BROADCOM®

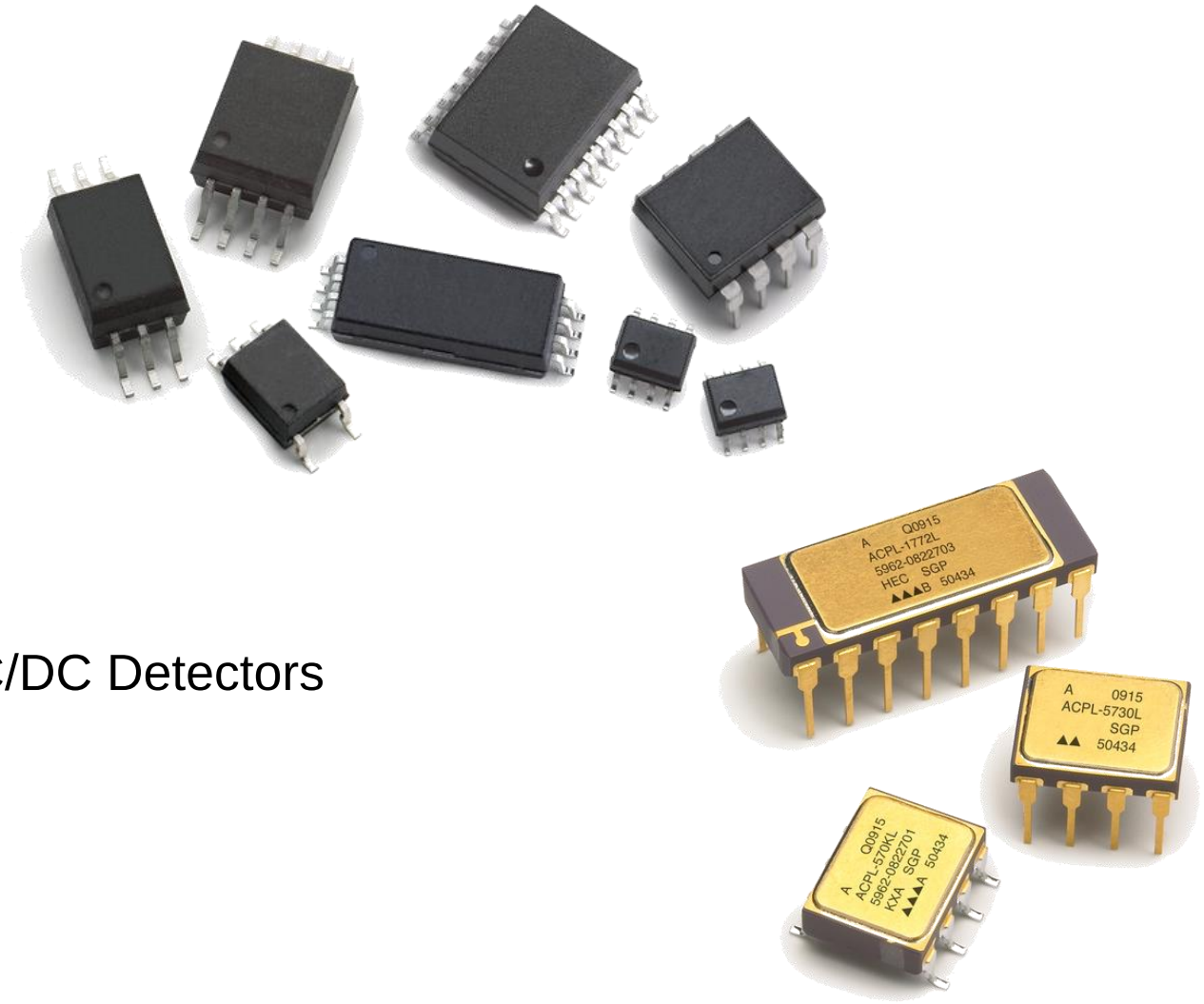
FAE Distributor Certification Training

Optocouplers

January 2024

Agenda

- Optocoupler milestones
- Key markets and applications
- Isolation product overview
- Digital optocouplers
- Gate drivers
- Current and voltage sensors
- Solid State Relay, SSR
- Hall Effect sensors
- Others – Analog Output Optocouplers & AC/DC Detectors
- Automotive optocouplers
- Hermetic optocouplers
- Our value proposition



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Broadcom Optocoupler Milestones:50Yrs of Manufacturing Experience

Isolation Products Milestones

1968 — Commercialized GaAsP LEDs

1970 — Introduced Optocouplers

1980s — Flagship Gate Drive Optocoupler HCPL-3120

1993 — Isolated Current Sensor HCPL-7800

1997 — 1st Gen. Smart Gate Drive Optocoupler HCPL-316J

1999 — Agilent Technologies

2005 — First Automotive Grade R²Coupler™

2008 — Avago Technologies

2008 — Frost & Sullivan: Global Optocouplers Company of the Year

2012 — Isolated Voltage Sensor ACPL-C87B

2014 — 15mm Wide High Voltage ACNT

2016 — 11mm Wide Optocouplers ACNU

2016 — Broadcom merged with Avago

2017 — 50mV Sigma Delta Modulator ACPL-C799

2021 — 5th Gen. Gate Drive Optocoupler **10A** Driving Current for SiC/GaN/IGBT

Beyond 2023 — New Packages, More Functions, Better Performance

GO with OPTO! BROADCOM® OPTOCOUPLERS — 50 YEARS

Key Markets & Product Roadmap

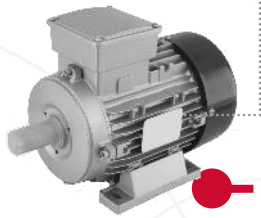
Automotive

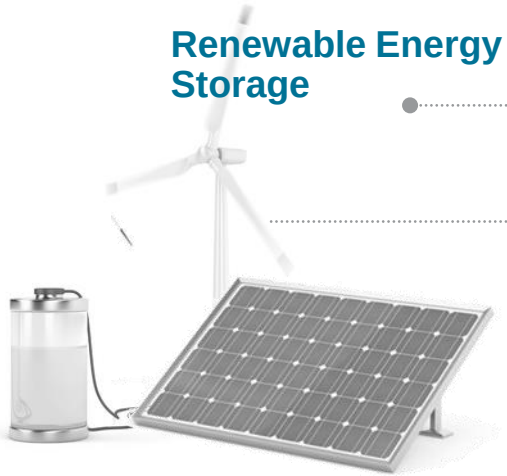
Charging

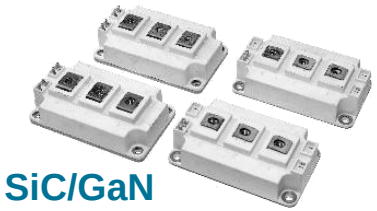
Servo/Robotics

Renewable Energy & Storage

Inverter / Variable Speed Drive







SiC/GaN Applications

2023 onwards

SO24/30/32 Pins

High Integration

- Slew Rate Control to Reduce EMI
- Fail-Safe Protections for Automotive

5th Gen.10A Gate Drivers

For Driving SiC/GaN Power Switches to Improve Efficiency

ACNT/ACNU Package

High Voltage & Wide Creepage for Regulatory Approval

20MHz Sigma Delta

Fast and Accurate Current Sensing

Platform & Performance

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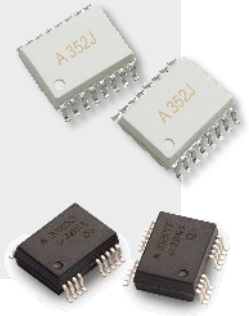
Broadcom Isolation Products Overview

Digital/IPM Optocoupler

- Low power and LED driving current
- Bi-directional configuration available
- Wide variety of packages (compact small-outline to 11/15mm creepage)

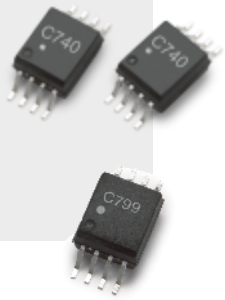
Gate Drive Optocoupler

- >10A high current rail-to-rail output
- >100kV/us high noise immunity
- Highly Integrated
  - Short circuit protection
  - Active Miller clamp
  - DC-DC controller



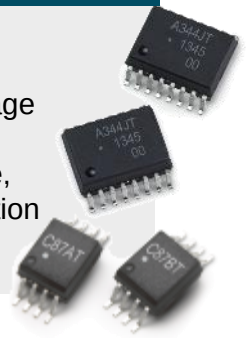
Current/Voltage Sense Optocoupler

- ±50mV or ±200mV optical isolated sigma-delta modulator
- Excellent temperature drift performance
- Immunity to external magnetic fields



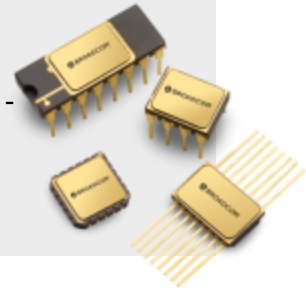
Automotive Optocoupler

- Qualified to AEC Q100 Grade 1
- Wide variety of packages with high voltage up to 1414Vpk
- Broad portfolio of products for gate drive, current/voltage sensing and digital isolation



Hermetic Optocoupler

- Qualified to classes E, H, K of MIL-PRF-38534
- Wide operating temperature, -55°C - 125°C
- Available on DLA SMDs



Other Isolation Products

- Application Specific Optocoupler
- Solid State Relay
- Hall Effect Sensor
- Phototransistor

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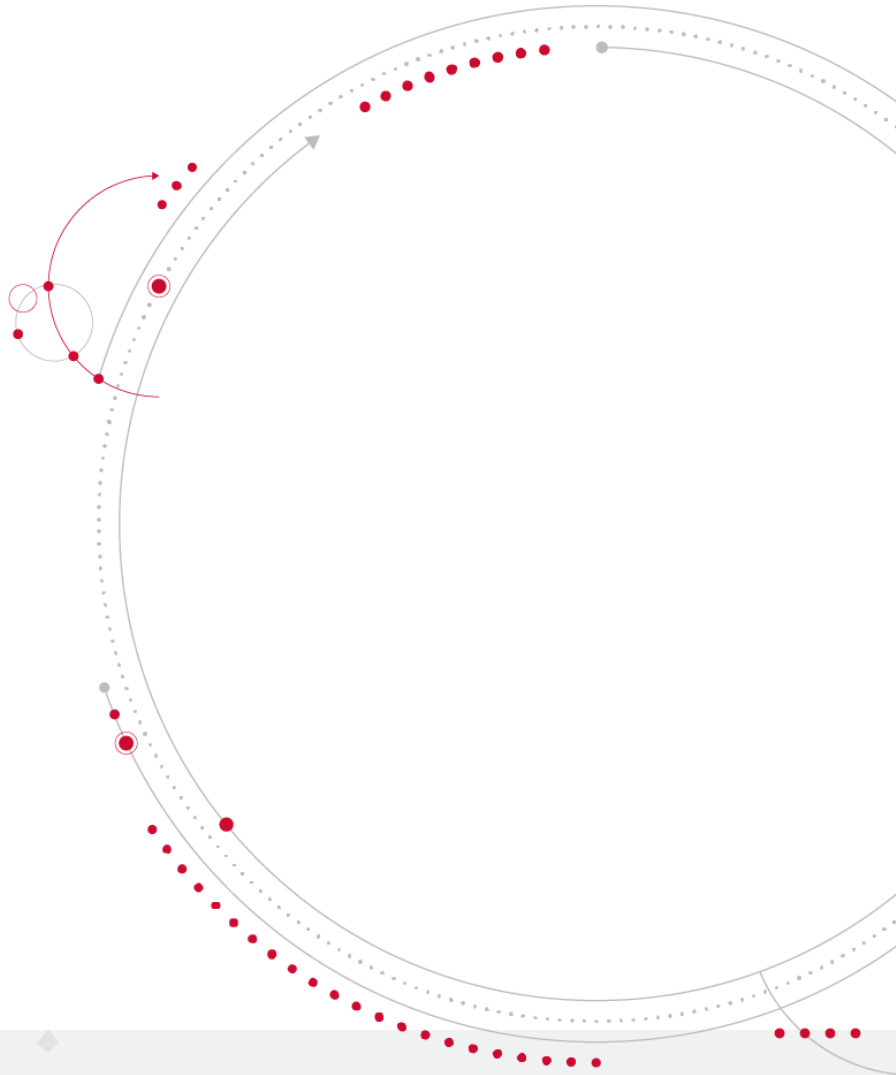
Digital Optocouplers



Digital Optocoupler Value Proposition

1. ***Robust EMI / EMC immunity* and *excellent susceptibility*** performance
   - ESD immunity (IEC 61000-4-2)
   - EFT / Burst immunity (IEC 61000-4-4)
   - Surge immunity

   Details later in presentation
2. IEC 60747-5-5 component certification for ***reinforced insulation***
3. High insulation voltage performance in ***compact packages***
   - 15 mm wide ACNT optocouplers family
   - 11 mm wide ACNU optocouplers
   - 8 mm bi-directional ACFL optocouplers
4. ***Small LED driving current*** and ***low supply voltage*** for increased system power efficiency and longer LED operating lifetime

EMI: electromagnetic interference
EMC: electromagnetic compatibility

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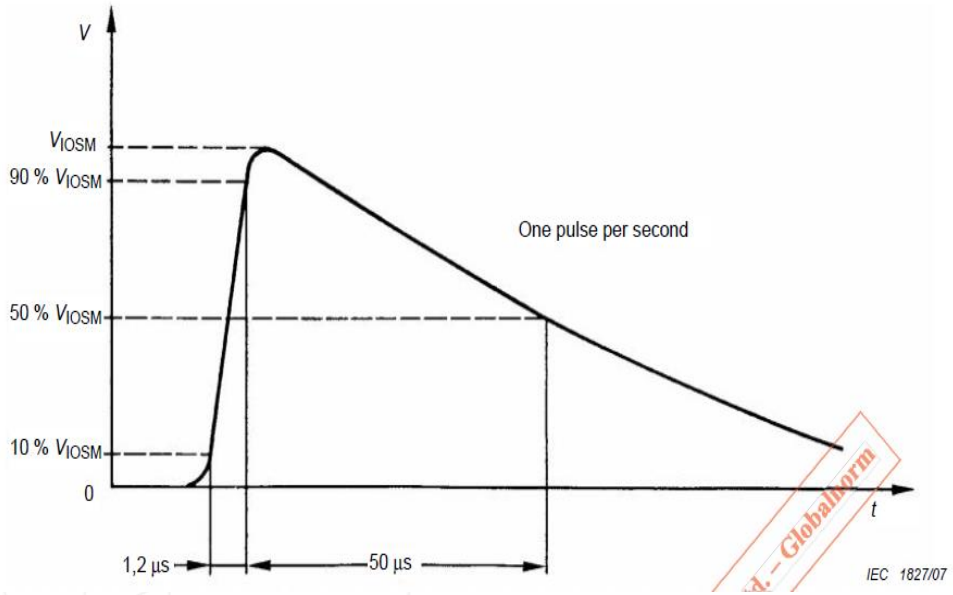
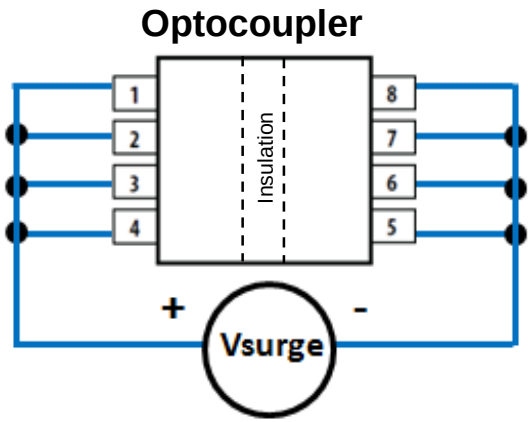
High Voltage Surge per IEC 60747-5-5

- Broadcom optocouplers are ***excellent*** in withstand **HV surge**
  - ACNT optocouplers **pass >25 kV (*TUV test report*)**
- Test 1.2/50 µs methodology reference IEC 60065 (AV electronic apparatus safety requirements)
- Pass criteria - No puncture or partial breakdown of solid insulation. Partial discharge ≤ 5 pC





PASS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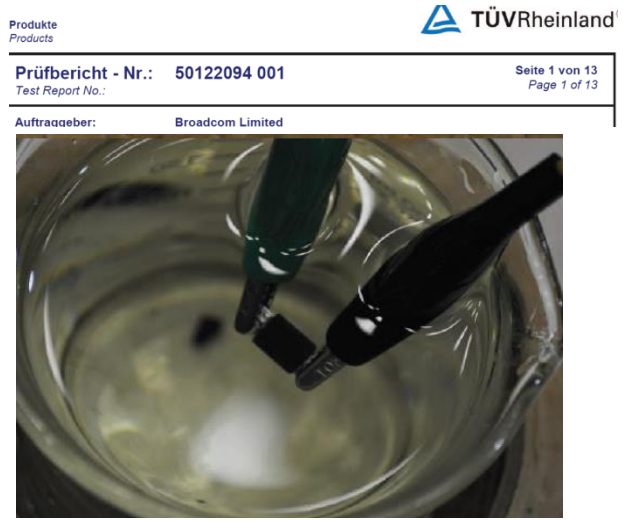
Technical Note

ACNT-H61L, ACNT-H343, ACNT-H313, ACNT-H50L, ACNT-H511, ACNT-H870, ACNT-H87A, ACNT-H87B, ACNT-H790, ACNT-H79A, ACNT-H79B

15-mm Wide ACNT Optocouplers for High Voltage Applications

Introduction


Produkte
Products

TÜVRheinland

Prüfbericht - Nr.: 50122094 001
Test Report No.:

Seite 1 von 13
Page 1 of 13

Auftraggeber: Broadcom Limited

Source: Broadcom ACNT-H50L **TUV test report**

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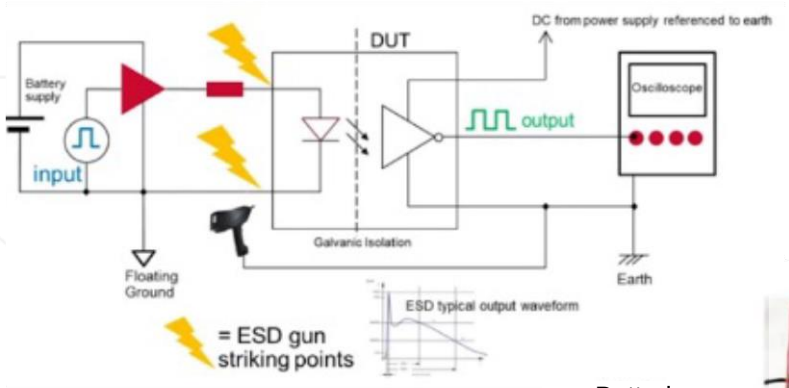
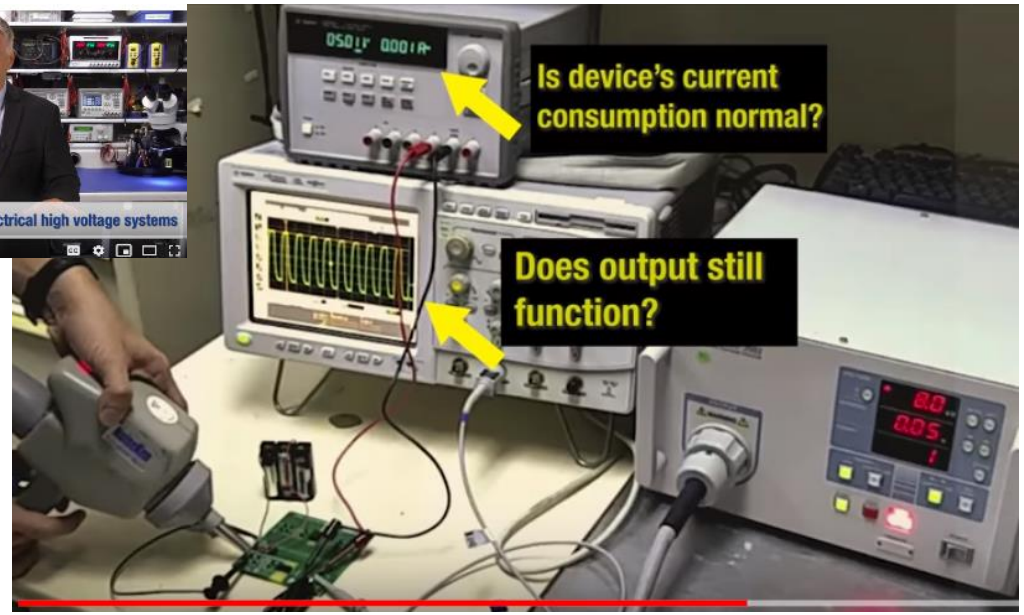
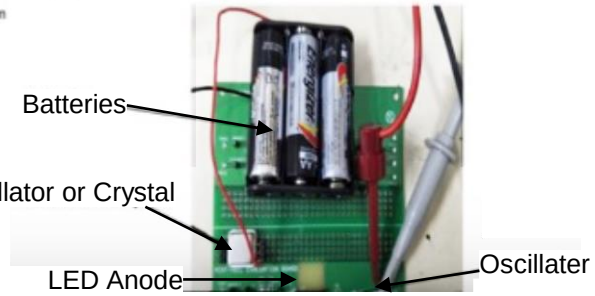
Broadcom Optocoupler Insulation

Provides Robust ESD Immunity (IEC 61000-4-2) and Best in Class EMC performance

- Below shows our ACNT-H61L optocoupler pass 8 kV ESD immunity during application
  - **No performance degradation** when **contact discharge 8 kV** across isolation barrier
  - Output signal showed **normal operation** during and after the test
- Other isolator types (ISO78xx) suffered latch-up & supply current increase
  - **Temperature increased**







ESD: electrostatic discharge

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High CTI Value Proposition: Safety and PCB Area Savings

- CTI measures the electrical breakdown, known as tracking, properties of an insulating material. Tracking is an electrical breakdown on the surface of an insulating material.
- Creepage requirement for Reinforced = Basic x 2
- With CTI ≥ 600V, insulating material group ***UPGRADE from Group IIIa to Group I*** In above case, the **25 mm** (12.5 mm x 2) creepage (Group IIIa) requirement becomes **12.5 mm** (6.3 mm x 2) creepage with Group I material

Table 10 – Creepage distances (mm)

Column 1	2	3	4	5	6	7	8	9	10	11	12
Working voltage (r.m.s.)	PWBs [a]		Other insulators								
	Pollution degree		Pollution degree								
	1	2	1	2				3			
				Insulating material group				Insulating material group			
(V)	b	c	b	I	II	IIIa	IIIb	I	II	IIIa	IIIb
≤ 2	0,025	0,04	0,056	0,35	0,35	0,35		0,87	0,87	0,87	
5	0,025	0,04	0,065	0,37	0,37	0,37		0,92	0,92	0,92	
10	0,025	0,04	0,08	0,40	0,40	0,40		1,0	1,0	1,0	
25	0,025	0,04	0,125	0,50	0,50	0,50		1,25	1,25	1,25	
32	0,025	0,04	0,14	0,53	0,53	0,53		1,3	1,3	1,3	
40	0,025	0,04	0,16	0,56	0,80	1,1		1,4	1,6	1,8	
50	0,025	0,04	0,18	0,60	0,85	1,20		1,5	1,7	1,9	
63	0,04	0,063	0,20	0,63	0,90	1,25		1,6	1,8	2,0	
80	0,063	0,10	0,22	0,67	0,95	1,3		1,7	1,9	2,1	
100	0,10	0,16	0,25	0,71	1,0	1,4		1,8	2,0	2,2	
125	0,16	0,25	0,28	0,75	1,05	1,5		1,9	2,1	2,4	
160	0,25	0,40	0,32	0,80	1,1	1,6		2,0	2,2	2,5	
200	0,40	0,63	0,42	1,0	1,4	2,0		2,5	2,8	3,2	
250	0,56	1,0	0,56	1,25	1,8	2,5		3,2	3,6	4,0	
320	0,75	1,6	0,75	1,6	2,2	3,2		4,0	4,5	5,0	
400	1,0	2,0	1,0	2,0	2,8	4,0		5,0	5,6	6,3	
500	1,3	2,5	1,3	2,5	3,6	5,0		6,3	7,1	8,0	
630	1,8	3,2	1,8	3,2	4,5	6,3		8,0	9,0	10,0	
800	2,4	4,0	2,4	4,0	5,6	8,0		10,0	11	12,5	e
1 000	3,2	5,0	3,2	5,0	7,1	10,0		12,5	14	16	
1 250	4,2	6,3	4,2	6,3	9	12,5		16	18	20	

Broadcom UPGRADE

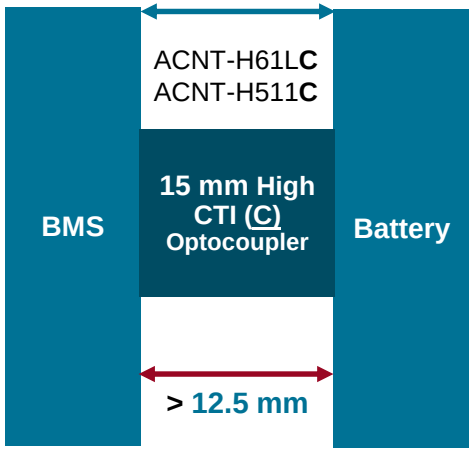
BASIC

Application: Traction Control in Trains

Minimum Creepage Requirement

(Group I)

> 12.5 mm



material group I:	600 ≤ CTI;
material group II:	400 ≤ CTI < 600;
material group IIIa:	175 ≤ CTI < 400;
material group IIIb:	100 ≤ CTI < 175.

- With a high CTI (≥ 600) optocoupler ***and*** Group I material, minimum creepage requirement is reduced from 25 mm to 12.5 mm for ***reinforced insulation***
- Our 15 mm stretched SO8, High CTI (≥ 600) ACNT-H61L**C** & ACNT-H511**C High CTI optocouplers** comply with the > 12.5 mm creepage requirements, giving ***Space Savings***.

CTI: Comparative Tracking Index, https://en.wikipedia.org/wiki/Comparative_Tracking_Index

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New Products: ACNT-H61LC (10MBd) / H511C (1MBd) High CTI Optocoupler in 15 mm Stretched SO8

Features

- CTI: ***600 V (Insulating Material group I)***
- UL1577 isolation voltage Viso: **7,500 Vrms**
- Working voltage Viorm: **2,262 Vpk**
- Transient overvoltage Viotm : **12,000 Vpk**
- Surge isolation voltage Viosm : **>12,000 Vpk**
- DTI: **0.5 mm**
- Package: **15 mm creepage, stretched SO-8**
- Operating Temperature: **–40º C to 105º C**
- Supply Voltage
  - 3.3 V and 5 V (ACNT-H61LC)
  - 4.5 V to 24 V (ACNT-H511C)

DTI: Distance Through Insulation

Stretched SO-8
15 mm creepage

New Product

Insulation Specs	ACNT-H61LC ACNT- H511C	ACNT-H61L ACNT- H511
CTI	**> 600V**	> 300V
Insulating Material Group	**I**	IIIa
Pollution Degree	**2**	2

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Benefits for ACNU-250L / 4803 / 4804

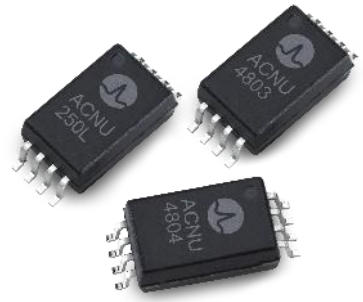
	HCNW	ACNU-250L / 4803 / 4804
Package	400mil Widebody	11mm SSO8
Creepage / Clearance	10mm / 9.6mm	11mm / 10.5mm
DTI	1.0mm	0.5mm
Height	5.10mm	3.607mm
Pitch	2.54mm	1.27mm
Isolation Voltage (Vrms/min)	5000	5000
Working Voltage (Vpeak)	1414	1414

400mil Widebody HCNW

40% smaller

Smaller Height, Fine Pitch

11mm C/C ACNU-250L / 4803 / 4804



Competitor	P/N	Description	ACNU-250L / 480x Benefits
Vishay / Toshiba/ Claire	Voxxx-006 TLP-xxx LF	Vishay : Option 6: Wide lead spacing (10.16 mm creepage / > 8mm clearance distance)	• Wider 11mm creepage and 10.5 mm clearance • Wider Operating Temperature up to 105degC • Lower supply voltage at 3.3V • Higher CMR • Guaranteed specifications over temperature
Vishay	CNY64, VOW13x / VOW2611	Phototransistor, CNY64x – 9.5mm creepage (400mil), 400mil DIP8 widebody 1MBd Open Collector / 10Mbd Logic Gate	
Everlight	ELW13x, ELW26x1	8PIN DIP Wide body 1Mbit/s Transistor Photocoupler, 10Mbits/s Logic Gate Photocoupler	

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New Product: ACPL-M61M

Value Proposition

Lower Supply Voltage 2.5 V	**Higher Max Operating Temperature 125° C**
LED I_F 1.6 mA	**Data rate 10MBd**

New Product

ACPL-M61M	ACPL-M61L	ACPL-M72U	ACPL-M21L
Supply Voltage 2.5 V	LED I_F 1.6 mA	Op Temp max 125° C	Supply Voltage 2.5 V
Op Temp max 125° C	Data rate 10MBd	Data rate 10MBd	LED I_F 1.6 mA
LED I_F 1.6 mA			
Data rate 10MBd			
Other Features	3.3 V / 5 V 105° C	3.3 V / 5 V 4 mA	5 MBd 105° C

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ACPL-M61M: 2.5 V / 3.3 V, Low Power, 10MBd Digital Optocoupler

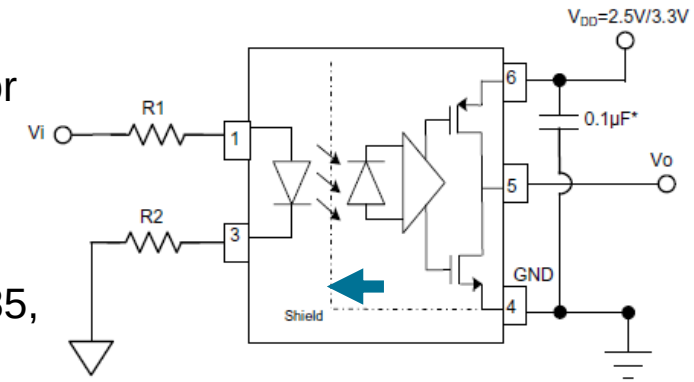
125° C Operating Temperature

Value Proposition

- High operating temperature up to 125º C to minimize thermal runaway
- Utilizes ASICs, mixed signal µP with low power supply voltage and low LED current drive
- IEC 60747-5-5 certification for ***Reinforced Insulation***
- ***Evaluation board speeds design evaluation***

Application

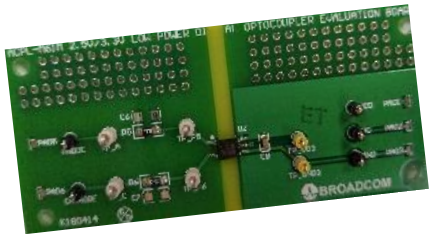
- Digital control isolation for A/D, D/A conversion
- ASIC system interface (PLCs, DCS, I/O)
- Industrial Network (RS485, RS232), Fieldbuses
- CAN Bus



ACPL-M61M

Features

- 2.5 V / 3.3 V CMOS c ompatible
- Operating temperature: -40° C to +125° C
- Package: SO5
- Low power I_{DD}: 1.5 mA max
- Low LED driving current I_F: 1.6 mA min
- High speed: 10MBd min
- Propagation delay (tp): 90 ns max
- Pulse width distortion (PWD): 45 ns max
- CMR: 20 kV/µs minimum @ Vcm 1000 V
- IEC 60747-5-5 Working voltage: 567 Vpk for Reinforced Insulation
- UL1577 Isolation voltage: 3750 Vrms



Evaluation board available

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15MBd Digital Optocouplers ACPL-M75N/-074N/-W70N/-K73N

Features

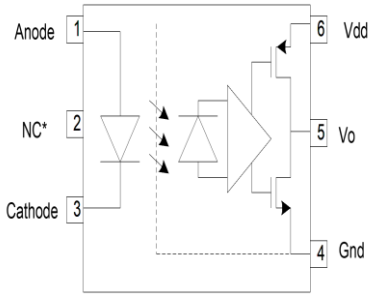
- **3.3 V / 5 V** CMOS
- Ambient Operating Temperature: **-40° C to +125° C**
- Package: SO5, SO8, Stretched SO6/8
- Low Power I_{DD}: **1.5 mA max**
- LED driving current I_F: **4 mA min**
- Speed: 15MBd min
- Propagation delay (tphl/tplh): **50 ns max**
- Pulse width distortion (PWD): 25 ns max
- Propagation delay skew (tpsk): 25 ns max
- Common-mode noise immunity (CMR): 20kV/µs minimum @ Vcm 1000 V

Applications

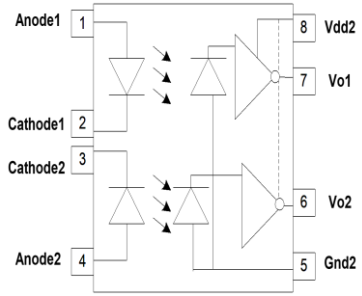
Smart homes & buildings, digital control isolation for A/D, D/A conversion, ASIC system interface (PLCs, DCS, I/O), industrial networks (RS485, RS232), ground loop elimination

New Product (*To be released by end'21*)

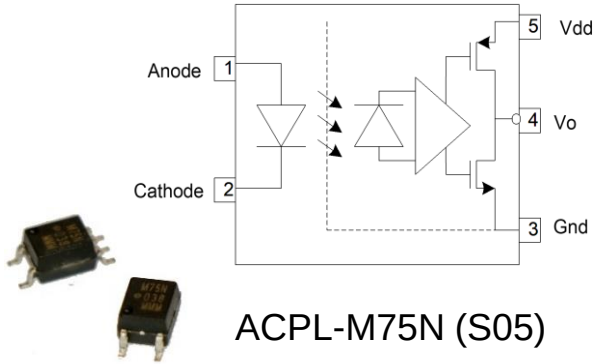
Part Number	Package	Channel	UL1577 V_{ISO} (Vrms/min)	IEC 60747-5-5 Working Voltage (Vpk)	Engr Samples status
ACPL-M75N	SO-5	1	3750	567	Available
ACPL-074N	SO-8	2	3750	567	Available
ACPL-W70N	SSO-6	1	5000	1140	Q4 2021
ACPL-K73N	SSO-8	2	5000	1140	Q4 2021



ACPL-W70N (SSO6)



ACPL-074N (SO8)
ACPL-K73N (SSO8)



ACPL-M75N (S05)

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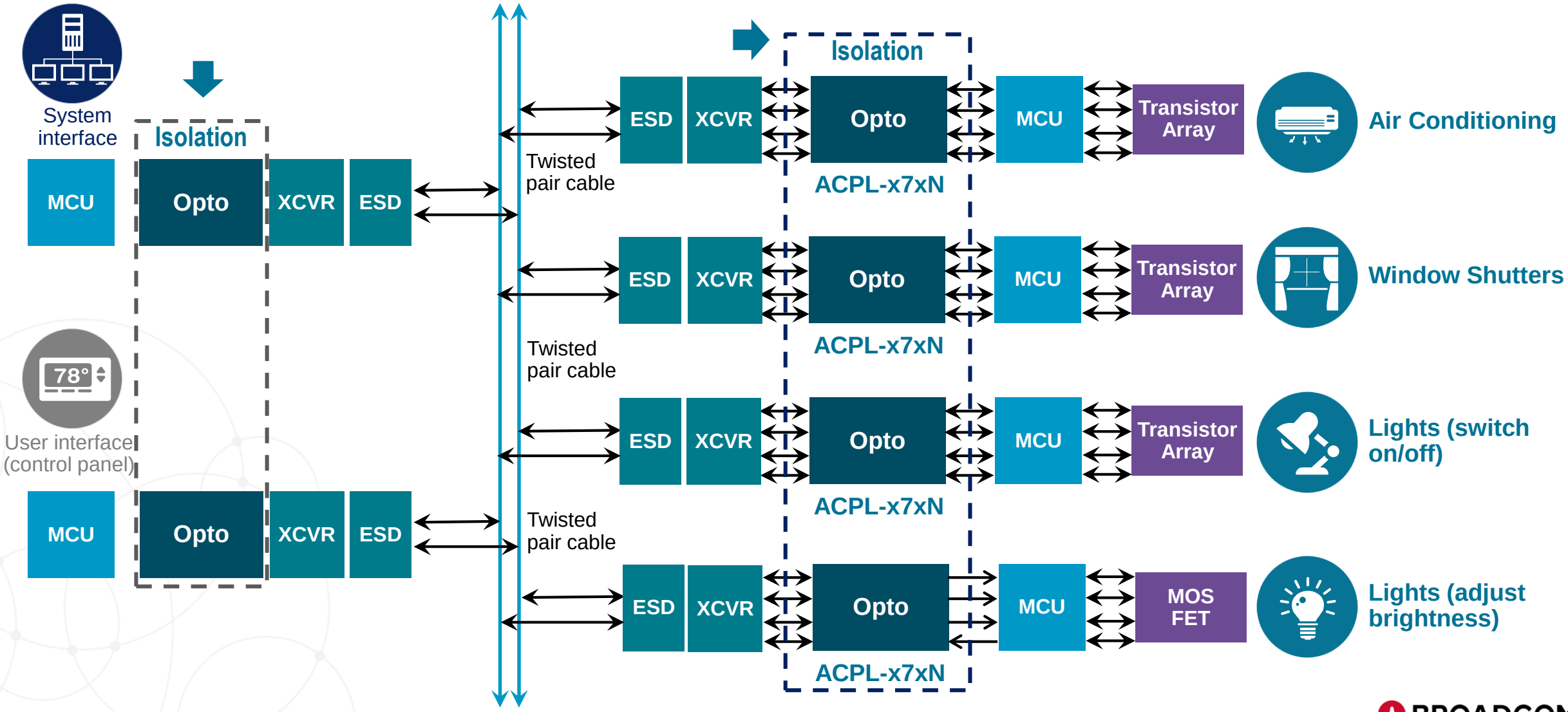
ACPL-M75N / -074N / -W70N /- K73N

Application: Smart Home and Building Automation



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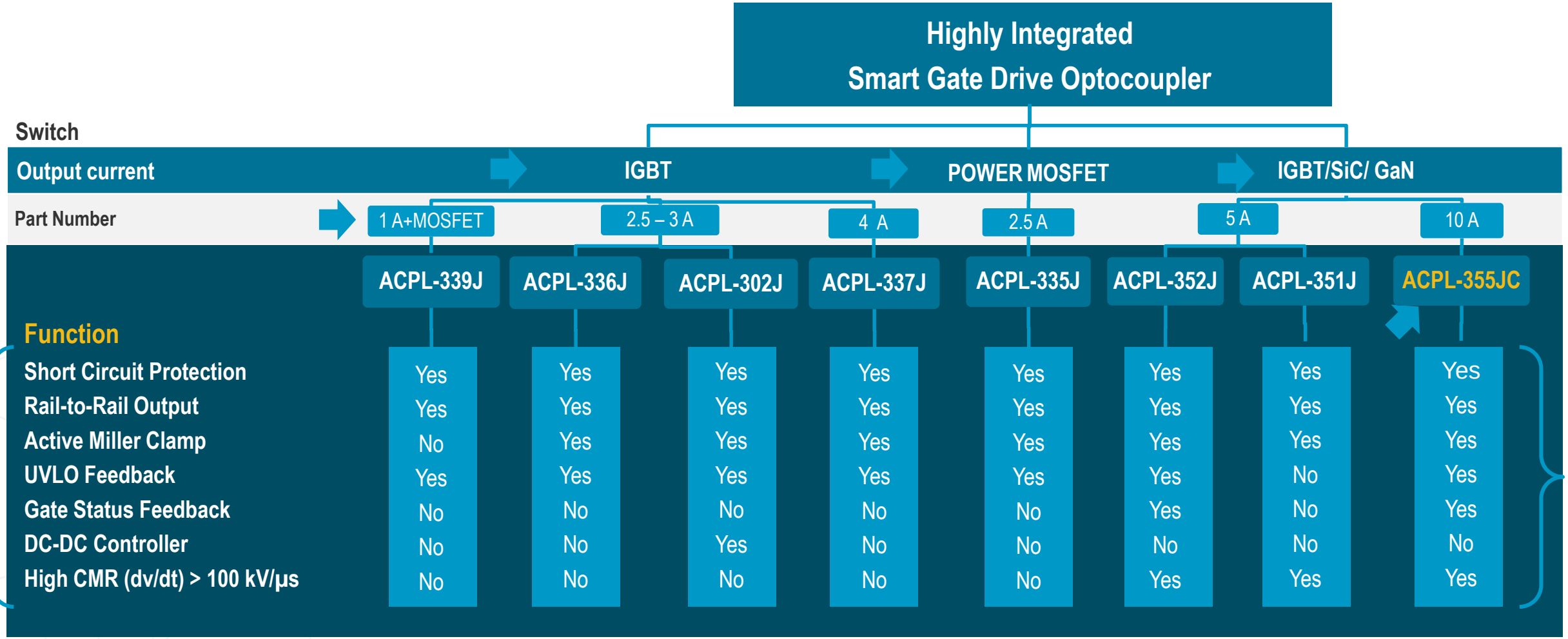
Gate Drive Optocouplers

Smart Gate Drive Product Tree



"More Integration, Higher Drive and Speed"

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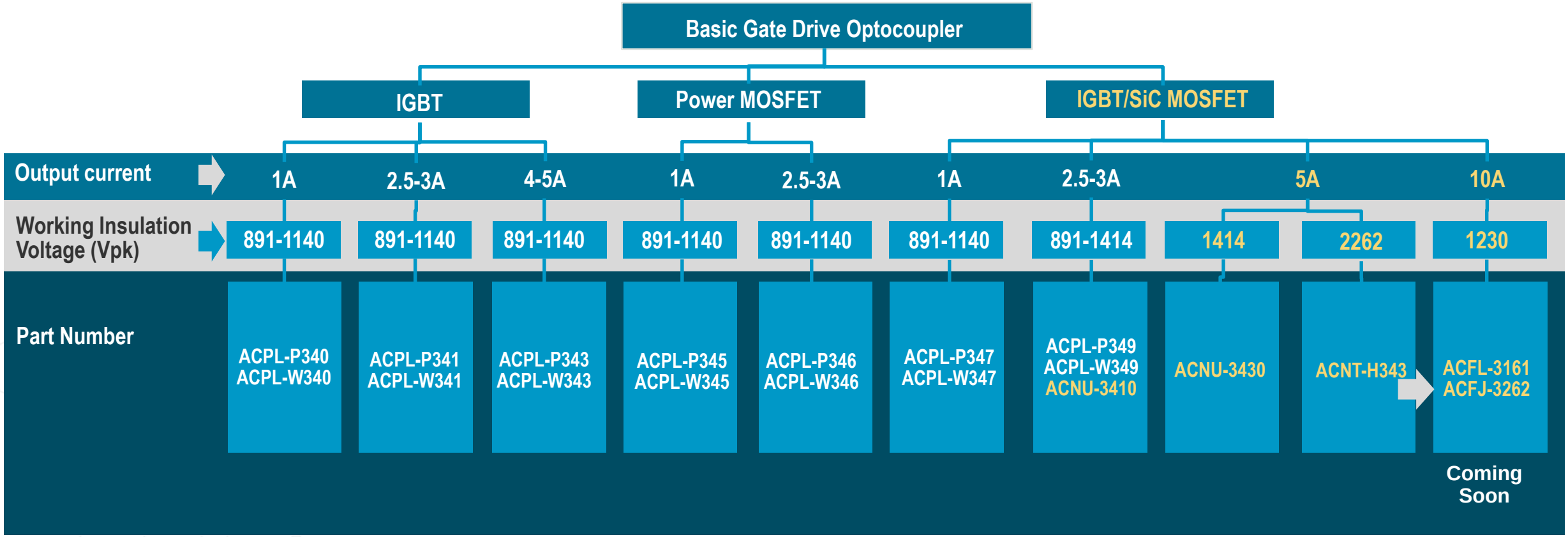
Basic Gate Drive Product Tree



- ACNT-H343: Wide creepage up to 15 mm
- ACFL-3161 (single channel), ACFJ-3262, High current (dual channel): 10 A

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ACPL-355JC – 10A Smart Gate Drive Optocoupler

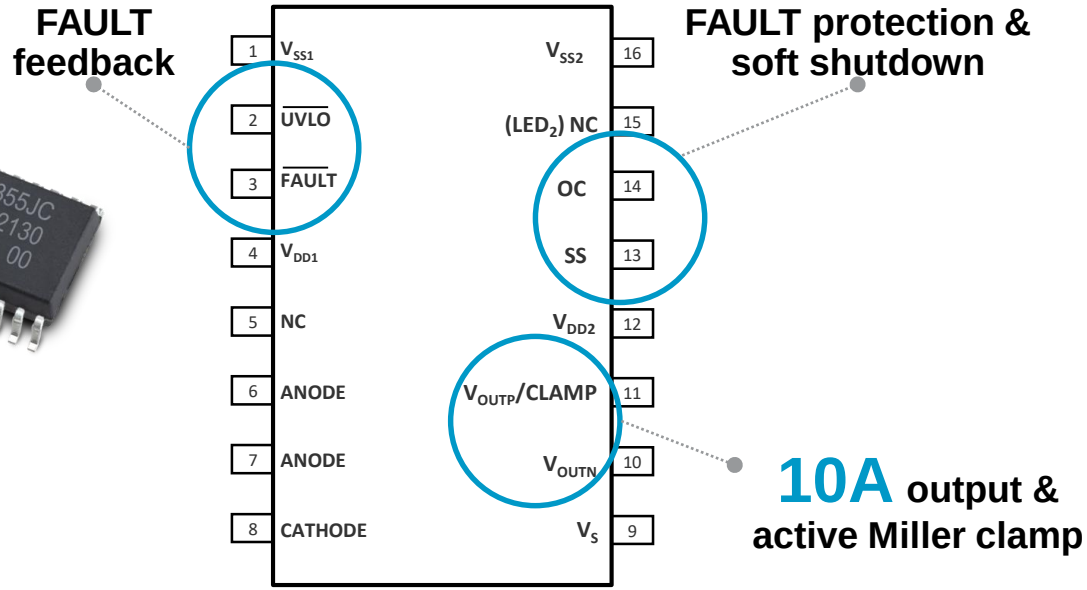
Features

- **10A peak** typical, peak output current
- **CTI > 600V**, material **Group I** package
- V_{IORM}=**2262V_{PEAK}** continuous working voltage
- Over current **FAULT protection & feedback**
- UVLO FAULT protection & feedback
- Adjustable **soft shutdown** during FAULT
- Integrated **active Miller clamp**
- Noise immunity, **CMR >100 kV/µs**
- **150 ns max**. propagation delay
- **WW Safety Approval**
  - UL/cUL Recognized 5000 V_{RMS} for 1min.
  - IEC/EN/DIN EN 60747-5-5 V_{IORM} = 2262 V_{PEAK}

Applications

- Mid-Voltage Motor Drives (**IEC 6188-5-1**)
- 1500V PV Inverter (**IEC 62109-1**)
- Static Var Generator (SVG) / High Voltage Converter (HVC) (**IEC 61439-2**)
- Traction/Railway (**IEC 61377**)
- Driving IGBT and SiC power switches

Pin-out & Functions



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ACPL-355JC - High Voltage Industrial Applications

Mid Voltage Drives

IEC 61800-5-1

Renewable Energy

IEC 62109-1

Electrical Switchgear

IEC 61439

Traction/Railway

IEC 61377

BROADCOM

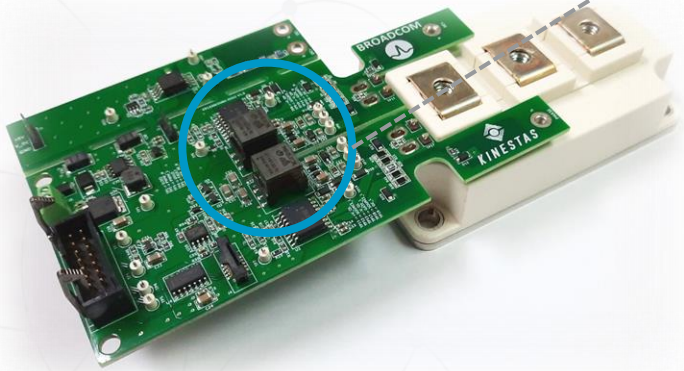
ACPL-355JC - SiC Module Reference Designs

INFINEON

DUAL 1B MODULE

FF23MR12W1M1_B11
FF11MR12W1M1_B11

Half-Bridge SiC Module
1200V 50-100A



62MM MODULE

FF2MR12KM1
FF3MR12KM1
FF6MR12KM1

Half-Bridge SiC Module
1200V 250-500A

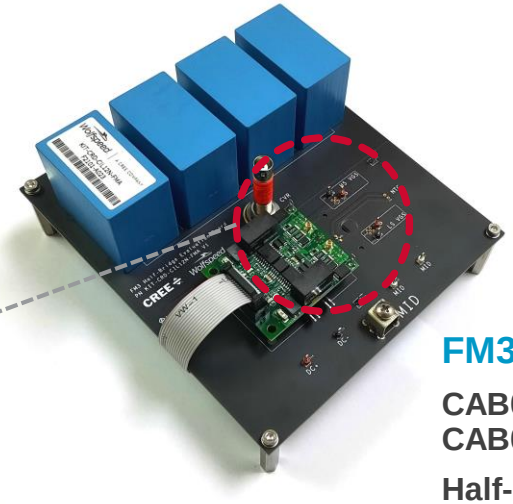
www.broadcom.com/products/optocouplers/reference-designs

BROADCOM®

ACPL-355JC

10A Gate Drive Optocouplers
with Short Circuit Protection

WOLFSPEED



FM3 MODULE

CAB011M12FM3
CAB016M12FM3

Half-Bridge SiC Module
1200V 78-105A

62MM MODULE

WAB300M12BM3
WAB400M12BM3

Half-Bridge SiC Module
1200V 300-400A

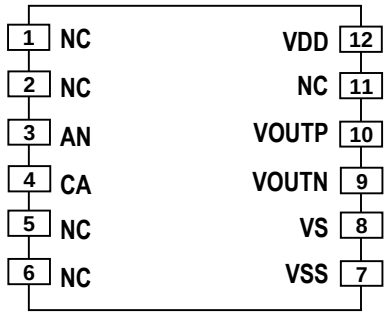
BROADCOM®

ACFL-3161: 10A IGBT / SiC Gate Drive Optocoupler

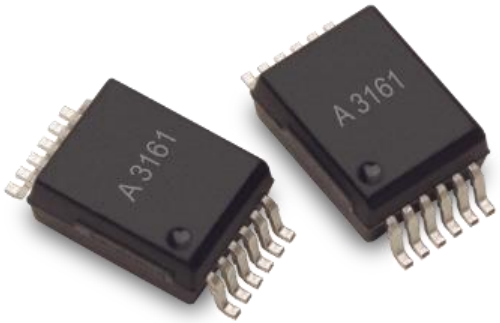
Features

- **10A peak** typical, 6 A min. peak rail-to-rail output
- R_{OUTP} 1.3 Ω max. and R_{OUTN} 1.2 Ω max.
- Separate source and sink outputs
- Wide operating V_{CC} Range: 12 V to 35 V
- Low supply current allows bootstrap half-bridge topology
  - IDD = 4 mA max.
- ***95 ns Maximum propagation delay***
- ***35 ns Maximum dead time distortion***
- ***500 kHz Operation***
- CMTI >100 kV/µs min. @ V_{CM} = 1000 V
- 13.6 V UVLO with hysteresis
- Single channel in SO-12 package
- **CT I > 600V**
- Common Mode Transient Immunity (CMTI) is greater than 100 kV/µs
  - 1000 V common mode voltage.
- Industrial temperature range: ***-40º C to 125º C***
- AECQ100 Grade 1 Qualified (ACFL-3161T)
- Safety Approval
  - UL Recognized 5000 VRMS for 1 min.
  - CSA
  - IEC/EN/DIN EN 60747-5-5 VIORM = 1230 VPEAK

Pin Configuration



ACFL-3161



New Product Released

Market Release

May 2021

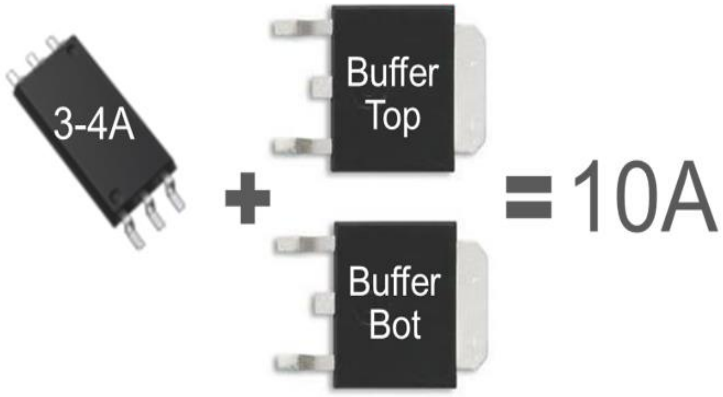
pcim EUROPE ...digital days

BROADCOM

ACFL-3161: Upgrade to Higher Current

Get an Upgrade to ***10 AMPs***

Replace Competition's Solution



TOSHIBA TLP57xx

ON FAIRCHILD FOD83xx

LITEON LTV-341W

3 to 4 A

Specifications	ACFL-3161 (NEW)
Package	**SSO12**
Single Channel	
Creepage/Clearance	**8.5** / **8.3** mm
Working Voltage, V_{IORM}	**1230** V_{PEAK}
CTI, Isolation Grp	**> 600V, I**
I_{OUT} Min/Max.	**6/10** A
t_{PLH}/t_{PHL} Max.	**95** ns
PDD Max.	**35** ns
t_R/t_F Typ.	**7** ns
CMR Min.	**100** kV/µs
Temperature	-40 ºC to **125º** C

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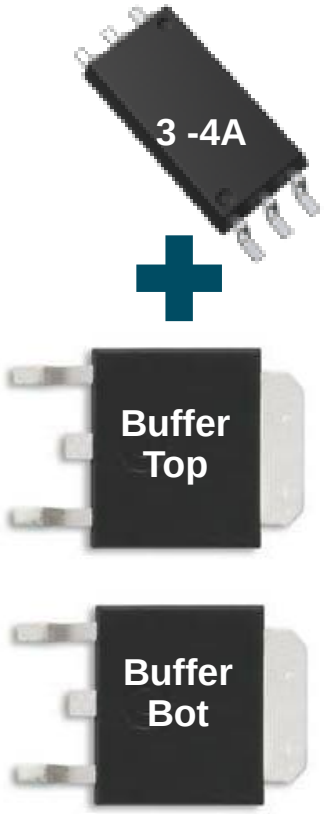
Industry's First 10 A Gate Drive Optocouplers

Industry's First

10A

GATE DRIVE OPTOCOUPLERS

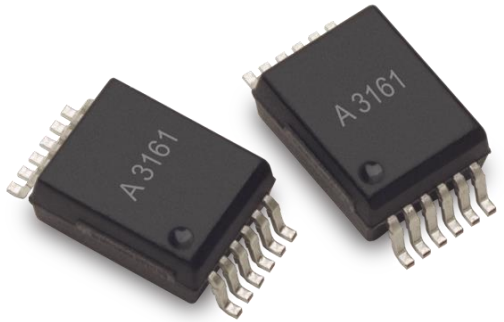


= 10A

Replace Direct Competition

ACFL-3161

Single-CHANNEL



TOSHIBA TLP57xx

ON Semiconductor FAIRCHILD FOD83xx

LITEON LTV-341W

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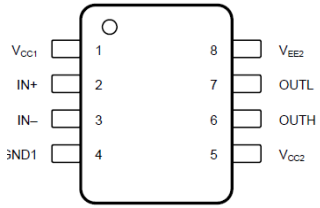
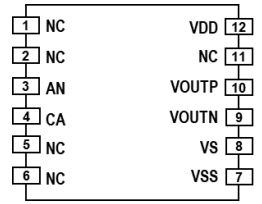
ACFL-3161: 10 A Gate Drive Competition

Specifications	NCD57090E	UCC5350SB	1EDI60H12AH	ACFL-3161 (NEW)
Package	SOIC8 WB	SOIC-8	PG-DSO-8	SSO12
	ON Semiconductor 	Texas Instruments 	Infineon 	Broadcom 
Creepage/Clearance	8 mm	8.5 mm	8 mm	8.5/8.3 mm
Working Voltage, V_{IORM}	1200 V_{PEAK}	2121 V_{PEAK}	1200 V	1230 V_{PEAK}
CTI, *(Isolation Group)*	>600V, *(I)*	>600 V, *(I)*	400 V, *(II)*	>600 V, *(I)*
I_{OUT} Min/Max.	**- / 6.5 A**	**5 / 10 A**	**6 / 10 A**	**6 / 10 A**
t_{PLH}/t_{PHL} Max.	90 ns	100 ns	142 ns	95 ns
PDD Max.	30 ns	25 ns	25 ns	35 ns
t_R/t_F Typ.	13 ns	10 ns	10 ns	7 ns
CMR Min.	100 kV/µs	100 kV/µs	100 kV/µs	100 kV/µs
Temperature	-40º C to 125º C	-40º C to 125º C	-40º C to 125º C	-40º C to 125º C

* Silabs and ADi have highest, 4A isolated gate drivers

Uncover & Replace *Competitions*

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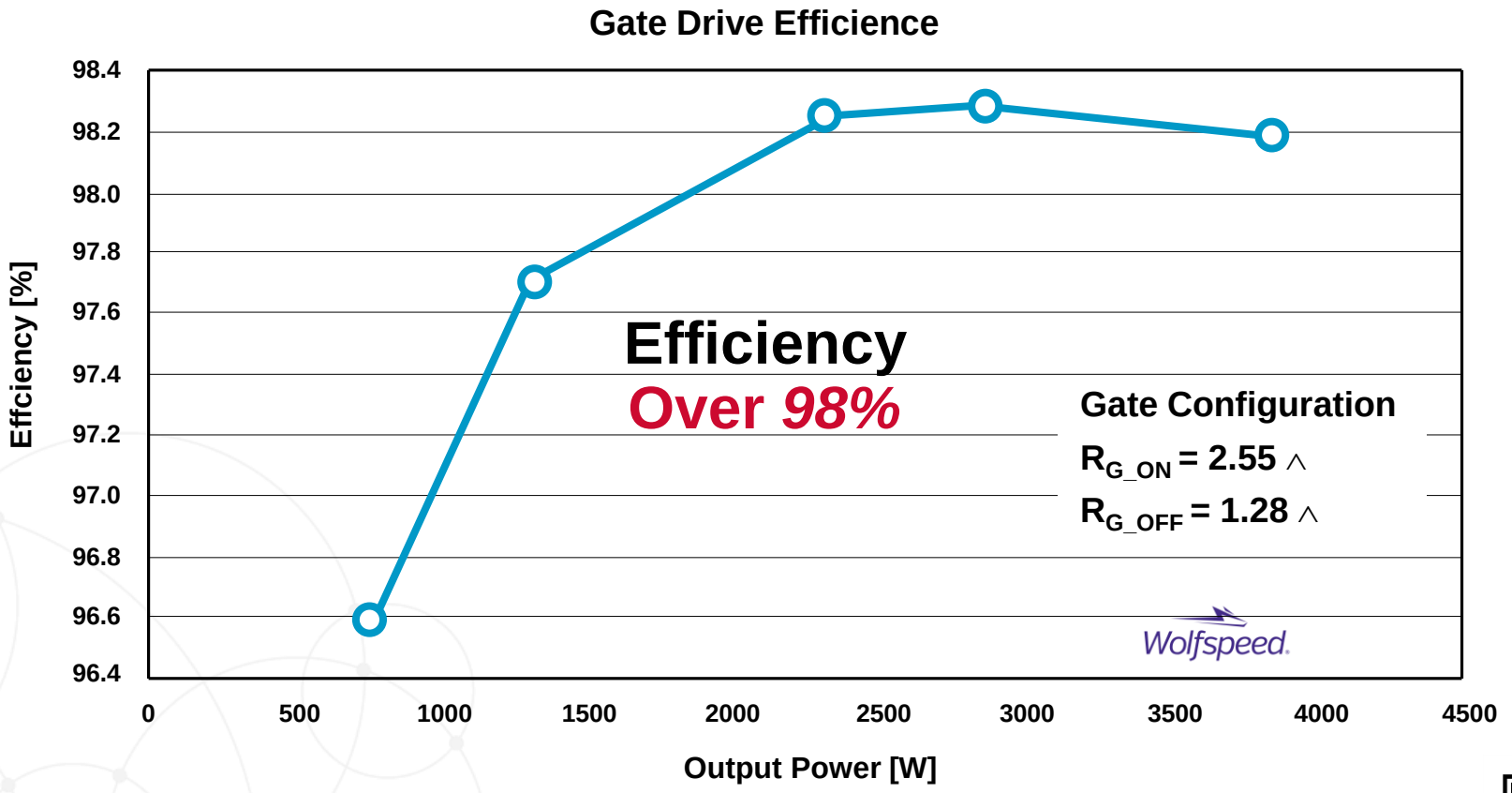
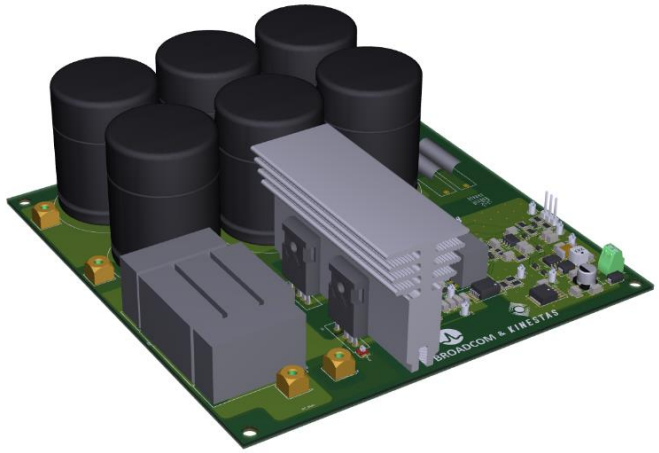
ACFL-3161: TO-247 1200 V / 100 A SiC Reference Designs

Hard Switching Buck for ACFJ-325XT at 200kHz





life.augmented **SCTWA70N120G2V**

Wolfspeed. **C3M0021120K**

Comment and Observation:

ACFJ-325XT perform well in this Hard Switching Buck circuit. The effect of the stronger output stage (0.8∧ sourcing, 0.6∧ sinking) is lower switching losses and higher efficiency.

https://www.broadcom.com/products/optocouplers/reference-designs

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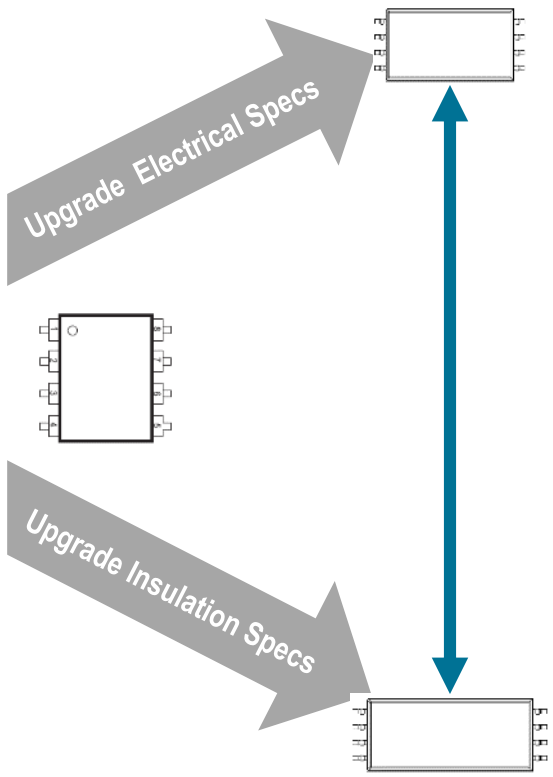
High Voltage, Wide Creepag /Clearance Basic Gate Drive Upgrades

Specifications	HCNW3120
I_{OUT} Min.	2.0 A
I_{OUT} Max.	2.5 A
V_{OH} Min. @100 mA	V_{CC} – 4 V
t_{PLH} / t_{PHL} Max.	500 ns
PDD Max.	350 ns
CMR Min.	25 kV/µs
V_E Pin	No
Creepage	10 mm
Clearance	9.6 mm
V_{ISO}	5000 V_{RMS}
VDE $V_{IORM,}$	1414 V_{PEAK}
VDE V_{IOTM}	8000 V_{PEAK}



Recommended Upgrade

Better Electrical Specifications

Specifications	ACNU-3430
Creepage	11 mm
Clearance	10.5 mm
V_{ISO}	5000 V_{RMS}
VDE $V_{IORM,}$	1414 V_{PEAK}
VDE V_{IOTM}	8000 V_{PEAK}
CMR Min.	100 kV/µs

Recommended Upgrade

Higher Insulation Specifications

Specifications	ACNT-H343
Creepage	15 mm
Clearance	14.2 mm
V_{ISO}	7500 V_{RMS}
VDE V_{IORM}	2262 V_{PEAK}
VDE V_{IOTM}	12000 V_{PEAK}

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ACNT-H343 5A Gate Drive Optocoupler in 15 mm SSO8 Package

Description

- 15 mm Creepage, 14.2 mm Clearance
- 5.0 A max. Peak output current
- UVLO with hysteresis
- CMR 100 kV/µs @VCM=1.5 kV
- Rail-to-Rail output voltage
- Wide operating VCC Range: 15 V to 30 V
- ICC = 5 mA Maximum supply current
- 150 ns Maximum switching speed
- Industrial temperature range: -40Cº C to 110º C
- Worldwide safety approval:
- IEC/EN/DIN EN 60747-5-5, VIORM = 2262 V_{PEAK}
- UL 1577 (7500 V_{RMS} /1 min.)
- CSA Notice #5

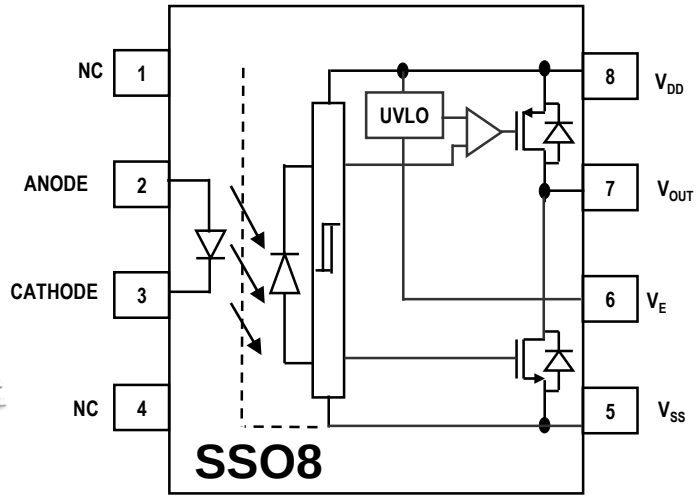
VAR: Volt-Ampere Reactive

*"**15 mm** Creepage SSO8 Package"*

Applications

- IGBT/MOSFET gate drive
- Renewable energy inverter
- AC/Brushless DC Motor drives
- Industrial inverters
- Switching power supplies
- Static VAR generator

Functional Diagram



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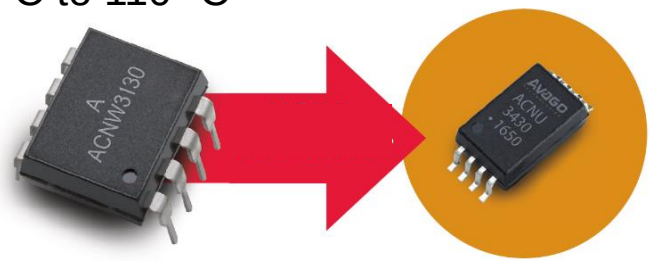
ACNU-3430 (5 A) / 3410 (3A) Gate Drive Optocoupler

11 mm SSO8 Package

Description

- 11 mm Creepage, 10.5 mm Clearance
- *5.0 A max Peak Output Current (ACNU-3430)*
- *3.0 A max Peak Output Current (ACNU-3410)*
- Rail-to-Rail Output Voltage
- UVLO with V_E reference for negative power supply
- CMR 100 kV/µs @ V_{CM} = 1.5 kV
- I_{CC} = 5 mA max. Supply Current
- Wide operating V_{CC} range: 15 V to 30 V
- 150 ns Maximum switching speed
- Industrial temperature range: -40º C to 110º C
- Worldwide safety approval
  - IEC/EN/DIN EN 60747-5-5, V_{IORM} = 1414 V_{PEAK}
  - UL 1577 (5000 V_{RMS}/1 min.)
  - CSA notice #5



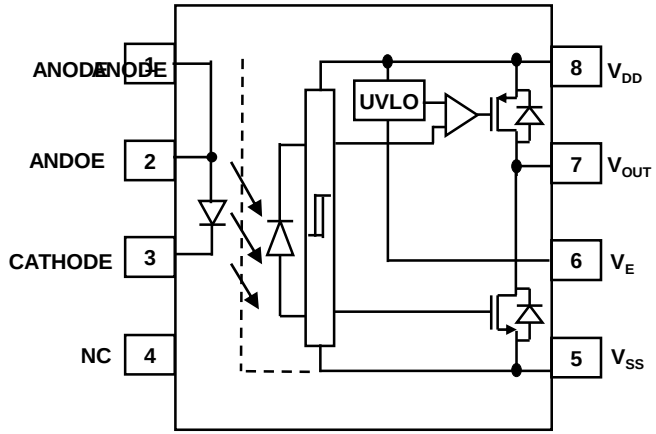
400mil Widebody
10mm Creepage and
9.6mm Clearance

11mm SSO8
11mm Creepage and
10.5mm Clearance

Applications

- IGBT/MOSFET Gate drive
- Renewable energy inverter
- AC/Brushless DC motor drives
- Industrial inverters
- Switching power supplies

Functional Diagram



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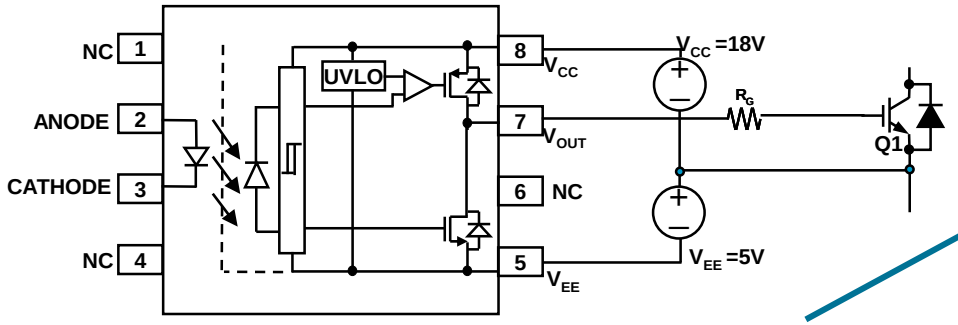
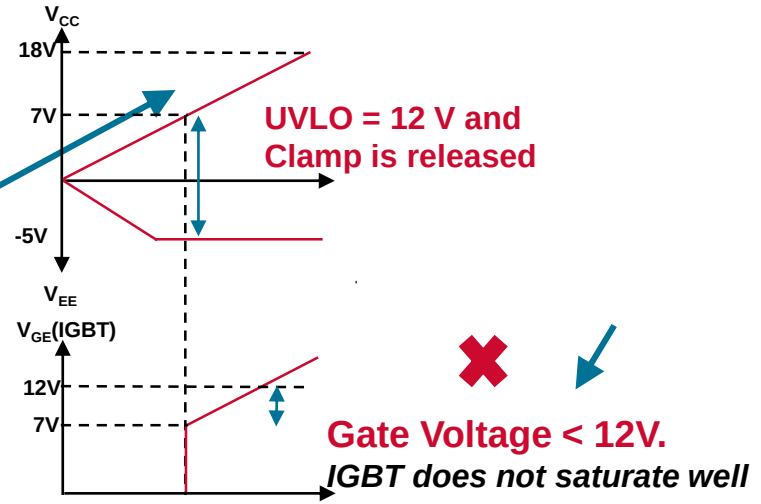
Application Diagram: UVLO with V_E reference for negative power supply

UVLO reference to V_{EE} ✖

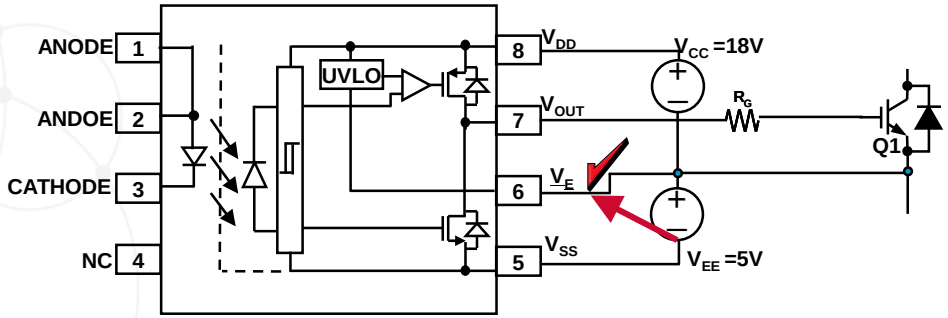


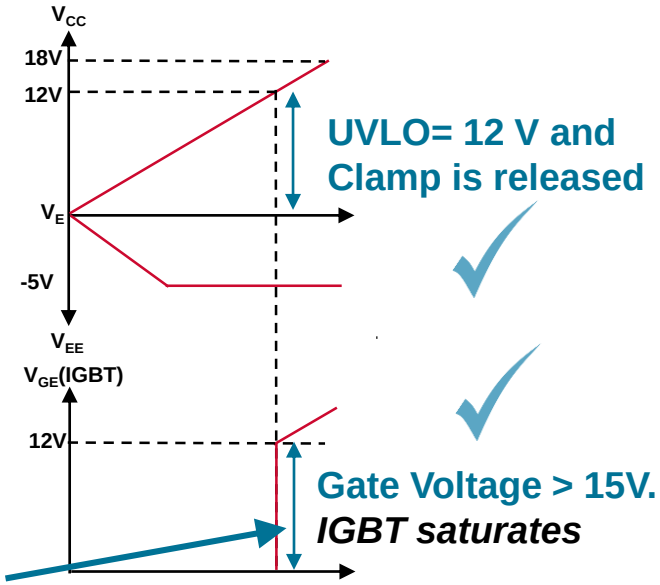


Temperature rise and possible damage to external IGBT

ACNU-3430, ACNU-3410

UVLO reference to V_E





IGBT saturates with UVLO referenced to V_{EE}

BROADCOM

Gate Drive Reference Designs & Evaluation Boards

- https://www.broadcom.com/products/optocouplers/reference-designs
- SiC/GaN Reference Designs
  - **10A** Smart GD ACPL-355JC and Basic GD ACFL-3161/3262

Infineon

ACPL-355JC
Infineon Half-Bridge
1200V SiC module

Wolfspeed

ACPL-355JC
Wolfspeed FM3 Half-Bridge
1200V SiC module

STM

ACFL-3161
STM TO247 1200V
SiC Discreet

Wolfspeed

ACFL-3161
Wolfspeed TO247 CM3
1200V SiC Discreet

nexperia

ACFJ-3262
Nexperia CCPAK 650V
GaN Discreet

Infineon
Wolfspeed

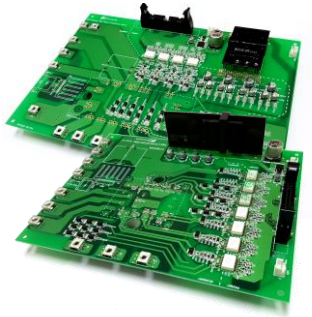
ACPL-355JC
62mm SiC
1200/300A-500A

- IGBT Reference Designs

ACPL-339J/C87B/736J
Fuji Electric & Infineon
DUAL 1200V IGBT

ACPL-352J
Infineon 1200V
IGBT4 PIM3

ACPL-337J
Infineon 600V
IGBT3 PIM IGBT



ACPL-337J
Fuji EP2/EP3
IGBT Module

ACPL-336J
Fuji PIM
IGBT Module

BROADCOM

Optocoupler Isolation and Gate Drive White Papers

Enhanced Galvanic Isolation Performance

- Faraday shield
- Small Cio

BROADCOM

White Paper

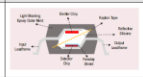
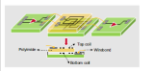
Internal Faraday Shield and Small Ci-o Enhance Broadcom Optocoupler Galvanic Isolation Performance

High-voltage isolation in today's context involves integrating subsystems with large voltage differences and systems ground potentials. This enables isolation applications ranging from power supply, motor control circuit of servo automation systems and industrial robots, battery management systems, photovoltaic (PV) inverters, electric vehicle (eV) inverters, ultra-fast charging and wireless-charging stations to data communication and digital logic interface circuits. Basically, the most important components, isolators (couplers), provide electrical isolation that allows integration of different subsystems by breaking direct conduction paths. Integrated circuits (ICs) can be combined into the isolators for various electrical functions, such as driving power electronic devices, high accuracy current and voltage measurements, analog and digital communications and logic interfaces, and isolated power supply conversions.

Isolation Technology

Three types of isolator technologies are available: optocoupler, magnetic coupler, and capacitive coupler. Table 1 shows the key differences between the different isolation techniques, component safety certifications, and lifetime reliability failure mechanisms.

Table 1: Key Differences between Different Isolation Techniques, Component Safety Certifications, and Lifetime Reliability Failure Mechanisms

Isolator/Coupler Types	Broadcom Optocoupler	Magnetic Coupler	Capacitive Coupler
Isolation Construction			
Insulation Material	3 layers Silicone/Kapton Tape/Silicone	1 layer Polyimide	1 layer Silicon Dioxide
Insulation Thickness	0.08 mm to 2.0 mm	▪ Up to ~0.02 mm for single coil ▪ Double coil (~ 0.04 mm)	▪ Up to ~0.014 mm for single cap ▪ Double cap (~0.028 mm)
Component Certification/ Lifetime Test Method	IEC 60747-5-5 For Optocoupler Only Partial Discharge (PD) Reinforced Isolation	VDE 0884-10 Alternative Isolator Partial Discharge (PD)	VDE 0884-11 Alternative Isolator Partial Discharge (PD)
Lifetime and Reliability Failure Mechanism	Partial Discharge	Space-Charge Degradation	TDDB-Time Dependent Dielectric Breakdown (oxide film degrade over time)

It is Easy to Drive and Protect SiC MOSFET

BROADCOM

White Paper

It Is Easy to Drive and Protect SiC MOSFET

Introduction

More than ten years ago, we started seeing increasing Silicon Carbide (SiC) Metal–Oxide–Semiconductor Field-Effect Transistors (MOSFETs) activities and a splash of product launches from key power semiconductor suppliers like Cree and Infineon. At the same time, many new suppliers were trying to dethrone the incumbent silicon and change the gameplay in their own ways. However, this is a mammoth task as Insulated-Gate Bipolar Transistors (IGBTs), which have been around for more than 40 years, are entrenched in every power electronics engineer's design.

Although SiC MOSFETs can bring forth many benefits, it took more than ten years for suppliers to consolidate and align SiC MOSFET specifications and standards, including definitions for driving and protecting the SiC MOSFET. Engineers faced many challenges. For example, the normally ON SiC Junction-Gate Field Effect Transistor (JFET) needed a negative gate voltage to turn it off. The more acceptable normally OFF switch could be used, but it required a very high gate voltage of 20V to ensure low conduction loss. That meant engineers had to redesign their power supply, which had been optimized for the IGBT at 15V gate-emitter voltage, V_{GE}. Common problems also included challenges like high-speed operation and dv/dt noise when SiC MOSFETs switch faster.

Today, most of the disparities have been aligned with how we will drive IGBTs. Most importantly, gate drive technologies have also improved tremendously to enable the adoption of SiC MOSFETs. Broadcom recently released a 10A gate drive optocoupler, the ACPL-355JC. It is able to fulfill the demanding requirements of driving and protecting SiC MOSFETs.

At the same time, most of the major suppliers in the power semiconductor industry are ramping up their SiC MOSFET production with packages and pinouts that can easily replace existing IGBTs. This drives the costs of SiC MOSFETs to a very competitive level, which is likely the most important factor to facilitate SiC MOSFET adoption.

The Standardization of SiC MOSFET Specifications

The Broadcom® gate drive optocoupler has evolved to meet the demand of SiC MOSFETs. Similarly, SiC MOSFETs have also evolved to be easily driven and protected by gate drivers. This section highlights some of the important changes in the specification, which enable the growing adoption of SiC MOSFETs.

The first specification is gate-source voltage, V_{GS}. Over the years, the optimum V_{GS} for SiC MOSFET operations has reduced from 20V to 18V and finally settled at 15V, the same level as the V_{GE} of IGBTs. This has made definitions of the gate driver power supply and under voltage lockout (UVLO) threshold more definite. The ACPL-355JC gate drive optocoupler has a wide supply range from 0V to 30V, which makes it very versatile for either unipolar gate driving or bipolar gate driving. These ensure the SiC MOSFETs are firmly switched on or off. The UVLO of the ACPL-355JC is set to 13V, which is suitable to drive most of the latest SiC MOSFET gates, which are designed to operate at 15V V_{GS}.

Gate Drive Optocouplers for GaN Power Devices

BROADCOM

White Paper

Gate Drive Optocouplers for GaN Power Devices

By Robinson Law, Applications Engineer, and Chun Keong Tee, Product Manager, Broadcom Inc.

Introduction

Gallium nitride (GaN) power devices are gaining popularity over silicon power devices because their faster switching capability can improve overall system efficiency and reduce the size of the device and the operating cost. The technical benefits coupled with lower costs due to the increase in GaN production have increased the adoption in applications such as industrial power supplies and renewable energy inverters.

Broadcom® Inc. (formerly Avago Technologies) gate drive optocouplers are used extensively in driving silicon-based semiconductors, such as IGBT and power MOSFETs. Optocouplers provide reinforced galvanic insulation between the control circuits and the high voltages. The ability to reject high common mode noise prevents erroneous driving of the power semiconductors during high-frequency switching. This paper describes the benefits of GaN, its gate drive requirements, and the gate drive designs, tests, and performance.

Benefits of GaN

Gallium nitride is a wide bandgap (3.4 eV) compound made up of gallium and nitrogen. Bandgap is a region formed at the junction of materials where no electron exists. Wide bandgap GaN has a high breakdown voltage and a low conduction resistance. It has a higher electron velocity and a lower parasitic capacitance, which improve its switching speed.

The benefits of GaN over silicon can be summarized by three main points:

- Smaller system designs
- Lower system costs
- Higher system efficiency

Lithium-Ion Battery-Stack Safety in EV

BROADCOM

White Paper

Improve Lithium-Ion Battery-Stack Safety in Electric Vehicles by Leveraging Optocouplers to Isolate High Voltages

Andy Poh, Product Marketing Manager, Broadcom, Inc.

Introduction

There are many challenges associated with high-voltage Li-ion battery-stack management in all-electric or hybrid automotive applications. Charge and discharge cycles must be monitored and controlled, and the battery stack, which often delivers voltages of several hundred volts, has to be isolated for safety concerns. In particular, this paper will examine the requirements for Li-ion cell monitoring, and review the architecture and components used in the cell-monitoring subsystem, digital-communications subsystem, and isolation interface.

Within the management system, the battery-monitoring boards use two key subsystems to reliably monitor cell health and deliver digital results to a host processor that orchestrates system operation. Separating those subsystems is a signal interface using optical isolation between high-voltage battery-sensing circuitry and communications devices on the boards, which ensures that the high voltages will not compromise the digital subsystem.

Li-ion Cell Characteristics

The sophisticated electronics system required to meet EV performance, safety, and reliability requirements is basically derived directly from the characteristics of Li-ion cells. In a discharging Li-ion cell, lithium is ionized in a (typically) graphite anode, and the Li ions move through an electrolyte to pass through a separator to a cathode, resulting in charge flow. The charging process reverses the flow, bringing Li-ions from the cathode through the separator to the anode.

The performance and reliability of this chemical process are dependent on cell temperature and cell voltage. At low temperatures, the chemical reaction slows, lowering cell voltage. As temperature increases, the reaction rate increases until the Li-ion cell components begin to break down. At temperatures above 100°C, the electrolyte begins to break down, releasing gases that can cause pressure to build within cells designed without pressure-relief mechanisms. At high enough temperatures, Li-ion cells can experience thermal runaway as oxides break down, releasing oxygen, which further accelerates the temperature increase.

Consequently, maintaining optimum operating conditions for Li-ion cells is a critical requirement for the battery-management system. The challenge in designing the control/management system is ensuring reliable data collection and analysis to monitor and control the state of the Li-ion cells in the vehicle-a problem exacerbated by the nature of Li-ion cells themselves.

In an EV, such as the Chevy Volt, the battery pack contains 288 prismatic Li-ion cells, which are, in turn, divided into 96 battery-cell groups that are connected to deliver a system voltage of 386.6V DC. Those battery-cell groups, in turn, are combined with temperature sensors and cooling elements into four main battery modules. Voltage-sense lines attached to each cell group terminate in a connector on top of each battery module, and a voltage-sense harness joins the connector to a battery-interface module that sits on top of each battery module. Here, four color- coded battery interface modules operate at different positions in the battery stack, corresponding to low-, medium-, and high-voltage ranges of DC voltage offset for the set of four modules.

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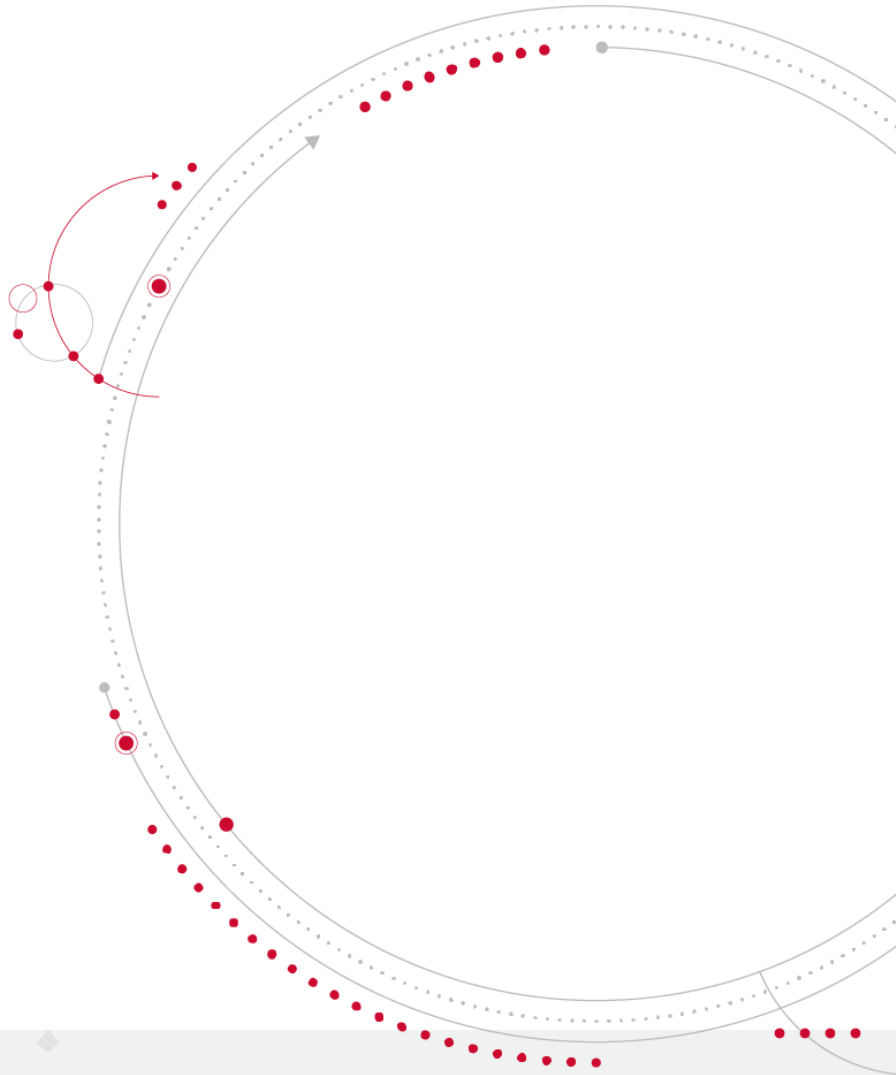
Current Sense



Current and Voltage Sense Optocouplers

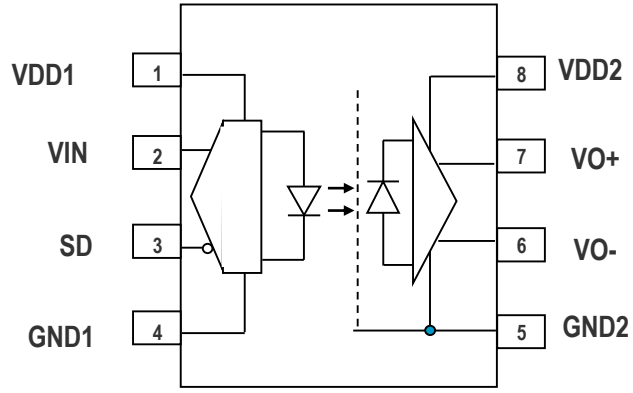
Current and Voltage Sense Optocouplers are used for **isolating current and voltage sense** and are typically used to measure phase currents (with shunt resistors) or DC-link voltages in three phase frequency converter power applications.

Target Applications

- Industrial automation process control
- AC drives and servo motor control
- Solar and wind turbine inverters
- Data acquisition system
- Uninterrupted power supplies (UPS)
- Battery management systems
- Isolated DC bus voltage measurement
- Isolated sensor interface
- General inverters

Broadcom Advantages and Key Considerations

- High accuracy
- Low drift over temperature
- Higher common mode rejection
- Compact size
- Cost-effective solution
- Safe and reliable insulation



Pinout Configuration
ACPL-C79x Family

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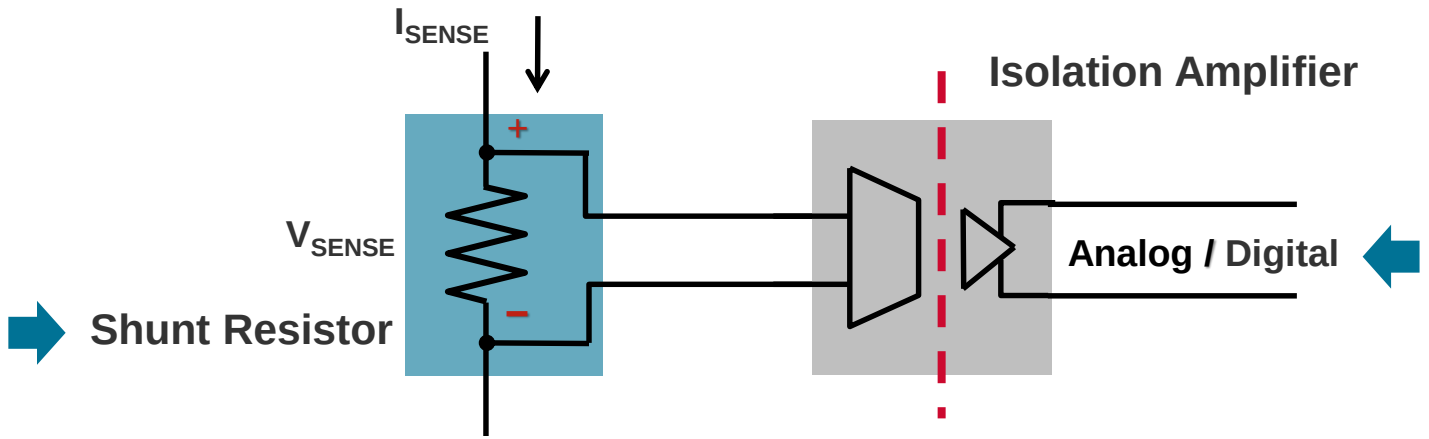
The Benefits of Broadcom Isolation Amplifiers



Shunt Resistor

- Easily address different current ranges by adjusting shunt resistance value
- Excellent accuracy over temperature
- Superior optical isolation technology
- ***Advanced sigma delta modulation***

+

Isolation Amplifier

Advanced sigma delta modulation

- Ease of assembly - surface mount solution
- Cost effective compared to Hall Effect sensors
  - Higher accuracy
  - Less space
- Market proven reliability
- Worldwide safety certified protection

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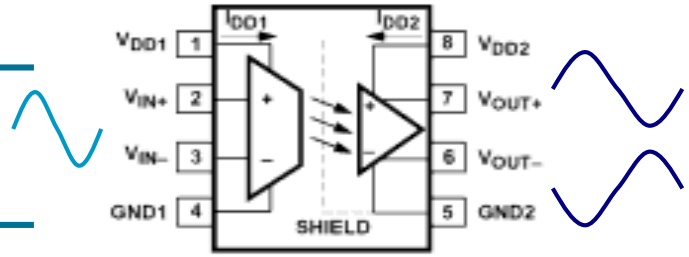
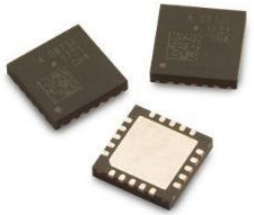
Analog and Digital Output Current/Voltage Sense with Isolated Modulator

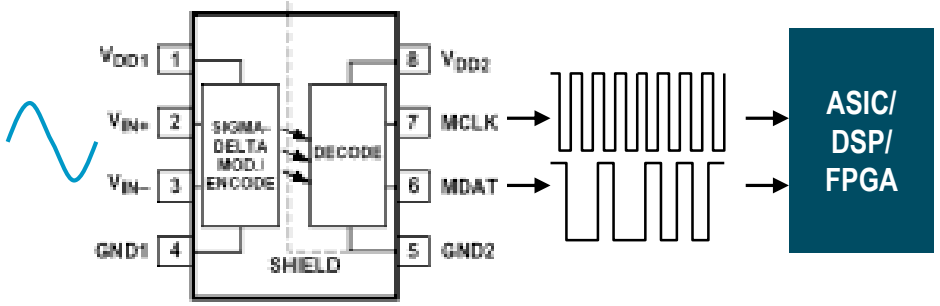
	Gain Tolerance ±0.5%	Gain Tolerance ±1%	Gain Tolerance ±3%
Analog output for *current sense*	ACPL-C79B ACNT-H79B	ACPL-C79A ACNT-H79A	ACPL-C790 ACNT-H790
Analog output for *voltage* sense	ACPL-C87B ACNT-H87B	ACPL-C87A ACNT-H87A	ACPL-C870 ACNT-H870



Analog output *current sense* with short circuit and overload detection	HCPL-788J ACPL-785J SO16
Digital output with internal clock	ACPL-C740 ACPL-C799 ACPL-C797 SSO8
Digital output with external clock	ACPL-798J (LVDS) ACPL-796J SO16



3-Ch Digital Filter
ACPL-0873



ACPL-C79B/A/0 ACPL-790B/A/0: 2nd Gen Isolation Amplifiers

Released

Features

- Advanced Sigma-Delta ADC core
- ***Superior optical isolation technology***
- Gain accuracy: **±0.5%, ±1%, ±3%**
- Input range: ±200 mV
- Low gain drift: –50 ppm/ºC
- **Input offset voltage: 0.6 mV**
- **Specified maximum non-linearity: 0.13%**
- SNR: 62 dB
- Wide bandwidth: 200 kHz
- Fast response time (t_{PD90}): 1.6 µsec
- Excellent CMTI: 15 kV/µs
- Wide output side supply range: 3 V to 5.5 V
- Wide operating temperature range: –40º C to +105º C
- Package options: C79x: SSO8, 790x: DIP8
- Creepage and clearance: 8 mm
- ***Reinforced insulation with worldwide safety approvals***
  - IEC/EN/DIN EN 60747-5-5: V_{IORM} = 1414 Vpk (C79x), 891Vpk (790x)
  - UL 1577: 5000 Vrms/1min (C79x),
  - 3750 Vrms (790x), CSA

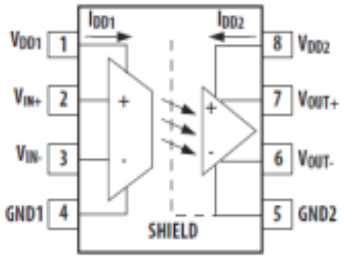
Key Benefits

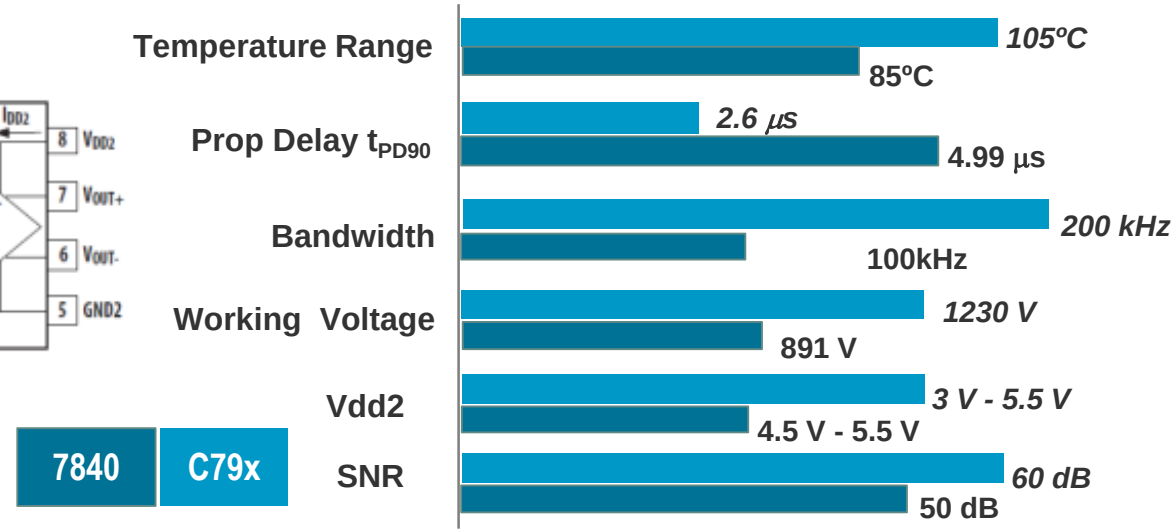
- Superior optical isolation for reinforced safety insulation and isolation
- Excellent drift performance over temperature.
- Fast response
- Excellent non-linearity

Applications

- Motor phase and rail I/V sensing
- Inverter current sensing
- Uninterrupted power supplies (UPS)
- Instrumentation

C79x / 790x Improvements Over 1st Generation





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ACPL-C87B / C87A / C870: Precision Isolated Voltage Sensors

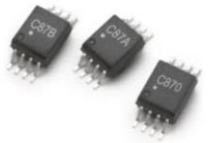
New Products

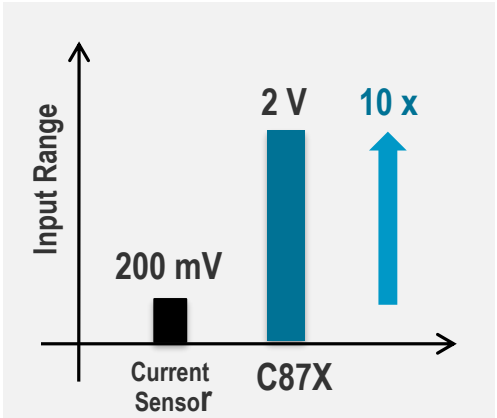
Features

- Linear input range: 0 V to 2 V
- High input impedance: ***1 GΩ***
- Unity gain, differential output
- Bandwidth: 100 kHz
- Gain accuracy: ±0.5% (C87B), ±1% (C87A) and ±3% (C870)
- Nonlinearity: 0.1% maximum
- Gain drift: -35 ppm/°C
- Supply voltage V_{DD2}: 3 V to 5.5 V
- Low power standby mode: 50 µA
- High CMR: 15 kV/µs at V_{CM} = 1500 V
- Package: SSO8
- Reinforced optical insulation with ***worldwide safety approvals***
  - UL 1577: 5 kV_{RMS} for 1 minute
  - IEC 60747-5-5: Viorm = CSA File Notice #5
- High operating temperature: -40° C to +105° C

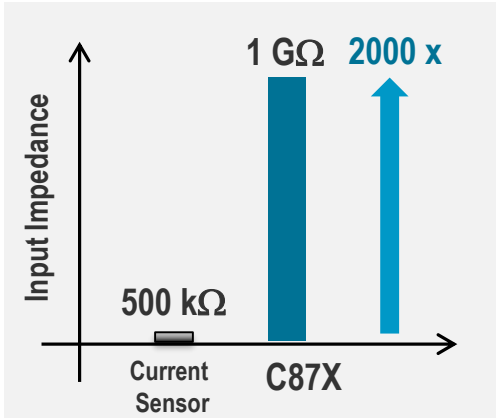
Applications

- Isolated voltage sensing in AC and servo motor drives
- Isolated dc-bus voltage sensing in solar inverters,
- Isolated sensor interfaces
- Signal isolation in data acquisition systems
- General purpose voltage isolation





Wide dynamic input range improves signal to noise ratio.



High input impedance minimizes loading errors.

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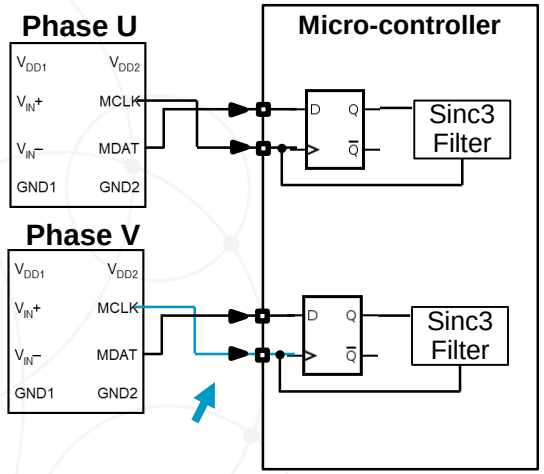
Internal Clock vs External Clock Sigma Delta Modulator (SDM)

Digital-output current sense products

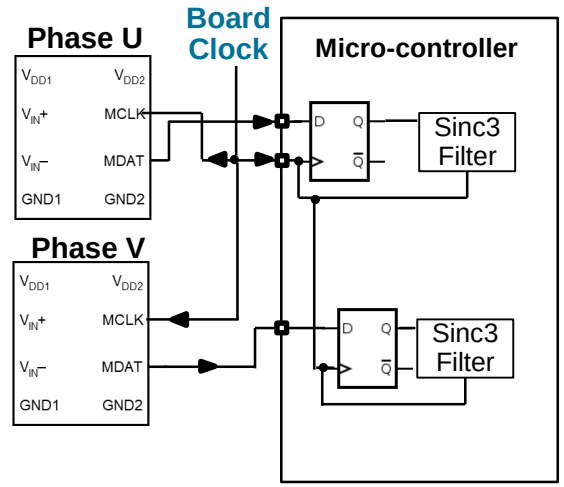
- **No external board clock source** required
- Clock frequency is fixed internally in the SDM
- Broadcom internal clock SDMs have **natural jitter** on the Mclk and spread the frequency peaks over a wider spectrum. *This helps to **reduce EMI**.*
- Different current sensing phase are referenced to different a Mclk and ***additional microcontroller port required***
- **There is no Mdat synchronization issue with** Mclk as the Mclk-Mdat delay is always the same for all clock cycles

Internal Clock SDM



- Requires **external board clock source**
  - **Additional cost**.
- **Clock frequency** is easily **changed** by changing clock source configurations (R-C).
- Only **one Mclk port** needed at the micro-controller as all current sensing phases are synchronized to the same clock.
- External clock source has **less jitter** and has peak power at the center frequency spread spectrum. *This may **cause EMI**.*

External Clock SDM



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ACPL-C799: ±50 mV Optically Isolated High Precision Σ-Δ Modulator

Key Features

- ***±50 mV Linear range***
- 1-bit, 2nd order Σ-Δ modulator
- 10 MHz internal clock
- ***16 bit resolution, no missing codes: 12 bits ENOB***
- SNR: 77 dB typical
- Maximum offset drift: 1.3 µV/°C
- Gain error :±1% typical
- Wide supply range for digital interface: 3 V to 5.5 V
- -40°C to +105°C ambient T_A
- Stretched-SO8 package
- CMTI: 25 kV/µs typical
- Reinforced insulation safety approval
  - UL Recognized 5 kVRMS for 1 min
  - IEC 60747-5-5 , Viorm = 1414 Vpeak
  - CSA File Notice #5

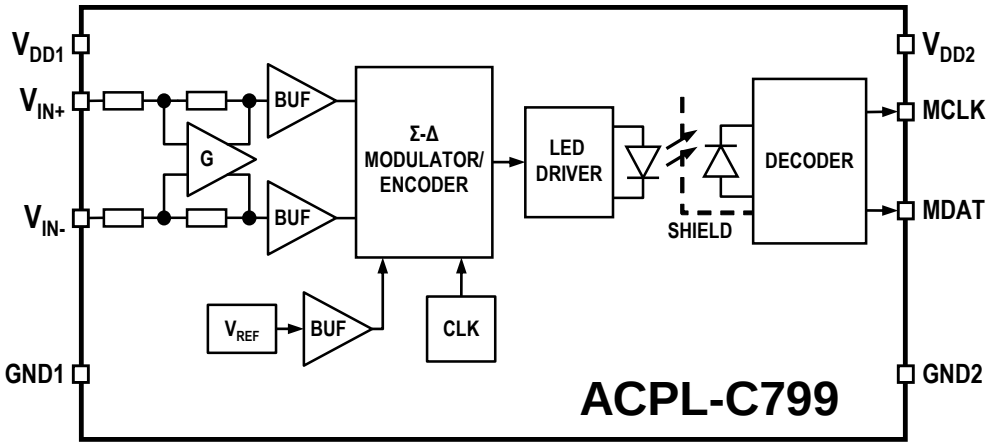
Benefits

- Lower shunt power dissipation with reduced input range.
- Suitable for heavy current sense applications

Applications

- Motor phase and rail current sensing
- Power inverter current sensing
- Industrial process control
- Data acquisition systems
- General purpose current sensing
- Traditional current transducer replacement

10 MHz Internal Clock



BROADCOM

ACPL-C740 High Precision Σ-Δ Modulator

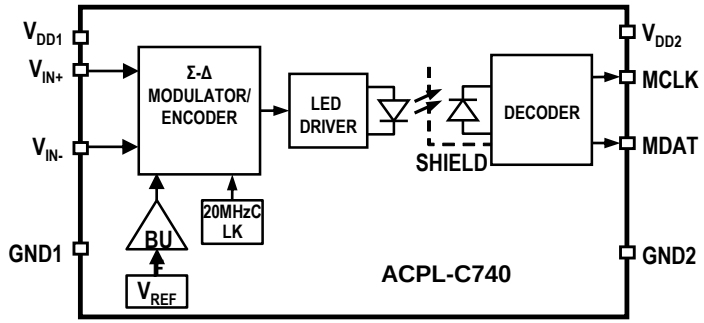
± 200 mV Input, 20 MHz Internal Clock, Optically Isolated CMOS Output

Key Features and Value Proposition

- ± 200 mV linear input range
  - ±320 mV full-scale
- **20 MHz** internal clock
- SSO-8 package
- Offset temperature drift: **0.8 µV/°C** typical
- **83 dB SNR**
  - 80 dB SNDR typical
- 16-bits resolution no missing codes
  - 12 bits ENOB
- ±1% Gain error
- Digital output supply range (V_{DD2}): 3 V to 5.5 V
- -40° C to +110° C Ambient temp operating range
- CMTI: 25 kV/µs
- 8 mm Creepage / Clearance
- ***Reinforced Insulation*** *Safety Approval*
  - UL Recognized 5kVrms for 1 min
  - IEC 60747-5-5 , Viorm = 1414Vpeak
  - CSA File Notice #5

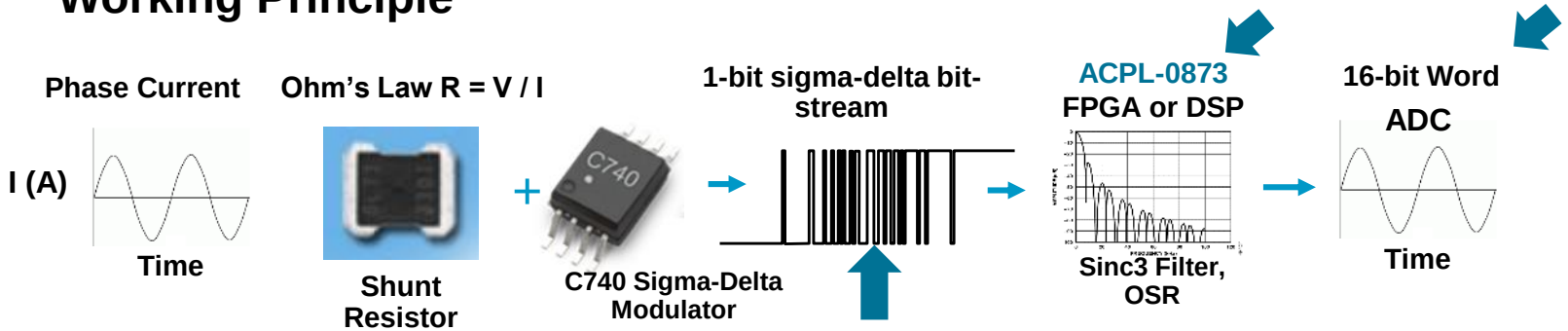
20 MHz Modulator Clock Frequency Advantages

- **Filter response time halved**
  - Sinc filter response time: T = Over Sampling Ratio (OSR / DR) / Clock Frequency (MCLK)
  - For 10 MHz clock and OSR=128, T = 12.8 µs
  - For 20 MHz clock and OSR=128, T = 6.4 µs
- **Higher OSR / DR means better SNR @ same filter response time**
  - 10 MHz clock and OSR=64, T = 6.4 µs: SNR ~ 74 dB typical
  - 20 MHz clock and OSR=128, T = 6.4 µs: ***SNR ~ 79 dB typical***



Simplified Block Diagram

Working Principle



BROADCOM

ACPL-C877 0V to 2V DC Input Precision Isolated Digital Output Voltage Sensor

Recent New Product Market Release Oct 2022

Key Features

- Linear input range: 0V – 2V
- Full scale range: -0.1V to 3.2V
- Input Impedance: 1GΩ (low power dissipation across resistive divider network – **Towards Green Energy Initiatives**)
- 1-bit, 2nd order Σ-Δ modulator
- 10 MHz internal clock
- 16 bits resolution no missing codes (10 bits ENOB)
- 76dB typ. SNR, 66dB typ. SNDR
- ± 10mV max. offset error @ Ta: room
- 20µV/°C max. offset drift
- ±1% gain error @ Ta: room
- Vdd1: 4.5V to 5.5V
- Vdd2: 3 V to 5.5 V wide supply range for digital interface
- -40°C to +110°C ambient Ta
- Output Slew Rate Control
- Stretched-SO8 Package
- High CMR : 25 kV/µs typ. at Vcm = 1,000 V
- Creepage / Clearance / DTI: 8.0mm / 8.0mm / 0.5mm

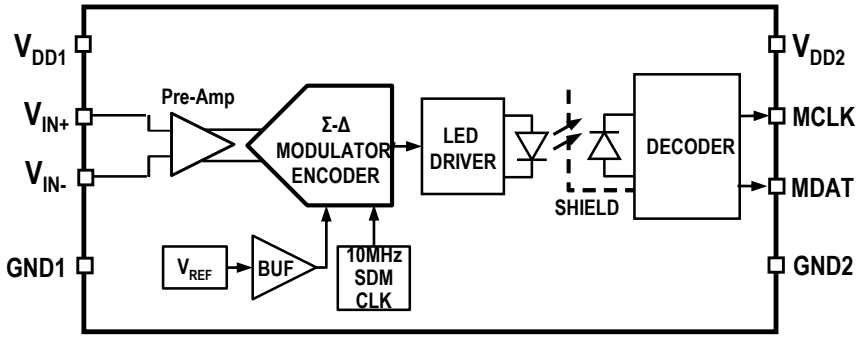
Reinforced Optical Insulation Safety Approval

- UL Recognized 5kVrms for 1 min
- IEC 60747-5-5 , Viorm = 1,414Vpeak
- CAN/CSA-C22.2 No. 62368-1

Applications

- Isolated voltage sensing in AC and servo motor drives
- Isolated dc-bus voltage sensing in solar inverters
- Isolated sensor interfaces
- Signal isolation in data acquisition systems
- General purpose voltage isolation

Functional Diagram



Pin Configuration

SSO8 Package

Samples and Evaluation Board available

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1GΩ High Input Impedance Allows Significant Reductions In Power Dissipation and Input Loading Effect Due To Rin

1. Same Input Error due to Rin, 300x less power dissipation through resistor divider

	Competitor	*ACPL-C877*
Rin	400 KΩ	**1 GΩ**
Vbus	400 V	400 V
Vin	0.25 V	2 V
R1	63.96 kΩ	19.9 MΩ
R2	40 Ω	100 KΩ
Rin // R2	39.996 Ω	99.99 KΩ
% Error due to Rin	**0.01 %**	**0.01 %**
Power Dissipation	**2.5 W**	**8 mW**

R2 selected such that error due to Rin is 0.01%

2. Same power dissipation: 300x less error due to Rin

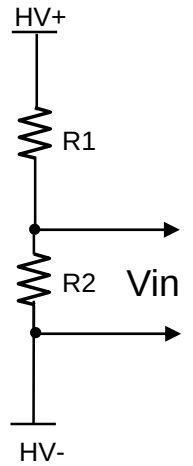
	Competitor	*ACPL-C877*
Rin	400 KΩ	**1 GΩ**
Vbus	400 V	400 V
Vin	0.25 V	2 V
R1	15.99 MΩ	15.92 MΩ
R2	10 kΩ	80 KΩ
Rin // R2	9.756 kΩ	79.994 KΩ
% Error due to Rin	**2.44 %**	**0.008 %**
Power Dissipation	**10 mW**	**10 mW**

Same Power Dissipation

3. Same R2: 2000x less error due to Rin

	Competitor	*ACPL-C877*
Rin	400 KΩ	**1 GΩ**
Vbus	400 V	400 V
Vin	0.25 V	2 V
R1	15.99 MΩ	1.99 MΩ
R2	10 kΩ	10 KΩ
Rin // R2	9.756 kΩ	9.999 KΩ
% Error due to Rin	**2.44 %**	**0.001 %**
Power Dissipation	10 mW	80 mW

Same R2



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ACHS-719x / 712x 1ϕ Hall Effect Current Sensors

Fully Integrated, Hall-Effect Linear Current Sensor IC with 3 kVRMS Isolation and 0.7 mΩ Current Conductor

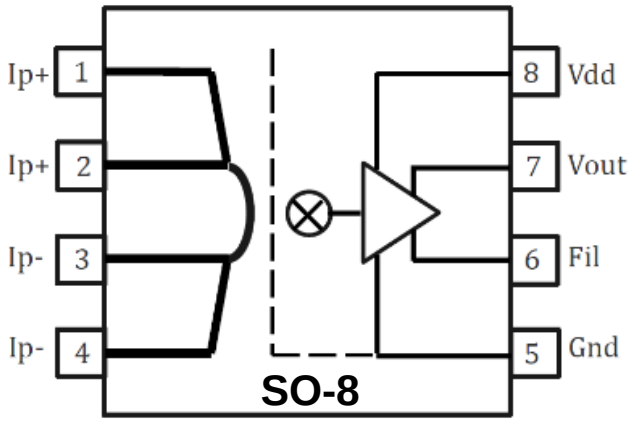
Released FY19 / FY18

Key Features for HES (Hall Effect current Sensor)

- Guaranteed min/max across Wide Operating Temperature: -40º C to 110º C
- Primary conductor resistance: **0.7 mΩ** typ.
- Sensing current range: ±10 A, ±20 A, ±30 A, ±40 A and ±50 A
- Output sensitivity: 40 mV/A to 185 mV/A
- Output voltage proportional to AC or DC currents
- Ratiometric output from supply voltage
- Single supply operation: 5.0 V
- Low noise analog signal path
- Device bandwidth is set via Filter pin: 80 kHz typ. Bandwidth with 1 nF filter capacitor
- ***Factory-trimmed for accuracy***
- Extremely stable output offset voltage
- Near zero magnetic hysteresis
- Total output error ≤±4.4% (7192) across -40º C to 110º C
- >25kV/µs Common-Mode Transient Immunity
- Small footprint, low-profile **SO-8** package
- Isolation Voltage: **3 kV_{RMS}**,1 minute
- Worldwide Safety : UL/cUL, **IEC/EN 62368-1***

SO-8

Functional Diagram



SO-8

Part Number	Current Range	Sensitivity
ACHS-7191/21	±10 A	185 mV/A
ACHS-7192/22	±20 A	100 mV/A
ACHS-7193/23	±30 A	66 mV/A
ACHS-7194/24	±40 A	50 mV/A
ACHS-7195/25	±50 A	40 mV/A

* For ACHS-719x only

BROADCOM

ACHL-724x 3ϕ Hall Effect Current Sensors

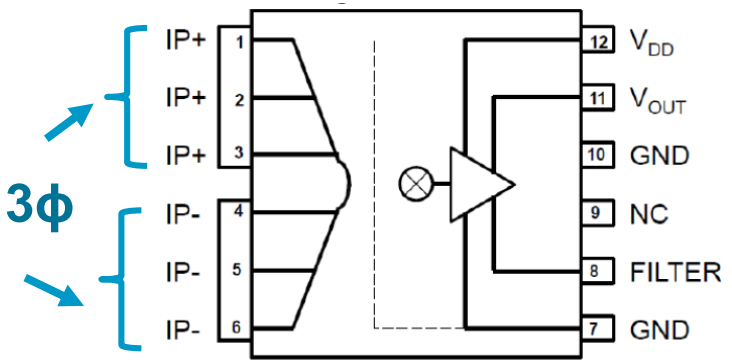
Fully Integrated, Hall Effect-Based Linear Current Sensor IC with 5 kVRMS Isolation and Low-Resistance Current Conductor

Release Schedule ACHL-7241/2 :Feb 2022 ACHL-7243/4/5:Jun 2022***

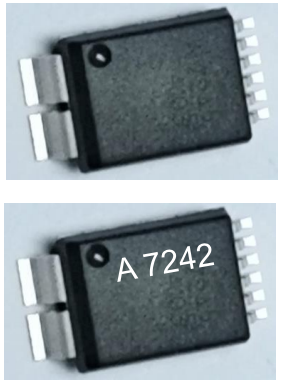
Key Features for HES (Hall Effect current Sensor)

- Guaranteed min/max across wide operating temperature: -40º C to 110º C
- Primary conductor resistance: **0.6 mΩ** typ.
- Sensing current range: ±10 A, ±20 A, ±30 A, ±40 A and ±50 A
- Output sensitivity: 40 to 200 mV/A
- Output voltage proportional to AC or DC currents
- Ratiometric output from supply voltage
- Single supply operation: 5.0 V
- Low noise analog signal path
- Device bandwidth is set via Filter pin: 80 kHz typ. Bandwidth with 1nF filter capacitor
- Factory-trimmed for accuracy
- Extremely stable output offset voltage
- Near zero magnetic hysteresis
- Total output error ≤±4.4% (7242) across -40º C to 110º C
- >25kV/µs Common-Mode Transient Immunity (CMTI)
- Small footprint, low-profile **SSO-12** package
- Isolation Voltage: **5 kV_{RMS}**,1 minute
- Worldwide Safety : UL/cUL, **IEC/EN 62368-1**

Functional Diagram



SSO-12



SSO-12

Part Number	Current Range	Sensitivity
ACHS-7241*	±10 A	200 mV/A
ACHS-7242*	±20 A	100 mV/A
ACHS-7243**	±30 A	66 mV/A
ACHS-7244**	±40 A	50 mV/A
ACHS-7245**	±50 A	40 mV/A

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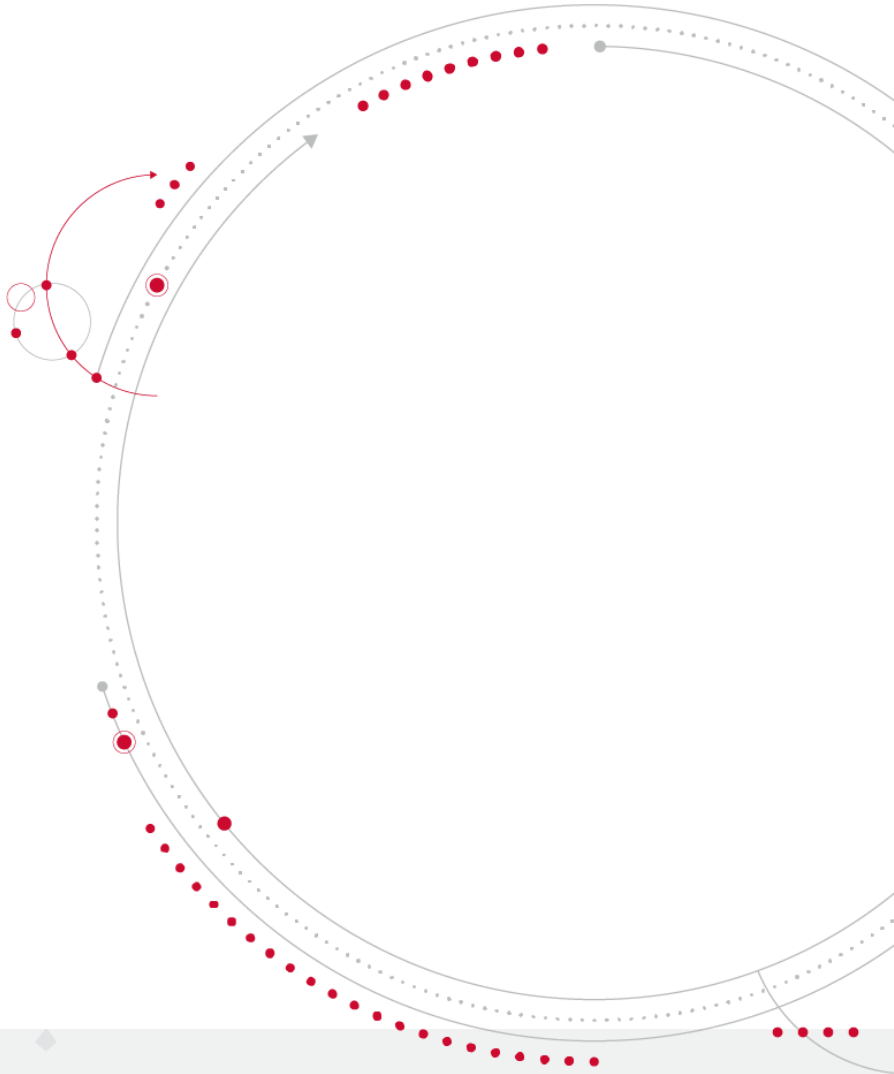
Broadcom Current Sensor Recommendations

	Current Sensor Types	Customer Requirements	Application Example
1	**Sigma-Delta Modulators** • **ACPL-C740: ±200 mV input, 20 MHz int clk** • **ACPL-C797: ±200 mV input, 10 MHz int clk** • **ACPL-C799: ±50 mV input, 10M Hz int clk**	• High accuracy	• Servo amplifiers • Robot controllers • CNC machines
2	**Isolation Amplifier** • **ACPL-C79B: ±200 mV input, 0.5% gain accuracy** • **ACPL-C79A: ±200 mV input, 1% gain accuracy** • **ACPL-C790: ±200 mV input, 3% gain accuracy**	• General purpose isolated current sensing	• General VFD inverters • Lift, elevators, pumps
3	**Hall Effect Sensor** • **ACHS-712x/719x: ±10 A to ±50 A (4 mm cc)** • **ACHL-724x: ±10 A to ±50 A (8 mm cc)**	• Isolated power supply, Vdd1 is not available.	• Consumer, whitegoods • All other applications where SDM and Iso Amps not suitable because isolated power supply is not available.

BROADCOM

Solid State Relay,
High Linearity Analog Optocoupler,
AC/DC Detectors



ACPL-K308U: *High Voltage* Industrial Photovoltaic Driver

PR Q3-2021

Key Features

- Operating Temperature T_A: -40° C to 125° C
- Short Circuit Current (typ), I_{SC} = 70 µA @ I_F=10 mA
- Open Circuit Voltage (typ), V_{OC} = 8.2 V @ I_F=10 mA
- ***Turn Off Time (typ): $T_{OFF,}$= 25 µs with C_L = 1nF, I_F = 10 mA***
- ***Turn On Time (typ): T_{ON} = 50 µs with C_L = 1 nF, I_F = 10 mA***
- Package: SSO-8
- **Creepage & Clearance ≥ 8 mm**
- V_{ISO} = 5 kV_{RMS} (UL 1 minute rating)
- Working voltage = 1140 V_{PEAK} (Reinforced)

Benefits

- ***High output current for faster MOSFET turn on***
- ***Configurable to industry standard high voltage MOSFETs***

Applications

- Solid State Relay modules
- Inrush current prevention
- Insulation resistance test in battery system; Solar PV Inverters, EV charging system, Motor Winding insulation
- 5G Telecom power
- Industrial appliances, T&M, Transportation

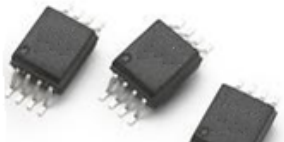
Test and Measurement Equipment

PV: photovoltaic

Intelligent Transportation System

Industrial Appliances, Airconditioning

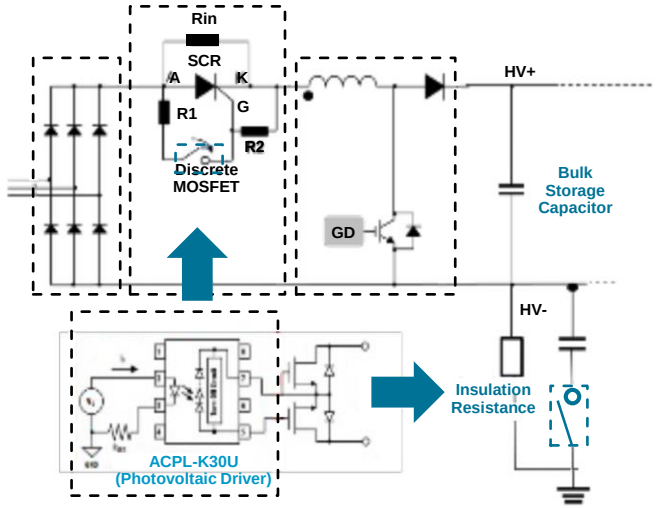
5G Telecom Power Supply



SSO-8

Insulation Resistance Measurement

Inrush Current Limiter



Insulation Resistance Value	Insulation Level
< 2 MΩ	Bad
2-5 MΩ	Critical
5-10 MΩ	Abnormal
10-50 MΩ	Good
50-100 MΩ	Very Good
> 100 MΩ or more	Excellent

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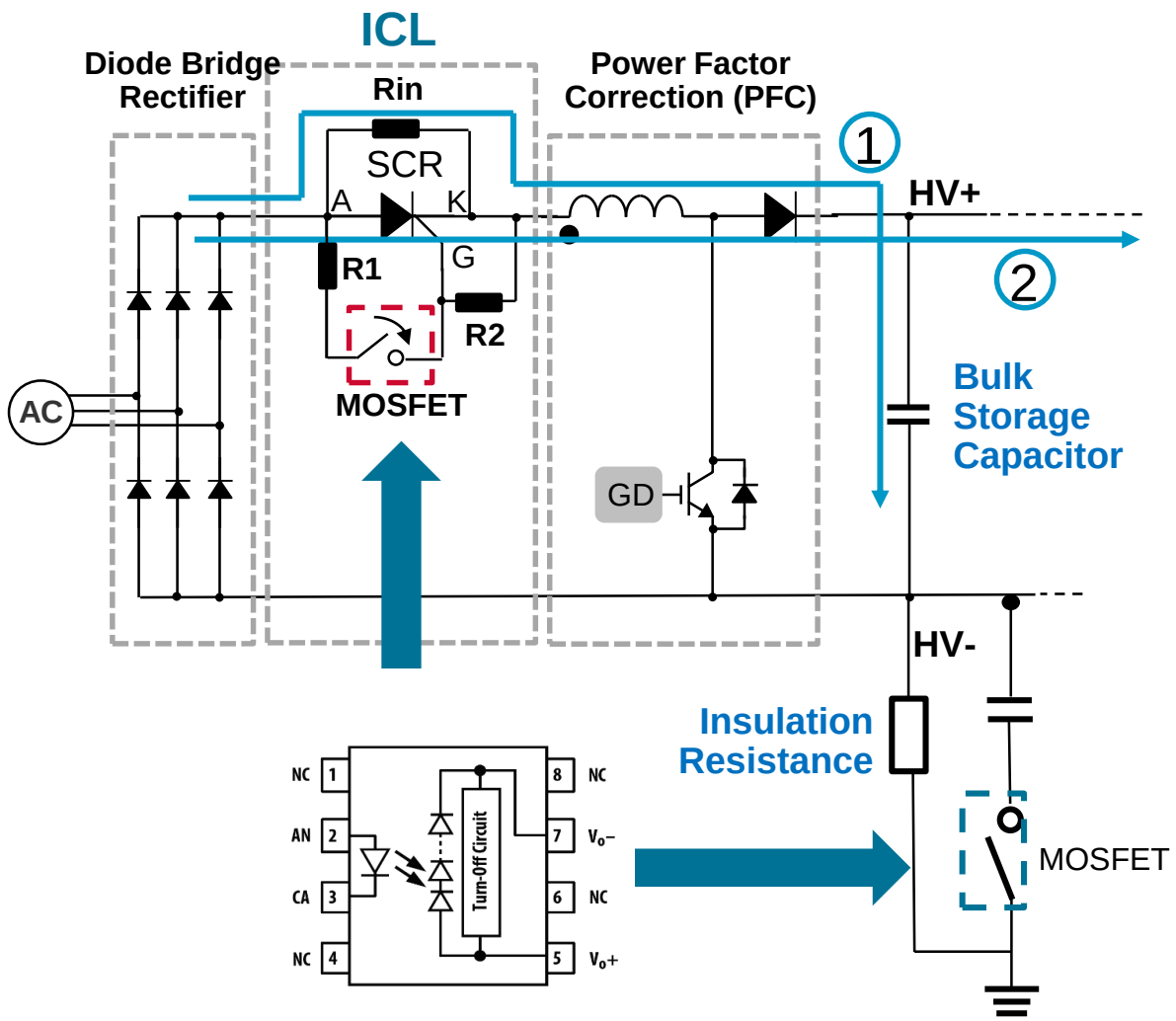
ACPL-K308U: *Inrush-current* Limiter Circuit (ICL) and Insulation Resistance Measurement

Inrush-current Limiter (ICL)

1) During Start-up, high inrush to Bulk Storage Capacitor. **Rin to limit current**
2) When current stabilized, **ACPL-K308U** turn on MOSFET that provides a gate signal to SCR switch for normal operation

Opportunities! ***ACPL-K308U + MOSFET Replaces Mechanical Relay*** *of ALL motor inverters, servo drives, & power supply*

Electromechanical Relay	ASSR-601J
Big form factor – vibration issue and thru hole	**Small form factor, SMT**
Hot switching – sparks created in contacts result in short lifetime.	**Semiconductor lifetime (100 times more than EMR)**
Slow response ~ 100 ms	**Fast response ~ 5 ms**



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ASSR-601J: Industrial Photo MOSFET Relay

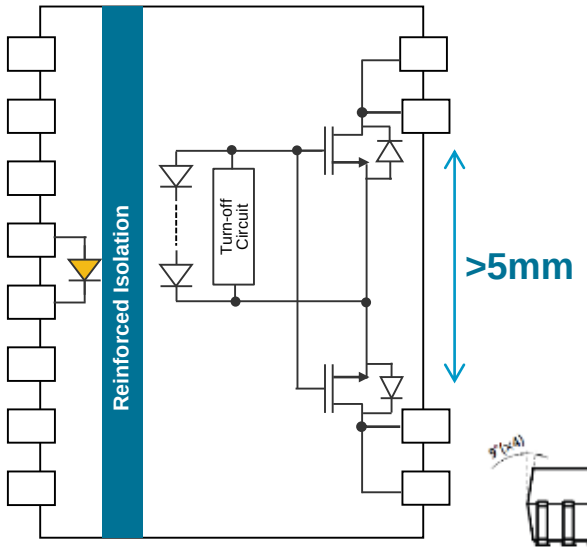
Key Features

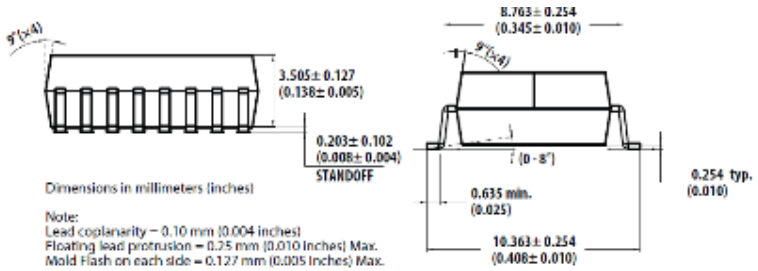
- Industrial Grade Operating Temperature **-40° C to +110° C**
- Breakdown Voltage, **BV_{DSS}: 1500 V** typ. @ I_{DSS}= 250 µA
- Avalanche rated MOSFETs
- Off-State Leakage, **I_{OFF} ≤ 1 µA @ V_{DS} = 1000 V, T_A = 25° C**
- On-resistance, **$R_{DS(ON)}$ ≤ 250 Ω @ I_{LOAD} = 50 mA**
- Turn On Time: T_{ON} ≤ 1 ms
- Turn Off Time: T_{OFF} ≤ 0.5 ms
- Package: 300 mil SO-16
- Creepage & Clearance ≥ 8 mm (Input-Output)
- V_{ISO} = **5000 V_{RMS}** (UL 1 minute rating)
  - Dielectric voltage rating
- Working voltage = 1414 VPEAK (Reinforced)
- MOS drain-to-drain Creepage > 5 mm
- CTI > 600V Mold compound

Applications

- Inrush current limiter for inverter and servo drives
- Insulation resistance measurement for motor-earth leakage current

Block Diagram





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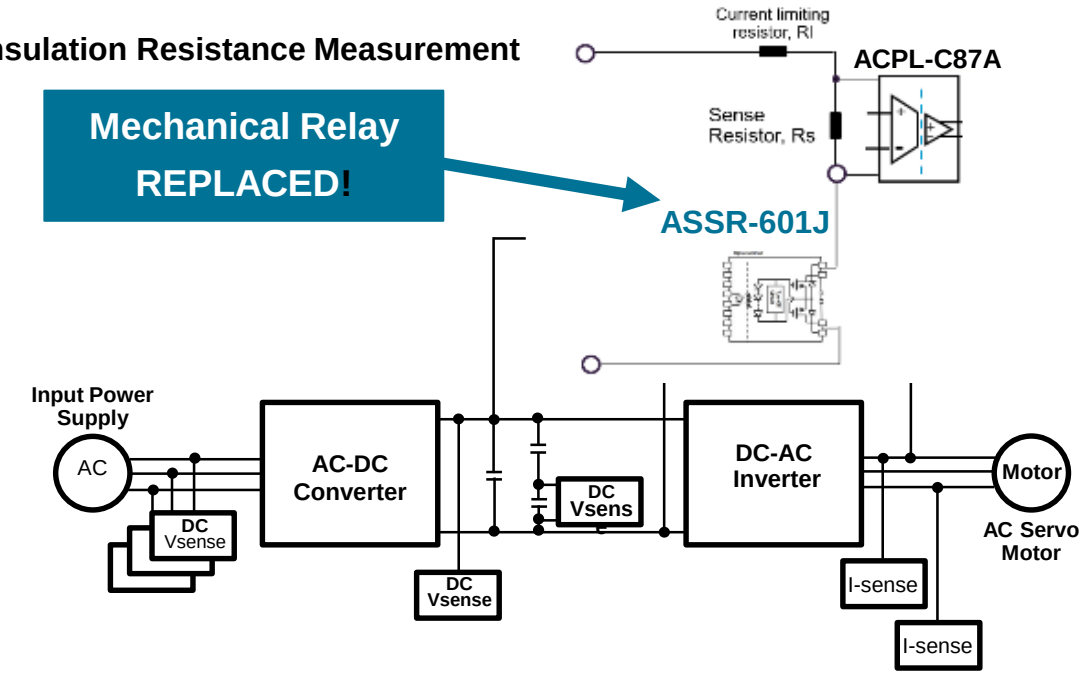
ASSR-601J + ACPL-C87A Application

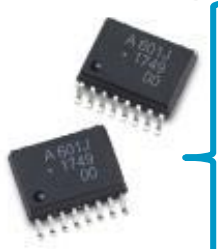
AC Servo Motor Insulation Resistance Measurement

Broadcom Part Numbers	Product Features
ASSR-601J **HV Solid State Switch**	• High breakdown voltage: 1500 V • Low Leakage Current < 1 μA • Semiconductor lifetime – 100x longer than EMR • Fast Response time, 4 ms
ACPL-C87A **Voltage Sense**	• High input impedance: 1 GΩ • 2 V nominal input range; • High precision tolerance: ±1% • High linearity

Insulation Resistance Measurement



ASSR-601J Photo-MOSFET Replace Mechanical Relay



ASSR-601J Solid State Relay	Electromechanical Relay (EMR)
Small form factor, SMT	Large form factor, vibration issues & through hole assembly
Semiconductor lifetime 100 x longer than EMR	Poor Hot Switching – ***sparks created in contacts shorten lifetime***
Fast response ~ 4 ms	Slow response ~ 100 ms
1500 V Breakdown voltage	
Viso withstand voltage 5000 Vrms per min per UL1577	

EMR

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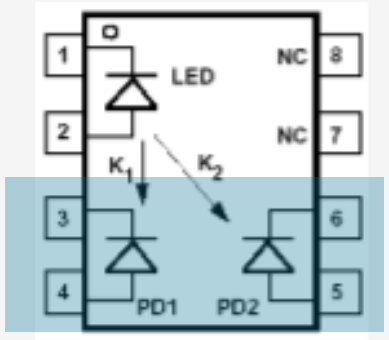
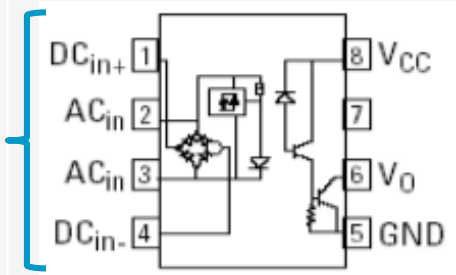
HCNR200 / 201: High Linearity Analog Optocoupler
ACPL-K370 / 376: AC/DC Voltage Detector

Part Numbers	Description	Key Features	Diagram
HCNR200 **HCNR201**	High linearity ***analog output*** optocoupler	• Gain accuracy – HCNR200: ±15% – HCNR201: ±5% • Wide bandwidth: DC to > 1 MHz • Low nonlinearity: 0.01%	
ACPL-K370 **ACPL-K376**	Standard / Low input current ***AC / DC detection*** to Logic Interface	• ± 5% Voltage detection accuracy • Wide AC or DC detection range: up to 1140 Vpeak • Built-in hysteresis improves noise immunity • **Standard (ACPL-K370) and low input current (ACPL-K376) version**	

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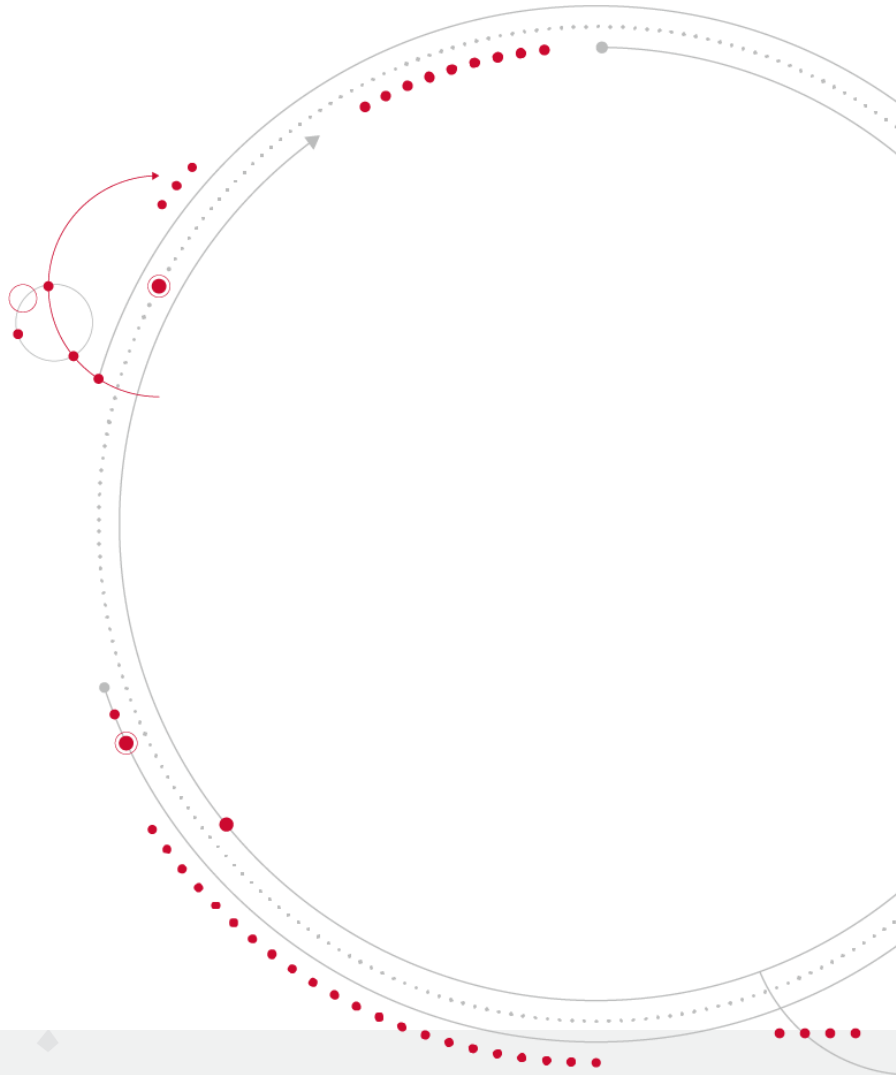
Automotive

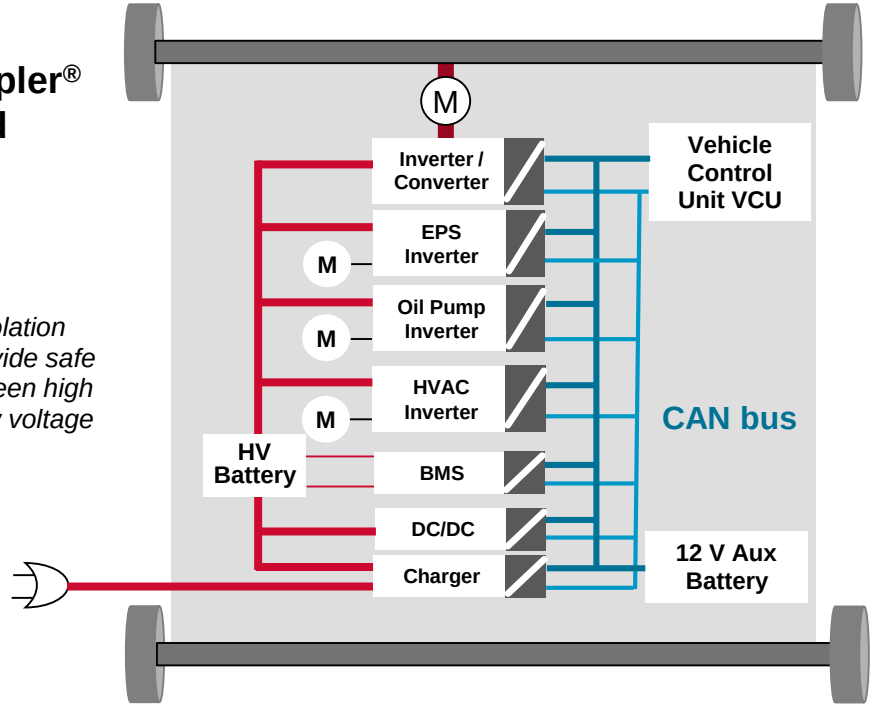


Broadcom Automotive Optocoupler Offering

- HVAC: Heating , Ventilation and Air Conditioner
- IPM: Intelligent Power Module
- SSR: Solid State Relay
- PV: Photovoltaic

Broadcom R²Coupler® Means Reinforced Insulation and Reliability

Optocoupler isolation required to provide safe insulation between high voltage and low voltage circuits.



Application	Gate Driver	Voltage / Current Sensor	IPM Driver	10 MBd Digital	≤ 1 MBd Digital	PV Driver / SSR
Inverter (Powertrain, EPS, HVAC*, Oil Pump)	✓	✓	✓	✓	✓	
Charger	✓	✓	✓	✓	✓	
DC/DC	✓	✓	✓	✓	✓	
Battery Management Systems (BMS)	✓	✓		✓	✓	✓
Data Communications				✓	✓	
Insulation Resistance Monitoring		✓				✓

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Gate Driver Isolation Technology Comparison

	Semiconductor Gate Driver	Optocoupler Gate Driver	Transformer
Isolation Technology	• Isolation is made on single silicon IC • Gate driver integrated on chip with high voltage diode, high voltage capacitor or coreless transformer for level shifting	• Transmitter and receiver are on different silicon chips - Both chips galvanically separated with insulation material inserted in-between to meet isolation requirements	• Primary and secondary coils are separated by insulation material
Size	• Small size • Good for multichannel and integration of smart feature	• Small size • Smart drive and protection features can be build into standard IC packages.	• Bulky • Only provides signal isolation • Need additional circuits for signal conditioning
Isolation Voltage	• Only good for low voltage and safety in non-critical applications: white goods and low power drives for industrial application	• Excellent for medium voltage (>100 V to 1 kV) applications – High power industrial drive, traction inverter	• Very high voltage for 3 kV or 6 kV applications
Reliability	• Lowest breakdown voltage • Thin insulation, sensitive to micro material defects • Difficult to perform 100% production test without causing isolation degradation	• Thick insulation material – Insulation breakdown higher than the package creepage and clearance rating suggest • Effective partial discharge test for 100% production high voltage testing	• Thick insulation material • Physical dimension determines the insulation voltage • Partial discharge high voltage testing is valid.
Suppliers	• STM, IRF, Infineon, TI, Silab, Rohm	• **Broadcom**, Renesas, Toshiba, onsemi	• Concept Drive

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ACFL-3161T – Automotive 10 Amp Peak Gate Drive Optocoupler for IGBT/SiC MOSFET with Rail-to-Rail Output Voltage in SO-12 Package

Key Features

- Qualified to AEC-Q100 Grade 1 Test Guidelines
- Automotive temperature range: -40 ºC to 125º C
- **High output driving current: 10A peak (typical), 6A peak (min.)**
- Rail-to-rail output voltage
- Low output on resistance: $R_{DS,OH}$ 1.5Ω (max.), $R_{DS,OL}$ 1.2Ω (max.)
- Separate source and sink outputs
- Low I_F drive: 10mA (min),13mA (typ),16mA (max)
- Propagation delay: 100ns (max.)
- Dead time distortion: 30ns (max)
- **Wide operating supply (V_{DD}) Range: 15 to 35 V**
- **Under Voltage Lock-out (UVLO) protection with hysteresis: 13.5V**
- High switching frequency operation: 500kHz
- **Common Mode Transient Immunity (CMTI): 100 kV/µs min at V_{CM} = 1500V**
- Single channel in SO-12 package with 8mm creepage and clearance
- Safety Approval (Pending):
  - UL1577 recognized 5k V_{RMS} for 1min.
  - CSA
  - IEC/EN/DIN EN 60747-5-5 V_{IORM} = 1414 V_{PEAK}

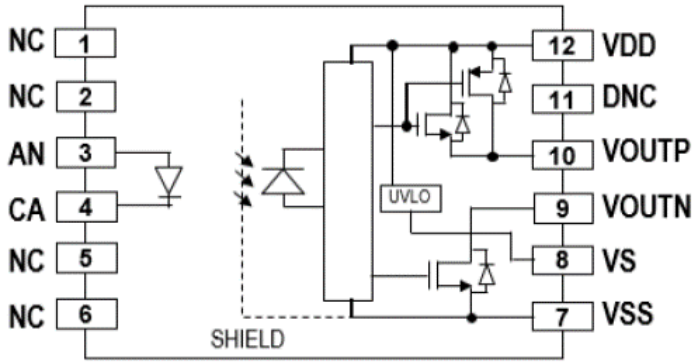
Applications

- Hybrid power train DC-DC converter
- EV/PHEV charger
- Automotive isolated MOSFET/IGBT gate driver for inverter and HVAC

Status Update

Update Preliminary Datasheet **Available**
Engineering Samples **Available**

Schematic Block Diagram



*This product information is subjected to change without notice.

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ACFJ-3262T – Automotive Dual Channel 10 Amp Peak Gate Drive Optocoupler for MOSFET/IGBT with Rail-to-Rail Output Voltage in SO-24 Package

Key Features

- Qualified to AEC-Q100 Grade 1 Test Guidelines
- Automotive temperature range: -40 ºC to 125º C
- **High output driving current: 10A peak (typical), 6A peak (min.)**
- Rail-to-rail output voltage
- Low output on resistance: $R_{DS,OH}$ 1.5Ω (max.), $R_{DS,OL}$ 1.2Ω (max.)
- Separate source and sink outputs
- Low I_F drive: 10mA (min),13mA (typ),16mA (max)
- **Propagation delay: 100ns (max.)**
- **Dead time distortion: 30ns (max)**
- Channel-to-channel skew: 10ns (max.)
- **Wide operating supply (V_{DD}) Range: 10 to 25 V (or 15V to 35V)**
- **Under Voltage Lock-out (UVLO) protection with hysteresis: 8.6V (or 13.5V)**
- High switching frequency operation: 500kHz
- **Common Mode Transient Immunity (CMTI): 100 kV/µs min at V_{CM} = 1500V**
- Dual channel in SO-24 package with 8mm creepage and clearance
- Creepage between two output drivers: 2.6mm (min.)
- Safety Approval (Pending):
  - UL1577 recognized 5k V_{RMS} for 1min.
  - CSA
  - IEC/EN/DIN EN 60747-5-5 V_{IORM} = 1414 V_{PEAK}

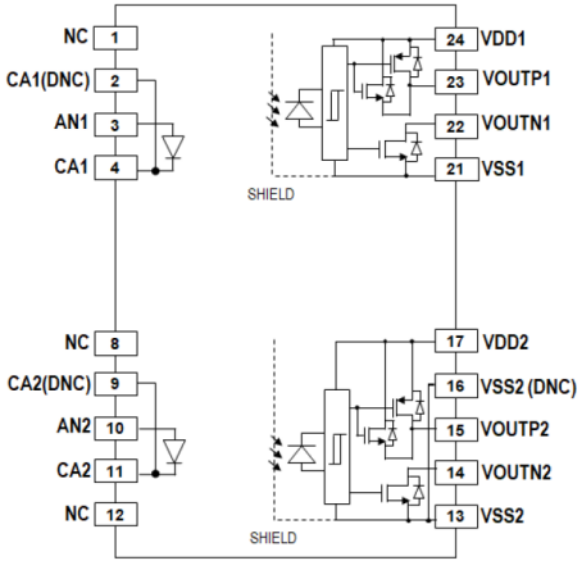
Applications

- Hybrid power train DC-DC converter
- EV/PHEV charger
- Automotive isolated MOSFET/IGBT gate driver for inverter and HVAC

Status Update

Update Preliminary Datasheet **Available**
Engineering Samples **Available**

Schematic Block Diagram



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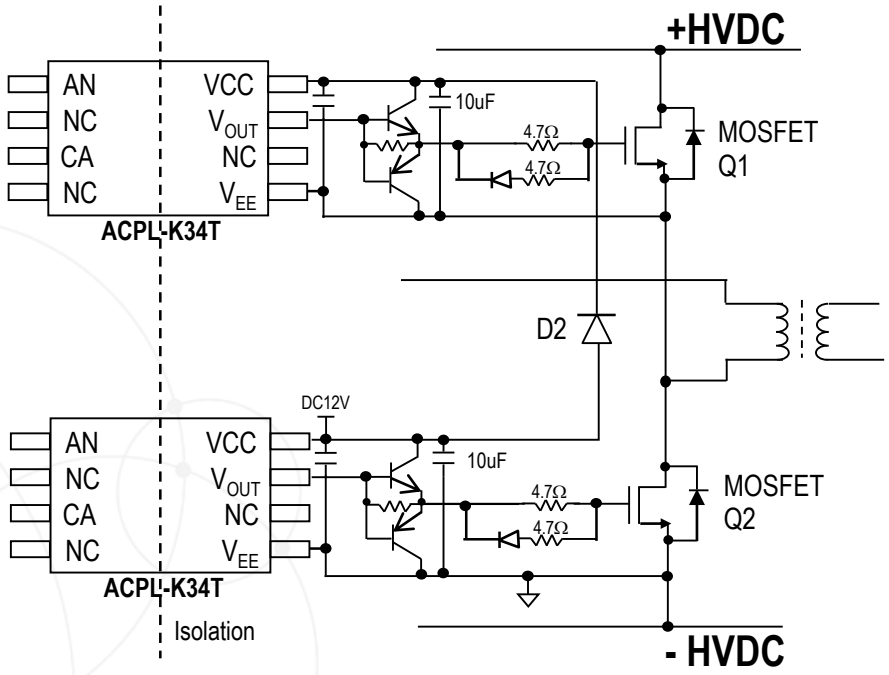
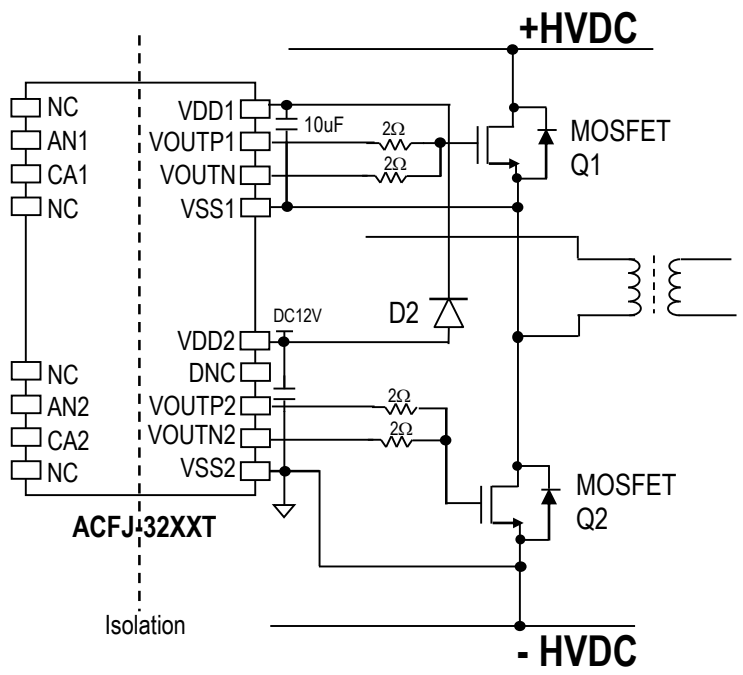
Product Value Proposition

1. For large power MOSFET, buffer stage is required
2. Additional diode needed to tune R_{GON} and R_{GOFF}
3. Channel-to-channel skew is too wide for dead time control at higher frequency operation

Current



Upgrade to ACFJ-32xxT



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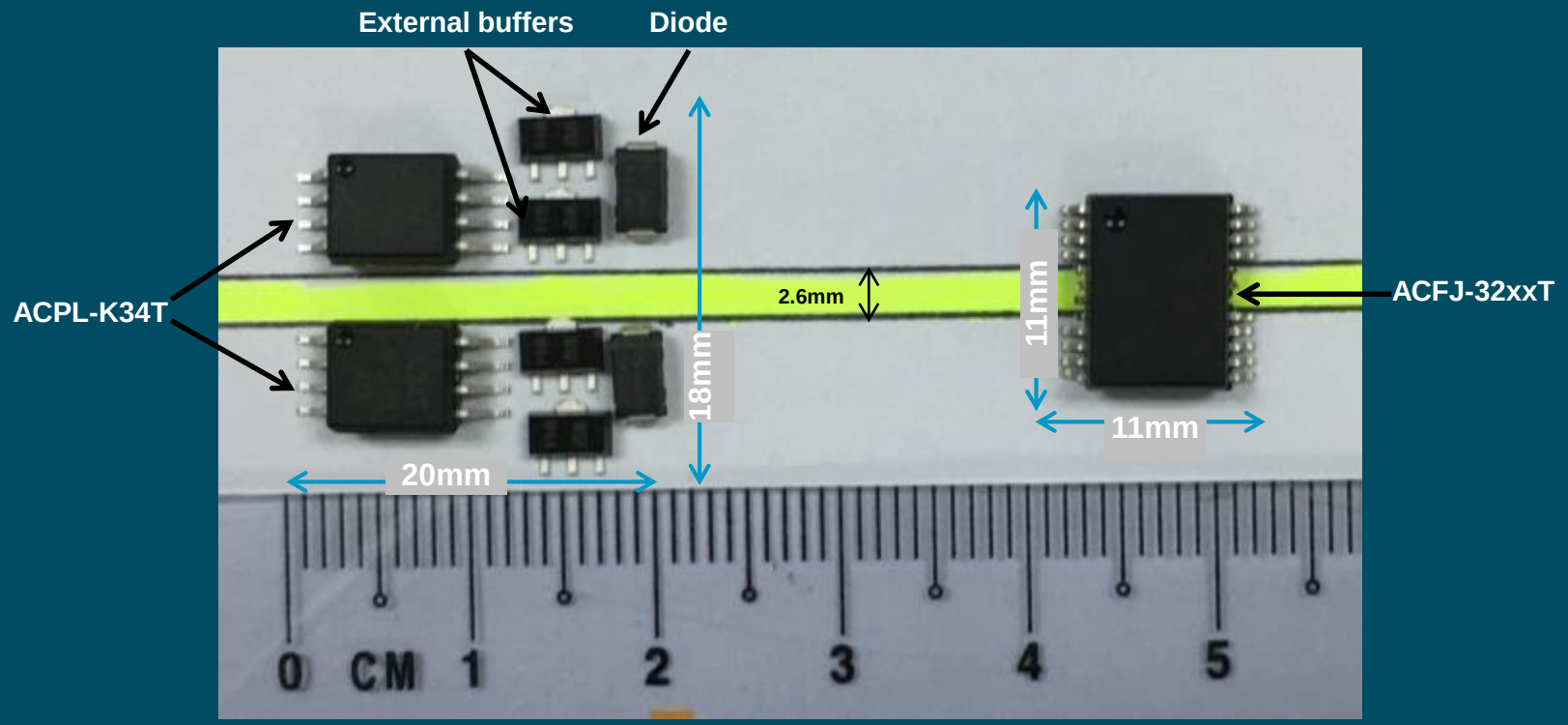
Example: PCB Cost and Space Saving with ACFJ-32xxT



NPN/PNP ~S0.26 (>50ku)
Diode ES1D ~ $0.05 (>100ku)
Price quoted by Element14

→ **External component cost saving ~ $0.62**

Area with buffer: 360mm² → **Area w/o buffer: 121mm²**

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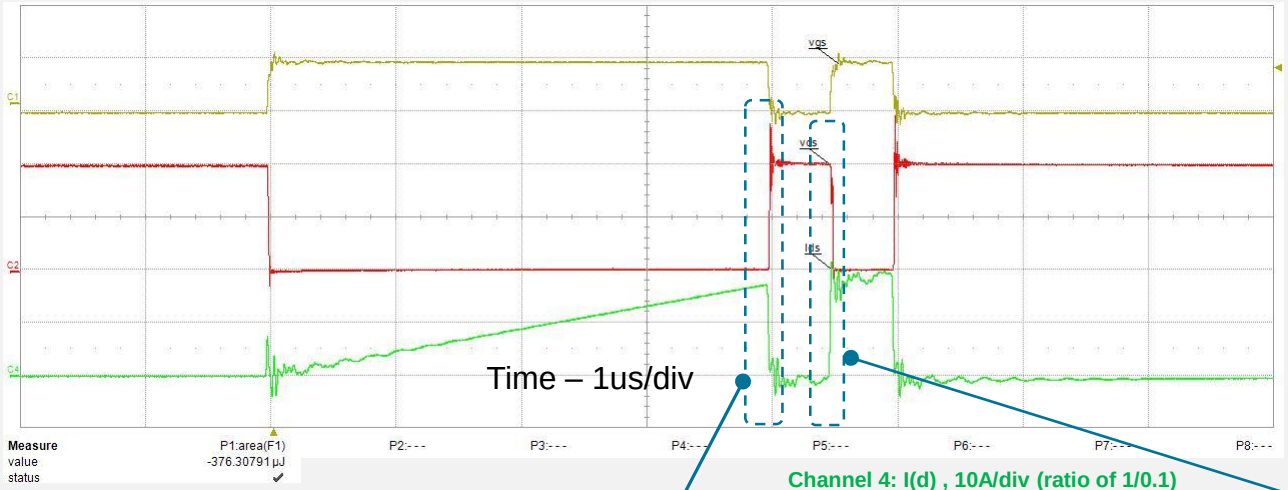
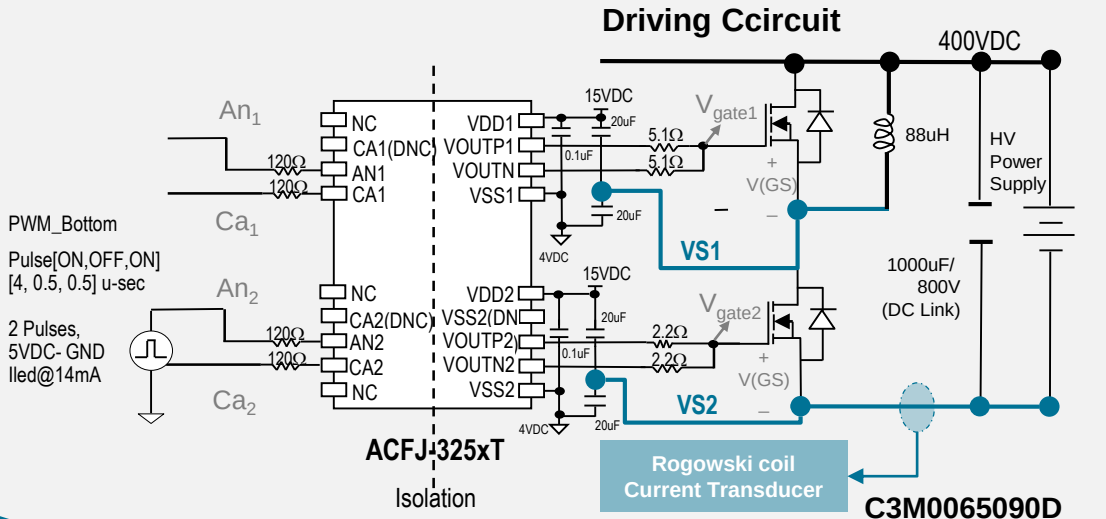
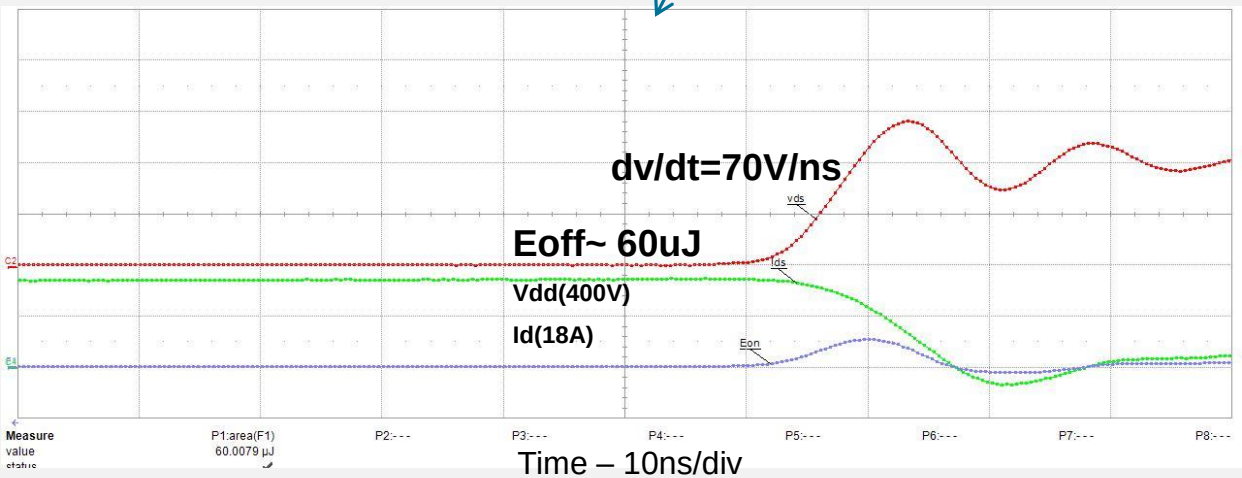
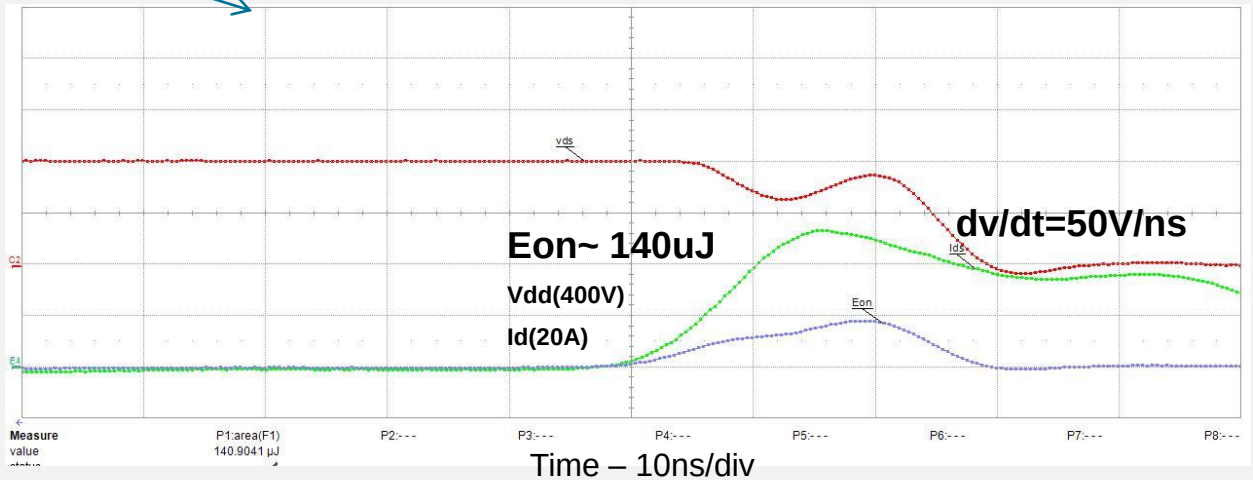
Reference Designs - 2-Pulse dv/dt, Eon/off Tests



Channel 4: I(d) , 10A/div (ratio of 1/0.1)
Channel 2: V(DS), 200V/div
Channel 1: V(g), 20V/div







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ACFJ-332xT/302xT: Automotive Dual Channel 4A Peak Gate Drive Optocoupler for MOSFET/IGBT with Rail-to-Rail Output Voltage in SO-24 Package

Key Features

- Qualified to AEC-Q100 Grade 1 Test Guidelines
- Automotive temperature range: -40 ºC to 125º C
- High output drive/sink current: **4A** peak (typical)
- Miller Clamp: **4A** peak (typical)
- Rail-to-rail output voltage
- Low output on resistance: R_{OH} **x.xΩ** (max.), R_{OL} **x.xΩ** (max.)
- Dead time control
- Propagation delay: **65ns** (max.)
- Dead time distortion: **15ns** (max)
- Channel-to-channel skew: **10ns** (max.)
- Wide operating supply (V_{DD}) Range: **10 to 25 V**
- Under Voltage Lock-out (UVLO) protection with hysteresis: **8V, 12V, 15V**
- High switching frequency operation: **500kHz**
- Common Mode Transient Immunity (CMTI): **100 kV/µs** min at V_{CM} = **1500V**
- Dual channel in SO-24 package with **8mm** creepage and clearance
- Creepage between two output drivers: **3.5mm** (min.)
- Safety Approval (Pending):
  - UL1577 recognized **5k** V_{RMS} for 1min.
  - CSA
  - IEC/EN/DIN EN 60747-5-5 V_{IORM} = **1414** V_{PEAK}

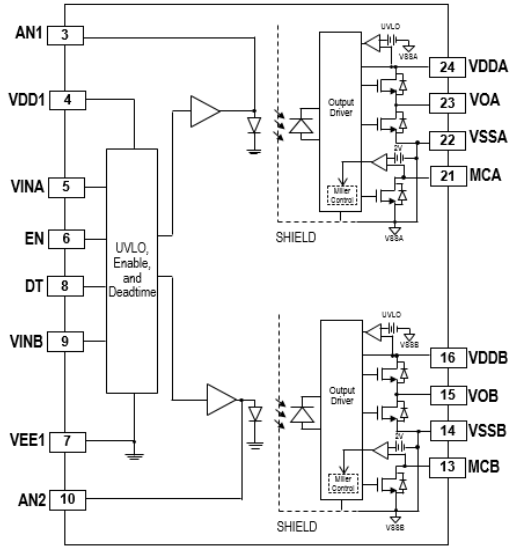
Applications

- DC-DC converter
- EV/PHEV on-board charger (OBC)

Status Update

Update Preliminary Datasheet **1H 2021**
Engineering Samples **2H 2021**

Schematic Block Diagram



Automotive 2.5 A Gate Driver R2Coupler® with Short Circuit Protection and UVLO Feedback, Active Miller Clamping and Negative Bias ACPL-344JT

Key Features

- **Automotive AEC-Q100 qualification**
- Programmable over current soft shutdown and feedback
- Under Voltage Lockout (UVLO) and feedback
- Active Miller clamping
- Negative gate biasing: up to -10 V
- IGBT Desaturation current sensing
- **Worldwide safety approval**
  - UL 1577 (5 kV_{RMS}1 minute)
  - CSA notice #5
  - IEC/EN/DIN EN 60747-5-5
- Creepage and clearance: > 8mm
- Isolation voltage: 5 kV_{RMS} 1 minute
- Working voltage: 1230 Vpeak continuous
- Wide operating temperature: -40˚C – 125˚C
- High Noise Immunity: dV/dt rejection > 50 kV/us

Benefit

- Integrated fault protection
- Easy to use
- Small size and board space saving

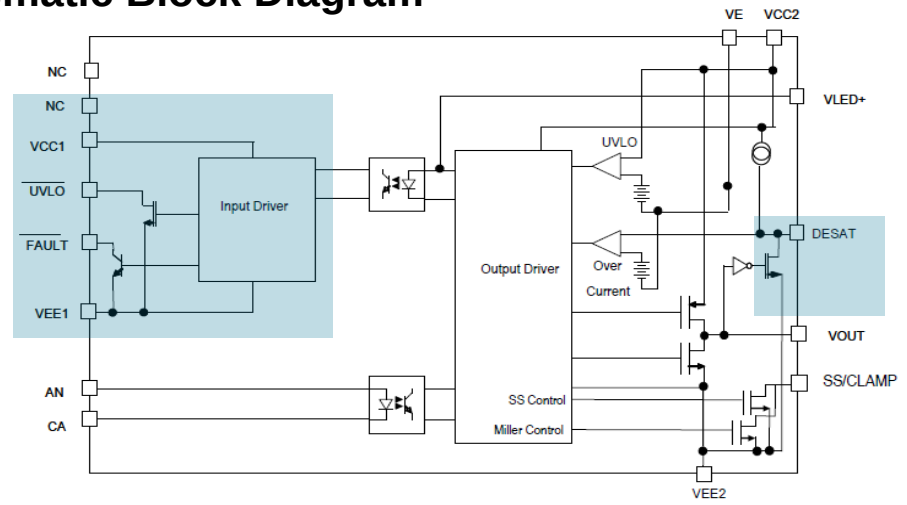
SO-16

Status: In Production

Applications

- Traction inverter
- Battery charger
- Air conditioning
- HEV/EV Oil-pump motor drive

Schematic Block Diagram



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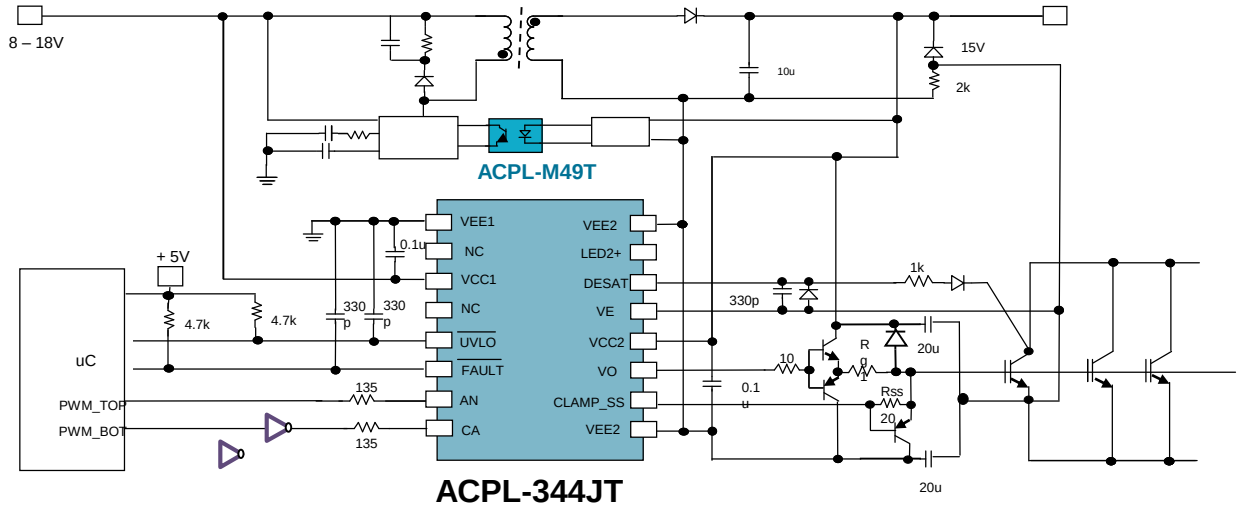
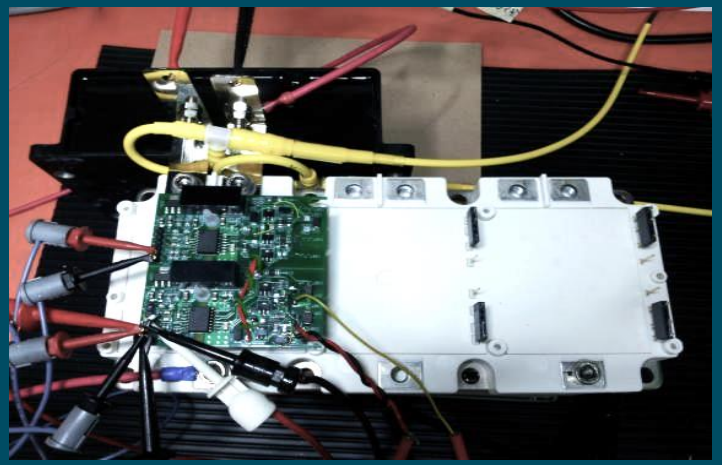
ACPL-344JT: IGBT Gate Driver with UVLO Feedback

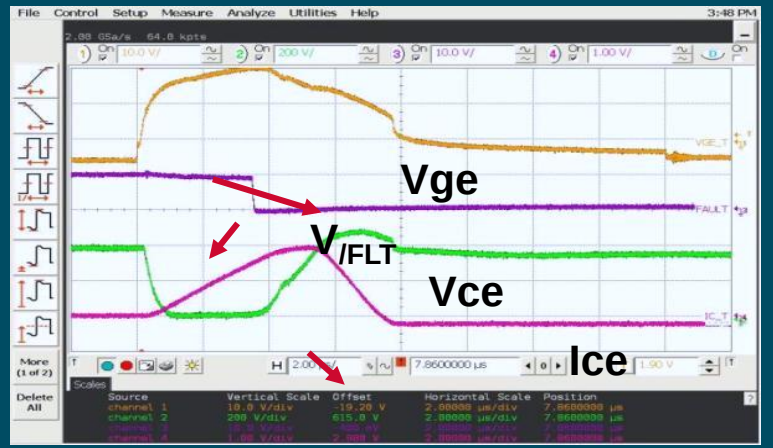
Key Features

- UVLO feedback
- Active Miller clamping
- Soft shutdown for short circuit protection
- Half bridge evaluation board available with short circuit and 2 pulse test result





Short Circuit Test Waveforms



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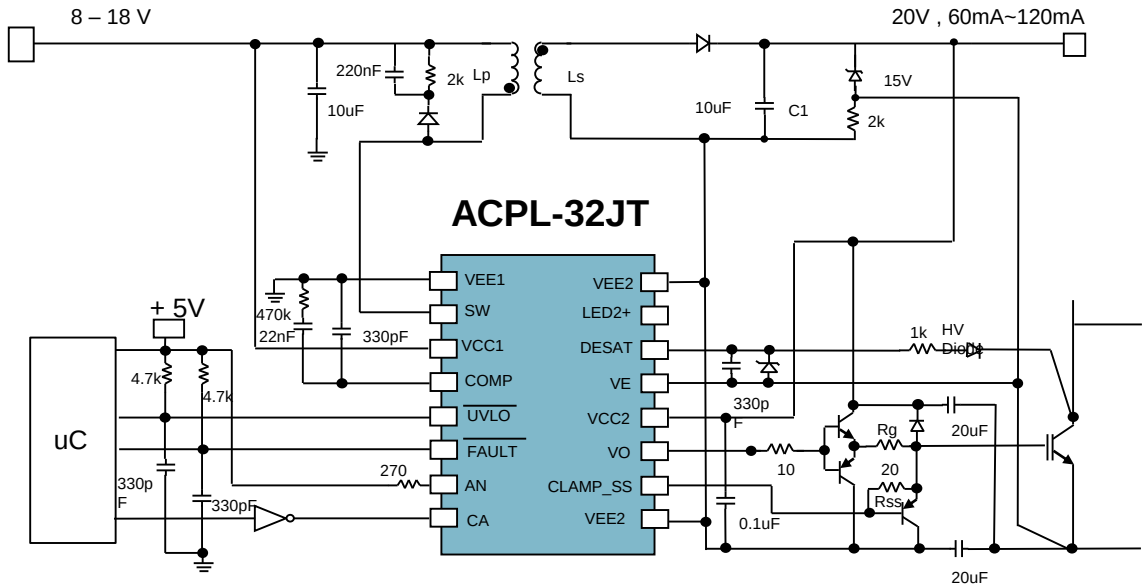
ACPL-32JT Compact Design with Integrated Flyback Controller

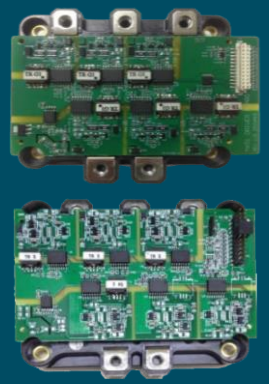
Features

- ***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
- Over current blanking time can be controlled through blanking capacitor
- Direct low impedance LED input, high dV/dt noise immunity

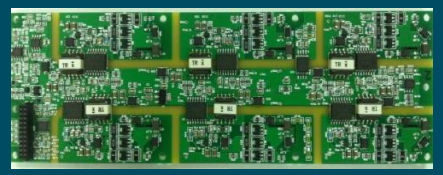


Broadcom Evaluation Board Available

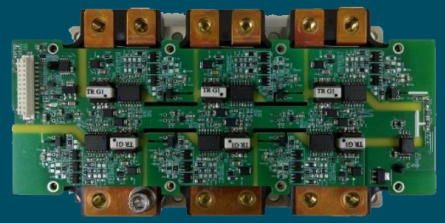
Single Channel



Fuji M651/2



Infineon Hybrid Pack 2



Hitachi 600 A / 650 V

Semikron Parallel 900 A / 1200 V

BROADCOM

ACPL-32JT: Automotive 2.5 A Gate Driver, with Flyback DC-DC Controller

Desat Sensing, UVLO Feedback, Active Miller Clamping and Negative Bias

Status In Production

Key Features

- Automotive AEC-Q100 qualification
- ***Integrated DC-DC Controller for floating power supply***
- Creepage and clearance: > 8 mm
- Isolation voltage: 5 kV_{RMS} 1 minute
- Working voltage: 1230 Vpeak continuous
- Wide operating temperature: -40˚C to 125˚C
- IGBT Desat current sensing, Desat sensing
- Programmable soft shutdown and feedback
- Under voltage lockout and feedback
- Negative gate biasing: up to -5 V
- Integrated Miller clamping
- Worldwide safety approval
  - UL 1577 (5 kV_{RMS} 1 minute)
  - CSA notice #5
  - IEC/EN/DIN EN 60747-5-5

Applications

- IGBT Gate driver for traction inverter, oil pump motor drives (HEV/EV), battery charging and HVAC

R^2Coupler®

SO-16

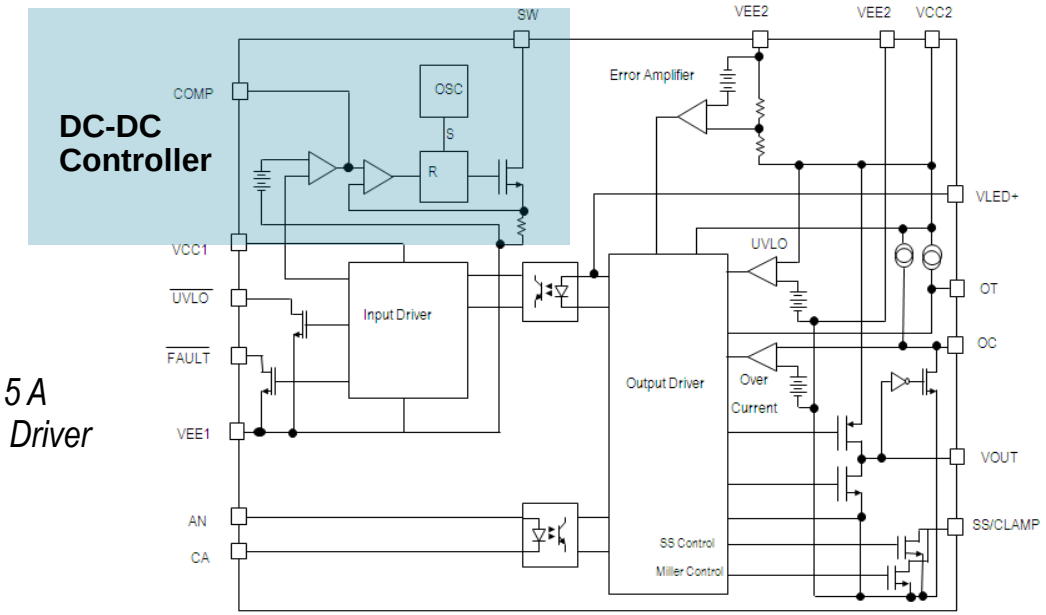
8 mm clearance/creepage

Benefits

- Distributed floating power supply architecture
- Less switching noise
- Smaller transformer
- Integrated fault protection
- Small size and board space saving

Schematic Block Diagram

2.5 A Gate Driver



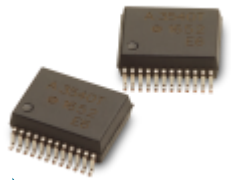
BROADCOM

ACFJ-3530T/31T: Automotive Gate Driver and Flyback DC-DC Controller

R2Coupler w/Desat Sensing, UVLO Feedback, Active Miller Clamping and Negative Bias

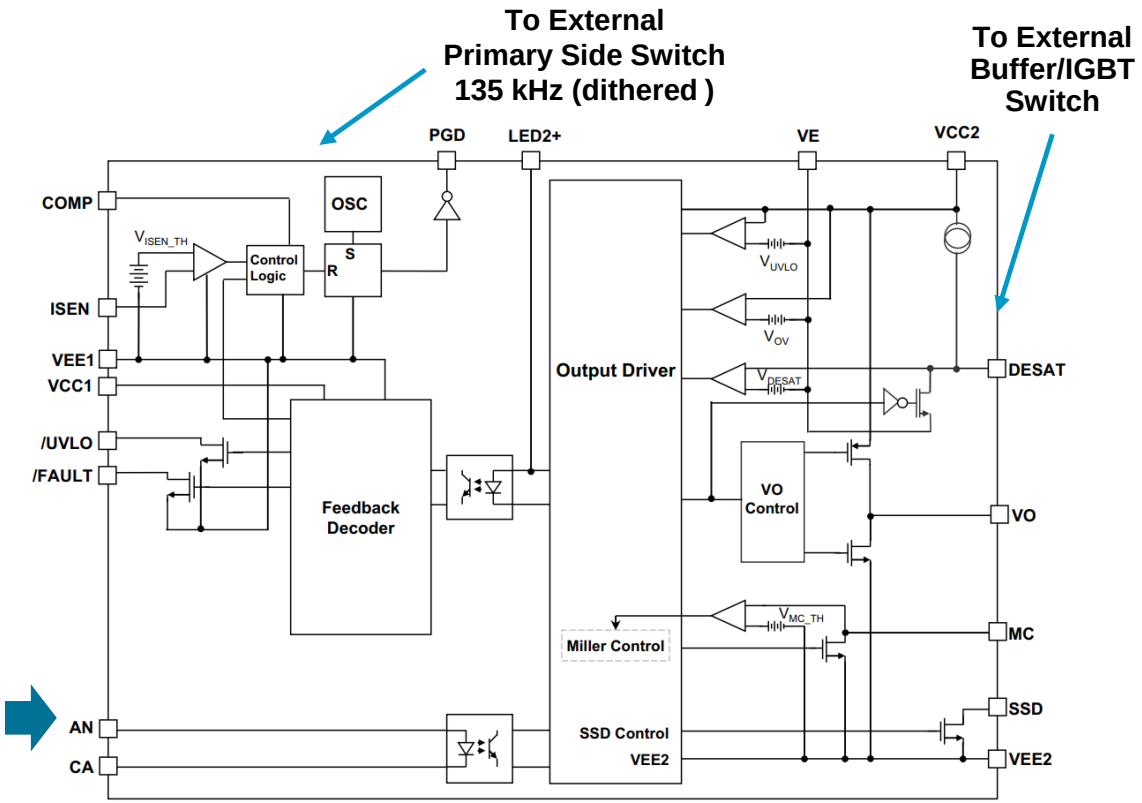
Key Features

- Integrated flyback controller for isolated DC-DC converter
- Regulated output voltage: 16 V ± 5% (ACFJ-3530T)
- Regulated output voltage: 18 V ± 5% (ACFJ-3531T) ***SOON***
- Driver to external primary winding switch to increase driving power
- Minimum peak output current (V_O): ±1.5 A
- Integrated fail-safe IGBT protection
  - Desat sensing, soft IGBT turn-off and fault feedback
  - Under voltage lock-out protection (UVLO) with feedback
- High noise immunity
  - 50 kV/µs Common Mode Rejection (CMR) at VCM = 1500 V
  - Negative gate bias
  - Direct LED input with low input impedance and low noise sensitivity
  - Miller Current Clamping
    - Typical Miller clamp sinking current: 2 A
- Propagation delay: 200 ns max
- Qualified to AEC-Q100 test guidelines
- Operating temperature range: -40º C to +125º C
- SO-24 package with 8 mm creepage and clearance
- Regulatory approvals



SO-24
0.8 mm pitch

Schematic Block Diagram



BROADCOM

ACFJ-3530T/31T: Automotive Gate Driver and Flyback DC-DC Controller

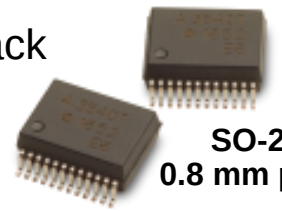
R2Coupler® w/Desat Sensing, UVLO Feedback, Active Miller Clamping and Negative Bias

Key Automotive Features

- Qualified to AEC-Q100 Test Guidelines
- Regulatory approvals
- **Integrated fail-safe IGBT protection includes** fault protection, fault feedback and negative gate bias
- **Regulated output voltage: 16 V ±5% (ACFJ-3530T)**
- **Regulated output voltage: 18 V ±5% (ACFJ-3531T)** ***COMING SOON***
- Operating temperature range: -40º C to +125º C
- SO-24 package with 8mm creepage and clearance

Benefit

- Distributed floating power supply architecture
- Less switching noise and smaller transformer
- Integrated fault protection and fault feedback
- Small size and board space saving
- Better efficiency and timing control

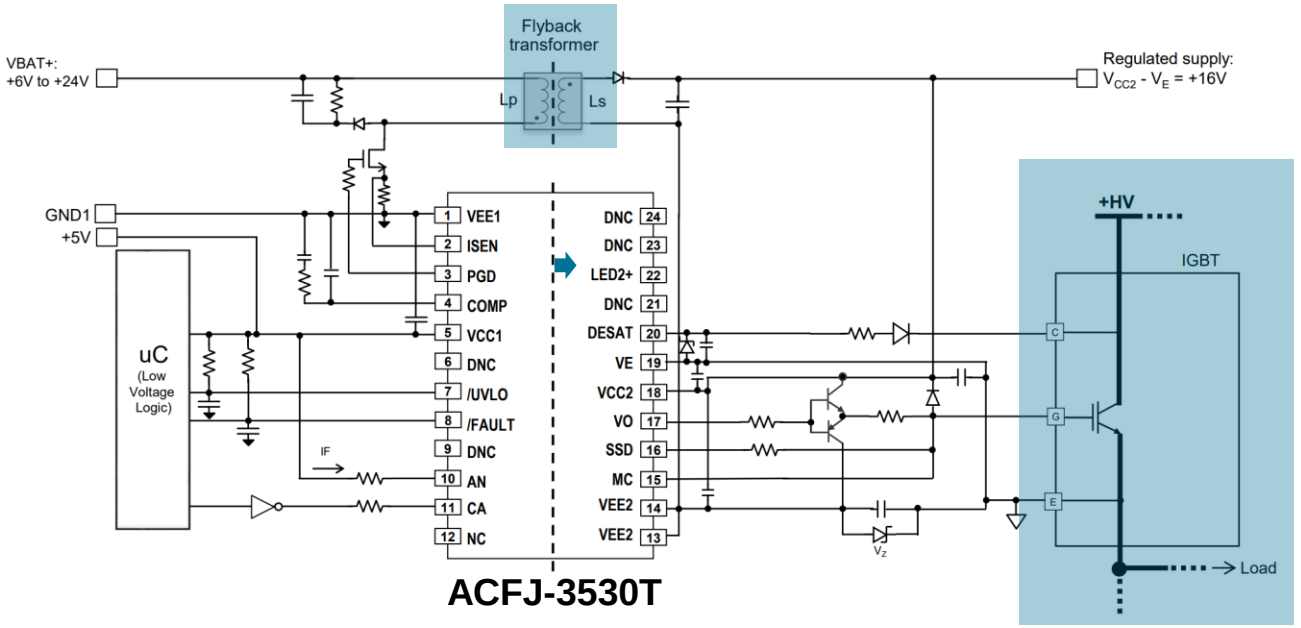


SO-24
0.8 mm pitch

Applications

- IGBT/SiC MOSFET gate driver for traction powertrain inverter, in-wheel; motor, HEV/HV chargers and HVAC

Typical Application



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ACFJ-3531T Driving Cree CAS300M12BM1 SiC Module

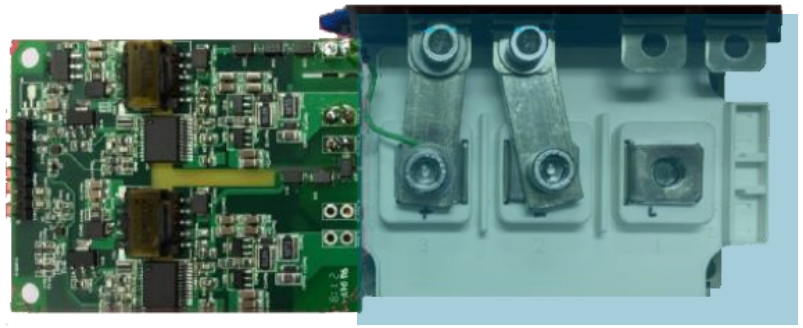
Evaluation board: Cree SiC Module driven by ACFJ-3531

- Half-bridge application
- Cree CAS300M12BNI SiC Module
  - 1.2 kV
  - 300 A

Key Features

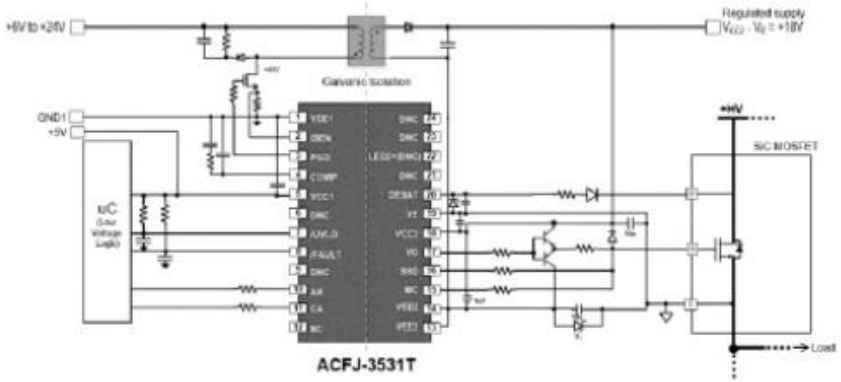
- Gate drive with DC-DC converter
- Output voltage options: 16 V and 18 V
  - Wide 6 V to 26.5 V input range
- Programmable negative output
- Supply output short circuit protection
- Status feedback for µC action: UVLO, output short circuit and desaturation
- Supply current overload protection
- Improved IGBT and SiC MOSFET protection
- Status Feedback

ACFJ-3531T Half Bridge Evaluation Board



Cree CAS300M12BNI SiC Module 1.2 kV300 A

ACFJ-3531T Typical Application



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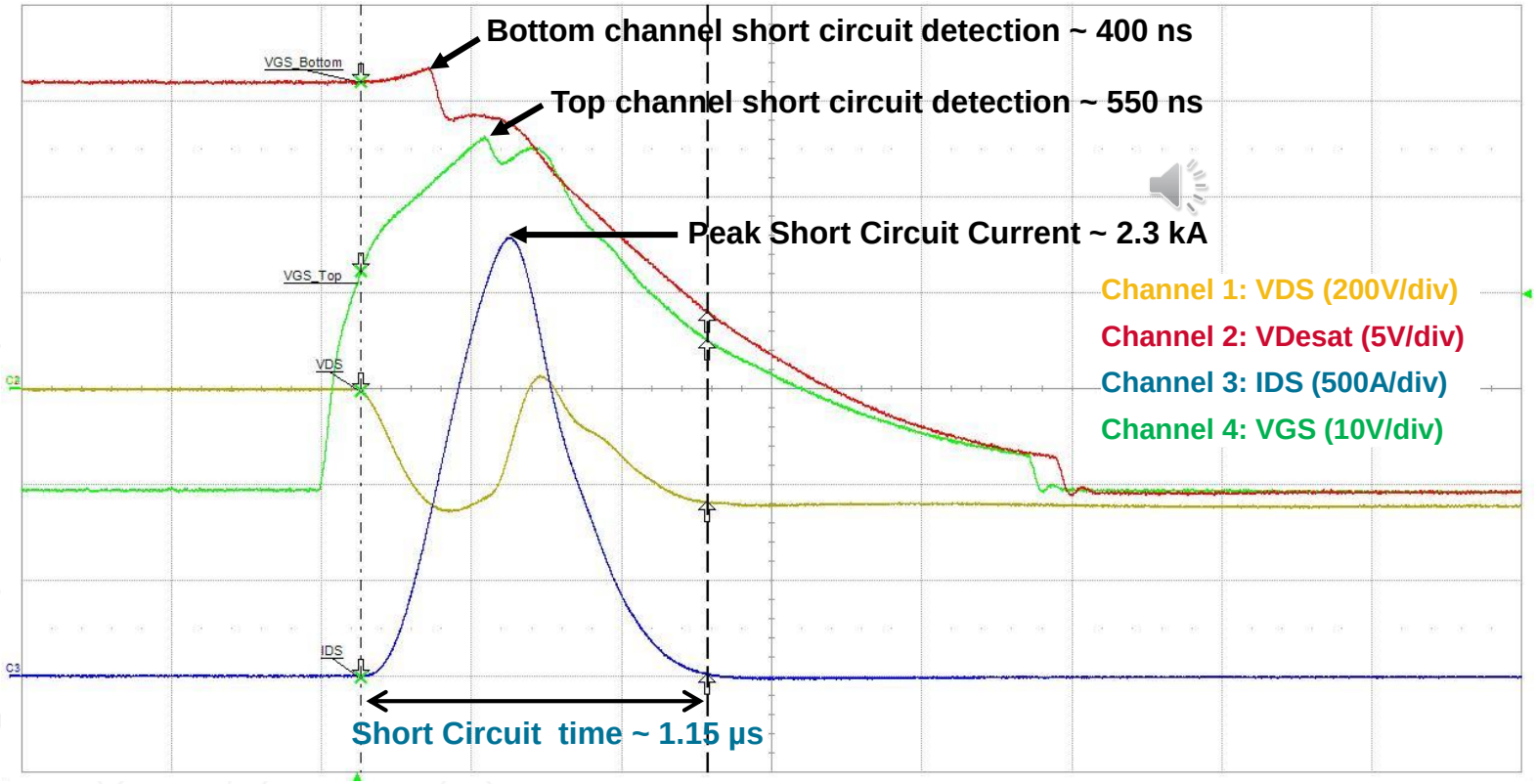
ACFJ-3531T SiC (Cree) Bridge Short Circuit Test at 600 V

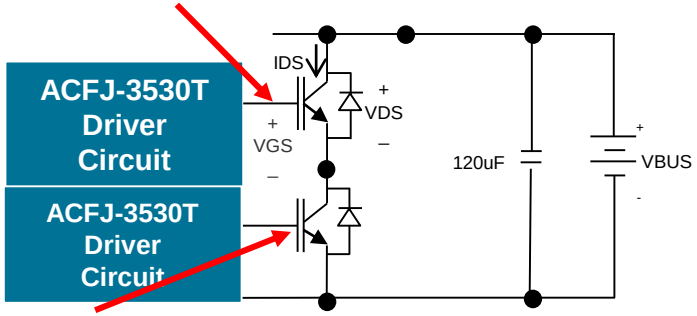
Highlights

- ACFJ-3531T can be configured to detect a SiC short circuit event within 550 ns
- Overall short circuit duration is less than 1.2 µs



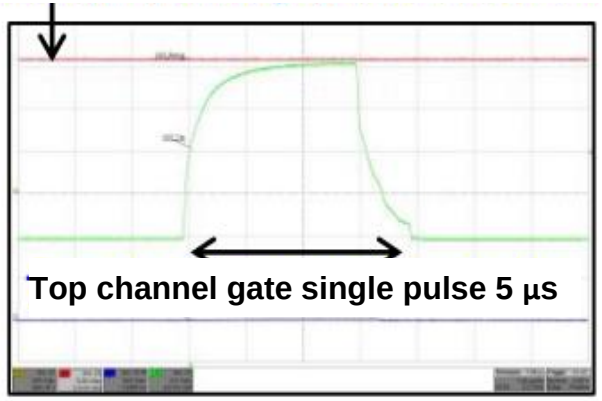
Short Circuit Test Setup

Top channel gate single pulse 5 µs



Bottom channel gate is turned on first

Bottom channel gate is turned on first



BROADCOM

ACFJ-3439T - Automotive Gate Driver R2Coupler with Short Circuit Protection and UVLO Feedback, Active Miller Clamping and Negative Bias

Features

- Qualified to AEC-Q100 Grade 1 Test Guidelines
- Automotive temperature range : -40ºC to +125ºC
- Minimum peak output current: +/-10 A
- Miller clamp sinking current: 2A
- Maximum propagation delay: 200ns
- Integrated fail-safe IGBT/MOSFET protection
  - IGBT/MOSFET over-current sensing with configurable “Soft” turn-off and feedback
  - Under Voltage Lock-Out protection (UVLO) with feedback
- Functional safety reporting
  - Over-current FAULT feedback
  - IGBT/MOSFET Gate status feedback
  - UVLO status feedback
- High noise immunity
  - Common Mode Rejection(CMR): 100kV/µs at VCM = 1000V
  - Miller current clamping
  - Direct LED input with low input impedance and low noise sensitivity
  - Negative gate bias
- SO-24 package with 8mm creepage and clearance
- Regulatory approvals (Pending):
  - UL1577, CSA
  - IEC 60747-5-5

Applications

- IGBT Gate Driver for Traction Inverter, Charger and HVAC

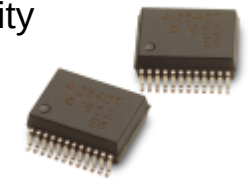
Benefit

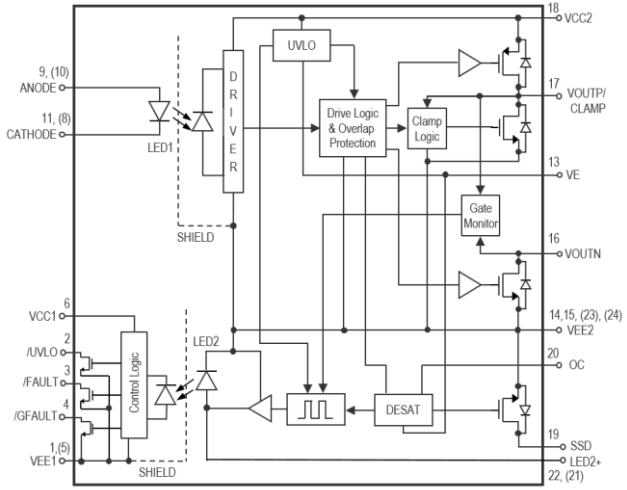
- Integrated fault protection
- Easy to use
- Small size and board space saving

Status Update

- Update Preliminary Datasheet **Available**
- Engineering Samples **Available**

Functional Diagram





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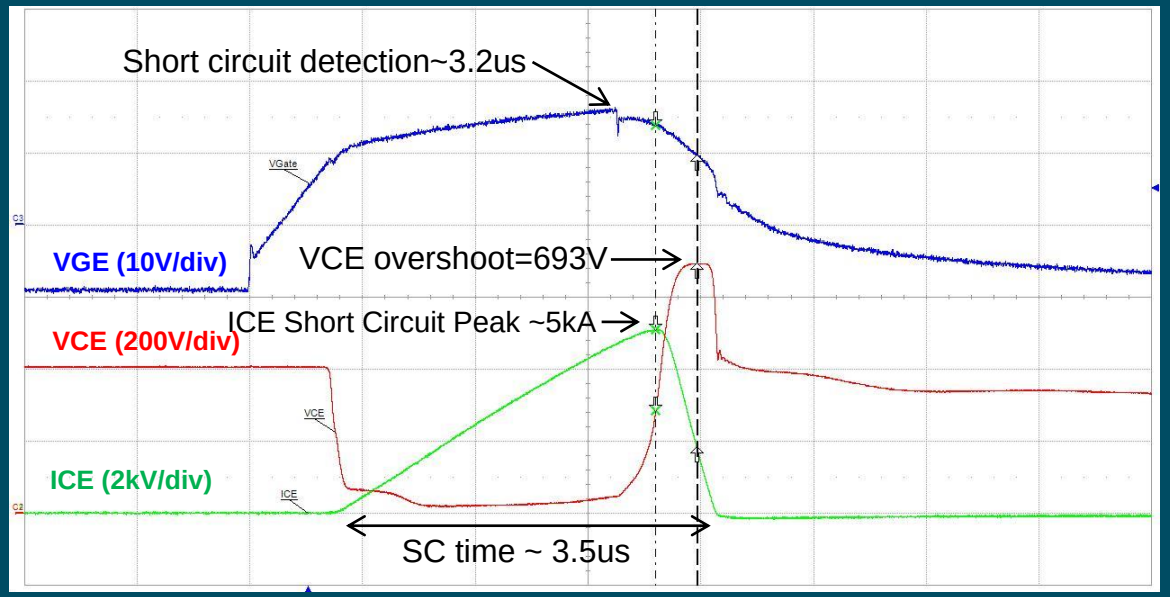
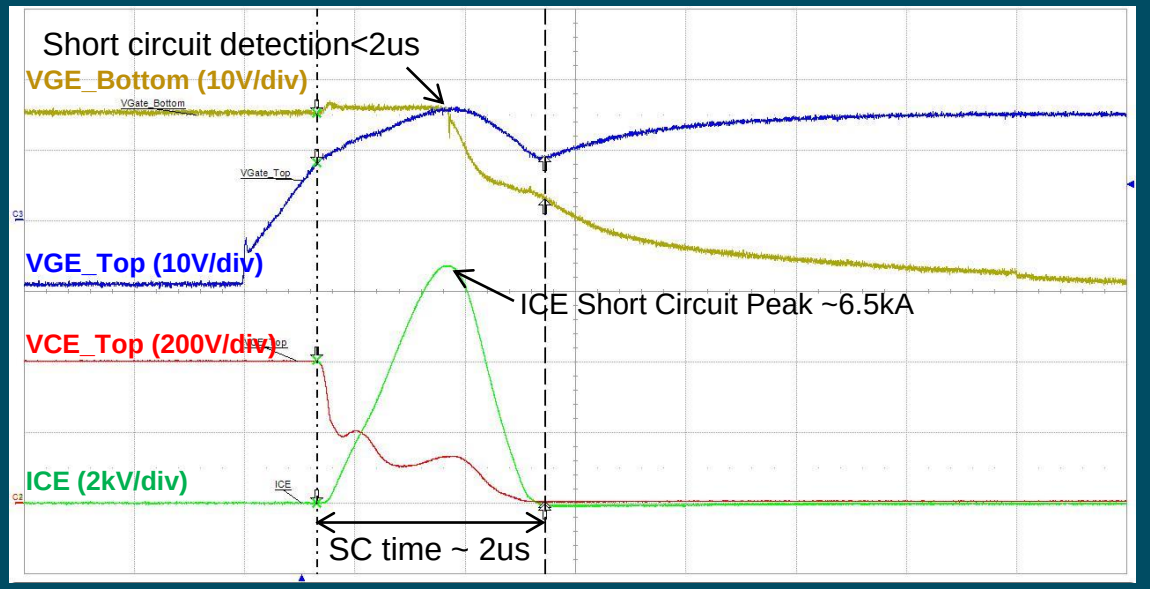
ACFJ-3439T Short Circuit Protection at Vbus=400V

(i) Wire short (Top channel short through external wire)



(ii) Arm short (Top and bottom channel shoot-through)



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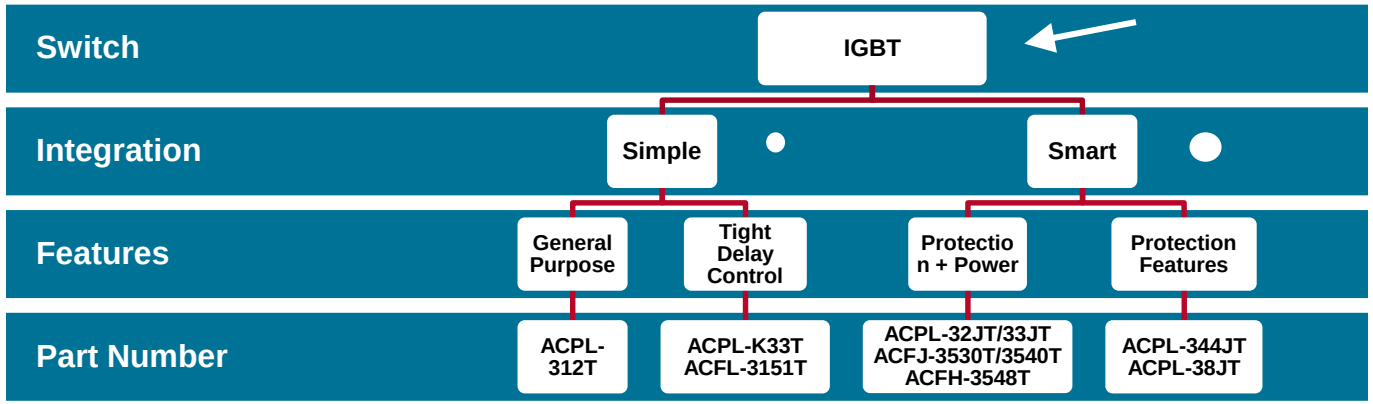
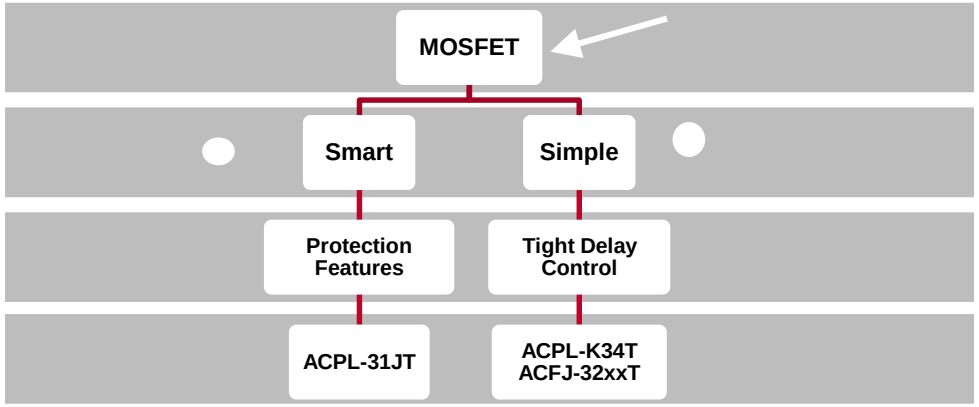
Automotive Gate Drive Portfolio





Heater Converters **Powertrain Inverters** **AC/DC, DC-DC Converters**

Part Number	Working Voltage	I_{O-} / I_{O+}	T_{PLH} / T_{PHL}	T_{PLH} - T_{PHL}	V_{CC2} Supply	Miller Clamp	UVLO / Feedback	Desat-Emitter / Feedback	DC-DC Flyback Controller	Negative Gate Bias
ACPL-312T	630V	-2.5A / 2.5A	500ns / 500ns	-350ns / 350ns	30V	NA	12.3V / No	NA	NA	No
ACPL-K33T	1140V	-2.5A / 2.5A	120ns / 120ns	-40ns / 50ns	30V	NA	13V / No	NA	NA	No
ACPL-K34T	1140V	-2.5A / 2.5A	110ns / 110ns	-40ns / 50ns	20V	NA	8.6V / No	NA	NA	No
ACPL-31JT	1230V	-2.5A / 2.5A	250ns / 250ns	-100ns / 15ns	20V	1.9A	10V / Yes	3.9V / Yes	NA	Yes
ACPL-32JT	1230V	-2.5A / 2.5A	250ns / 250ns	-160ns / 60ns	20V	2A	12.5V / Yes	7V / Yes	20V, 2W	Yes
ACPL-33JT	1230V	-2.5A / 2.5A	250ns / 300ns	-230ns / 175ns	16V	2A	13.4V / Yes	7V / Yes	16V, Power dependant on External MOSFET	No
ACFJ-3530T	1230V	-2.5A / 2.5A	150ns / 150ns	-70ns / 70ns	16V	2A	12.5V / Yes	9V / Yes		Yes
ACPL-344JT	1230V	-2.5A / 2.5A	250ns / 250ns	-150ns / 105ns	25V	1.9A	12.4V / Yes	7V / Yes	NA	Yes
ACPL-38JT	1230V	-2.5A / 2.5A	500ns / 500ns	-350ns / 350ns	30V	NA	12.3V / No	7V / Yes	NA	Yes
ACFJ-3540T	1230V	-1A / 2.5A	150ns / 150ns	-70ns / 70ns	15V	2.5A	12.5V / Yes	0.7V / Yes	15V, 2W	Yes
ACFH-3548T	1230V	-1.5A / 1.5A	300ns / 300ns	-150ns / 150ns	16V±10% (adj)	2.5A	12.5V / Yes	10V / 0.7V / Yes	16V, Power dependent on external MOSFET	Yes

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Automotive Solid-State Relay: ASSR-601JV/T

Key Features

- Automotive grade temperature range
  - ASSR-601JV: -40° C to 105° C
  - ASSR-601JT: -40° C to 125° C
- ***Breakdown voltage, BV_{DSS} : 1700 V typical @ I_{DSS} = 0.25 mA***
- Avalanche rated MOSFETs
- ***Off-state leakage: I_{OFF} ≤ 1μA @ V_{DS} = 1000 V across temperature***
- On-resistance: $R_{DS(ON)}$ ≤ 300 Ω @ I_{LOAD} =2 mA
- Turn-on time: T_{ON} ≤ 4 ms
- Turn-off time: T_{OFF} ≤ 0.5 ms
- Package: 300 mil SO-16
- Creepage and Clearance ≥ 8 mm (input-output)
  - Creepage > 5 mm (between drain pins of MOSFETs)
- V_{ISO} = 5 kV_{RMS} (UL 1 minute rating)
- Working voltage: 1414 V_{PEAK} (Reinforced)
- CTI > 600 V Mold compound

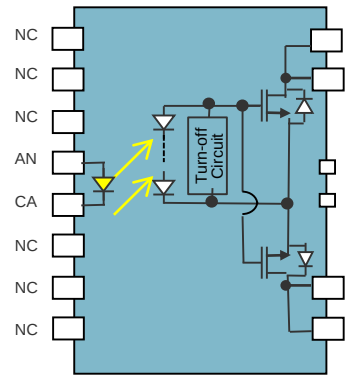
Benefit

- Ability to leverage high voltage, low leakage MOSFET at AECQ101 Grade 1 (125°C) temperature

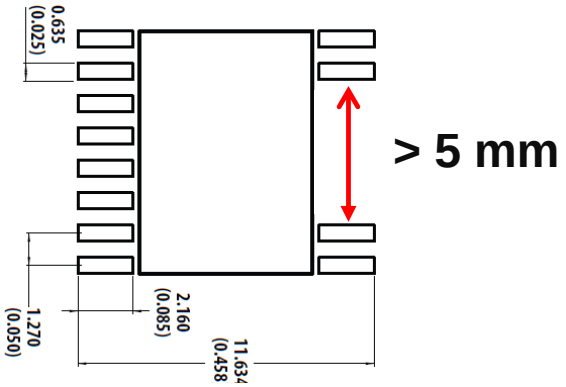
Applications

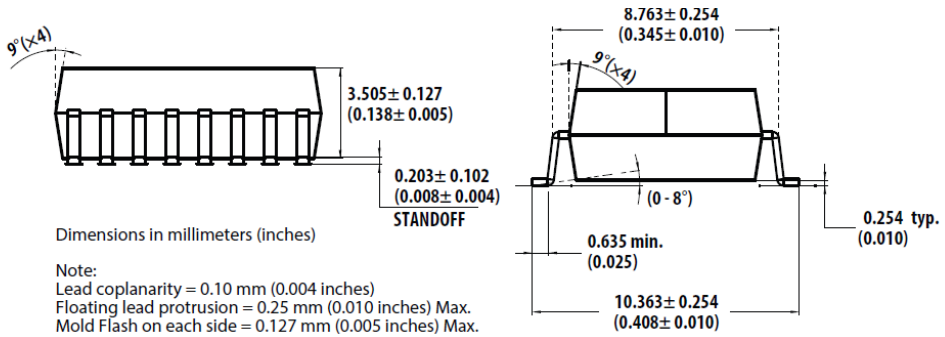
- Insulation resistance test in battery system

Block Diagram



ASSR-601JV





Dimensions in millimeters (inches)

Note:
Lead coplanarity = 0.10 mm (0.004 inches)
Floating lead protrusion = 0.25 mm (0.010 inches) Max.
Mold Flash on each side = 0.127 mm (0.005 inches) Max.

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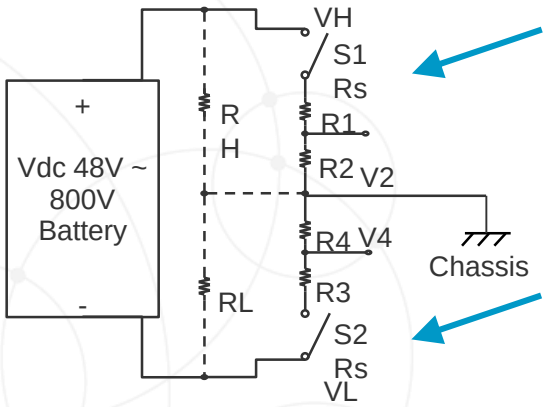
Application: Insulation Resistance Measurement

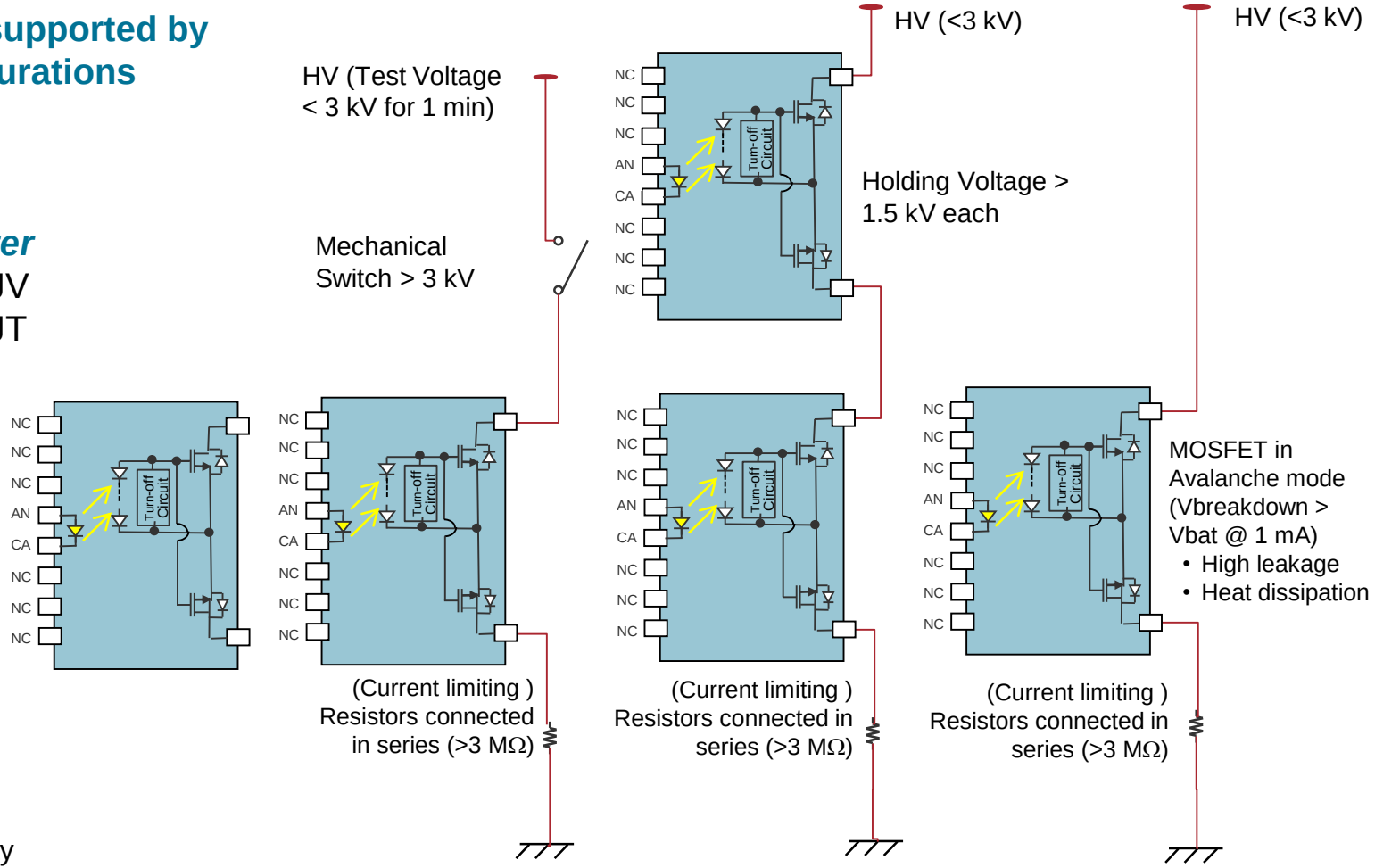
Requirements

- Insulation resistance / leakage current detection Isolation Testing voltage: 2 x Battery voltage + 1000 V, **supported by 2x SSR in series or other application configurations**
- Bipolar load voltage: ***Requires two MOSFETs back-to-back***
- Several mA MOSFET load current is sufficient
- ***Switch leakage current critical, lower is better***
  - I_{OFF} < 1 µA at VDS = 1000 V for ASSR-601JV
  - I_{OFF} < 5 µA at VDS = 1000 V for ASSR-601JT

Typical Application Circuit



Broadcom R²Coupler provides reinforced insulation and reliability



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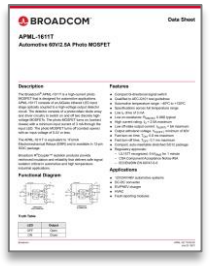
APML-1611T: Automotive 60 V Photo MOSFET

Key Features

- Breakdown voltage (BV_{DSS}): ***>60 V @ I_{DSS} = 0.25 mA***
  - Avalanche rated MOSFETs
- On-resistance, $R_{DS(ON)}$ ≤ 0.2 Ω @ I_{LOAD} = 2.5 A
- Break Before Make (BBM) operation
- **Off-state leakage: I_{OFF} ≤ 10 µA**
  - **V_{DS} = 48 V across temperature**
  - Turn on time (T_{ON}): ≤ 2 ms
- Turn off time (T_{OFF} *):* ≤ 0.2 ms
- Automotive Grade: -40° C to 125° C
- Low LED drive (I_F) : 3 mA
- Package: Stretched S012
- Creepage and cclearance distance ≥ 8 mm (input-output)
- AEC-Q101 test guidelines
- Input-Output momentary withstand voltage (V_{ISO})
  - 5 kV_{RMS} (UL 1577, 1 minute Rating)
- Working voltage (V_{IORM}): 1140 VPEAK (reinforced)
  - EN60747-5-5

Benefit

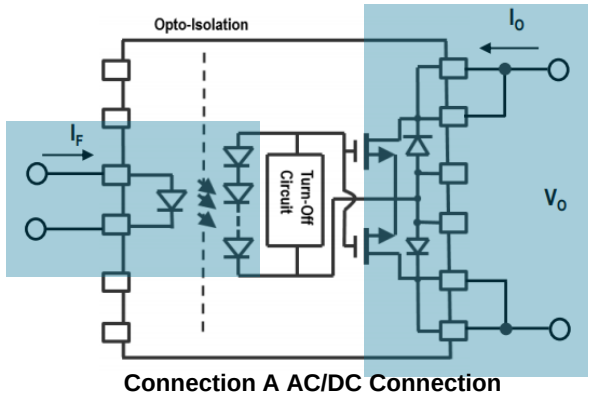
- Ability to leverage high voltage, low leakage MOSFET at AECQ101 Grade 1 (125^{O} C) temperature



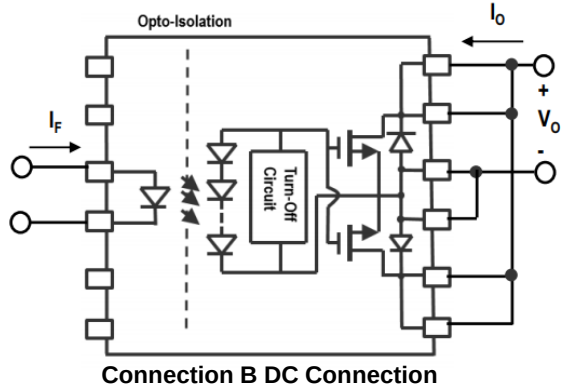
Applications

- Electric vehicle powertrain, DC-DC Converter, EV/PHEV Charger, HVAC, fault reporting modules, and 48 V systems

Functional Diagram



Connection A AC/DC Connection



Connection B DC Connection

Part	BV_{DSS}	I_{LOAD}	$R_{DS(ON)}$
APML-1611T	60 V	2.5 A	0.2 Ω

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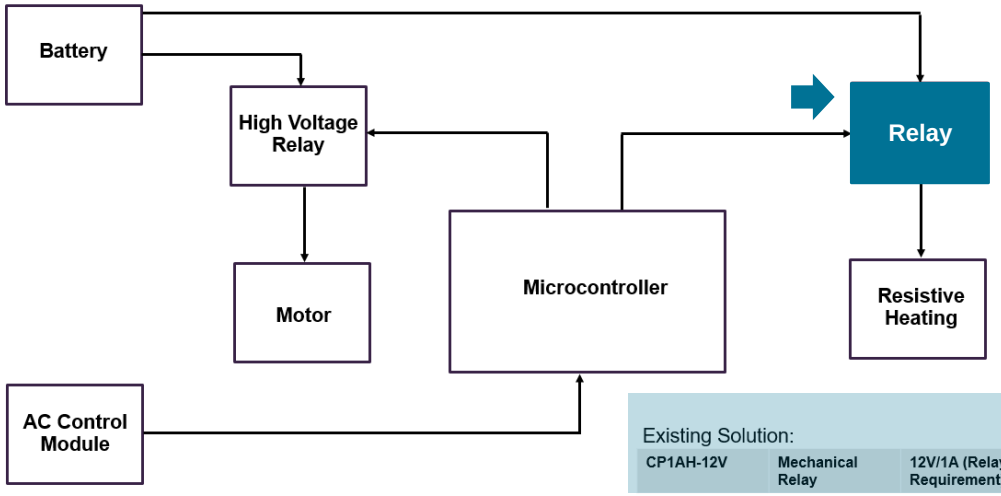
Typical application example

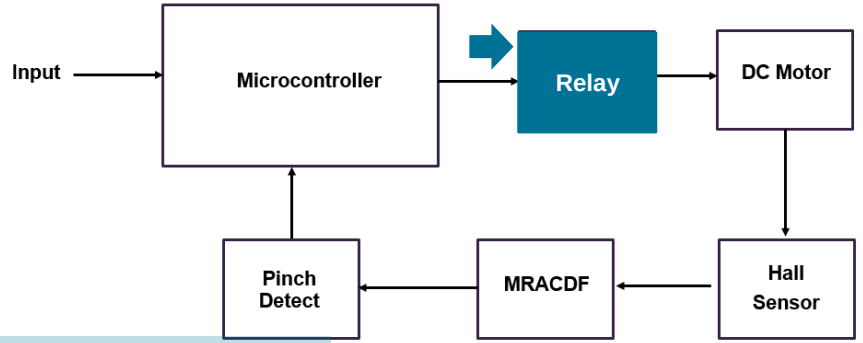
HVAC



Existing Solution:

CP1AH-12V	Mechanical Relay	12V/1A (Relay Requirement)

Powered Sunroof



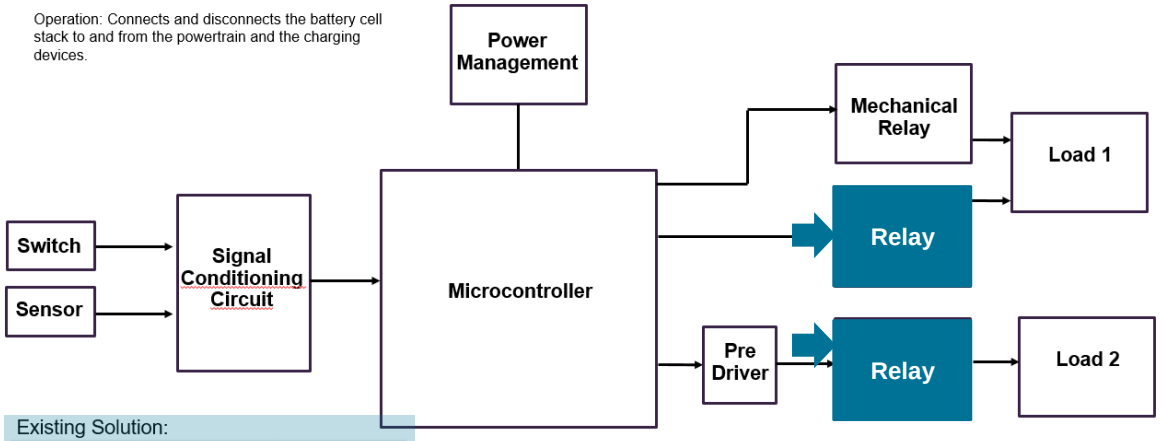
Existing Solutions:

1. ACTB11	Mechanical Relay	12V/1A (Relay Requirement)
2. DRV8703 + SQJ940EP	Driver + MOSFET	

Operation: The DC motor is driven by two relays. This configuration allows the relay to also act as an H bridge allowing the MCU to polarize the motor in either direction

HV Battery Junction Box (EV and HEV)

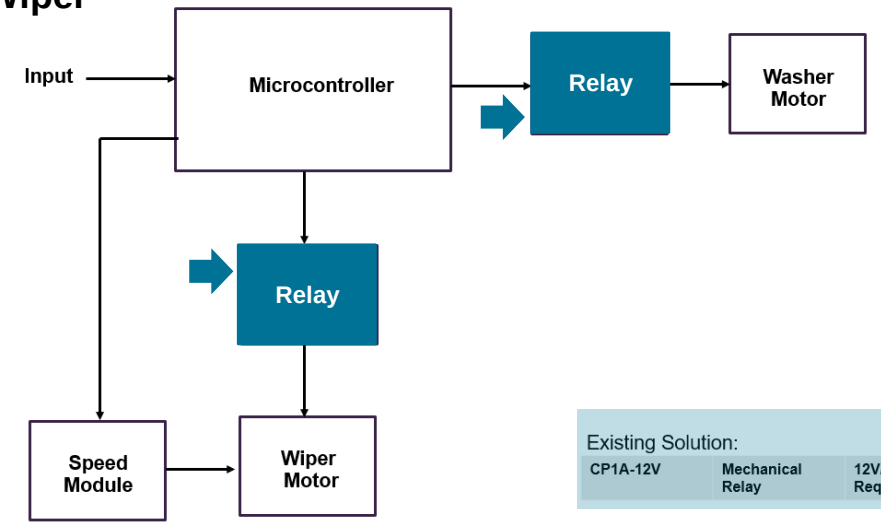
Operation: Connects and disconnects the battery cell stack to and from the powertrain and the charging devices.



Existing Solution:

SSM3H137TU	Driver+MOSFET	34V/2A
TPCP8R01	Driver+MOSFET	60V/2A

Wiper



Existing Solution:

CP1A-12V	Mechanical Relay	12V/1A (Relay Requirement)

BROADCOM

Hermetic Optocouplers

Hermetic Optocoupler Markets

Harsh Industrial: transportation, down-hole drilling, refineries/chemical processing

- High temperature applications
- Motor control
- Directional drilling control
- Power distribution
- Engine control

Military: missiles, ships, aircraft, armored vehicles

- Ordnance fire control
- Radar systems
- Digital communication systems

Space: satellites, space station, launch vehicles

- Signal tracking systems
- Guidance systems
- Environmental controls
- Reaction wheel assemblies

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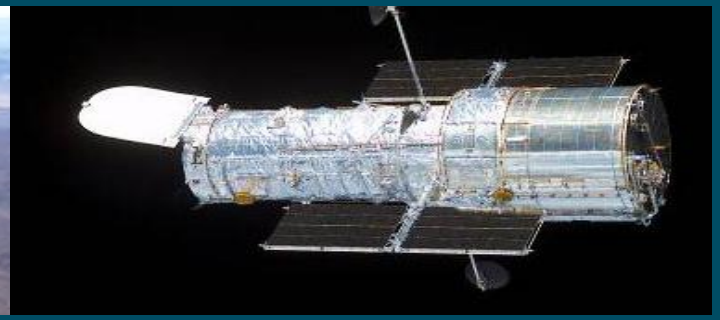
Value Proposition: Broadcom Hermetic Optocoupler





- Zero obsolescence
- Document control
- Certified and qualified by US Department of Defense
- Specified from -55° C to +125° C operation
- Active JEDEC membership

- Hermetically sealed = zero moisture or corrosion intrusion
- Gold or tin-lead options
- Radiation data available
- Reliability data available on-line
- Proven quality, reliability and customer support since 1978

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Hermetic Optocoupler Portfolio Overview

15 Base Parts (-55˚ C to +125˚ C)

Digital: (1ch/2ch/4ch)

- 100 kbd Darlington (3.3 V available)
- 700 kbd Transistor output
- 5 Mbd Logic output
- 10 Mbd Logic output (3.3V available)
- 20 Mbd Logic output
- Line receiver

Gate Drivers

- 2.5 A Integrated IGBT / MOSFET driver
- 0.5 A/2.5 A Basic IGBT / MOSFET driver
- IPM Interface

Current and Voltage Sense

- ±200 mV, 100 kHz Analog isolation

Solid State Relay

- 0.8 A, 1 Ω AC/DC SSR

AC/DC to Logic Interface

- AC/DC threshold detector

Availzable Grades

Commercial: Harsh Environments & Industrial Applications

- Built and tested per best commercial practices

Class H: Military, Mission Critical & High Value Applications

- Built and tested to assure dependability and longevity

Class K: Highest Reliability for Space & Life-Critical Applications

- Built/tested to perform for years in extreme conditions

Hermetic Optocoupler Packages			
8-Pin DIP	16-Pin DIP	20 Pad LCCC	16-Pin Flat Pack
			

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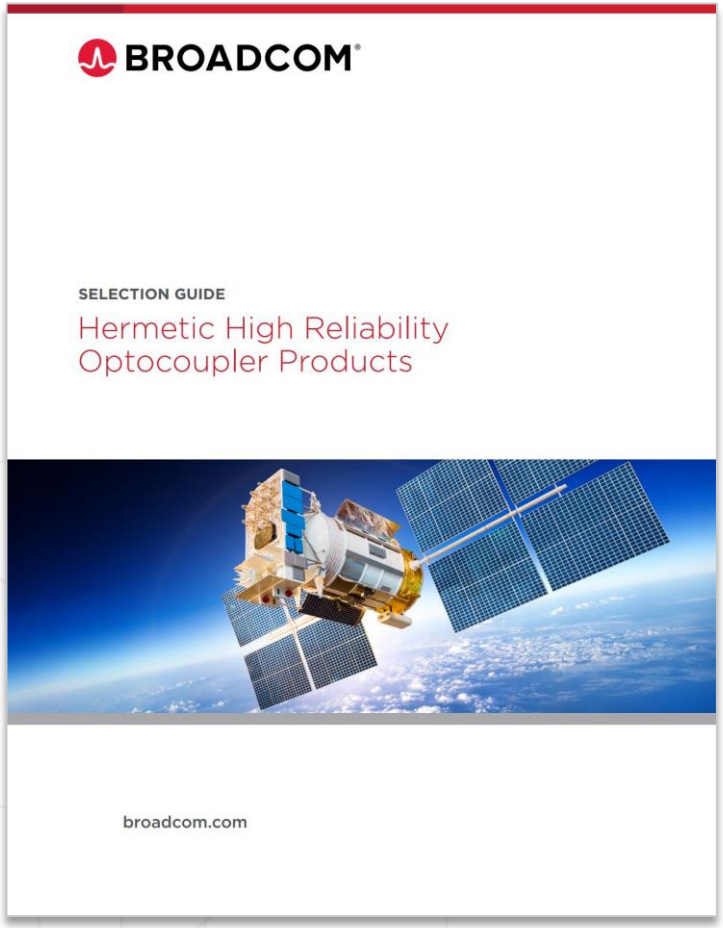
Broadcom Hermetic High Reliability Optocoupler Products

Selection Guide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SELECTION GUIDE

Hermetic High Reliability Optocoupler Products

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Hermetic High Reliability Optocouplers

Description

Isolating one portion of an electrical circuit from another is the primary function of an optocoupler. These devices isolate different voltage levels between the input and output source. Broadcom optocouplers are ideally suited for isolating highly sensitive portions of a circuit from the effects of transmitted common mode signals; offering a variety of input and output characteristics that enable their use in high speed, high performance applications. Broadcom' hermetic optocouplers excel in designs for harsh environments that require an exceptionally strong, rugged enclosure.

For design ease, we offer most functions in 8- and 16-Pin DIPs, 20 terminal LCCC's and 16-Pin Flat Packs with various lead configurations for thru-hole or surface mount, with either single, dual or quad channels. These products are capable of operation and storage over the full military temperature range of -55°C to +125°C and can be purchased as either commercial product or with full MIL-PRF-38534 Class Level E, H or K. In line with regulations and our customers needs, we do not offer unleaded solder on our solder dipped devices. All devices are manufactured and tested on a MIL-PRF-38534 certified line and are included in the DLA (Defense Logistics Agency) Qualified Products Database Supplemental Information Sheets QPDSIS-38534 as Hybrid Microcircuits.

Broadcom has supplied high reliability hermetic optocoupler products since 1975 for use in state-of-the-art applications. To meet the requirements of high reliability, products must be designed with rugged capabilities. They must be able to withstand severe levels of environmental stress and exposure without failure over extended periods of time. We have accomplished this objective in designing optocouplers that have proven their merits in numerous advanced space and defense programs in the international marketplace. Broadcom continuity and support of the industry has remained stable, with zero product obsolescence. We are committed to continued process and performance upgrades, backed up with diligent notification to our customers of any changes made using the GIDEP system.

Statistical Process Control and extensive reliability monitoring (life testing of hundreds of thousands of hours) are standard processes for hermetic optocouplers. Control charts are utilized at each critical step of the process and reviewed by product engineering to assure expected quality and reliability.

Broadcom is a champion of DLA's QPDSIS and SMD (Standard Microcircuit Drawing) programs. We support standardization, which results in cost-effectiveness and a streamlined acquisition process. As such Broadcom offers Class E, H and K products under SMD numbers. Products are dual marked with the DLA SMD and Broadcom part numbers.

Our Screening and Quality Conformance Inspection is outlined on the following page.

Benefits

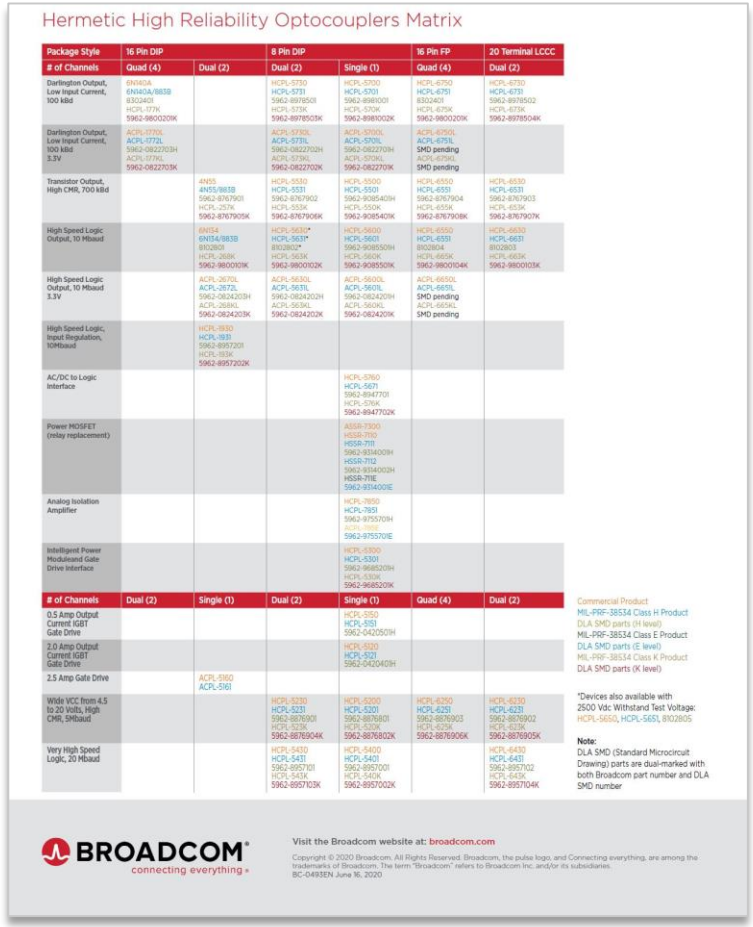
- Long term commitment - zero obsolescence
- Recognized for high quality, reliability, and customer support
- Certified and qualified to Classes E, H and K of MIL-PRF-38534
- -55°C to +125°C operating temperature range
- Products available on DLA SMD's
- General purpose and application specific products available

Applications

Military, aerospace and harsh industrial applications such as:

- Switching power supplies/UPS
- Motor control
- Field bus
- Inverters
- Power distribution
- Communications

2


Hermetic High Reliability Optocouplers Matrix

Package Style	16 Pin DIP		8 Pin DIP		16 Pin FP	20 Terminal LCCC
# of Channels	Quad (4)	Dual (2)	Dual (2)	Single (1)	Quad (4)	Dual (2)
Darlington Output, Low Input Current, 100 kBd	6N140A 6N140A/883B 8302401 HCPL-077K 5962-9800201K		HCPL-5730 HCPL-5731 5962-8978501 HCPL-573K 5962-8978503K	HCPL-5700 HCPL-5701 5962-8981001 HCPL-570K 5962-8981002K	HCPL-6750 HCPL-6751 8302401 HCPL-675K 5962-9800201K	HCPL-6730 HCPL-6731 5962-8978502 HCPL-673K 5962-8978504K
Darlington Output, Low Input Current, 100 kBd 3.3V	ACPL-177XL ACPL-077XL 5962-0822703H ACPL-577XL 5962-0822703K		ACPL-5730L ACPL-5731L 5962-0822702H ACPL-573XL 5962-0822702K	ACPL-5700L ACPL-5701L 5962-0822701H ACPL-570XL 5962-0822701K	ACPL-6750L ACPL-6751L SMD pending ACPL-675XL SMD pending	
Transistor Output, High CMR, 700 kBd		4N55 4N55/883B 5962-8767901 HCPL-257K 5962-8767905K	HCPL-5530 HCPL-5531 5962-8767902 HCPL-553K 5962-8767906K	HCPL-5500 HCPL-5501 5962-9085401H HCPL-550K 5962-9085401K	HCPL-6550 HCPL-6551 5962-8767904 HCPL-655K 5962-8767908K	HCPL-6530 HCPL-6531 5962-8767903 HCPL-653K 5962-8767907K
High Speed Logic Output, 10 Mbaud		6N134 6N134/883B 8102601 HCPL-268K 5962-9800101K	HCPL-5631* HCPL-5631* 8102602* HCPL-563K 5962-9800102K	HCPL-5600 HCPL-5601 5962-9085501H HCPL-560K 5962-9085501K	HCPL-6550 HCPL-6551 8102604 HCPL-665K 5962-9800104K	HCPL-6630 HCPL-6631 8102603 HCPL-663K 5962-9800103K
High Speed Logic Output, 10 Mbaud 3.3V		ACPL-2670L ACPL-2672L 5962-0824203H ACPL-268KL 5962-0824203K	ACPL-5630L ACPL-5631L 5962-0824202H ACPL-563KL 5962-0824202K	ACPL-5600L ACPL-5601L 5962-0824201H ACPL-560KL 5962-0824201K	ACPL-6650L ACPL-6651L SMD pending ACPL-665KL SMD pending	
High Speed Logic, Input Regulation, 10Mbaud		HCPL-9130 HCPL-9131 5962-8957201 HCPL-913K 5962-8957202K				
AC/DC to Logic Interface				HCPL-5760 HCPL-5671 5962-8947701 HCPL-576K 5962-8947702K		
Power MOSFET (relay replacement)				ASSR-7300 HSSR-7110 HSSR-711I 5962-9314001H HSSR-7112 5962-9314002H HSSR-711E 5962-9314001E		
Analog Isolation Amplifier				HCPL-7850 HCPL-7851 5962-9755701H ACPL-785E 5962-9755701E		
Intelligent Power Module and Gate Drive Interface				HCPL-5300 HCPL-5301 5962-9685201H ACPL-530E 5962-9685201K		
# of Channels	Dual (2)	Single (1)	Dual (2)	Single (1)	Quad (4)	Dual (2)
0.5 Amp Output Current IGBT Gate Drive				HCPL-5150 HCPL-5151 5962-0420501H		
2.0 Amp Output Current IGBT Gate Drive				HCPL-5120 HCPL-5121 5962-0420401H		
2.5 Amp Gate Drive		ACPL-5160 ACPL-5161				
Wide VCC from 4.5 to 20 Volts, High CMR, 5Mbaud			HCPL-5230 HCPL-5231 5962-8876901 HCPL-523K 5962-8876904K	HCPL-5200 HCPL-5201 5962-8876801 HCPL-520K 5962-8876802K	HCPL-6250 HCPL-6251 5962-8876903 HCPL-625K 5962-8876906K	HCPL-6230 HCPL-6231 5962-8876902 HCPL-623K 5962-8876905K
Very High Speed Logic, 20 Mbaud			HCPL-5430 HCPL-5431 5962-8957001 HCPL-543K 5962-8957103K	HCPL-5400 HCPL-5401 5962-8957001 HCPL-540K 5962-8957002K		HCPL-6430 HCPL-6431 5962-8957702 HCPL-643K 5962-8957104K

Commercial Product
MIL-PRF-38534 Class H Product
DLA SMD parts (H level)
MIL-PRF-38534 Class E Product
DLA SMD parts (E level)
MIL-PRF-38534 Class K Product
DLA SMD parts (K level)

*Devices also available with 2500 Vdc Withstand Test Voltage: HCPL-5650, HCPL-5651, 8102805

Note: DLA SMD (Standard Microcircuit Drawing) parts are dual-marked with both Broadcom part number and DLA SMD number

BROADCOM connecting everything

Visit the Broadcom website at: broadcom.com

BC-0493EN June 16, 2020

https://docs.broadcom.com/doc/BC-0493EN

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Our Value Proposition

Track Record

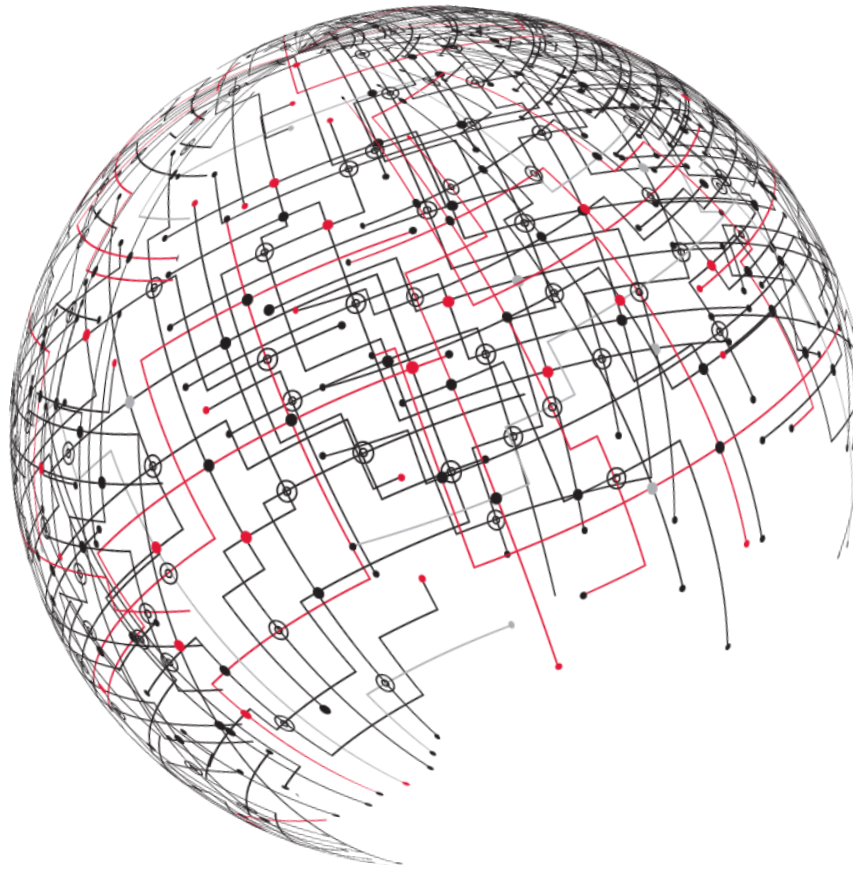
- Over 50 years of manufacturing experience
- More than 15 years experience in 30 car models in automotive applications
- #1 Photo IC supplier

Technology Leadership

- Advance LED technology for long lifetime and high temperature operation
- Semiconductor technology
- New packages
- High EMI and noise immunity
- Robust galvanic reinforced isolation

Worldwide Safety Approvals

- IEC 60747-5-5
- UL 1577
- CSA
- Automotive AECQ100 Grade 1



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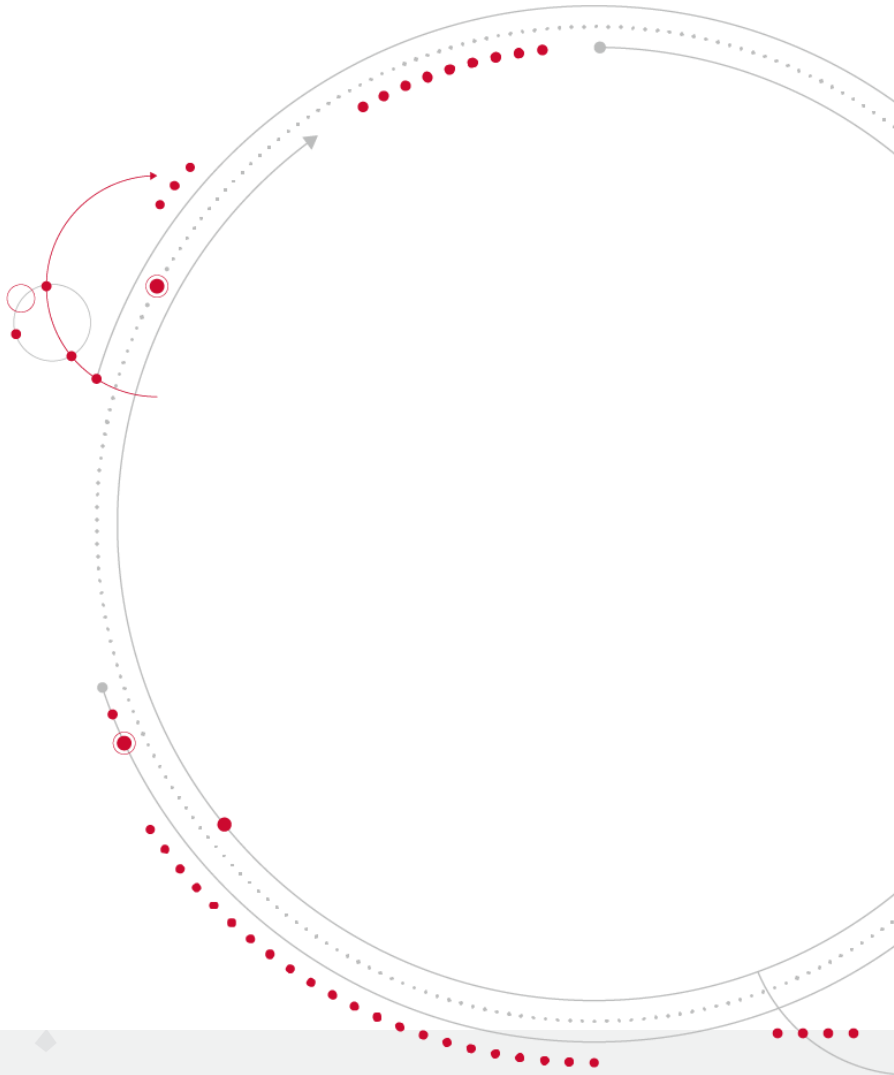
Summary

- Company history and milestones
- Digital optocouplers
- Gate drivers: standard and smart
- Current and voltage sensors
- Hall effect sensors
- Solid state relays, analog output optocouplers and AC/DC detectors
- Automotive isolation solutions
- Hermetic high reliability isolation solutions
- Value proposition



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FAE Certification Quiz

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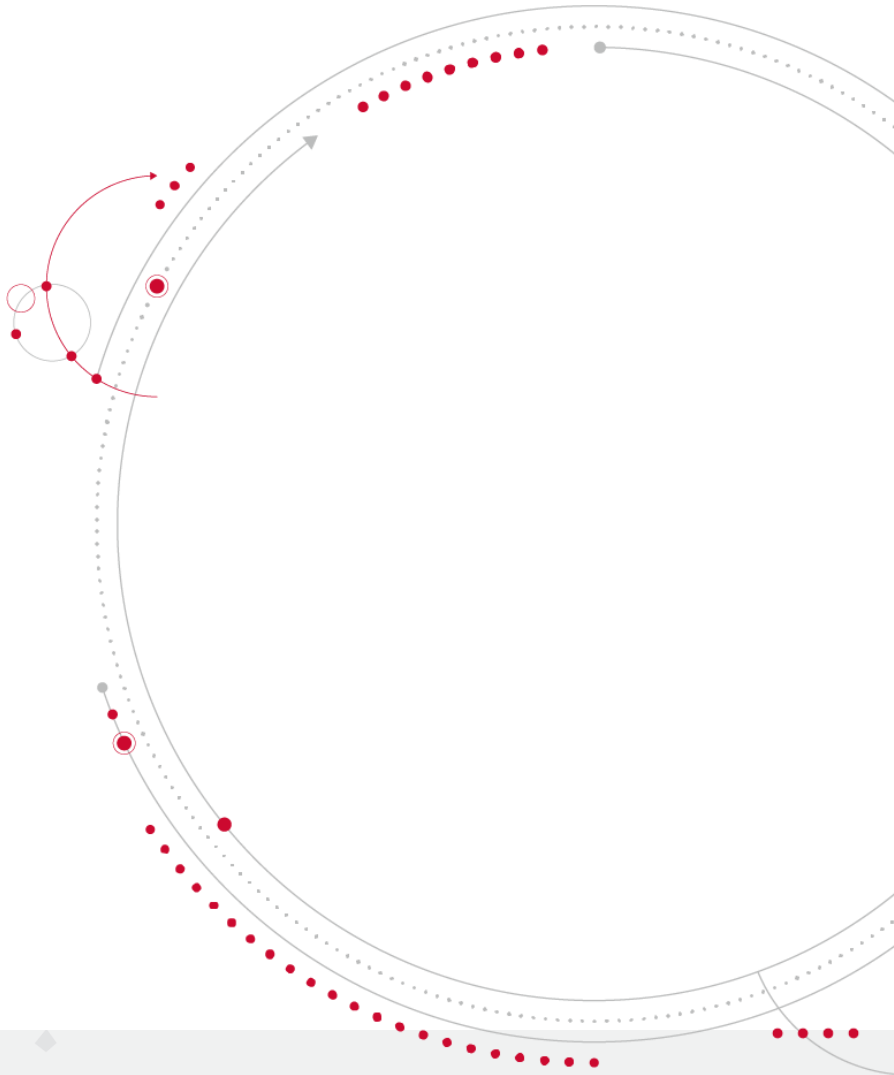
- Presentation download
  - Go to your ***Learner Dashboard*** and find the presentation in the ***Knowledge Base***.



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50 YEARS

Thank You

FAE Distributor Certification Training