功能全面的光耦驱动并保护下一代功率器件

Broadcom Optocouplers – Driving and Protecting Next-generation Power Devices For Automotive Designs

Hong Lei Chen
November 23, 2017 • Tech Shanghai
Agenda

• Broadcom Optocouplers Overview
• Optocoupler Introduction
• Automotive-grade Optocouplers and Applications
• EV Charging Station Introduction and New Gate Driver Introduction
• Design Tools and Technical Support
• Summary
Broadcom Optocouplers – Market and Product Leadership

- HP commercialized GaAsP LEDs
- HP introduced Optocouplers
- Agilent spun off from Hewlett Packard
- Avago spun off from Agilent
- TS16949 Certified Test/Assembly Factory
- TS16949 Certified Epi/Wafer Fab
- Broadcom merged with Avago

Company Name

Isolation Products Milestone

- 1968: HP commercialized GaAsP LEDs
- 1970: HP introduced Optocouplers
- 1989: Agilent spun off from Hewlett Packard
- 1992: Avago spun off from Agilent
- 2000: TS16949 Certified Test/Assembly Factory
- 2004: TS16949 Certified Epi/Wafer Fab
- 2005: Broadcom merged with Avago

- 1968: 3.3V/5V Optocouplers
- 1999: Industry’s First Smart Gate Drive Optocoupler
- 2000: Multi-Channel, Bi-Directional Optocouplers
- 2004: First Automotive Grade Optocoupler R²Coupler™ (ACPL-xxxT)
- 2007: Optically Isolated Voltage Sensor
- 2009: Ultra-Low Power Optocoupler
- 2010: 14mm C/C Package Optocouplers (ACNT-xxxx)
- 2012: Fine-Pitch SSO12/20/24 Package (ACFL/ACFJ-xxxx)
- 2014: TS16949 Certified Epi/Wafer Fab
- 2015: >100M R²Couplers Shipped
- 2016: Broadcom merged with Avago

- 1989: HS CMOS & Widebody Optocoulers (HCNW)
- 1993: HS CMOS & Widebody Optocoulers (HCNW)
- 1997: Iso-Amp (Optically Isolated Current Sensor)
- 2000: Multi-Channel, Bi-Directional Optocouplers
- 2004: First Automotive Grade Optocoupler R²Coupler™ (ACPL-xxxT)
- 2007: Optically Isolated Voltage Sensor
Broadcom Optocouplers Overview

Product Families

Digital Optocouplers
- **Signal Isolation**
  - Digital Optocouplers (up to 50MBd)
  - Digital Isolators (up to 100MBd)
  - Analog Optocouplers & Special Functions

Gate Drivers
- **Power Device Gate Driving**
  - IPM Interface
  - IGBT/MOSFET Gate drivers
    - Smart gate drivers
    - Basic gate drivers

Isolation Amplifiers
- **Current / Voltage Sensing**
  - Isolated ADC
  - Analog Output Iso-Amp

Markets Segments

- **Industrial**
- **Automotive-grade Optocouplers**
  - AEC-Q100 certification
- **Hermetic Optocouplers**
  - MIL-PRF-38534
What is Optocoupler?
(also known as: Photocoupler, Opto-isolator, Optical isolator)

Optocoupler Selection Criteria

**Basic Electrical Parameters:**
- CTR (= Io/If) range
- LED Vf, If
- Vcc power supply range
- Data rate (MBd) / tprop delay
- Operating temp. range
- CMRR kV/µs (noise immunity)

**Other Parameters:**
- Package: SO, SSO, DIP, ACNV, ACNW, ACNT
- Reliability / Operating Lifetime

**Basic Safety Parameters:**
- Viso : dielectric withstand voltage (UL1577)
- Viorm : max. working insulation voltage (IEC 60747-5-5)
- Clearance, creepage, DTI : insulation coordinates
- “Functional”, “Basic”, “Reinforced Insulation”
- Safety certificates (component level standards):
  - UL1577, IEC 60747-5-5, CSA #5
- ESD: HBM, MM, CDM
- MSL=1 (most optocouplers)
## Broadcom Optocoupler Package Types

<table>
<thead>
<tr>
<th>Package Type</th>
<th>Dimensions</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO-5</td>
<td>5.0 x 5.0</td>
<td>0.08 mm</td>
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<tr>
<td>SO-6</td>
<td>8.0 x 7.0</td>
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<tr>
<td>SO-8</td>
<td>11.4 x 8.0</td>
<td>0.08 mm</td>
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</table>

- **SO-12** (Stretched SO-8) and **SO-16** (Stretched SO-16) have additional features for different applications.

### DIP Packages

- **DIP-4, DIP-6, DIP-8, DIP-16**
- **White Housing**
- **Jade DIP-8**
- **SO-4, SO-5, SO-8, SSO-6, SSO-8**

### Widebody Packages

- **400mil DIP8**
- **500mil DIP10**
- **15mm SSO-8**
- **SO-8, SO-16 Narrow body**

### Transparent Silicon

- **Jade S0-16**
- **Stag S0-8, SO-16**

### Reflective Silicon

- **LED**
- **Photo Detector**
Optocoupler Market Segments
Introduce R²Couplers™ – Broadcom Automotive-grade Optocouplers

Broadcom offers reliable isolation technology with a wide selection of products
Applications in xEV Systems

**Charger & Converters**
- **Gate Drive**
  - High Speed MOSFET Driver
  - Smart IGBT/MOSFET Driver
- **Analog Sensing**
  - Voltage Sensing
  - Current Sensing
  - Analog Feedback
- **Digital Interface**
  - Digital Communications
  - Status Control / Wake-Up
  - Fault Feedback

**Oil Pump**
- IPM Drive Interface
- Integrated IGBT
- Gate Drive

**CANBus Interface**
- Digital Communications
- Status Control

**Traction Inverter System**
- **Gate Drive**
  - High Speed MOSFET Driver
  - Smart IGBT/MOSFET Driver
- **Analog Sensing**
  - Voltage Sensing
  - Current Sensing
  - Temperature Sensing
- **Digital Interface**
  - Digital Communications
  - Status Control / Wake-Up
  - Fault Feedback

**Heating, Ventilation & Air Conditioning**
- **Aircon Inverter**
  - IPM Digital Interface
  - IGBT Gate Driver
- **Heater**
  - IPM Digital Interface
  - Voltage Sensing
  - Current Sensing

**Battery Management System**
- **Battery Pack Monitoring**
  - Voltage sensing
  - Cell Management
  - Digital Communications
  - Status Control / Wake-Up
  - Fault Feedback
- **Insulation Resistance Measurement**
  - Solid State Relay
  - Voltage Sensing

**Different packages to meet different high voltage requirement**

<table>
<thead>
<tr>
<th>Part Numbers</th>
<th>Gate Driver</th>
<th>IsoAmp</th>
<th>Digital</th>
<th>Relay</th>
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<tbody>
<tr>
<td>ACPL-K33T/K34T</td>
<td>ACPL-782T</td>
<td>ACPL-M49T/K49T/ACFL-5212T</td>
<td>ACPL-K30T</td>
<td></td>
</tr>
<tr>
<td>ACPL-31JT/344JT</td>
<td>ACPL-C87AT/C87BT</td>
<td>ACPL-M43T/K43T/K44T/ACFL-5211T</td>
<td>ASSR-601J&gt;V*</td>
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<tr>
<td>ACPL-32JT/33JT</td>
<td>ACPL-C797T/C799T* /0873T*</td>
<td>ACPL-M71T/K71T/K74T/ACFL-6211T</td>
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<td>ACFL-5212T</td>
<td>ACPL-M72T/K72T/K75T/ACFL-6212T</td>
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<tr>
<th>Traction Inverter</th>
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<td>Charger</td>
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<td>Converter</td>
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<td>BMS</td>
<td>O</td>
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<td>HVAC</td>
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<tr>
<td>Oil Pump</td>
<td>O</td>
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<tr>
<td>Isolation / Power</td>
<td>Benefits</td>
<td>&lt; 10kW</td>
<td>10kW – 100kW - 250kW</td>
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<td>------------------</td>
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</tbody>
</table>
| • Flyback Converter  
• Isolation  
• Driver | • Distributed power architecture  
• Better performance and lower cost | | ACPL-32JT  
2A Gate Drive  
Desat Sensing  
Miller Clamp  
2W Flyback Controller |
| | | | ACPL-33JT  
2A Gate Drive  
Desat Sensing  
Miller Clamp  
> 4W Flyback Controller |
| • Isolation  
• Driver | • Fully compatible to existing power architecture | | ACFJ-3540T  
2A Gate Drive  
Emitter Sensing  
Miller Clamp  
2W Flyback Controller |
| Application | DC/DC, Charger | Drive Systems | |
| | | | ACPL-31JT  
Smart MOSFET Driver |
| | | | ACPL-344JT  
2A Gate Drive, Desat Sensing  
Miller Clamp, UVLO Feedback |
| | | | ACPL-312T  
2A IGBT Gate Drive |
| | | | ACPL-38JT  
2A Gate Drive, Desat Sensing, Fault Feedback |
| | | | ACPL-K34T  
200kHz MOSFET Driver |
| | | | ACPL-K33T  
SiC MOSFET Driver |
| | | | Miller Clamp |
| | | | UVLO Feedback |

Application

ACPL-32JT  
ACPL-33JT  
ACFJ-3540T

Drive Systems

ACPL-31JT  
ACPL-344JT  
ACPL-312T

ACPL-K34T  
ACPL-K33T  
ACPL-38JT

ACFJ-3540T

ACPL-312T  
ACPL-38JT

ACFJ-3540T
ACPL-32JT Compact Design with Integrated Flyback Controller

Features

- Integrated flyback controller
- Rail to rail driving output
- Negative Gate Biasing and Miller Clamp for gate noise rejection
- Adjustable Desat Sensing threshold through additional Desat Diode
- Soft shutdown timing can be adjusted by Rss
- Direct low impedance LED input, high dV/dt noise immunity
- Over current blanking time can be controlled through blanking capacitor

Evaluation Board Available

Single Channel
ACFJ-3540T - Gate Driver with Flyback DC-DC Controller, Emitter Sensing, Miller Clamping and UVLO Feedback

Key Features

• Qualified to AEC-Q100 Grade 1 Test Guidelines

• Automotive temperature range : -40°C to +125°C

• Integrated flyback controller for isolated DC-DC converter
  – Regulated output voltage (V_{CC}-V_E): 15V +/- 5%
  – Configuration negative supply (V_E-V_{EE})

• 1A / 2.5A minimum peak output drive / sink current

• Miller clamp sinking current : 2.5A

• Propagation delay: 150ns max.

• Integrated fail-safe IGBT protection
  – Emitter over-current sensing, “Soft” IGBT turn-off and fault feedback
  – Under Voltage Lock-Out protection (UVLO) with feedback
  – Over temperature detection, with auto shutdown and feedback

• High noise immunity
  – Direct LED input with low input impedance and low noise sensitivity
  – Common Mode Rejection (CMR): 50kV/μs at V_{GM} = 1500 V

• SO-24 package with 8mm creepage and clearance

• Regulatory approvals:
  – UL1577, CSA (5kV_{RMS} / 1 minute)
  – IEC 60747-5-5 (Continuous working voltage, V_{IOTM}, of 1230V_{PEAK})

Applications

• IGBT Gate Driver for Traction Inverter, Charger and HVAC

• Status Update

• Datasheet : Available

• Engineering Samples: Available
Driver Board using ACFJ-3540T and ACPL-C87AT for Fuji M653 IGBT Module

About the driver board:

- Direct mount to IGBT module
- **Driver IC: ACFJ-3540T with integrated flyback DC/DC controller**
  - Over current and short circuit protection (emitter sense) with soft shutdown capability and fault feedback
  - UVLO protection and feedback
  - Over temperature protection and feedback
- +15.5/0V Distributed 2W Power Supply
- 5A peak buffer output for gate driving
- Temperature feedback for each channel
- Buffer driven PWM gate driver input

About the Fuji M653 Series Automobile IGBT Module

- 800A/750V emitter current sensing IGBT module
- 6 switch elements

About emitter sensing IGBT:

![Short Circuit Event Waveform](Image)

Source: Fuji Electric M653 Series Application Manual
## Isolation Amplifier Selection

### Digital Outputs

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACPL-C799T</td>
<td>Sigma Delta Output +/-50mV Current Sensor</td>
<td>1%</td>
</tr>
<tr>
<td>ACPL-C797T</td>
<td>Sigma Delta Output +/-200mV Voltage Sensor</td>
<td>1%</td>
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</table>

### Differential Analog Outputs

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>ACPL-782T</td>
<td>+/-200mV Input Range</td>
<td>2%</td>
</tr>
<tr>
<td>ACPL-C87BT / C87AT</td>
<td>2V Input Range</td>
<td>0.5% / 1%</td>
</tr>
</tbody>
</table>

### Interface

<table>
<thead>
<tr>
<th>Current sensing</th>
<th>Voltage Sensing</th>
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</thead>
<tbody>
<tr>
<td>50A – 500A</td>
<td>&lt; 50A</td>
</tr>
<tr>
<td>AC Voltage</td>
<td>DC Voltage</td>
</tr>
<tr>
<td>Temperature Sensing</td>
<td></td>
</tr>
</tbody>
</table>
3-Phase Motor Current Sensing

**ACPL-C799T Sigma-Delta Modulator:**
- Full input range +/-80mV, Linear input range: +/-50mV
- ENOB: 12 bits
- $V_{\text{REF}}$ error @ 25°C max: ±1%
- Input offset voltage typ: 0.3mV
- SNR typ: 78dB
- Clock frequency over temp: 9MHz min, 10MHz max
- High CMR (15 kV/µs at $V_{\text{CM}} = 1000$ V)
- Stretched SO-8 package (8 mm Creepage)
- Reinforced insulation with worldwide safety approvals:
  - IEC/DIN EN 60747-5-5: $V_{\text{IORM}} = 1414$ $V_{\text{PEAK}}$
  - UL 1577: 5000 $V_{\text{RMS}}$/1 minute

**Evaluation Board:**
- Sensing up to 500A current together with selected 0.1mΩ Shunt
- SPI source code available
- GUI Demo Software available for Arduino DUE board
- Specialized for 3-phase current sensing in motor drive
# Digital Optocoupler Selection

<table>
<thead>
<tr>
<th>Up to 1414Vdc (BUS/Truck)</th>
<th>Dual Channel Uni / Bi-Directional</th>
<th>Isolation Voltages</th>
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<tbody>
<tr>
<td><strong>ACPL-5212T</strong></td>
<td>Wide Supply Range</td>
<td>Up to 100kBd</td>
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<tr>
<td></td>
<td>4 pin, Linear Response</td>
<td>100kBd – 1MBd</td>
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<tr>
<td></td>
<td>Zero off state power</td>
<td>1MB – 15MBd</td>
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<tr>
<td></td>
<td>SSO8 Single</td>
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<td></td>
<td><strong>ACPL-5211T</strong></td>
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<tr>
<td></td>
<td>Wide Supply Range</td>
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<td>Linear Response</td>
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<td>Zero Off state power</td>
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<tr>
<td></td>
<td>SSO12 Bi-direction</td>
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<td><strong>ACPL-K49T</strong></td>
<td>Wide Supply Range</td>
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<td>20kBd</td>
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<td>4 pin configuration</td>
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<td>Zero off state power</td>
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<td></td>
<td>SSO8 Single</td>
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<tr>
<td><strong>ACPL-K43T</strong></td>
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<td>1MBd</td>
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<td>Prop Delay &lt; 1us</td>
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<td>Linear Response</td>
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<td>SSO8 Single</td>
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<td><strong>ACPL-K46T</strong></td>
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<td>1MBd</td>
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<td><strong>ACPL-6212T</strong></td>
<td>Supply Current &lt; 1.5mA</td>
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<td><strong>ACPL-6211T</strong></td>
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<tr>
<th>Up to 560Vdc (Passenger Cars)</th>
<th><strong>ACPL-M49T</strong></th>
<th><strong>ACPL-M43T</strong></th>
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<td>Prop Delay &lt; 1us</td>
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<tr>
<td>SSO5 Single</td>
<td>SSO5 Single</td>
<td>SSO5 Single</td>
<td>SSO5 Single</td>
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<tr>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
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<tr>
<td><strong>ACPL-M72T</strong></td>
<td>Supply Current</td>
<td>Supply Current</td>
<td>Supply Current</td>
<td>Supply Current</td>
<td></td>
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<tr>
<td>1MBd</td>
<td>1MBd</td>
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<td>1MBd</td>
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<tr>
<td>CMOS Output</td>
<td>CMOS Output</td>
<td>CMOS Output</td>
<td>CMOS Output</td>
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<tr>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
<td>Prop Delay &lt; 32ns</td>
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<td>SSO8 Single</td>
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<td>SSO8 Single</td>
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<tr>
<td>10MBd</td>
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<tr>
<td>Open Collector Output</td>
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<td>Open Collector Output</td>
<td>Open Collector Output</td>
<td>Open Collector Output</td>
<td>Open Collector Output</td>
</tr>
</tbody>
</table>

**Supply Current < 1.5mA**: Low current consumption for efficient power usage.

**Prop Delay < 1us**: Minimal propagation delay for fast signal transmission.

**Linear Response**: Constant output regardless of input level for consistent performance.

**Zero Off state power**: No power consumption in the off state for energy-saving design.

**Wide Supply Range**: Compatibility with a broad range of supply voltages for versatile applications.
A Complete Safety Isolation Solution for Electric Vehicle Charging Station Designs
EV Charging Station Value Chain

- Charging station suppliers fulfills an important supportive activity.
- The EV user can choose products and services according to his needs and preferences; which energy source, who to produce it, who to distribute it, etc.
On-board Charger and Charging Station

AC/DC Charging Electrical Ratings

<table>
<thead>
<tr>
<th>Charge Method</th>
<th>Nominal Supply Voltage</th>
<th>Maximum Continuous Current</th>
<th>Output Power</th>
<th>Estimated Charge Time¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Level 1</td>
<td>120 V AC Supply, 1-phase</td>
<td>12 A</td>
<td>1.4 kW</td>
<td>17 Hrs (OBC, SOC² – 20% to full)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 A</td>
<td>1.9 kW</td>
<td></td>
</tr>
<tr>
<td>AC Level 2</td>
<td>208-240 V AC Supply, 1-phase</td>
<td>80 A</td>
<td>Up to 19.2 kW</td>
<td>SOC – 20% to full: 7 Hrs (3.3 kW OBC); 3.5 Hrs (7 kW OBC); 1.2 Hrs (20 kW OBC).</td>
</tr>
<tr>
<td>DC Level 1</td>
<td>200-500 V DC (EVSE Output)</td>
<td>80 A</td>
<td>Up to 40 kW</td>
<td>1.2 Hrs (SOC – 20% to 100%, 20 kW off-board charger)</td>
</tr>
<tr>
<td>DC Level 2</td>
<td>200-500 V DC (EVSE Output)</td>
<td>200 A</td>
<td>Up to 100 kW</td>
<td>20 min (SOC – 20% to 80%, 45 kW off-board charger)</td>
</tr>
</tbody>
</table>

Notes:
1) For ease of discussion, only BEV (battery electric vehicle) examples are listed.
2) SOC (state of charge) is the equivalent of a fuel gauge for the battery pack in a BEV. 0% SOC means the battery pack is completely discharged; and 100% SOC means it’s fully charged.
3) Rated Power is at nominal configuration operating voltage and coupler rated current.
4) Ideal charge times assume 90% efficient chargers, 150W to 12V loads and no balancing of Traction Battery Pack.
5) BEV (25 kWh usable pack size) charging always starts at 20% SOC, faster than a 1C rate (total capacity charged in one hour) will also stop at 80% SOC instead of 100%.

AC charging
- Every vehicle has an on-board charger.
- Limited power rating, slow charging.
- Requires Automotive-grade components

DC charging
- Infrastructure investment is shared with hundreds of users.
- Large power rating, fast charging.
- Industrial-grade components suffice

Global EV Charging Station Market to Grow to 12.8 Million Units in 2020

Source: IHS.
DC Fast Electric Vehicle Charging Station – Broadcom provides complete isolation solution to ensure safety

Recommended Optocouplers

- Voltage sensor – ACPL-C87B/C87A/C870
- Current sensor – Analog output ACPL-C79B/C79A/C790; digital output ACPL-C797/796J/798J
- MOSFET gate drivers – ACPL-W345/346; IGBT/SiC/GaN MOSFET gate drivers – ACPL-W347/349
- Smart IGBT gate drivers for large power charging stations – ACPL-339J/336J/337J
- CAN Bus isolation – 5/10 MBd ACPL-W21L/W61L, 2X; 25 MBd ACSL-7210, 1X
- Insulation Resistance Detection – ASSR-601J/601JV
Recommended Optocouplers for EV Charging Stations

The needs of Optocouplers in EV Charging system:

- **Need gate drive optocoupler to drive IGBT/MOSFET**
  - **Power MOSFET gate drivers**: ACPL-W346/345, ACPL-W347/349
  - **IGBT gate drivers**: ACPL-339J/336J/337J
  - **SiC MOSFET / GaN device gate driver**: ACPL-352J [NEW]

- **Need voltage, current and temperature sensor in inverters, DCDC converters**
  - **Voltage/Temperature Sensor**: ACPL-C87B/C87A/C870
  - **Current Sensor**: ACPL-C79B/C79A/C790

- **CAN bus communication requires high CMR Digital Optocouplers**
  - **CAN Bus isolation 5/10 MBd**: ACPL-W21L/W61L
  - **High speed communication 25 MBd**: ACSL-7210

- **Insulation resistance detection**
  - **Solid state relay**: ASSR-601J/601JV [NEW]
ACPL-352J – 5A Gate Drive Optocoupler with Over Current Protection and Isolated FAULT feedbacks

Key Features
- 5A(max)/4.5A(min) Peak Output Current
- Rail-to-rail Dual Output
- Features for Functional Safety
  - IGBT/MOSFET Over Current Fault
  - UVLO Fault
  - IGBT/MOSFET Gate Status Fault
- Adjustable Soft Shut
- Integrated Miller Clamping
- SiC/GaN MOSFET ready
  - 150ns max. Propagation Delay
  - 75ns max. Propagation Delay Difference
  - 10ns typ. Rise and Fall Time
  - 150kHz Data Rate
- 1mA Blanking Capacitor Charging Current
- Isolation Voltage: 5kV_{RMS} 1 minute
- Working Voltage: 1414V_{PEAK} continuous
- Wide Operating Temperature: -40°C – 105°C
- Worldwide Safety Approval:
  - UL 1577
  - CSA notice #5
  - IEC60747-5-5
Application Circuit
Features for Functional Safety

Reinforced galvanic isolation separates input LED from high voltage secondary side

- **Low Voltage Isolation**
  - Input LED functionally isolated from low voltage power supply

- **High Voltage Isolation**
  - Feedback LED is always switching to ensure ALL fault conditions are not lost

- **Active Miller Clamp**
  - Monitors if IGBT/MOSET goes in over current or short circuit
  - Holds IGBT/MOSET gate low during “OFF” state

- **Gate Monitor**
  - Monitors IGBT/MOSET gate “ON/OFF” status vs input LED signal

- **DESAT**
  - Monitors isolated fault feedbacks
  - Feedback LED is always switching to ensure ALL fault conditions are not lost
SiC MOSFET / GaN Device Ready Gate Drivers

Reference Designs

- Fuji Electric, Gate Drive for SiC MOSFET
  1200V 100A SiC MOSFET 2CSI100AM-120-50

- Vincotech, H6.5 3-Level IGBT
  10-FY07HVA0x0S5—650V/50A-100A IGBT

- Panasonic, Gate Drive for X-GaN
  PGA26E19BA – 600V/10A GaN Transistor
# Smart Gate Drive Upgrades

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I\textsubscript{OUT} Max</td>
<td>2.5 A</td>
<td>2.5 A</td>
<td>4.0 A</td>
<td>5.0 A</td>
<td>Eliminate Buffer</td>
</tr>
<tr>
<td>Rail2Rail</td>
<td>No (Single)</td>
<td>No (Single)</td>
<td>Yes (Single)</td>
<td>Yes (Dual)</td>
<td>Control On/Off time and eliminate gate diode</td>
</tr>
<tr>
<td>t\textsubscript{PLH}/t\textsubscript{PHL} Max</td>
<td>500 ns</td>
<td>250 ns</td>
<td>250 ns</td>
<td>150 ns</td>
<td>SiC Ready</td>
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<tr>
<td>tR/tF Typ.</td>
<td>100ns</td>
<td>50ns</td>
<td>80ns</td>
<td>10ns</td>
<td>SiC Ready</td>
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<tr>
<td>Miller Clamp</td>
<td>No</td>
<td>1.7 A</td>
<td>2 A</td>
<td>2.5 A</td>
<td>Eliminate –ve supply</td>
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<tr>
<td>Soft Shut Slew Rate</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Fixed</td>
<td>Adjustable</td>
<td>Suppress Transient Over Voltage Stress</td>
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<tr>
<td>DESAT Protection</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Short Circuit Protection</td>
</tr>
<tr>
<td>UVLO Feedback</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Eliminate additional feedback path</td>
</tr>
<tr>
<td>Gate Status Feedback</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Functional Safety</td>
</tr>
</tbody>
</table>
Industrial Photo Mosfet – ASSR-601J Overview

Key Features

- Industrial Grade Operating Temperature -40°C to +110°C
- Breakdown Voltage, $B_{V_{OFF}}$: 1500V typ. @ $I_{OFF}=0.25mA$
- Avalanche rated MOSFETs
- Off-State Leakage, $I_{OFF} \leq 1\mu A$ @ $V_O=1000V$, $T_A=25°C$
- On-resistance, $R_{DS(ON)} \leq 250\Omega$ @ $I_{LOAD} = 50mA$
- Turn On Time: $T_{ON} \leq 1ms$
- Turn Off Time: $T_{OFF} \leq 0.5ms$
- Package: 300mil SO-16
- Creepage & Clearance $\geq 8mm$ (Input-Output)
- $V_{ISO} = 5000V_{RMS}$ (UL 1min Rating)
- Working voltage = 1414V_{PEAK} (Reinforced)
- MOS drain-to-drain Creepage $> 5mm$
- CTI $>600V$ Mold compound

Applications

- Insulation resistance measurement for Motor-Earth leakage current
- Inrush Current Limiter for Inverter and Servo Drives
Insulation Resistance Detection for EV and DC Charging Station

- GB/T 20243.3-2015 requires insulation detection for both DC Charging Equipment and EV.
Using C87x Voltage Sensor, 601J/601JV SSR Switch

- Using C87x to measure DC voltage across DC+ and COM, and DC- and COM.

- Using ASSR-601J/601JV SSR as the K1, K2, Km switches.

- EV charging station side and Automotive side use the same design.

![Diagrams showing voltage measurement and SSR switching configurations.](image-url)
Evaluation Boards

Basic Gate Drive Optocoupler

- ACPL-H342/K342 Gate Driver with Active Miller Clamp
- ACPL-P343/W343 IGBT Gate Driver
- ACPL-P346/W3436 MOSFET Gate Driver
- ACNT-H313 High Creepage/Clearance/Insulation Voltage Gate Driver

Smart Gate Drive Optocoupler

- ACPL-339J MOSFET Buffer Interface Gate Driver
- ACPL-337J Highly Integrated Gate Driver
- ACPL-302J Gate Driver with DC-DC controller
Reference Designs

- **Fuji Electric AT-NPC 3 Level 4-in-1/12-in-1 IGBT Modules. ACPL-339J/332J Gate Driver with DESAT Protection**
- **Mitsubishi “Mega Power Dual” Series IGBT modules. CM1800DY 1800A/1700V. ACPL-339J Gate Driver with DESAT Protection**
- **Cree 2nd Gen SiC MOSFET C2M0080120D. ACPL-W346 High Speed Basic Gate Driver and ACPL-339J Gate Driver with DESAT Protection**
- **ST SiC MOSFET SCT30N120. ACPL-H342 Gate Driver and ACPL-C797/796J Sigma-Delta Modulator**
- **Altera Multi-Axis Motor Control Series. ACPL-798J Sigma-Delta Modulator with LVDS interface. ACPL-W61L 10MBd Digital I/O logic isolation**
光电耦合隔离放大器在光伏电系统中的灵活应用

双路输出的智能IGBT驱动光耦ACPL-339J

碳化硅功率器件(SiC MOSFET)门驱动光耦

设计完整和极具成本效益的门驱动方案

车规级光耦ACPL-32JT

驱动三相全桥IGBT模块

http://www.broadcom.com/support/resources/video-webinar-library#webinars
More Technical Evaluation Tools

• **Spice Models**

  ![Spice Models Diagram](image-url)

  Download: http://www.avagotech.com/products/optocouplers/spicemodels/

• **Power and Thermal Modeling**

  ![Power and Thermal Modeling Table](image-url)

  Contact Broadcom FAE for this tool.

• **IGBT Gate Current Calculator**

  1. Bus Voltage, $V_B$ 
  2. Gate-Emitter Voltage, $V_{GE}$ 
  3. Turn-on Delay Time, $t_{on}$ 
  4. Rise Time, $t_r$ 
  5. Reverse Transfer Capacitance, $C_{off} = C_{IG}$ 
  6. Input Capacitance, $C_{in}$

  Contact Broadcom FAE for this tool.

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