

## ASSR-601J 1500V High Voltage Industrial Photo MOSFET

#### Description

The Broadcom® ASSR-601J is a high-voltage Photo MOSFET that is designed for high voltage industrial applications. The ASSR-601J consists of an AlGaAs infrared light-emitting diode (LED) input stage optically coupled to a high-voltage output detector circuit. The detector consists of a high-speed photovoltaic diode array and driver circuitry to switch on/off two discrete high-voltage MOSFETs. The relay turns on (contact closes) with a minimum input current of 7 mA through the input LED. The relay turns off (contact opens) with an input voltage of 0.4V or less.

The ASSR-601J is equivalent to 1FormA Electromechanical Relays (EMR) and is available in 16-pin SOIC package. This Photo MOSFET provides reinforced insulation and reliability that delivers safe signal isolation critical in automotive and high temperature industrial applications.

#### **Features**

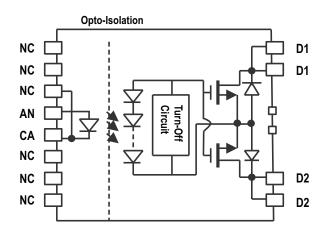
- Compact solid-state bidirectional signal switch
- Operating temperature range: -40°C to +110°C
- Breakdown voltage,  $V_{OFF}$ : 1500V at  $I_{DSS}$  = 250  $\mu A$
- Avalanche rated MOSFETs
- Output Leakage Current, I<sub>O</sub> = 10 nA at 1000V
- On-resistance,  $R_{ON}$  < 250 $\Omega$  at  $I_{O}$  = 50 mA
- Turn on time: T<sub>ON</sub> < 4 ms
- Turn off time:  $T_{OFF} < 0.5 \text{ ms}$
- Package: 300 mil SO-16
- Creepage and clearance ≥ 8 mm (input-output)
- Creepage > 5 mm (between drain pins of MOSFETs)
- Safety and regulatory approvals:
  - IEC/EN/DIN EN 60747-5-5
  - Maximum working insulation voltage 1414V<sub>PFAK</sub>
  - 5000V<sub>RMS</sub> for 1 minute per UL1577
  - CSA component acceptance

#### **Applications**

- Battery/motor/solar panel insulation resistance measurement/leakage detection
- BMS flying capacitor topology for sensing batteries
- Electro mechanical relay replacement
- Inrush current limiter protection

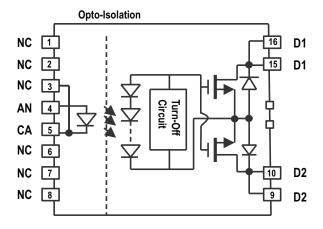
**CAUTION!** It is advised that normal static precautions be taken in handling and assembly of this component to prevent damage and/or degradation which may be induced by ESD. The components featured in this data sheet are not to be used in military or aerospace applications or environments.

#### **Functional Diagram**



#### **Truth Table**

LED	Output
Off	Open
On	Close



#### **Pin Description**

Pin Number	Pin Name	Description
1, 2, 6, 7, 8	NC	No connection.
3	NC	Do not connect (internally connected to Pin 5).
4	AN	Anode.
5	CA	Cathode.
9, 10	D2	Drain 2 (internally connected).
15, 16	D1	Drain 1 (internally connected).

### **Ordering Information**

Specify part number followed by option number.

Part Number	Option (RoHS Compliant)	Package	Surface Mount	Tape and Reel	UL 5000V <sub>rms</sub> / 1 Minute Rating	IEC 60747-5-5 EN/DIN EN 60747-5-5	Quantity
ASSR-601J	-000E	SO-16	X		X	X	45 per tube
	-500E		Х	Х	X	X	850 per reel

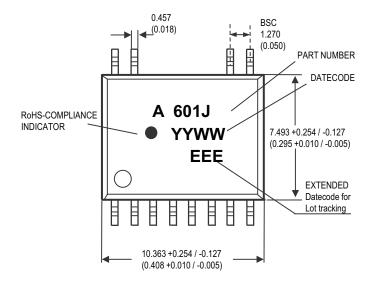
To order, choose a part number from the part number column and combine with the desired option from the option column to form an order entry.

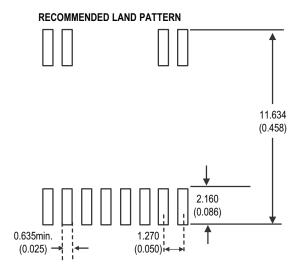
#### Example 1:

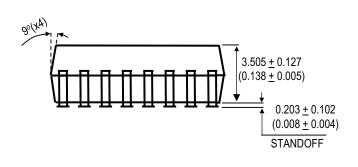
ASSR-601J-500E to order product of SO-16 Surface Mount package in Tape and Reel packaging with IEC/EN/DIN EN 60747-5-5 Safety Approval in RoHS compliant.

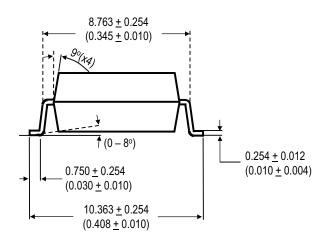
Option data sheets are available. Contact your Broadcom sales representative or authorized distributor for information.

### **Package Outline Drawings (SO-16)**









NOTE: Dimensions in millimeters (inches).

#### NOTE:

- Lead coplanarity = 0.10 mm (0.004 in.) maximum.
- Floating lead protrusion = 0.254 mm (0.010 in.) maximum.
- Mold Flash on each side = 0.127 mm (0.005 in.) maximum.

#### **Recommended Pb-Free IR Profile**

Recommended reflow condition as per JEDEC Standard J-STD-020 (latest revision).

NOTE: Non-halide flux should be used.

### **Regulatory Information**

The ASSR-601J is approved by the following organizations:

UL/cUL	IEC/EN/DIN EN 60747-5-5
UL 1577, component recognition program up to V <sub>ISO</sub> = 5 kV <sub>RMS</sub> Approved under CSA Component Acceptance Notice #5.	IEC 60747-5-5 EN 60747-5-5 DIN EN 60747-5-5

### **Insulation and Safety Related Specifications**

Parameter	Symbol	ASSR-601J	Unit	Conditions
Minimum External Air Gap (Clearance)	L(101)	8.3	mm	Measured from input terminals to output terminals, shortest distance through air.
Minimum External Tracking (Creepage)	L(102)	8.3	mm	Measured from input terminals to output terminals, shortest distance path along body.
Minimum Internal Plastic Gap (Internal Clearance)		0.5	mm	Through insulation distance conductor to conductor, usually the straight line distance thickness between the emitter and detector.
Tracking Resistance (Comparative Tracking Index)	CTI	>600	V	IEC 60695.

#### IEC/EN/DIN EN 60747-5-5 Insulation Related Characteristics

Description	Symbol	Characteristic	Units
Installation classification per DIN VDE 0110/1.89, Table 1			
For rated mains voltage < 600 V <sub>RMS</sub>		1 - 111	
For rated mains voltage < 1000 V <sub>RMS</sub>		1 - 11	
Climatic Classification		40/125/21	
Pollution Degree (DIN VDE 0110/1.89)		2	
Maximum Working Insulation Voltage	V <sub>IORM</sub>	1414	V <sub>PEAK</sub>
Input to Output Test Voltage, Method b	V <sub>PR</sub>	2651	V <sub>PEAK</sub>
$V_{IORM}$ x 1.875 = $V_{PR}$ , 100% Production Test with $t_m$ = 1s, Partial Discharge < 5 pC			
Input to Output Test Voltage, Method a	V <sub>PR</sub>	2262	V <sub>PEAK</sub>
$V_{IORM}$ x 1.6 = $V_{PR}$ , Type and sample test, $t_{m}$ = 10s, Partial Discharge < 5 pC			
Highest Allowable Overvoltage	V <sub>IOTM</sub>	6000	$V_{PEAK}$
(Transient Overvoltage, t <sub>ini</sub> = 60 sec)			
Safety Limiting Values			
(Maximum values allowed in the event of a failure)			
Ambient Safety Temperature	T <sub>S</sub>	175	°C
Input Current	I <sub>S,INPUT</sub>	400	mA
Output Power	P <sub>S,OUTPUT</sub>	1200	mW
Insulation Resistance at T <sub>S</sub> , V <sub>IO</sub> = 500V	R <sub>S</sub>	>10 <sup>9</sup>	Ω

### **Absolute Maximum Ratings**

All specifications at  $T_A$ = 25°C unless otherwise specified.

Parameter		Symbol	Min.	Max.	Units	Note	
Storage Tempera	Storage Temperature		T <sub>S</sub>	-55	150	°C	
Operating Ambie	nt Temperature		T <sub>A</sub>	-40	125	°C	
Junction Temper	ature		TJ	-40	150	°C	
Input Current	Average		I <sub>F(avg)</sub>	_	30	mA	T <sub>A</sub> = -40°C to +125°C
	Surge (50%	duty cycle)	I <sub>F(surge)</sub>	_	60	mA	T <sub>A</sub> = -40°C to +125°C
Peak Transient Input Current		I <sub>FP</sub>	_	1	Α	f = 100 Hz, duty cycle = 0.1%	
Reversed Input \	/oltage		$BV_R$	_	6	V	$T_A = -40^{\circ}\text{C to } +125^{\circ}\text{C}$
Input Power Diss	sipation		P <sub>IN</sub>	_	100	mW	
Output Load Cur	rent		Io	_	50	mA	
Output Avalanche Current		I <sub>AV</sub>	_	0.6	mA	t <sub>m</sub> = 1 min, duty cycle = 0.1%, cumulative of 5 mins over lifetime	
Output Power Dissipation		Po	_	1000	mW		
Lead Soldering Cycle	Cycle	Temperature			260	°C	
		Time		_	10	s	
Solder Reflow Temperature Profile		Recommended reflow condition as per JEDEC Standard J-STD-020 (latest revision).					

### **Recommended Operating Conditions**

Parameter	Symbol	Min.	Max.	Units	Note
Input Current (ON)	I <sub>F(ON)</sub>	7	30	mA	
Input Voltage (OFF)	V <sub>F(OFF)</sub>	<b>-</b> 5	0.4	V	
Operating Temperature	T <sub>A</sub>	-40	110	°C	
Continuous Load Voltage	Vo	_	1000	V <sub>DC</sub>	а
Load Current	I <sub>O</sub>	-10	10	mA	

a.  $V_{O}$  is the voltage across output terminals, pins 9, 10 and pins 15, 16.

### **Electrical Specifications (DC)**

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions. All typical values are at  $T_A = 25$ °C,  $I_F = 10$  mA.

Parameter	Symbol	Min.	Тур.	Max.	Units	Test Conditions	Figure	Note
Input Reverse Breakdown Voltage	V <sub>R</sub>	5	_		V	I <sub>R</sub> =10 μA		
Input Forward Voltage	V <sub>F</sub>	1.25	1.55	1.85	V	I <sub>F</sub> = 10 mA	1	
Output Withstand Voltage	V <sub>O(OFF)</sub>	1500	1700	_	V	I <sub>O</sub> = 250 μA, T <sub>A</sub> = 25°C	3	а
Output Leakage Current	I <sub>O(OFF)</sub>		0.3	10	nA	V <sub>O</sub> = 1000V, T <sub>A</sub> = 25°C	4	а
Output Capacitance	C <sub>OUT</sub>		190		pF	V <sub>O</sub> = 0V, f = 1 MHz	7	а
Output Resistance	R <sub>ON</sub>		100	300	Ω	I <sub>O</sub> = 2 mA	8	
			100	250	Ω	I <sub>O</sub> = 10 mA	8	
		_	77	250	Ω	I <sub>O</sub> = 50 mA, T <sub>A</sub> = 25°C	8	

a. Device is in OFF state with  $V_F \le 0.4V$ .

#### **Switching Specifications (AC)**

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions. All typical values are at  $T_A = 25$ °C,  $I_F = 10$  mA.

Parameter	Symbol	Min.	Тур.	Max.	Units	Test Conditions	Figure	Note
Turn-On Time	T <sub>ON</sub>		0.8	4.0	ms	$I_F = 10 \text{ mA}, V_{DD} = 40 \text{V}, R_{LOAD} = 20 \text{ k}\Omega$	9, 11, 13	
			0.3	1.0	ms	$I_F = 30 \text{ mA}, V_{DD} = 40 \text{V}, R_{LOAD} = 20 \text{ k}\Omega$		
Turn-Off Time	T <sub>OFF</sub>		0.05	0.5	ms	$V_{DD}$ = 40V, $R_{LOAD}$ = 20 k $\Omega$	10, 12, 13	

#### **Package Characteristics**

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions. All typical values are at  $T_A = 25$ °C.

Parameter	Symbol	Min.	Тур.	Max.	Units	Test Conditions	Figure	Note
Input-Output Momentary Withstand	V <sub>ISO</sub>	5000	_	_	V <sub>RMS</sub>	RH ≤ 50%, t <sub>m</sub> = 1 minute;		a, b, c
Voltage						T <sub>A</sub> = 25°C		
Input-Output Resistance	R <sub>I-O</sub>	10 <sup>9</sup>	10 <sup>14</sup>	_	Ω	V <sub>I-O</sub> = 1000 V <sub>DC</sub>		b
Input-Output Capacitance	C <sub>I-O</sub>	_	0.6	_	pF	f = 1 MHz; V <sub>I-O</sub> = 0 V <sub>DC</sub>		b

- a. The Input-Output Momentary Withstand Voltage is a dielectric voltage rating that should not be interpreted as an input-output continuous voltage rating.
- b. Device considered a two-terminal device: pins 1 to 8 shorted together, and pins 9, 10, 15, and 16 shorted together.
- c. In accordance with UL 1577, each optocoupler is proof tested by applying an insulation test voltage ≥ 6000 V<sub>RMS</sub> for 1 second.

### **Typical Characteristic Curves**

Figure 1: LED Forward Current vs. LED Forward Voltage

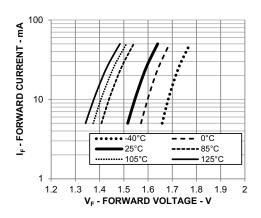


Figure 3: Output Withstand Voltage vs. Ambient Temperature (Test Condition:  $I_O$  = 250  $\mu$ A)

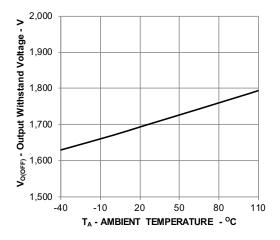


Figure 5: Output Leakage Current vs. Load Voltage (Test Condition:  $T_A = 25$ °C)

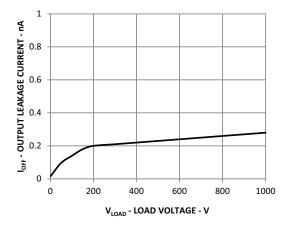


Figure 2: LED Forward Current Threshold vs. Ambient Temperature (Test Condition:  $I_0 = 2 \text{ mA}$ )

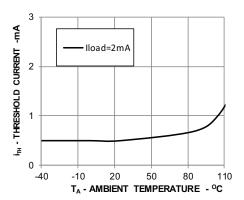


Figure 4: Output Leakage Current vs. Ambient Temperature (Test Condition:  $V_0 = 1000V$ )

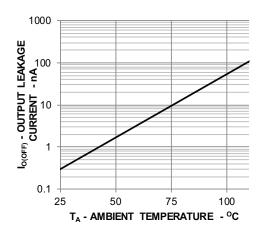


Figure 6: Output Current vs. Output Voltage

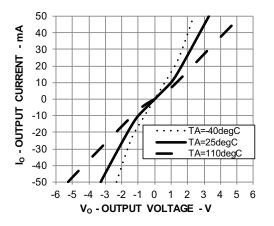


Figure 7: Output Capacitance vs. Load Voltage (Test Condition: V<sub>LOAD</sub> = 0V, f = 1 MHz, T<sub>A</sub> = 25°C)

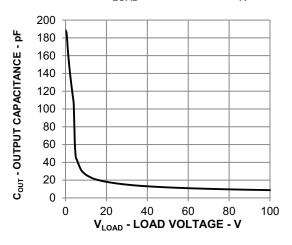


Figure 9: Turn-On Time vs. Ambient Temperature (Test Condition:  $V_{DD}$  = 40V,  $R_{LOAD}$  = 20 k $\Omega$ )

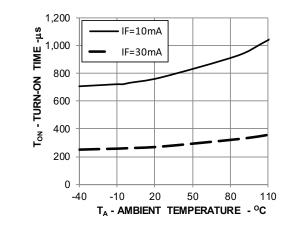


Figure 11: Turn-On Time vs. Input Forward Current (Test Condition:  $V_{DD} = 40V$ ,  $R_{LOAD} = 20 k\Omega$ )

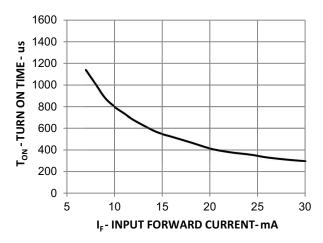


Figure 8: Typical On-Resistance vs. Ambient Temperature

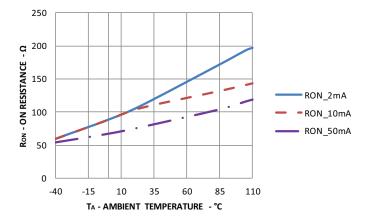


Figure 10: Turn-Off Time vs. Ambient Temperature (Test Condition:  $V_{DD}$  = 40V,  $R_{LOAD}$  = 20 k $\Omega$ )

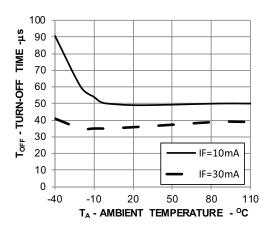


Figure 12: Turn-Off Time vs. Input Forward Current (Test Condition:  $V_{DD} = 40V$ ,  $R_{LOAD} = 20 \text{ k}\Omega$ )

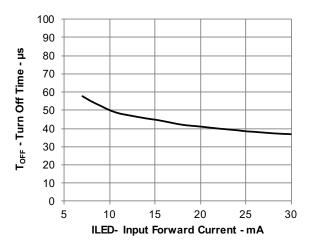
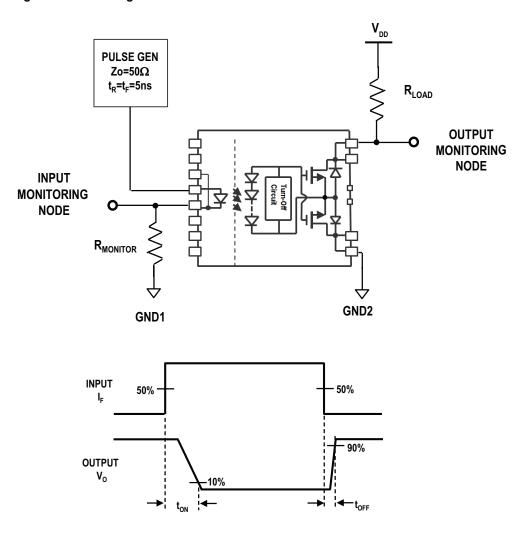


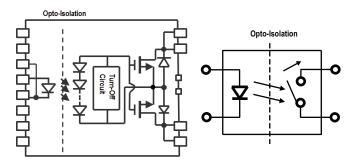
Figure 13: Switching Time Test Circuit and Waveform



### **Application Information**

The ASSR-601J is a single-channel Photo MOSFET that is equivalent to 1FormA electromechanical relay (EMR) as shown in Figure 14. It functions like a bidirectional switch with no output power requirement. The input side is LED driven and requires a current limiting resistor (Figure 15). Recommended input forward current is 7 mA to 30 mA.

Figure 14: ASSR-601J Equivalent Circuit

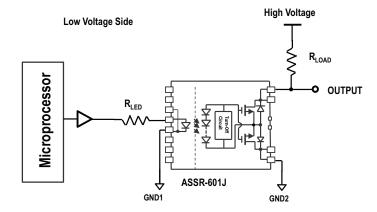


The input LED is optically coupled through a photodiode stack and a driver circuitry to switch two high-voltage MOSFETs. When current is driven into the LED, the light generates photo current on the photodiode to charge the gate of the MOSFETs, to switch and keep the power device on.

A typical application circuit (Figure 15) shows the ASSR-601J's input being controlled by the microprocessor to switch the output (high voltage side). The ASSR-601J's galvanic isolation protects the low voltage side of the circuit (input) from the high-voltage side (output).

Pins 9 to 10 and 15 to 16 are internally connected. In routing the PCB layout, either of the pins can be used. Shorting the pins (9 to 10) and (15 to 16) is also acceptable.

Figure 15: Typical Application Circuit

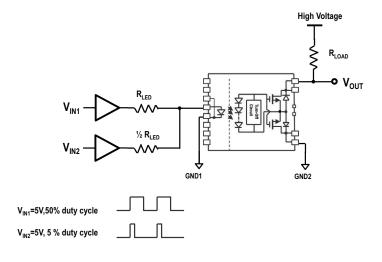


#### **Turn On Time**

 $T_{ON}$  is influenced by the level of input current. As input current is increased, the  $T_{ON}$  becomes shorter. In a situation where  $T_{ON}$  needs to be shorter than what the maximum level of input current can achieve, peaking can be implemented as shown in Figure 16.

In this peaking circuit, the LED can be driven by two inputs to achieve shorter T<sub>ON</sub>. The second input V<sub>IN2</sub>'s duty cycle must set to a lower duty cycle to achieve the peaking effect.

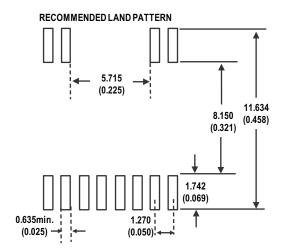
Figure 16: Peaking Circuit and Sample Input Timing



# Land Pattern for 8-mm Creepage and Floating Pins

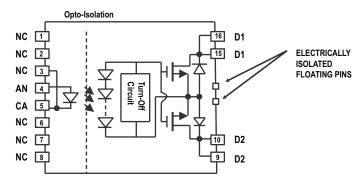
For applications that require PCB creepage of 8 mm between the control and switch sides, the land pattern below can be used.

Figure 17: Land Pattern for 8-mm Creepage



At the output side, in between pins 10 and 15, there are two floating pins. These floating pins are electrically isolated and have no circuit connection to any of the internal circuitry.

Figure 18: Floating Pins



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