

### Hybrid Integrated Circuit For Driving IGBT Modules

#### Description:

M57962K is a hybrid integrated circuit designed to provide optimum gate drive for IGBT modules. This device provides high current optically isolated gate drive with a large output voltage swing. The driver also provides short circuit protection based on desaturation detection.

#### Features:

- Electrical Isolation between input and output with opto-couplers. ( $V_{iso} = 3750V_{RMS}$  for 1 min.)
- Two supply drive topology
- Built in short circuit protection circuit with a pin for fault output
- TTL compatible input interface

#### Application:

To drive IGBT modules for general industrial use apparatus.

#### Recommended Modules:

V<sub>CES</sub> = 600V Series  
(up to 600A Class)

V<sub>CES</sub> = 1200V Series  
(up to 400A Class)

V<sub>CES</sub> = 1700V Series  
(up to 400A Class)

**M57962K**  
Hybrid IC for IGBT Gate Driver

**Absolute Maximum Ratings,  $T_a = 25^\circ\text{C}$  unless otherwise specified**

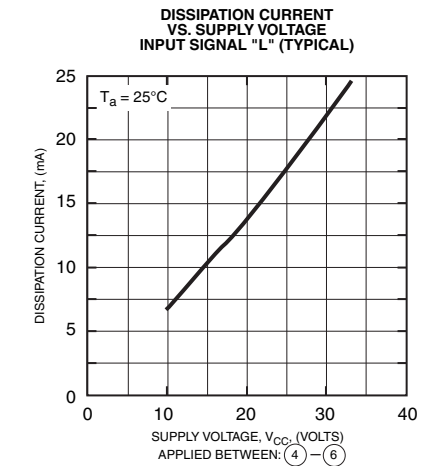
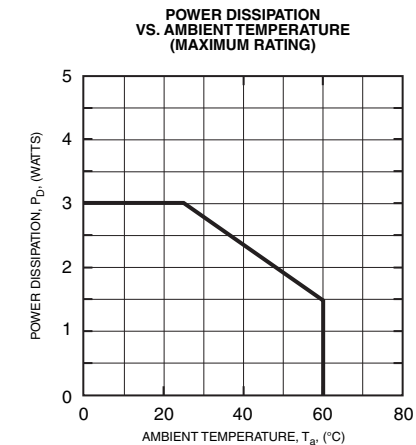
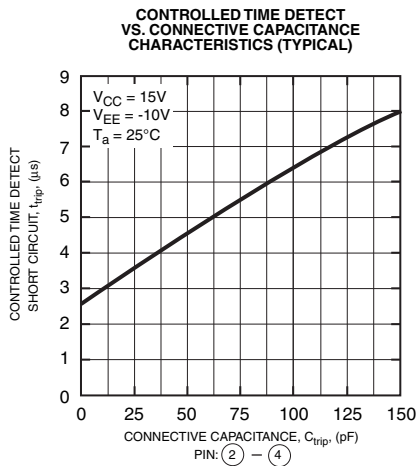
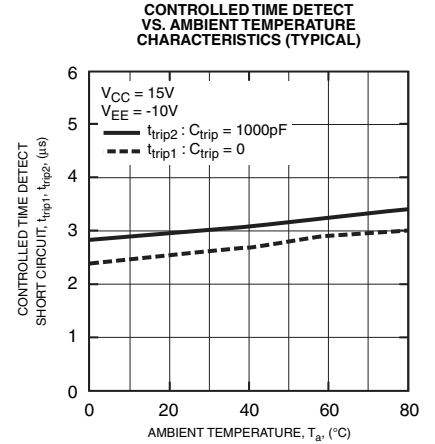
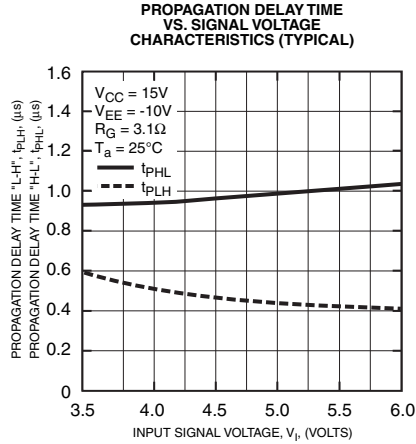
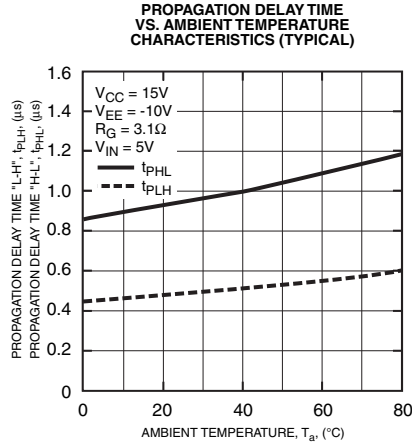
| Item                  | Symbol    | Test Conditions   | Limit     | Units            |
|-----------------------|-----------|---|-----------|------------------|
| Supply Voltage        | $V_{CC}$  | DC  | 18        | Volts            |
|                       | $V_{EE}$  | DC  | -15       | Volts            |
| Input Voltage         | $V_I$     | Applied between: (13) – (14)<br>50% Duty Cycle, Pulse Width 1ms | -1 ~ 7    | Volts            |
| Output Voltage        | $V_O$     | Output Voltage "H"  | $V_{CC}$  | Volts            |
| Output Current        | $I_{OHP}$ | Pulse Width 2 $\mu$ s, $f \leq 20\text{kHz}$                    | -5        | Amperes          |
|                       | $I_{OLP}$ | Pulse Width 2 $\mu$ s, $f \leq 20\text{kHz}$                    | 5         | Amperes          |
| Isolation Voltage     | $V_{iso}$ | Sinewave Voltage 60Hz, 1 min.                                   | 3750      | $V_{RMS}$        |
| Case Temperature      | $T_c$     |   | 85        | $^\circ\text{C}$ |
| Operating Temperature | $T_{opr}$ | No Condensation Allowable                                       | -20 ~ 60  | $^\circ\text{C}$ |
| Storage Temperature   | $t_{stg}$ | No Condensation Allowable                                       | -25 ~ 100 | $^\circ\text{C}$ |
| Fault Output Current  | $I_{FO}$  | Applied Pin (8)   | 20        | mA               |
| Input Voltage         | $V_{R1}$  | Applied Pin (1)   | 50        | Volts            |

**Electrical Characteristics,  $T_a = 25^\circ\text{C}$ ,  $V_{CC} = 15\text{V}$ ,  $V_{EE} = -10\text{V}$  unless otherwise specified**

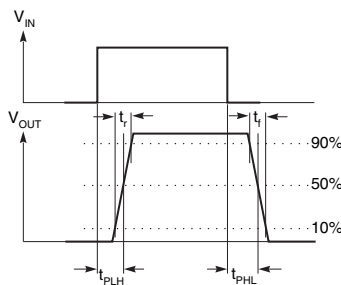
| Characteristics                         | Symbol      | Test Conditions  | Min. | Typ. | Max. | Units         |
|---|-------------|--|------|------|------|---------------|
| Supply Voltage                          | $V_{CC}$    | Recommended Range  | 14   | 15   | —    | Volts         |
|   | $V_{EE}$    | Recommended Range  | -7   | —    | -10  | Volts         |
| Pull-up Voltage on Input Side           | $V_{IN}$    | Recommended Range  | 4.75 | 5.00 | 5.25 | Volts         |
| "H" Input Current                       | $I_{IH}$    | Recommended Range  | 15.2 | 16   | 19   | mA            |
| Switching Frequency                     | $f$         | Recommended Range  | —    | —    | 20   | kHz           |
| Gate Resistance                         | $R_G$       | Recommended Range  | 2    | —    | —    | $\Omega$      |
| "H" Input Current                       | $I_{IH}$    | $V_{IN} = 5\text{V}$   | —    | 16   | —    | mA            |
| "H" Output Voltage                      | $V_{OH}$    |  | 13   | 14   | —    | Volts         |
| "L" Output Voltage                      | $V_{OL}$    |  | -8   | -9   | —    | Volts         |
| "L-H" Propagation Time                  | $t_{PLH}$   | $I_{IH} = 16\text{mA}$   | —    | 0.5  | 1.0  | $\mu\text{s}$ |
| "L-H" Rise Time                         | $t_r$       | $I_{IH} = 16\text{mA}$   | —    | 0.3  | 1.0  | $\mu\text{s}$ |
| "H-L" Propagation Time                  | $t_{PHL}$   | $I_{IH} = 16\text{mA}$   | —    | 1.0  | 1.3  | $\mu\text{s}$ |
| "H-L" Fall Time                         | $t_f$       | $I_{IH} = 16\text{mA}$   | —    | 0.3  | 1.0  | $\mu\text{s}$ |
| Timer                                   | $t_{timer}$ | Between start and cancel<br>(under input sign "L")                     | 1.0  | —    | 2.0  | ms            |
| Fault Output Current                    | $I_{FO}$    | Applied (8) pin, $R = 4.7\text{k}\Omega$                               | —    | 5.0  | —    | mA            |
| Controlled Time Detect Short Circuit 1  | $t_{trip1}$ | Pin (1): 15V and more, Pin (2): Open                                   | —    | 2.6  | —    | $\mu\text{s}$ |
| Controlled Time Detect Short Circuit 2* | $t_{trip2}$ | Pin (1): 15V and more,<br>Pin (2) – (4): 10pF (Connective Capacitance) | —    | 3.0  | —    | $\mu\text{s}$ |
| SC Detect Voltage                       | $V_{SC}$    | Collector Voltage of Module  | 15   | —    | —    | Volts         |

\*Length of wiring of condenser controlled time detect short circuit is within 5cm from (2) and (4) pin coming and going.

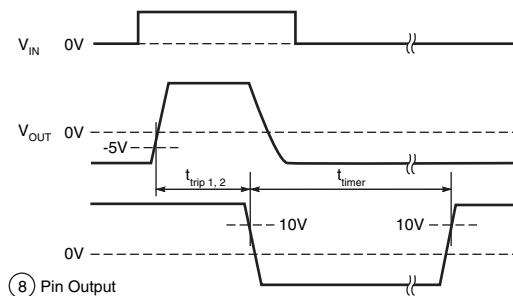
**M57962K**  
Hybrid IC for IGBT Gate Driver



## Switching Time Definitions

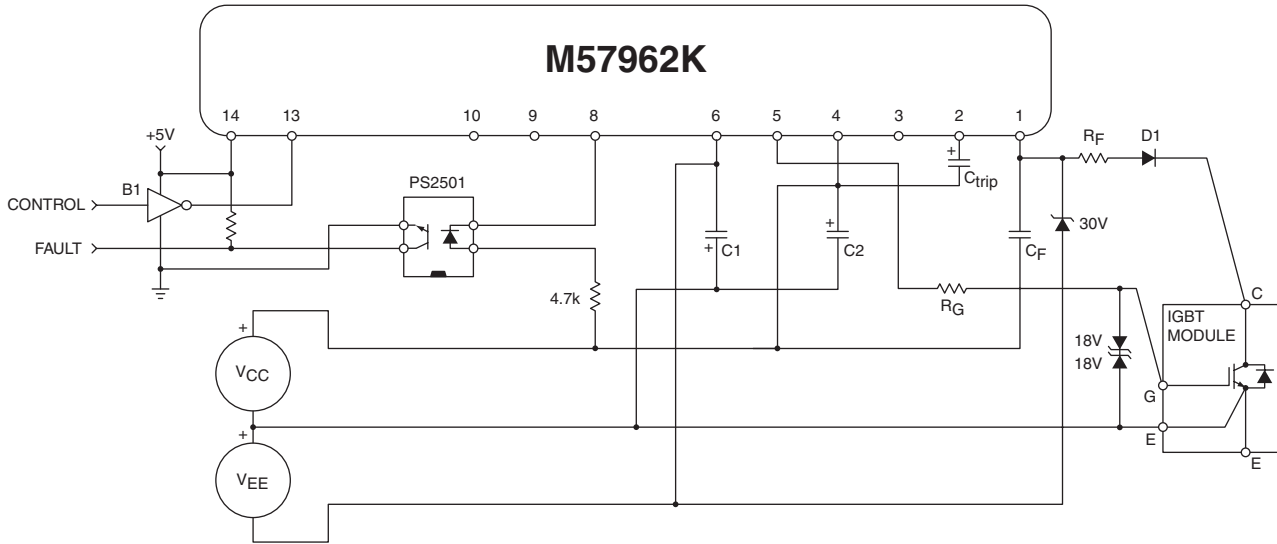


## Short Circuit Protection



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**Application Circuit**

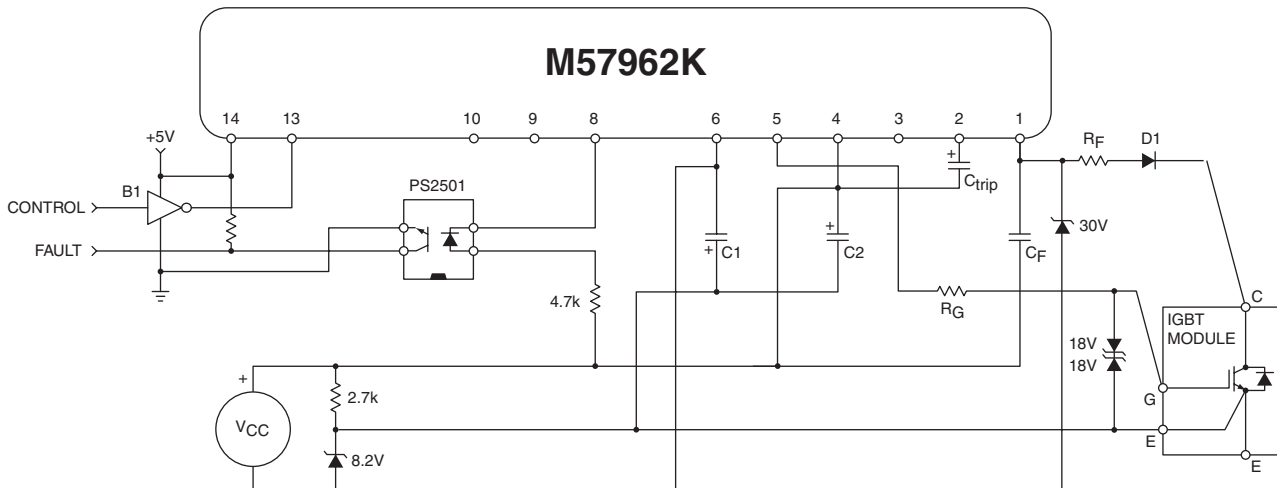


**Component Selection:**

| Design   | Description   |
|----------|---|
| VCC, VEE | +15V/-10V Typical, See data sheet for usable limits   |
| RG       | Adjust for application requirements. See IGBT module application notes for recommendations and power rating |
| C1, C2   | 10µF-100µF 25V low impedance electrolytic   |
| D1       | Ultra fast recovery $t_{rr} < 100\text{ns}$ , High voltage $V_{rrm} > V_{ces}(\text{IGBT})$                 |
| Ctrip    | 0-200pF adjusts desaturation trip time ( $t_{trip}$ )   |
| B1       | CMOS Buffer 74HC04 or similar – Must actively pull high to maintain noise immunity                          |
| RF       | 390Ω - 510Ω (Usually unnecessary)   |
| CF       | 100pF – 470pf (Usually unnecessary)   |

**Notes:**

- (1) Power supply decoupling capacitors C1 and C2 should be connected as close as possible to the pins of the gate driver and must be sized to have appropriate ESR and ripple current capability for the IGBT being driven.
- (2) Ctrip should be connected as close as possible to the pins of the gate driver to avoid noise pick-up.
- (3) All zener diodes 1W, all resistors 0.25W unless otherwise noted.
- (4) When RG is less than 3 times the minimum value, Collector Voltage surges may affect Gate Drive.



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## General Description

The M57962K is a hybrid integrated circuit designed to provide gate drive for high power IGBT modules. This circuit has been optimized for use with Powerex 1700V IGBT modules. However, the output characteristics are compatible with most MOS gated power devices. The M57962K features a compact single-in-line package design. The upright mounting minimizes required printed circuit board space to allow efficient and flexible layout. The M57962K converts logic level control signals into fully isolated +15V/-8V gate drive with up to 5A of peak drive current. Control signal isolation is provided by an integrated high speed optocoupler. Short circuit protection is provided by means of desaturation detection.

## Short Circuit Protection

Figure 1 shows a block diagram of a typical desaturation detector. In this circuit, a high voltage fast recovery diode (D1) is connected to the IGBT's collector to monitor the collector to emitter voltage. When the IGBT is in the off state,  $V_{CE}$  is high and D1 is reverse biased. With D1 off the (+) input of the comparator is pulled up to the positive gate drive power supply (V+) which is normally +15V. When the IGBT turns on, the comparators (+) input is pulled down by D1 to the IGBT's  $V_{CE(sat)}$ . The (-) input of the comparator is supplied with a fixed voltage ( $V_{TRIP}$ ). During a normal on-state condition the comparator's (+) input will be less than  $V_{TRIP}$  and it's output will be low. During a normal off-state condition the comparator's (+) input will be larger than

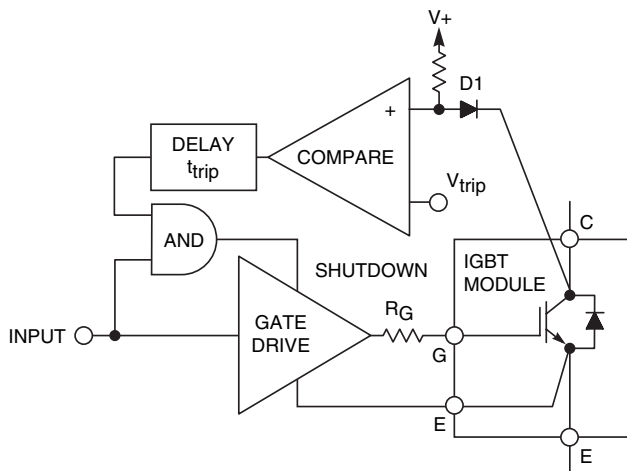
$V_{TRIP}$  and it's output will be high. If the IGBT turns on into a short circuit, the high current will cause the IGBT's collector-emitter voltage to rise above  $V_{TRIP}$  even though the gate of the IGBT is being driven on. This abnormal presence of high VCE when the IGBT is supposed to be on is often called **desaturation**. Desaturation can be detected by a logical AND of the driver's input signal and the comparator output. When the output of the AND goes high a short circuit is indicated. The output of the AND can be used to command the IGBT to shut down in order to protect it from the short circuit. A delay ( $t_{TRIP}$ ) must be provided after the comparator output to allow for the normal turn on time of the IGBT. The  $t_{TRIP}$  delay is set so that the IGBTs Vce has enough time to fall below  $V_{TRIP}$  during normal turn on switching. If  $t_{TRIP}$  is set too short, erroneous desaturation detection will occur. The maximum allowable  $t_{TRIP}$  delay is limited by the IGBT's short circuit withstanding capability. In typical applications using Powerex IGBT modules the recommended limit is 10 $\mu$ s.

## Operation of the M57962K Desaturation Detector

The Powerex M57962K incorporates short circuit protection using desaturation detection as described above. A flow chart for the logical operation of the short-circuit protection is shown in Figure 2. When a desaturation is detected the hybrid gate driver performs a soft shut down of the IGBT and starts a timed ( $t_{timer}$ ) 1.5ms lock out. The soft turn-off helps to limit the transient voltage that may be generated while interrupting the large short circuit current flowing in the IGBT. During the lock out the driver pulls Pin 8 low to indicate the fault status. Normal operation of the driver will resume after the lock-out time has expired and the control input signal returns to its off state.

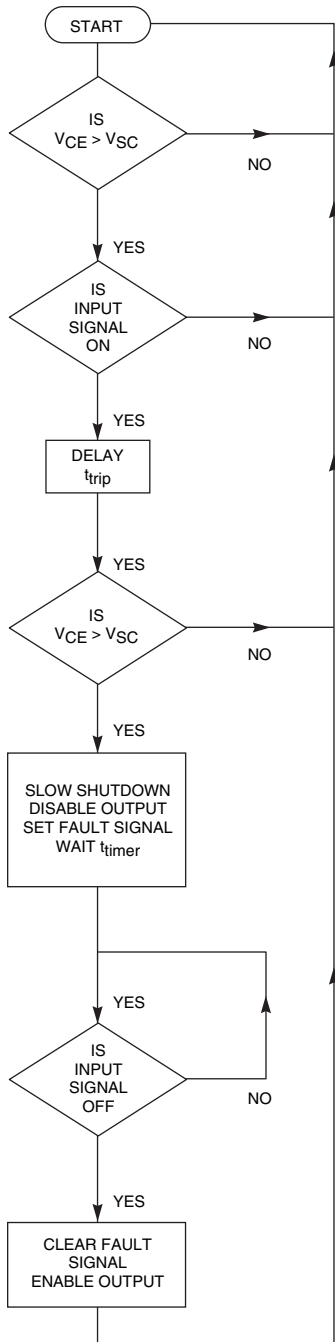
## Adjustment of Trip Time

The M57962K has a default short-circuit detection time delay ( $t_{TRIP}$ ) of approximately 2.5 $\mu$ s. This will prevent erroneous detection of short-circuit conditions as long as the series gate resistance ( $R_G$ ) is near the minimum recommended value for the module being used. The 2.5 $\mu$ s delay is appropriate for most applications so adjustment will not be necessary. However, in some low frequency applications it may be desirable to use a larger series gate resistor to slow the switching of the IGBT, reduce noise, and limit turn-off transient voltages. When  $R_G$  is increased, the switching



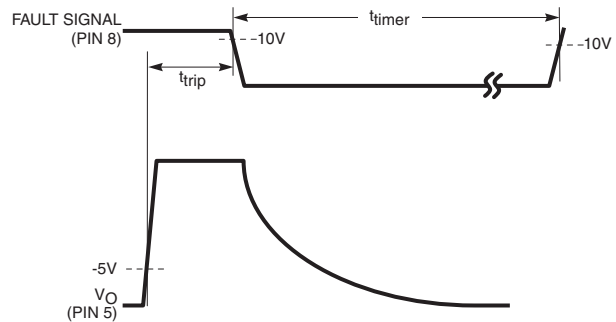
**Figure 1. Desaturation Detector**

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**Figure 2. VLA504-01 Desaturation Detector**

delay time of the IGBT will also increase. If the delay becomes long enough so that the voltage on the detect Pin 1 is greater than  $V_{SC}$  at the end of the  $t_{TRIP}$  delay the driver will erroneously indicate that a short circuit has occurred. To avoid this condition the M57962K has provisions for extending the  $t_{TRIP}$  delay by connecting a capacitor ( $C_{TRIP}$ ) between Pin 2 and  $V_{CC}$  (Pins 4). The effect of adding  $C_{TRIP}$  on trip time is shown in Figure 3. If  $t_{TRIP}$  is extended care must be exercised not to exceed the short-circuit withstanding capability of the IGBT module. Normally this will be satisfied for Powerex NF and A-Series IGBT modules as long as the total shut-down time does not exceed  $10\mu s$ .



**Figure 3. Adjustment of  $t_{trip}$**