

## Automotive Solid State Relay with R<sup>2</sup>Coupler™ Isolation

### Data Sheet

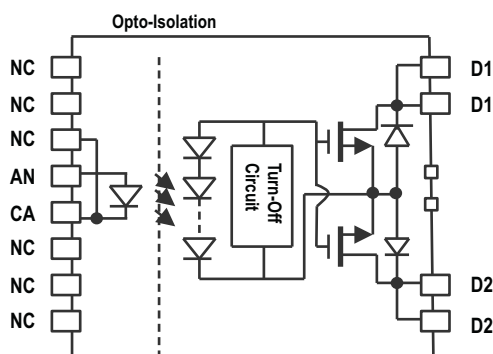
#### Description

The ASSR-601JV/JT is a high-voltage solid state relay that is designed for automotive applications. ASSR-601JV/JT 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 10 mA through the input LED. The relay turns off (contact opens) with an input voltage of 0.4V or less.

The ASSR-601JV/JT is equivalent to 1FormA Electromechanical Relays (EMR) and is available in 16-pin SOIC package.

The Broadcom R<sup>2</sup>Coupler provides reinforced insulation and reliability that delivers safe signal isolation critical in automotive and high temperature industrial applications.

#### Functional Diagram



#### Truth Table

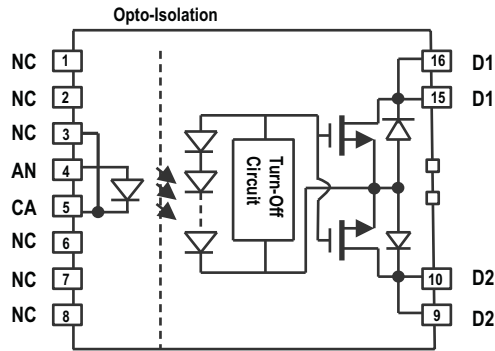
LED	Output
Off	Open
On	Close

#### Features

- Compact solid-state bidirectional signal switch
- Qualified to AEC-Q101 test guidelines
- Automotive temperature range:
  - $T_A = -40^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$  for ASSR-601JV
  - $T_A = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  for ASSR-601JT
- Breakdown voltage,  $BV_{DSS}$ : 1500V at  $I_{DSS} = 250 \mu\text{A}$
- Avalanche rated MOSFETs
- Low off-state leakage:
  - $I_{OFF} < 1 \mu\text{A}$  at  $V_{DS} = 1000\text{V}$  for ASSR-601JV
  - $I_{OFF} < 5 \mu\text{A}$  at  $V_{DS} = 1000\text{V}$  for ASSR-601JT
- On-resistance,  $R_{DS(ON)} < 250\Omega$  at  $I_{LOAD} = 10 \text{ mA}$
- Turn on time:  $T_{ON} < 4 \text{ ms}$
- Turn off time:  $T_{OFF} < 0.5 \text{ ms}$
- Package: 300 mil SO-16
- Creepage and clearance  $\geq 8 \text{ mm}$  (input-output)
- Creepage  $> 5 \text{ mm}$  (between drain pins of MOSFETs)
- Safety and regulatory approvals:
  - IEC/EN/DIN EN 60747-5-5
  - Maximum working insulation voltage  $1414 V_{PEAK}$
  - $5000 V_{RMS}$  for 1 minute per UL1577
  - CSA component acceptance

#### Applications

- Battery insulation resistance measurement/leakage detection
- BMS flying capacitor topology for sensing batteries
- Solid state relay



## 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 & Reel	UL 5000 V <sub>rms</sub> / 1 Minute Rating	IEC 60747-5-5 EN/DIN EN 60747-5-5	Quantity
ASSR-601JV	-000E	SO-16	X		X	X	45 per tube
	-500E		X	X	X	X	850 per reel
ASSR-601JT	-000E	SO-16	X		X	X	45 per tube
	-500E		X	X	X	X	850 per reel

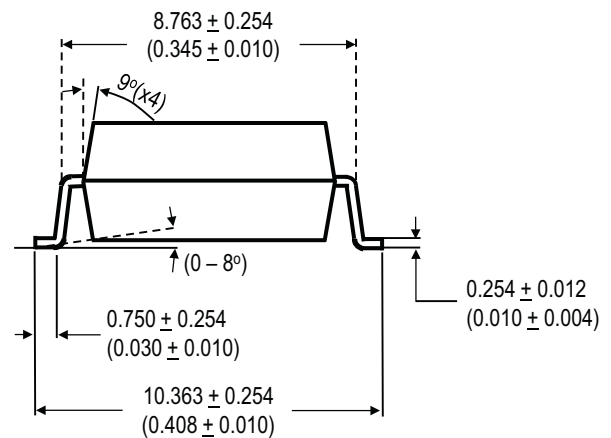
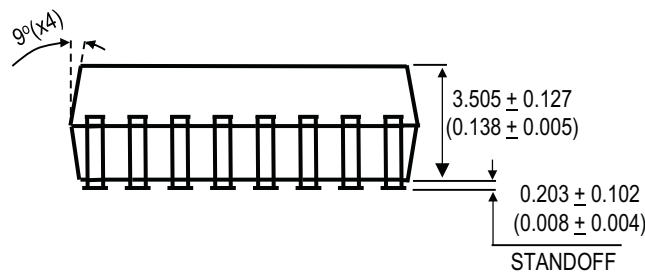
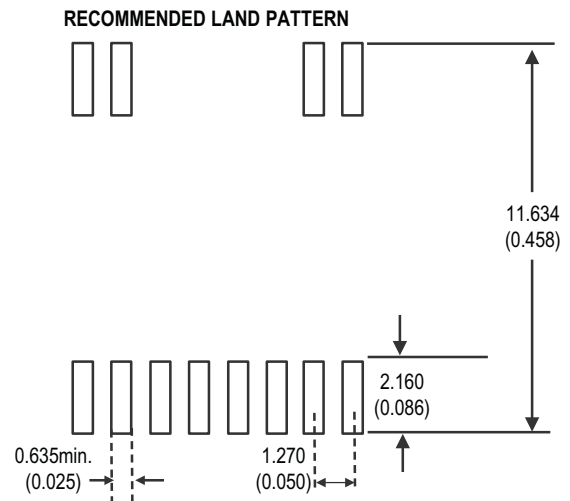
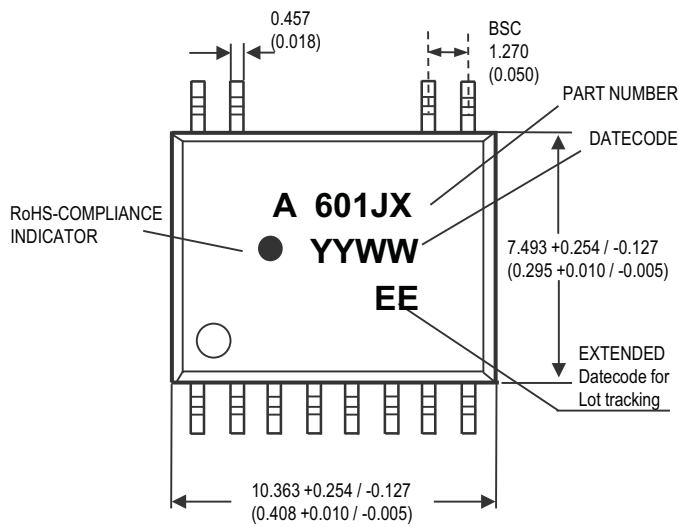
To order, choose a part number from the part number column and combine with the desired option from the option column to form an order entry.

Example 1:

ASSR-601JT-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).

### Notes:

Lead coplanarity = 0.10 mm (0.004 inches) Max.

Floating lead protrusion = 0.254 mm (0.010 inches) Max.

Mold Flash on each side = 0.127 mm (0.005 inches) Max.

## 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-601JV and ASSR-601JT are approved by the following organizations:

UL/cUL	IEC/EN/DIN EN 60747-5-5
UL 1577, component recognition program up to $V_{ISO} = 5 \text{ kV}_{RMS}$ 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-601JV/JT	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 Characteristic

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

## Absolute Maximum Ratings

All specifications at  $T_A = 25^\circ\text{C}$  unless otherwise specified.

Parameter		Symbol	Min.	Max.	Unit	Note
Storage Temperature		$T_S$	-55	150	$^\circ\text{C}$	
Operating Ambient Temperature		$T_A$	-40	125	$^\circ\text{C}$	
Junction Temperature		$T_J$	-40	150	$^\circ\text{C}$	
Input Current	Average	$I_{F(\text{avg})}$	—	30	mA	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$
	Surge (50% duty cycle)	$I_{F(\text{surge})}$	—	60	mA	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$
Peak Transient Input Current		$I_{FP}$	—	1	A	$f = 100\text{ Hz}$ , duty cycle = 0.1%
Reversed Input Voltage		$BV_R$	—	6	V	$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$
Input Power Dissipation		$P_{IN}$	—	100	mW	
Output Load Current		$I_O$	—	50	mA	
Output Avalanche Current		$I_{AV}$	—	0.6	mA	$t_m = 1\text{ min}$ , duty cycle = 0.1%, cumulative of 5 mins over lifetime
Output Power Dissipation		$P_O$	—	1000	mW	
Lead Soldering Cycle	Temperature		—	260	$^\circ\text{C}$	
	Time		—	10	s	
Solder Reflow Temperature Profile		Recommended reflow condition as per JEDEC Standard J-STD-020 (latest revision).				

## ESD Rating

Parameter	Level	Note
Human Body Model	H2 ( $2000\text{V} < \text{HBM} \leq 4000\text{V}$ )	Per AEC Q101-001
Charge Device Model	C4 ( $750\text{V} < \text{CDM} \leq 1000\text{V}$ )	Per AEC Q101-005

## Recommended Operating Conditions

Parameter	Symbol	Device	Min.	Max.	Unit	Note
Input Current (ON)	$I_{F(\text{ON})}$		7	30	mA	
Input Voltage (OFF)	$V_{F(\text{OFF})}$		-5	0.4	V	
Operating Temperature	$T_A$	ASSR-601JV	-40	105	$^\circ\text{C}$	
		ASSR-601JT	-40	125	$^\circ\text{C}$	
Continuous Load Voltage	$V_O$		—	1000	$V_{DC}$	a
Load Current	$I_O$		-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  $T_A = 25^\circ\text{C}$ ,  $I_F = 10\text{ mA}$ .

Parameter	Symbol	Device	Min.	Typ.	Max.	Unit	Test Conditions	Fig.	Note
Input Reverse Breakdown Voltage	$V_R$		5	—	—	V	$I_R = 10\text{ }\mu\text{A}$		
Input Forward Voltage	$V_F$		1.25	1.55	1.85	V	$I_F = 10\text{ mA}$	1	
Output Withstand Voltage	$ V_{O(\text{OFF})} $		1500	1700	—	V	$I_O = 250\text{ }\mu\text{A}$ , $T_A = 25^\circ\text{C}$	3	a, b
Output Leakage Current	$I_{O(\text{OFF})}$	ASSR-601JV	—	0.3	1000	nA	$V_O = 1000\text{V}$	4	a
		ASSR-601JT	—	0.3	5000	nA	$V_O = 1000\text{V}$	4	a
Output Capacitance	$C_{\text{OUT}}$		—	190	—	pF	$V_O = 0\text{V}$ , $f = 1\text{ MHz}$	7	a
Output Resistance	$R_{\text{ON}}$		—	100	300	$\Omega$	$I_O = 2\text{ mA}$	8	
			—	100	250	$\Omega$	$I_O = 10\text{ mA}$	8	

a. Device is in OFF state with  $V_F \leq 0.4\text{V}$ .

b. Per AEC-Q101, device performance is demonstrated with high temperature reverse bias stress at 1200V (80% of rated voltage).

## Switching Specifications (AC)

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions. All typical values are at  $T_A = 25^\circ\text{C}$ ,  $I_F = 10\text{ mA}$ .

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Fig.	Note
Turn-On Time	$T_{\text{ON}}$	—	0.8	4.0	ms	$I_F = 10\text{ mA}$ , $V_{\text{DD}} = 40\text{V}$ , $R_{\text{LOAD}} = 20\text{ k}\Omega$	9, 11, 13	
		—	0.3	1.0	ms	$I_F = 30\text{ mA}$ , $V_{\text{DD}} = 40\text{V}$ , $R_{\text{LOAD}} = 20\text{ k}\Omega$		
Turn-Off Time	$T_{\text{OFF}}$	—	0.05	0.5	ms	$V_{\text{DD}} = 40\text{V}$ , $R_{\text{LOAD}} = 20\text{ k}\Omega$	10, 12, 13	

## Package Characteristics

Unless otherwise stated, all minimum/maximum specifications are over recommended operating conditions. All typical values are at  $T_A = 25^\circ\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Unit	Test Conditions	Fig.	Note
Input-Output Momentary Withstand Voltage <sup>a</sup>	$V_{\text{ISO}}$	5000	—	—	$V_{\text{RMS}}$	$\text{RH} \leq 50\%$ , $t_m = 1\text{ minute}$ ; $T_A = 25^\circ\text{C}$		b, c
Input-Output Resistance	$R_{\text{I-O}}$	$10^9$	$10^{14}$	—	$\Omega$	$V_{\text{I-O}} = 1000\text{ V}_{\text{DC}}$		b
Input-Output Capacitance	$C_{\text{I-O}}$	—	0.6	—	pF	$f = 1\text{ MHz}$ ; $V_{\text{I-O}} = 0\text{ V}_{\text{DC}}$		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  $\geq 6000\text{ V}_{\text{RMS}}$  for 1 second.

## Typical Characteristic Curves

Figure 1 LED Forward Current vs LED Forward Voltage

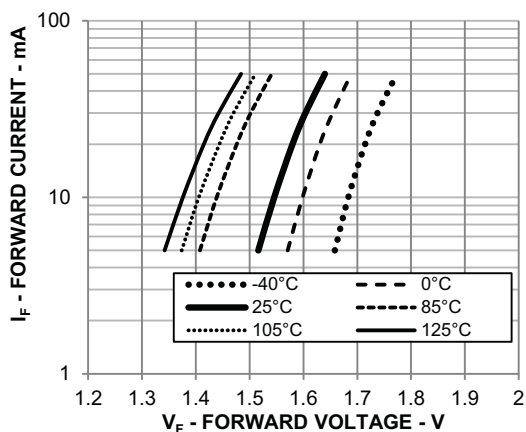


Figure 3 Output Withstand Voltage vs Ambient Temperature  
(Test Condition:  $I_O = 250 \mu A$ )

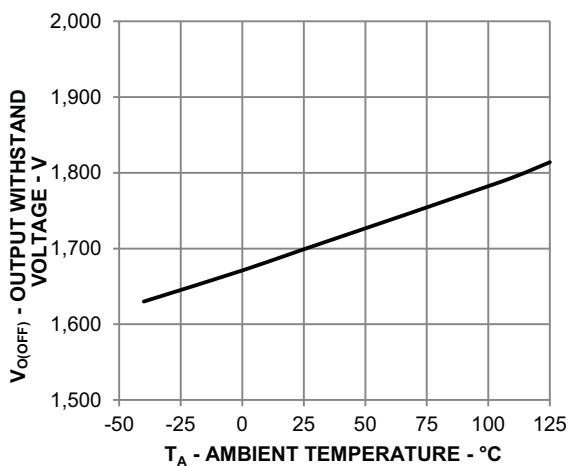


Figure 5 Output Leakage Current vs Load Voltage  
(Test Condition:  $T_A = 25^\circ C$ )

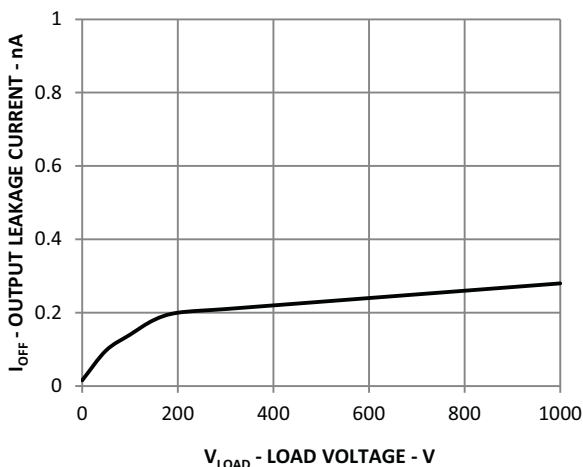


Figure 2 LED Forward Current Threshold vs Ambient Temperature  
(Test Condition:  $I_O = 2 \text{ mA}$ )

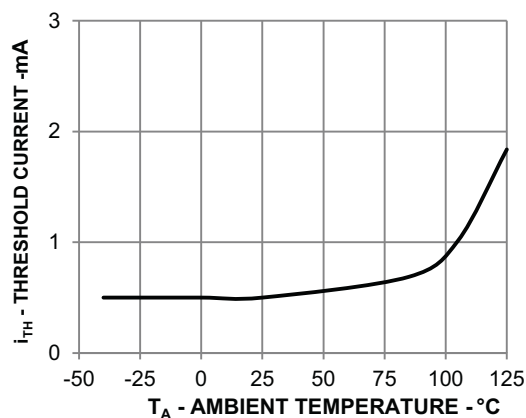


Figure 4 Output Leakage Current vs Ambient Temperature  
(Test Condition:  $V_O = 1000V$ )

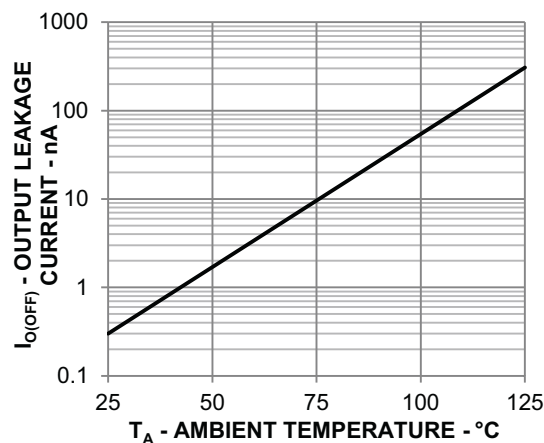
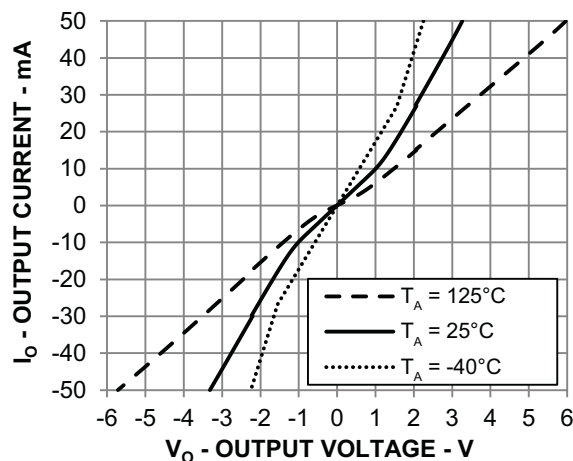
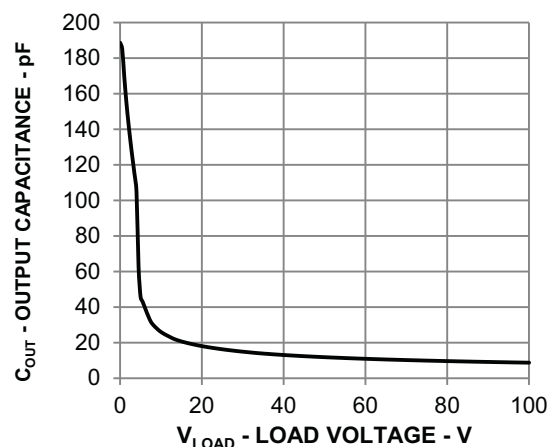


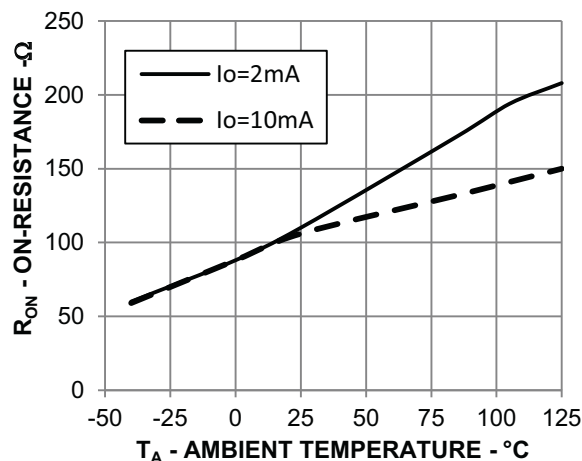
Figure 6 Output Current vs Output Voltage



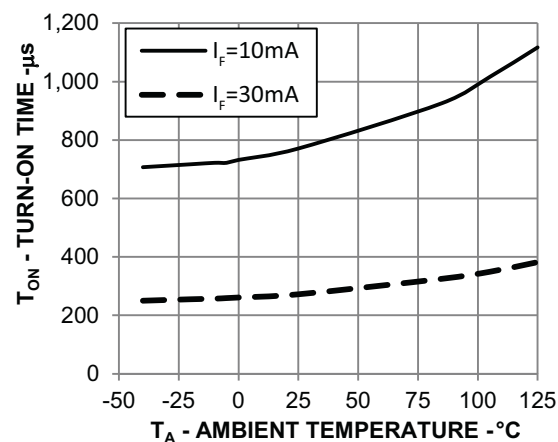
**Figure 7 Output Capacitance vs Load Voltage**  
(Test Condition:  $V_{LOAD} = 0V$ ,  $f = 1\text{ MHz}$ ,  $T_A = 25^\circ\text{C}$ )



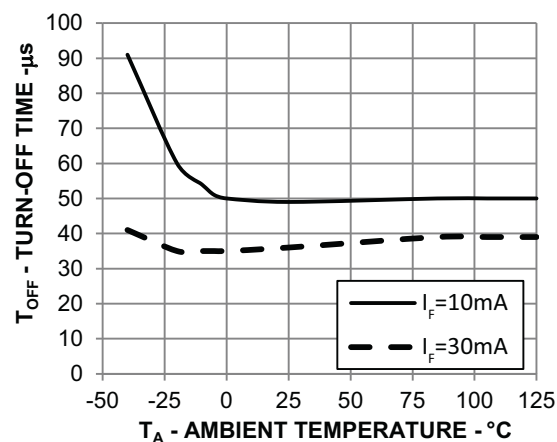
**Figure 8 Typical On-Resistance vs Ambient Temperature**



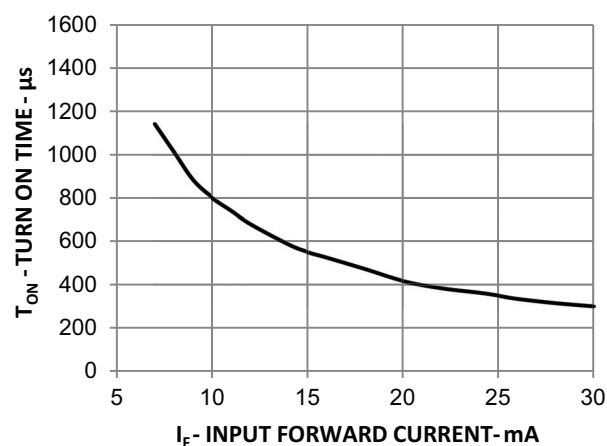
**Figure 9 Turn-On Time vs Ambient Temperature**  
(Test Condition:  $V_{DD} = 40V$ ,  $R_{LOAD} = 20\text{ k}\Omega$ )



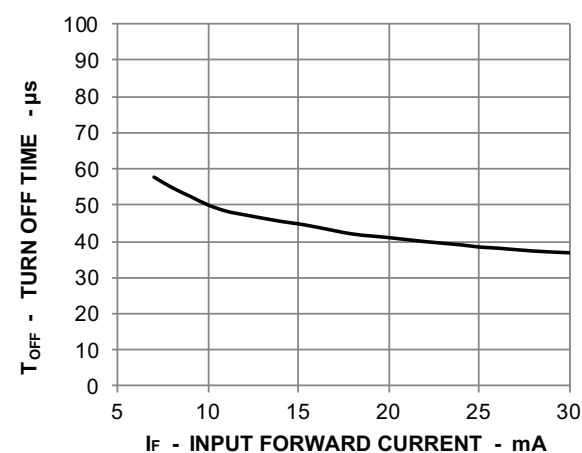
**Figure 10 Turn-Off Time vs Ambient Temperature**  
(Test Condition:  $V_{DD} = 40V$ ,  $R_{LOAD} = 20\text{ k}\Omega$ )



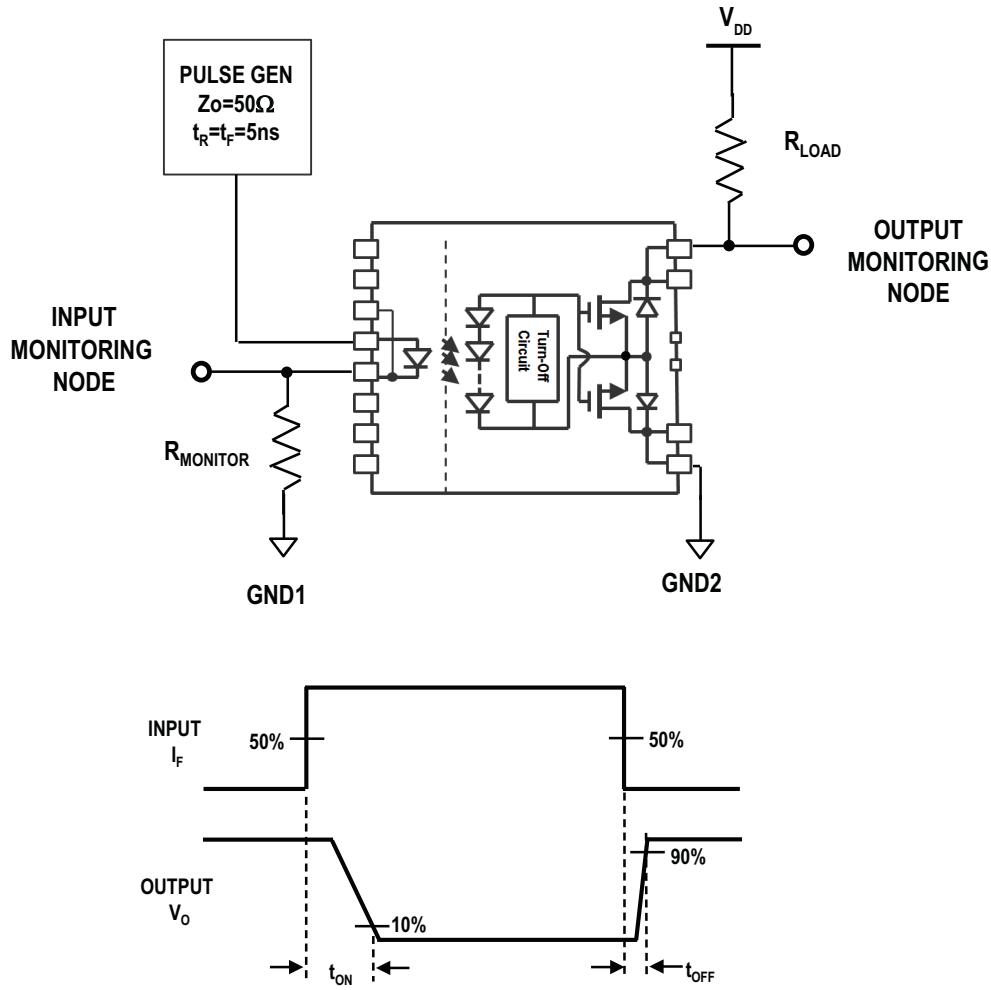
**Figure 11 Turn-On Time vs Input Forward Current**  
(Test Condition:  $V_{DD} = 40V$ ,  $R_{LOAD} = 20\text{ k}\Omega$ )



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



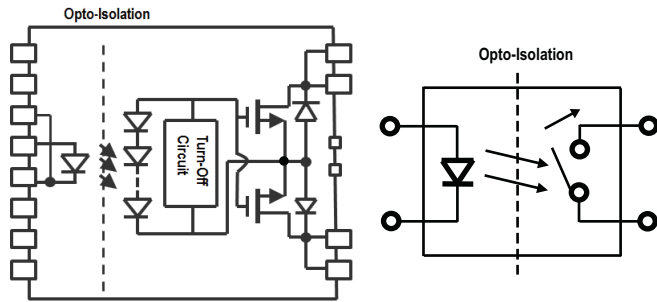


**Figure 13 Switching Time Test Circuit and Waveform**

## Application Information

ASSR-601JV/JT is a single-channel solid state relay 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-601JV/JT Equivalent Circuit**

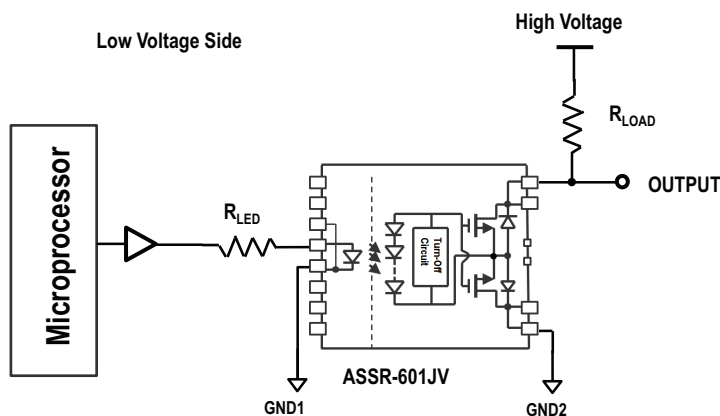


The input LED is optically coupled through a photodiode stack and a driver circuitry to switch two high-voltage MOSFETs. When current is driven into the LED, the light generates photo current on the photodiode to charge the gate of the MOSFETs, to switch and keep the power device on.

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

Pins 8 to 9 and 15 to 16 are internally connected. In routing the PCB layout, either of the pins can be used. Shorting the pins (8 to 9) and (15 to 16) is also acceptable.

**Figure 15 Typical Application Circuit**

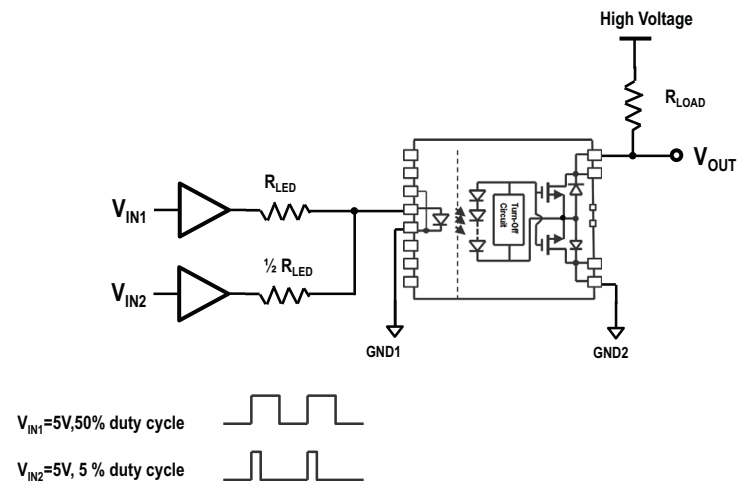


## Turn On Time

$T_{ON}$  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  $T_{ON}$ . The second input  $V_{IN2}$ 's duty cycle must be set to a lower duty cycle to achieve the peaking effect.

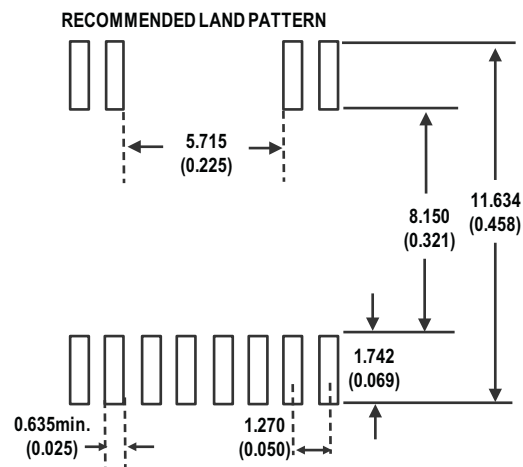
**Figure 16 Peaking Circuit and Sample Input Timing**



## Land Pattern for 8-mm Creepage and Floating Pins

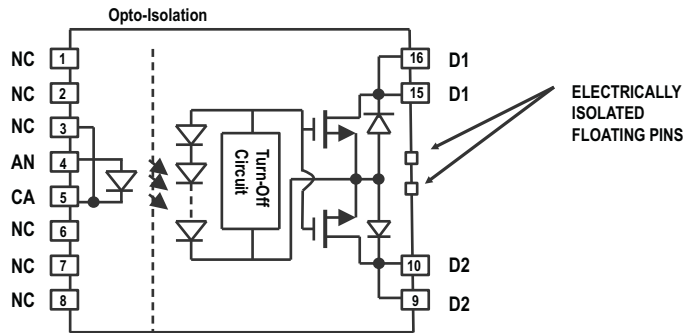
For applications that require PCB creepage of 8 mm between the control and switch sides, the land pattern below can be used.

**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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ASSR-601Jx-DS102 – November 22, 2017



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