Description:
VLA554-01R is a hybrid integrated circuit designed for driving n-channel IGBT modules in any gate-amplifier application. This device contains a fully isolated DC-DC converter designed to be used with a fiber optic interface for control signal input and fault signal output. The gate driver provides an over-current protection function based on desaturation detection.

Features:
- Built in Isolated DC-DC Converter for Gate Drive
- SIP Outline Allows More Space
- Built in Short Circuit Protection with a pin for Fault Output
- Built in Collector Clamp Circuit
- Variable Fall Time on Short-Circuit Protection
- Electrical Isolation Voltage 4000 Vrms (for 1 Minute)
- CMOS Compatible Input Interface
- Interfaces with Fiber Optic Connector for Isolation of Input Signal

Applications:
- To Drive IGBT Modules for General Industrial Use.

Recommended IGBT Modules:
- \( V_{CES} = 1200V \) Series up to 3600A Class
- \( V_{CES} = 1700V \) Series up to 3600A Class
VLA554-01R
IGBT Gate Driver + DC/DC Converter

Absolute Maximum Ratings, $T_a = 25^\circ$C unless otherwise specified

<table>
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<th>Characteristics</th>
<th>Symbol</th>
<th>Rating</th>
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<tr>
<td>Supply Voltage (DC)</td>
<td>$V_D$</td>
<td>$-1 \sim 16.5$ Volts</td>
<td></td>
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<tr>
<td>Output Voltage (&quot;H&quot; Output Voltage)</td>
<td>$V_O$</td>
<td>$V_{CC}$ Volts</td>
<td></td>
</tr>
<tr>
<td>Input Current - Pulse (PW 10msec, Duty Cycle 50%, Applied Pin 1,2)</td>
<td>$I_{IN(PULSE)}$</td>
<td>4</td>
<td>Amperes</td>
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<tr>
<td>Output Current (Pulse Width 3μs)</td>
<td>$I_{OH}$</td>
<td>-24</td>
<td>Amperes</td>
</tr>
<tr>
<td>Output Current (Pulse Width 3μs)</td>
<td>$I_{OLP}$</td>
<td>24</td>
<td>Amperes</td>
</tr>
<tr>
<td>Isolation Voltage (Sine Wave Voltage 60Hz, for 1 min., R.H. &lt;60%)</td>
<td>$V_{iso}$</td>
<td>4000 V rms</td>
<td></td>
</tr>
<tr>
<td>Case Temperature (Surface Temperature)</td>
<td>$T_C$</td>
<td>100 °C</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature (No Condensation Allowable)</td>
<td>$T_{opr}$</td>
<td>-30 – 70 °C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature (No Condensation Allowable)</td>
<td>$T_{stg}$</td>
<td>-40 – 100°F</td>
<td></td>
</tr>
<tr>
<td>Fault Output Current (Applied at Pin 28)</td>
<td>$I_{FO}$</td>
<td>20 mA</td>
<td></td>
</tr>
<tr>
<td>Input Voltage to Pin 30 (Applied at Pin 30)</td>
<td>$V_{R30}$</td>
<td>60 Volts</td>
<td></td>
</tr>
<tr>
<td>Gate Drive Current (Gate Average Current)</td>
<td>$I_{drive}$</td>
<td>$210^{*2}$ mA</td>
<td></td>
</tr>
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Electrical Characteristics, $T_a = 25^\circ$C, $V_D = 15V$, $R_G = 1Ω$, $C_L = 1.6μF$, $f = 3k$Hz unless otherwise specified

<table>
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<tr>
<th>Characteristics</th>
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<th>Test Conditions</th>
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<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
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<tr>
<td>Supply Voltage</td>
<td>$V_D$</td>
<td>Recommended Range</td>
<td>14.2</td>
<td>15</td>
<td>15.8</td>
<td>Volts</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>$f$</td>
<td>Recommended Range</td>
<td>—</td>
<td>—</td>
<td>10</td>
<td>kHz</td>
</tr>
<tr>
<td>Gate Resistance</td>
<td>$R_G$</td>
<td>Recommended Range</td>
<td>0.33</td>
<td>—</td>
<td>—</td>
<td>Ω</td>
</tr>
<tr>
<td>Gate Positive Supply Voltage</td>
<td>$V_{CC}$</td>
<td></td>
<td>15.2</td>
<td>16.5</td>
<td>17.5</td>
<td>Volts</td>
</tr>
<tr>
<td>Gate Negative Supply Voltage</td>
<td>$V_{EE}$</td>
<td></td>
<td>-6</td>
<td>-8</td>
<td>-11.5</td>
<td>Volts</td>
</tr>
<tr>
<td>Gate Supply Efficiency</td>
<td>$\eta$</td>
<td>Load Current = 210mA, $\eta = (V_{CC} +</td>
<td>V_{EE}</td>
<td>) \times 0.21 / (15 \times I_D) \times 100$</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td>&quot;H&quot; Output Voltage</td>
<td>$V_{OH}$</td>
<td>10kΩ Connected Between Pins 23-20</td>
<td>14</td>
<td>15.3</td>
<td>16.5</td>
<td>Volts</td>
</tr>
<tr>
<td>&quot;L&quot; Output Voltage</td>
<td>$V_{OL}$</td>
<td>10kΩ Connected Between Pins 23-20</td>
<td>-5.5</td>
<td>-7</td>
<td>-11</td>
<td>Volts</td>
</tr>
<tr>
<td>&quot;L-H&quot; Propagation Time</td>
<td>$t_{PLH}$</td>
<td>$I_H = 30mA^{*3}$, Propagation Time from Pin 15</td>
<td>0.3</td>
<td>0.5</td>
<td>1.0</td>
<td>μs</td>
</tr>
<tr>
<td>&quot;L-H&quot; Rise Time</td>
<td>$t_r$</td>
<td>$I_H = 30mA^{*3}$</td>
<td>—</td>
<td>0.6</td>
<td>1.2</td>
<td>μs</td>
</tr>
<tr>
<td>&quot;L-H&quot; Propagation Time</td>
<td>$t_{PHL}$</td>
<td>$I_H = 30mA^{*3}$, Propagation Time from Pin 15</td>
<td>0.2</td>
<td>0.4</td>
<td>1.0</td>
<td>μs</td>
</tr>
<tr>
<td>&quot;H-L&quot; Fall Time</td>
<td>$t_f$</td>
<td>$I_H = 30mA^{*3}$</td>
<td>—</td>
<td>0.3</td>
<td>1.2</td>
<td>μs</td>
</tr>
<tr>
<td>Timer</td>
<td>$t_{timer}$</td>
<td>Between Start and Cancel (Under Input Sign “OFF”)</td>
<td>1</td>
<td>—</td>
<td>2</td>
<td>ms</td>
</tr>
<tr>
<td>Fault Output Current</td>
<td>$I_{FO}$</td>
<td>Applied Pin 28, $R = 2.4kΩ$</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>mA</td>
</tr>
<tr>
<td>Controlled Time Detect Short Circuit 1</td>
<td>$t_{trip1}$</td>
<td>Pin 30: 15V and more, Pin 29: Open</td>
<td>—</td>
<td>3.5</td>
<td>—</td>
<td>μs</td>
</tr>
<tr>
<td>Controlled Time Detect Short Circuit 2&lt;sup&gt;4&lt;/sup&gt;</td>
<td>$t_{trip2}$</td>
<td>Pin 30: 15V and more, Pins 29-21, 22: 10pF (Connective Capacitance)</td>
<td>—</td>
<td>3.9</td>
<td>—</td>
<td>μs</td>
</tr>
<tr>
<td>SC Detect Voltage</td>
<td>$V_{SC}$</td>
<td>Collector Voltage of IGBT</td>
<td>15</td>
<td>—</td>
<td>—</td>
<td>Volts</td>
</tr>
</tbody>
</table>

<sup>1</sup> Differs from H/C condition.
<sup>2</sup> Refer to $I_{Oh}$ characteristics.
<sup>3</sup> $I_H$ is the current which flows through the LED in the optical link of the input interface. Refer to the Measurement Circuit schematic on page 3.
<sup>4</sup> Length of wiring of capacitor controlled time detect short-circuit is within 5cm from Pins 21, 22 and 29 coming and going.
Definition of Characteristics

**SWITCHING OPERATION**

- **IN** (Pin 15)
- **V_O** (Pin 23, 24)

**OPERATION OF SHORT CIRCUIT PROTECTION**

- More than 5 µs

Measurement Circuit

```
MEASUREMENT CONDITIONS

T_a = 25°C    SW1: ON → Switching Mode
V_D = 15V     SW1: OFF → Short Circuit Protect Mode
R_G = 1Ω      SW2: OFF → Measurement of t_tr1
C_G = 1.6µF   SW2: ON → Measurement of t_tr2
```
**Application Example**

- **VD** = 15V ±5%
- **FOT1,2**: HFBR-1532Z (AVAGO) etc.
- **FOR1,2**: HFBR-2532Z (AVAGO) etc.
- **Ctrip**: Depends on **RG**
- **CS**: Depends on Surge Voltage
- **DZ1**: 30V, 0.5W~1W
- **DZ2**: 18V, Bidirectional
- **D1**: Fast Recovery Diode (t<sub>rr</sub>: 200ns max.)
- **RP1H**: SanKen etc.
- **C1, C2**: 470/uni, 35V (Low Impedance)
- **D2~4**: SBD V<sub>RM</sub> = 60V, IF<sub>SM</sub> > 60A Class
- **R1**: 1Ω, 1W Class
- **R2**: 10Ω, 1/4W Class
- **DZ3~6**: V<sub>pn</sub> < Total V<sub>Z</sub> < V<sub>CES</sub> of IGBT
  - Rough guide of total V<sub>Z</sub> is as follows:
    - For V<sub>CES</sub> 1200V Series → 900~1000V
    - For V<sub>CES</sub> 1700V Series → 1300~1400V
  - It depends on V<sub>pn</sub>, I<sub>C(max)</sub>, R<sub>G</sub>, snubber circuit inductance of power main circuit, and kind of main condenser.

**NOTE:**
1. Decoupling capacitors should be located as close as possible to the Hybrid IC pins.
2. The gate circuit path should be kept as short as possible to minimize influence of switching noise.
3. D1 requires approximately the same blocking voltage as the IGBT modules.
4. When recovery current flows in D1, Pin 30 sees high voltage. A zener diode between Pin 21 and Pin 30 is necessary as shown in above diagram.
5. To decrease the speed of output fall time (reverse bias) when protection circuit is operating, connect C<sub>S</sub> between Pin 21 and Pin 27.
6. If the short-circuit protection circuit is not used, please connect a 4.7k ohm resistor between Pin 30 and Pin 20. (D4 and D<sub>Z1</sub> are not required.)
7. If the collector clamp circuit is activated repeatedly, it may be destroyed as a result of overheating. For this reason, power dissipation of the zener diode should be determined by testing in the actual inverter.
Operation of Protection Circuit

1. When an “ON” input signal is applied for a period longer than $T_{\text{trip}}$ and the collector voltage is high, the hybrid IC will recognize the condition as a short-circuit and immediately reduce the gate voltage. It will also produce a low voltage fault signal at the respective Pin 28 alerting that the protection circuit is in operation.

2. The protection circuit will reset if an “OFF” input signal is applied and the minimum 1–2ms shutdown time has passed. “OFF” signal must be $15\mu$s or more.

3. The controlled time to detect a short-circuit ($T_{\text{trip}}$) should be set so that the IGBT can be fully turned “ON” before a short-circuit condition can be detected. It is possible to adjust $T_{\text{trip}}$ by connecting a capacitor ($C_{\text{trip}}$) between Pins 21, 22 and 29.

4. When the short-circuit protection is activated, the soft gate shutdown circuit reduces the collector surge voltage on the IGBT. The gate shutdown speed can be slowed even more by adding a capacitor to the CS terminal (between Pins 21, 27).

Operation Flow on Detecting Short Circuit

- **START**
- DETECTION OF SHORT CIRCUIT
- GATE SHUTDOWN TIMER START
- OUTPUT FAULT SIGN
- **END OF TIMER**
  - NO
  - **YES**
    - INPUT SIGN IS “OFF”
      - NO
      - **YES**
        - CLEAR ALARM
        - ENABLE OUTPUT

1 ~ 2ms

NOTE: Output voltage with protection circuit operating is about $-|V_{EE}| + 2V$

Adjustment of Output Fall Time

$V_D = 15V$
$T_a = 25^\circ C$

$t_1$, $t_2$ vs $C_S$ CHARACTERISTICS (TYPICAL)

CONNECTIVE CAPACITANCE, $C_S$, (pF)
PIN: 27 – 21
Capacity for Power Supply on Input Side

This product has an isolated DC-DC converter built in for gate drive. Follow these three steps to determine the proper capacity of the power supply on the input side.

1. Calculate the average gate current.
   \[ I_{\text{drive}} = (Q1 + |Q2|) \times F \]
   - \( I_{\text{drive}} \): Gate average current
   - \( Q1 \): Gate charge at +15V (read from IGBT datasheet)
   - \( Q2 \): Gate charge at -7V (read from IGBT datasheet)
   - \( f \): Switching frequency of IGBT

2. Required current from performance curve.
   - If the result of the calculation for \( I_{\text{drive}} \) is 100mA, \( I_D \) is about 270mA as shown on the graph.
   - \( I_D \): Consumption current of DC-DC converter in this HIC

3. Calculate the margin
   \[ I_{\text{out}} = I_D \times (1 + \text{margin}) \]
   - \( I_{\text{out}} \): Output current of input power supply
   - Margin: 0.4
   - If the result of \( I_D \) is 270mA, the power supply spec is:
     - Output voltage: 15V
     - Output current: greater than 350mA

Timing Chart

![Timing Chart](image-url)
**VLA554-01R**  
**IGBT Gate Driver + DC/DC Converter**

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**VCC, | VEE | -Ta CHARACTERISTICS**  
*(TYPICAL)*

- VD = 15V  
- RG = 1Ω  
- f = 3kHz  
- D.F. = 50%  
- LOAD C = 1.6μF

**VCC, | VEE | -IO CHARACTERISTICS**  
*(TYPICAL)*

- Ta = 25°C, DC LOAD  
- VD = 15.8V  
- VD = 15V  
- VD = 14.2V

**tPLH, tPHL-Ta CHARACTERISTICS**  
*(TYPICAL)*

- VD = 15V  
- VIN = 5V  
- RG = 1Ω  
- Ta = 25°C  
- LOAD C = 1.6μF

**ttrip-Ta CHARACTERISTICS**  
*(TYPICAL)*

- VD = 15V  
- RG = 1/Ω  
- Load: C = 1.6μF

- ttrip1 (Ctrip = 0pF)  
- ttrip2 (Ctrip = 10pF)
VLA554-01R
IGBT Gate Driver + DC/DC Converter

**Ambient Temperature, \( T_a, \) (°C)**

**\( V_{OH}, |V_{OL}| - T_a \) Characteristics (Typical)**

- \( V_{OD} = 15V \)
- \( T_a = 25°C \)

**\( t_{trip} \cdot C_{trip} \) Characteristics (Typical)**

- \( V_{D} = 15V \)
- \( T_a = 25°C \)

**\( I_d-I_o \) Characteristics (Typical)**

- \( V_{D} = 15V \)
- \( T_a = 25°C \)

**\( \eta-I_{drive} \) Characteristics (Typical)**

- \( V_{D} = 15V \)
- \( T_a = 25°C \)

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[Graphs showing characteristics and curves related to gate drive current, efficiency, and output voltage under various conditions.]