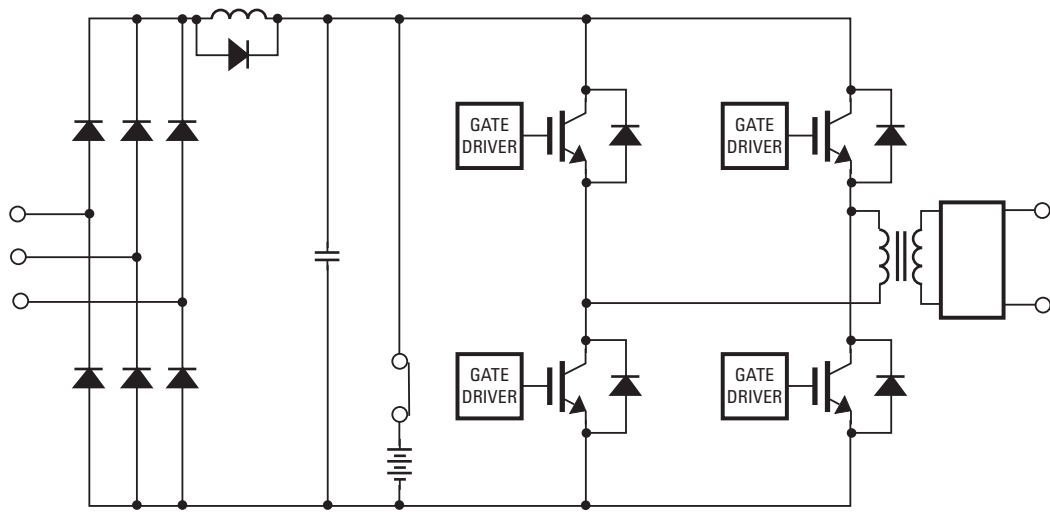


Figure 5. Low Power CVCF Inverter (UPS)

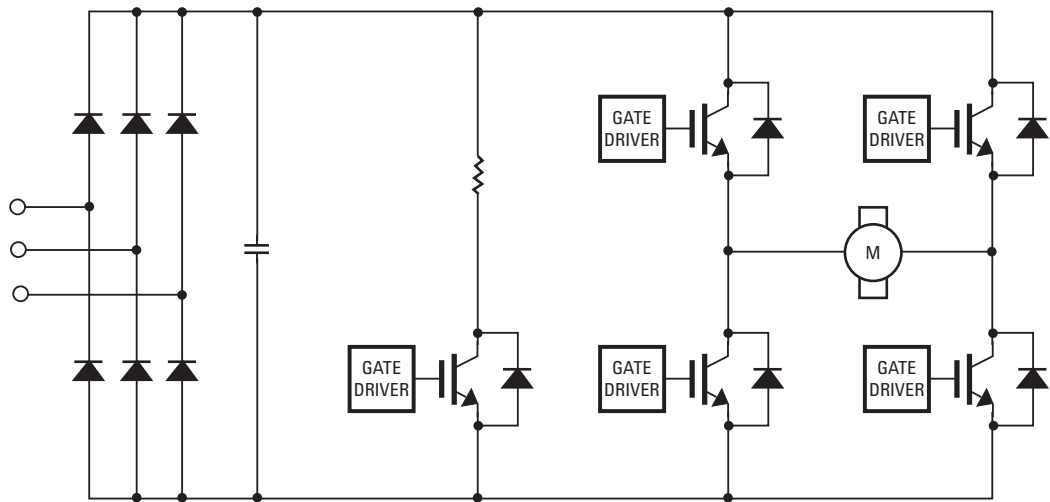


Figure 6. DC Servo

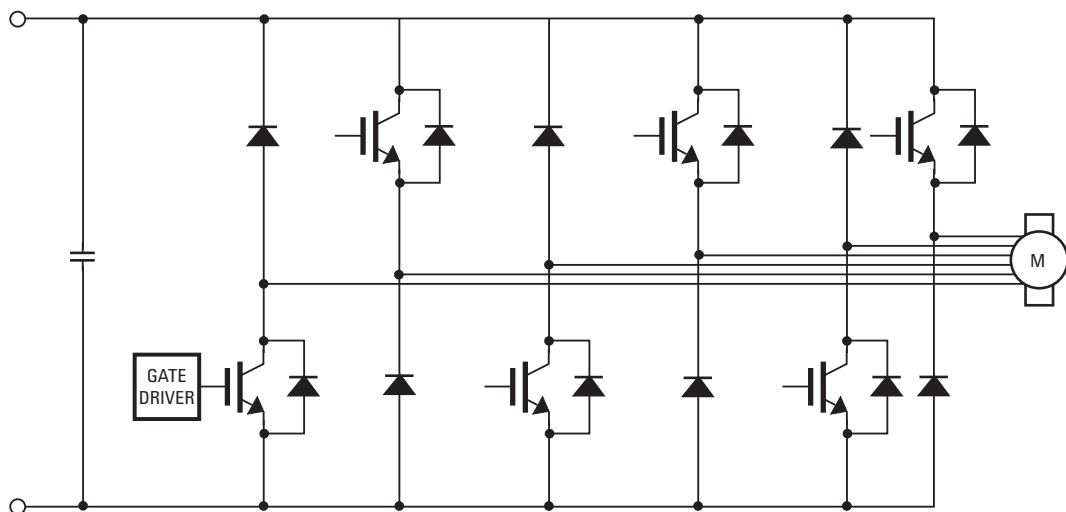


Figure 7. Switched Reluctance Drive

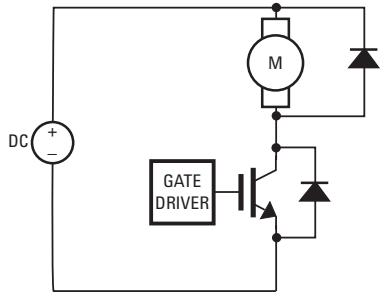


Figure 8. DC Chopper

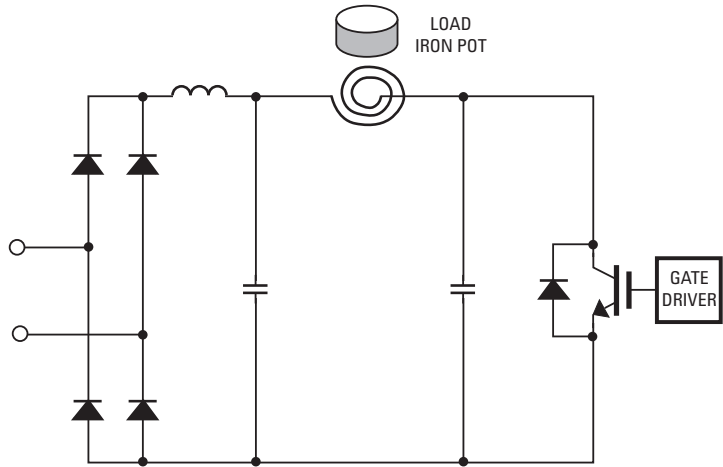


Figure 9. Induction Cooker

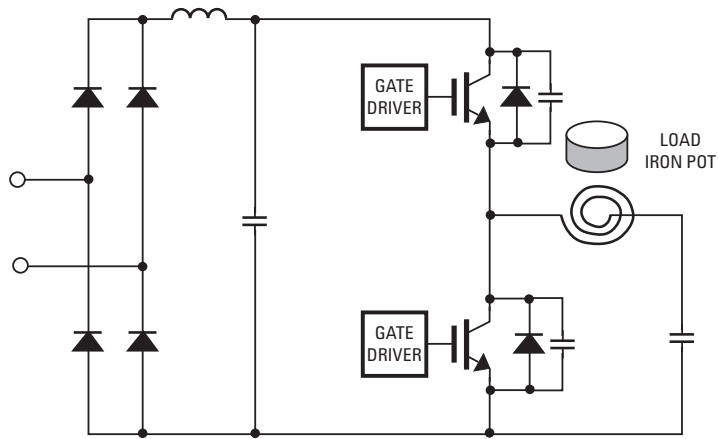


Figure 10. Series Resonant Induction Cooker

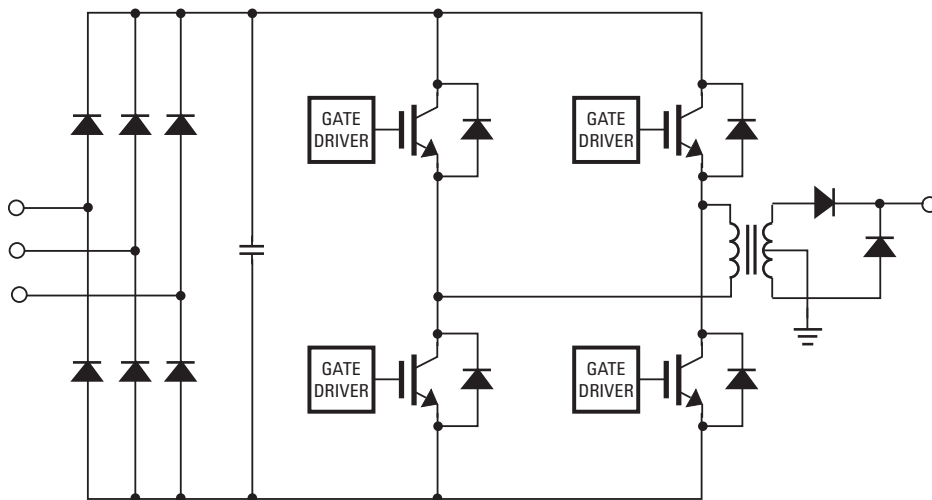


Figure 11. Welder

Calculation of Minimum Output Current (I_{OL}) to Drive IGBT / MOSFET

The key requirement for any IGBT/ MOSFET gate drive optocoupler is for it to supply the Minimum Output Current (I_{OL}) needed to switch the IGBT/MOSFET to the low-impedance state. A common misunderstanding in selecting a gate drive optocoupler is looking at the Maximum Peak Output Currents [$I_{OH(PEAK)}/I_{OL(PEAK)}$] in the Absolute Maximum Rating Section of the data sheet. Though Maximum Peak Output Currents are no less important, they are meant to define the maximum permissible operational condition that could result in the destruction of the device, if exceeded.

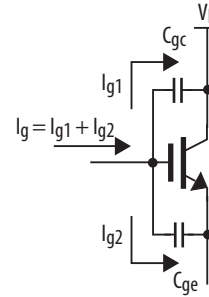
To determine the suitability of a gate drive optocoupler, it is necessary to look at the Minimum Output Currents (I_{OH} / I_{OL}) of the gate drive optocoupler in the Electrical Specifications Section of the data sheet. Particularly important, the I_{OL} needs to be specified at the condition when V_O is low, that is when the gate drive optocoupler is at the charging state. This is because under this condition the load draws the highest output current. Avago Technologies specifies I_{OL} at $V_O = V_{CC} - 10V$. Similarly for I_{OH} , it is important to specify the condition when V_O is high, that is when the gate drive optocoupler is discharging. Avago Technologies specifies I_{OH} at $V_O = V_{EE} + 10V$.

This Minimum Output Current (I_{OL}) required to switch IGBT/ MOSFET to the low-impedance state can be easily calculated using the gate capacitance charging equations. Gate capacitance of IGBT /MOSFET can be obtained from the data sheet. After calculating the Minimum Output Current required to drive the IGBT/ MOSFET, the suitable gate drive optocouplers can be selected from Avago Technologies' Gate Drive Optocoupler Selection Guide.

The gate capacitance of the IGBT / MOSFET determines how much current is required from the driver for basic switching:

$$V_{C(GE)} = \frac{1}{C_{ge}} \cdot \int_{\tau=0}^{\tau=t_{sw}} i_g(\tau) \cdot d\tau$$

$$V_{C(GE)} = \frac{1}{C_{ge}} \cdot I_g \cdot t_{sw}$$



$$I_{G1} = \frac{V_B \times C_{GC}}{t_{sw}}$$

$$I_{G2} = \frac{V_{C(GE)} \times C_{GE}}{t_{sw}}$$

where,

C_{gc} - gate-to-collector capacitor

C_{ge} - gate-to-emitter capacitor

$V_{C(GE)}$ - Voltage across gate-to-emitter capacitor

I_g - total gate current flows into gate

I_{g1} - gate current flows into C_{gc}

I_{g2} - gate current flows into C_{ge}

V_B - bus voltage

t_{sw} - switching time

Figure 11. IGBT / MOSFET Parasitic Capacitances (C_{ge} and C_{gc})

A gate resistor, R_g , must be selected such that the maximum peak output current rating, $I_{OL(PEAK)}$, is not exceeded,

$$R_g = \frac{V_{CC} - V_{EE} - V_{OL}}{I_{OLPEAK}}$$

where,

V_{CC} - Positive supply voltage of gate drive optocoupler

V_{EE} - Negative supply voltage of gate drive optocoupler

V_{OL} - Low level output voltage of gate drive optocoupler

$I_{OL(PEAK)}$ - Maximum peak output current of gate drive optocoupler

Other Key Parameters in Selecting a Gate Drive Optocoupler

Other key parameters in selecting a gate driver optocoupler are propagation delay and common mode rejection ratio. For typical motor control applications, high speed gate drive optocouplers with propagation delays, t_{PLH} , $t_{PHL} \leq 0.8 \mu s$ and common mode rejection ratio, $CMR \geq 10 \text{ kV} / \mu s @ V_{CM} = 1000 \text{ V}$ are recommended. Avago Technologies' gate drive optocouplers meet all these basic requirements.

Selection Guideline for IGBT Class and AC Motor Rating

Different sizes of IGBT need different gate drive optocouplers with different output driving currents. Tables 1 and 2 below list basic selection guides based on operating line voltage, IGBT ratings, AC motor power ratings, and the appropriate gate drive optocouplers.

References

1. Khan, J. N. "Optocouplers for Variable Speed Motor Control Electronics in Consumer Home Appliances." Avago Technologies' Publication Number 5980-1297 (5/00).

Table 1. Gate Drive Optocouplers Selection Guide for 220 Vac Operating Motor

IGBT V_{CES} (V)	IGBT I_C (A)	AC Motor Rating		Recommended Gate Drive Optocouplers
		kW	HP	
600 V	15	0.4	0.5	HCPL-0314/ 3140/J314/314J, HCPL-3150/ 315J
	20	1.5	2	HCPL-0314/ 3140/J314/314J, HCPL-3150/ 315J
	30	2.2	3	HCPL-0314/ 3140/J314/314J, HCPL-3150/ 315J
	50	3.7	5	HCPL-0314/ 3140/J314/314J, HCPL-3150/ 315J
	75	7.5	10	HCPL-0314/ 3140/J314/ 314J, HCPL-3150/ 315J
	100	11	15	HCPL-3120/J312, HCNW3120, HCPL-316J
	150	15	20	HCPL-3120/J312, HCNW3120, HCPL-316J
	200	22	30	HCPL-3120/J312, HCNW3120, HCPL-316J
	300	30	40	HCPL-3120/J312, HCNW3120, HCPL-316J
	400	45	60	Gate Drive Optocoupler + Buffer
	600	55	75	Gate Drive Optocoupler + Buffer

Note: The actual application depends on ventilation, power dissipation, heat sinking and other applications conditions.

V_{CES} - Collector-Emitter Breakdown Voltage

I_C - Collector Current

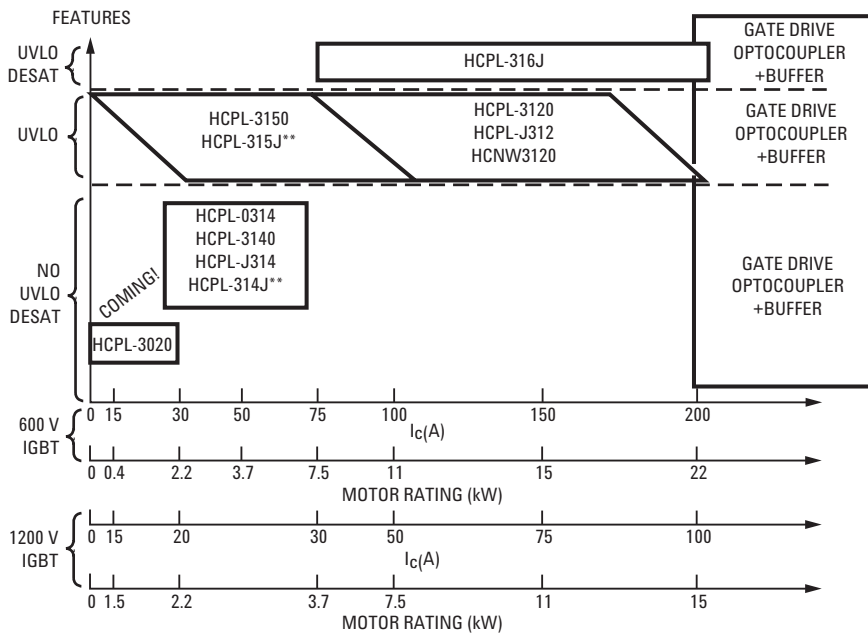
Table 2. Gate Drive Optocouplers Selection Guide for 440 Vac Operating Motor

IGBT V_{CES} (V)	IGBT I_C (A)	AC Motor Rating		Recommended Gate Drive Optocouplers
		kW	HP	
1200 V	15	1.5	2	HCPL-0314/ 3140/ J314/ 314J, HCPL-3150 /315J
	20	2.2	3	HCPL-0314/ 3140/ J314/ 314J, HCPL-3150 /315J
	30	3.7	5	HCPL-0314/ 3140/ J314/ 314J, HCPL-3150 /315J
	50	7.5	10	HCPL-3120/ J312, HCNW3120, HCPL-316J
	75	11	15	HCPL-3120/ J312, HCNW3120, HCPL-316J
	100	15	20	HCPL-3120/ J312, HCNW3120, HCPL-316J
	150	22	30	Gate Drive Optocoupler + Buffer
	200	37	50	Gate Drive Optocoupler + Buffer
	300	55	75	Gate Drive Optocoupler + Buffer
	400	75	100	Gate Drive Optocoupler + Buffer
	600	110	150	Gate Drive Optocoupler + Buffer

Note: The actual application depends on ventilation, power dissipation, heat sinking and other applications conditions.

V_{CES} - Collector-Emitter Breakdown Voltage

I_C - Collector Current



* ESTIMATION, ACTUAL APPLICATION DEPENDS ON VENTILATION, HEAT SINKING AND OTHER APPLICATION CONDITIONS.

** INDICATE DUAL CHANNEL DEVICE.

Figure 13. Driving Capability of Gate Drive Optocouplers

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