

# FDG901D

## Slew Rate Control IC for P-Channel MOSFETs

### Features

- Three Programmable Slew Rates
- Reduces Inrush Current
- Minimizes EMI
- Normal Turn-Off Speed
- Low-Power CMOS Operates Over Wide Voltage Range
- Compact Industry Standard SC70-5 Surface Mount Package
- RoHS Compliant

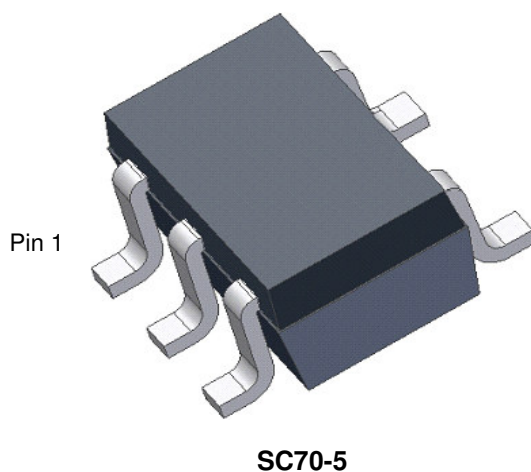
### Applications

- Battery Load switch
- Power management



### General Description

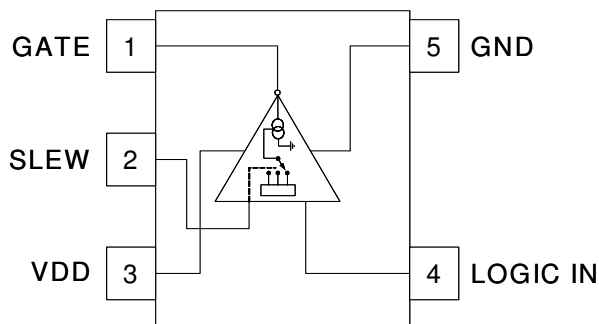
The FDG901D is specifically designed to control the turn on of a P-Channel MOSFET in order to limit the inrush current in battery switching applications with high capacitance loads. During turn-on, the FDG901D drives the MOSFET's gate low with a regulated current source, thereby controlling the MOSFET's turn on. For turn-off, the IC pulls the MOSFET gate up quickly for efficient turn off.



### Package Marking and Ordering Information

| Device Marking | Device  | Reel Size | Tape Width | Quantity   |
|----------------|---------|-----------|------------|------------|
| 91             | FDG901D | 7"        | 8mm        | 3000 units |

## Pin Configuration



## Absolute Maximum Ratings

| Parameter                                        | Min. | Max. | Unit |
|--------------------------------------------------|------|------|------|
| Supply Voltage                                   | -0.5 | 10   | V    |
| DC Input Voltage (Logic Inputs)                  | -0.7 | 9    | V    |
| Power Dissipation for Single Operation @ 85 °C   |      | 150  | mW   |
| Operating and Storage Junction Temperature       | -65  | 150  | °C   |
| Thermal Resistance, Junction to Ambient (note 1) |      | 425  | °C/W |

## Recommended Operating Range

| Parameter                      | Min. | Max. | Unit |
|--------------------------------|------|------|------|
| Supply Voltage                 | 2.7  | 6    | V    |
| Operating Junction Temperature | -40  | 150  | °C   |

## Electrical Characteristics

$T_A = 25^\circ\text{C}$  unless otherwise noted

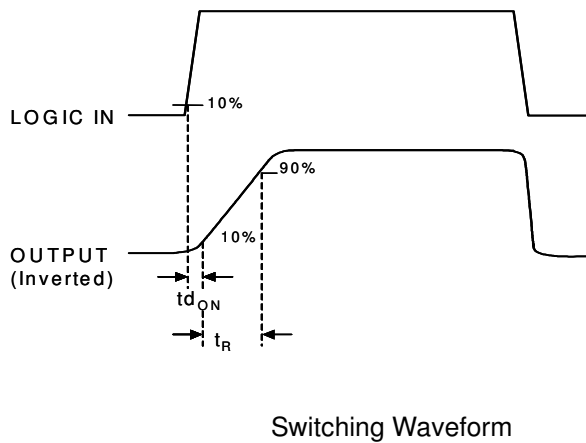
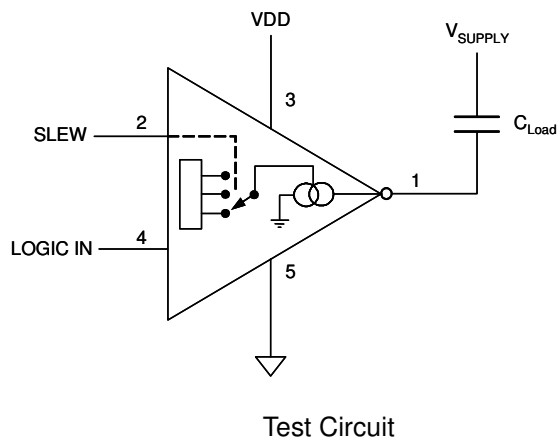
| Parameter                                             | Symbol      | Conditions                                                               | Min.                | Typ. | Max. | Units             |
|-------------------------------------------------------|-------------|--------------------------------------------------------------------------|---------------------|------|------|-------------------|
| <b>Logic Levels</b>                                   |             |                                                                          |                     |      |      |                   |
| Logic High Input Voltage                              | $V_{IH}$    | $V_{DD} = 2.7\text{V to } 6.0\text{V}$                                   | 2.55                |      |      | V                 |
| Logic Low Input Voltage                               | $V_{IL}$    | $V_{DD} = 2.7\text{V to } 6.0\text{V}$                                   |                     |      | 2.0  | V                 |
| <b>Off Characteristics - Slew Rate Control Driver</b> |             |                                                                          |                     |      |      |                   |
| Supply Input Breakdown Voltage                        | $BV_{DG}$   | $I_{DG} = 10\mu\text{A}$ , $V_{IN} = 0\text{V}$ , $V_{SLEW} = 0\text{V}$ | 9                   |      |      | V                 |
| Slew Input Breakdown Voltage                          | $BV_{SLEW}$ | $I_{SLEW} = 10\mu\text{A}$ , $V_{IN} = 0\text{V}$                        | 9                   |      |      | V                 |
| Logic Input Breakdown Voltage                         | $BV_{IN}$   | $I_{IN} = 10\mu\text{A}$ , $V_{SLEW} = 0\text{V}$                        | 9                   |      |      | V                 |
| Supply Input Leakage Current                          | $IR_{DG}$   | $V_{DG} = 8\text{V}$ , $V_{IN} = 0\text{V}$ , $V_{SLEW} = 0\text{V}$     |                     |      | 100  | nA                |
| Slew Input Leakage Current                            | $IR_{SLEW}$ | $V_{SLEW} = 8\text{V}$ , $V_{IN} = 0\text{V}$                            |                     |      | 100  | nA                |
| Logic Input Leakage Current                           | $IR_{IN}$   | $V_{IN} = 8\text{V}$ , $V_{SLEW} = 0\text{V}$                            |                     |      | 100  | nA                |
| <b>On Characteristics - Slew Rate Control Driver</b>  |             |                                                                          |                     |      |      |                   |
| Gate Current                                          | $I_G$       | $V_{IN} = 6\text{V}$ ,<br>$V_{GATE} = 2\text{V}$                         | Slew Pin = Open     |      | 90   | 120 $\mu\text{A}$ |
|                                                       |             |                                                                          | Slew Pin = GND      |      | 1    | 10 $\mu\text{A}$  |
|                                                       |             |                                                                          | Slew Pin = $V_{DD}$ |      | 10   | 50 nA             |

Notes:  $R_{\theta JA}$  is the sum of the junction-to-case and case-to-ambient thermal resistance where the case thermal reference is defined as the solder mounting surface of the drain pins.  $R_{\theta JC}$  is guaranteed by design while  $R_{\theta CA}$  is determined by the user's board design.

## Electrical Characteristics Cont.

$T_A = 25^\circ\text{C}$  unless otherwise noted

| Parameter                                                                                                                                                                | Symbol           | Conditions        | Min. | Typ. | Max. | Units         |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-------------------|------|------|------|---------------|
| <b>P-Channel Switching Times</b> ( $V_{\text{SUPPLY}} = 5.5\text{V}$ , $V_{\text{DD}} = 5.5\text{V}$ , Logic IN = 5.5V, $C_{\text{LOAD}} = 510\text{pF}$ , Test Circuit) |                  |                   |      |      |      |               |
| Delay On Time                                                                                                                                                            | $t_{\text{dON}}$ | Slew Pin = Open   |      | 8.3  |      | $\mu\text{s}$ |
|                                                                                                                                                                          |                  | = GND             |      | 0.6  |      | ms            |
|                                                                                                                                                                          |                  | = $V_{\text{DD}}$ |      | 2.2  |      | ms            |
| $V_{\text{OUT}}$ Rise Time                                                                                                                                               | $t_{\text{R}}$   | = Open            |      | 28   |      | $\mu\text{s}$ |
|                                                                                                                                                                          |                  | = GND             |      | 1.8  |      | ms            |
|                                                                                                                                                                          |                  | = $V_{\text{DD}}$ |      | 11   |      | ms            |
| Output Slew Rate                                                                                                                                                         | $\text{dv/dt}$   | = Open            |      | 162  |      | V/ms          |
|                                                                                                                                                                          |                  | = GND             |      | 26   |      | V/ms          |
|                                                                                                                                                                          |                  | = $V_{\text{DD}}$ |      | 0.3  |      | V/ms          |



## Typical Characteristics

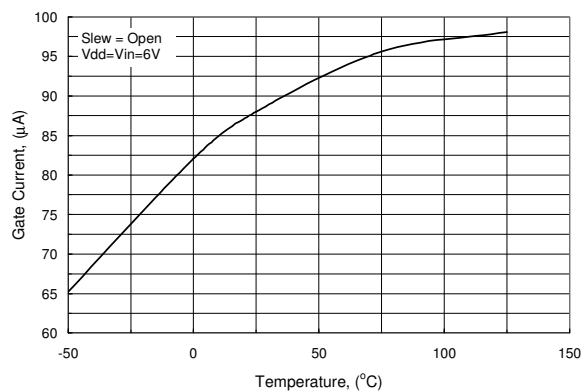


Figure 1. Gate Output Current vs. Temperature (SLEW = OPEN)

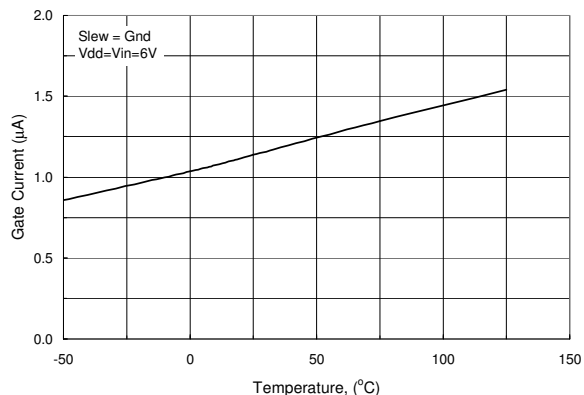


Figure 2. Gate Output Current vs. Temperature (SLEW = GROUND)

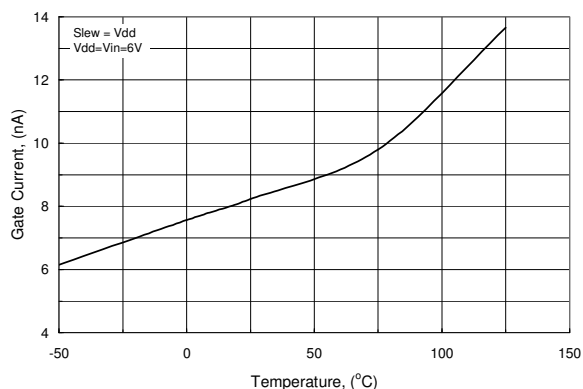


Figure 3. Gate Output Current vs. Temperature (SLEW =  $V_{DD}$ )

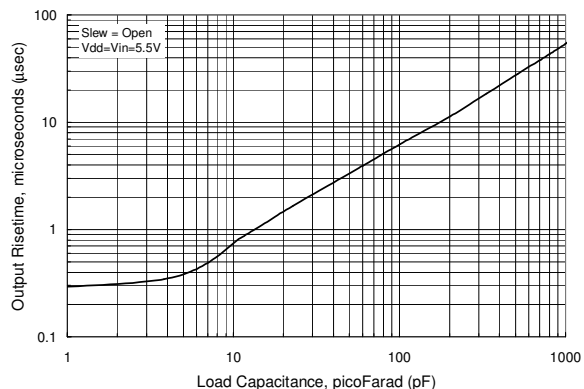


Figure 4.  $t_{RISE}$  vs. Load Capacitance (SLEW = OPEN)

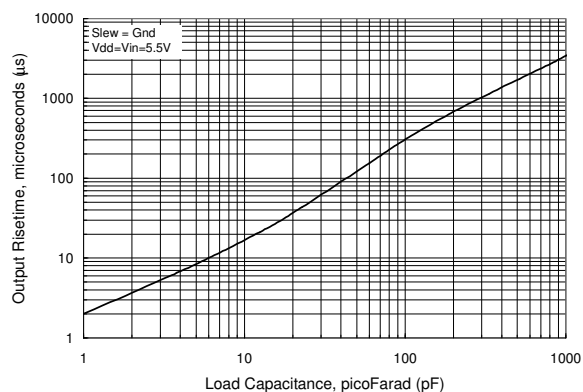


Figure 5.  $t_{RISE}$  vs. Load Capacitance (SLEW = GROUND)

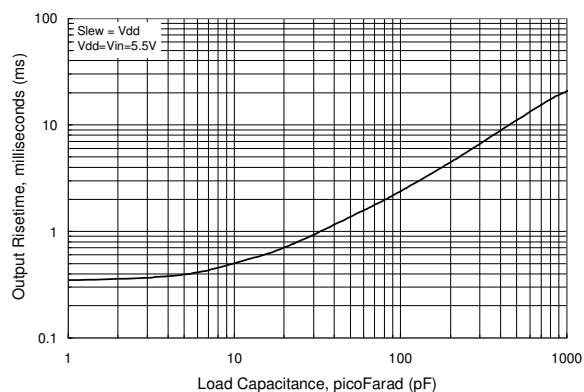


Figure 6.  $t_{RISE}$  vs. Load Capacitance (SLEW =  $V_{DD}$ )

# Typical Characteristics

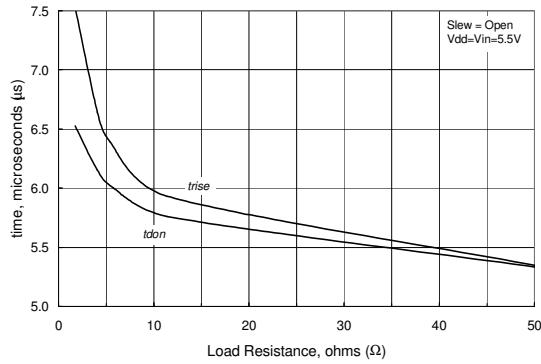


Figure 7. Switching Time vs. Load Resistance (SLEW = OPEN)

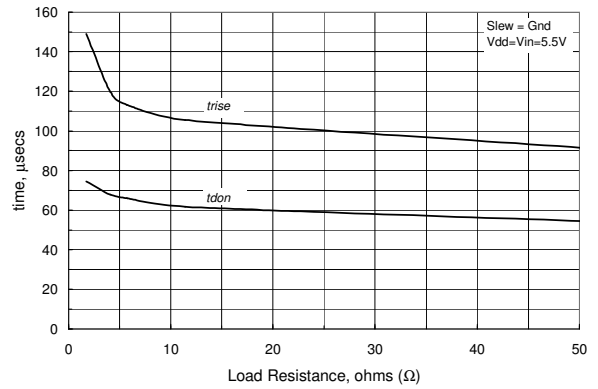


Figure 8. Switching Time vs. Load Resistance (SLEW = GROUND)

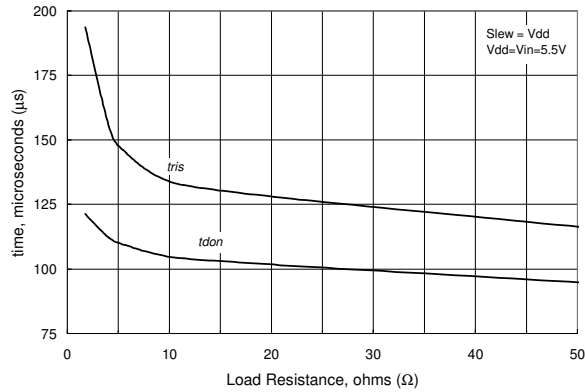


Figure 9. Switching Time vs. Load Resistance (SLEW = V<sub>DD</sub>)

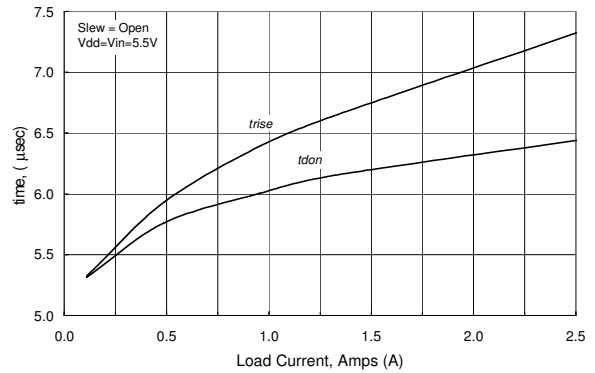


Figure 10. Switching Time vs. Load Current (SLEW = OPEN)

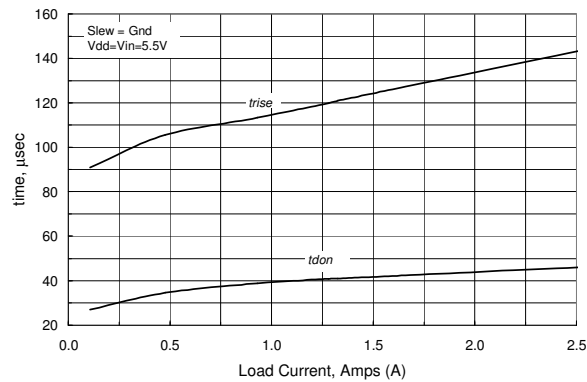


Figure 11. Switching Time vs. Load Current (SLEW = GROUND)

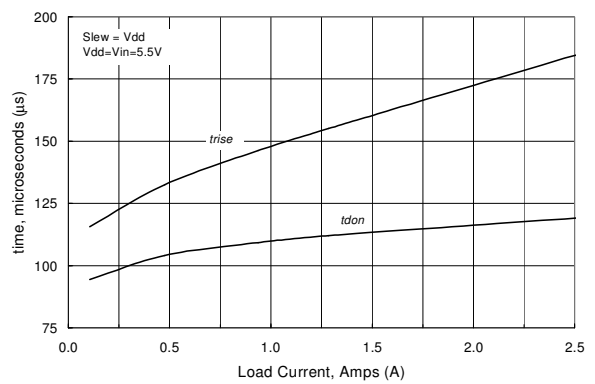
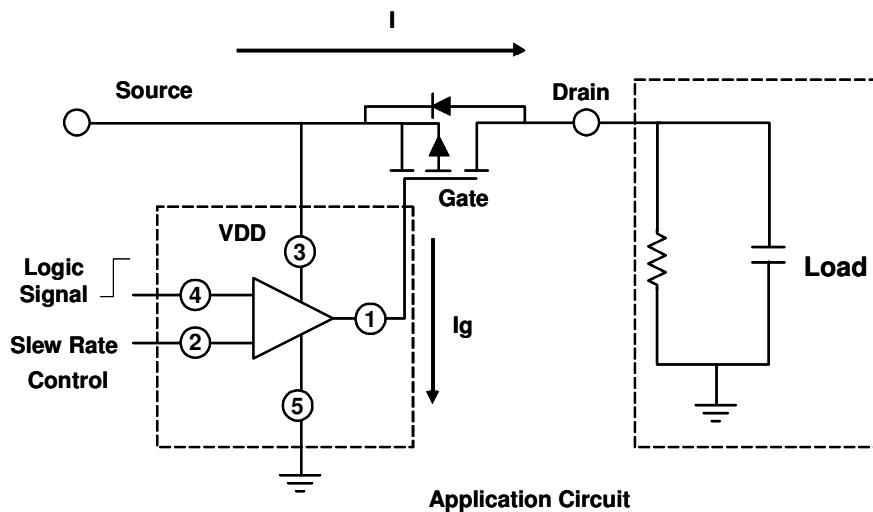


Figure 12. Switching Time vs. Load Current (SLEW = V<sub>DD</sub>)

## Application Information

### Typical Application



Battery powered systems make extensive usage of load switching, turning the power to subsystems off, in order to extend battery life. Power MOSFETs are used to accomplish this task. In PDA's and Cell phones, these MOSFETs are usually low threshold P-Channels. Since the loads typically include bypass capacitor components (high capacitive component), a high inrush current can occur when the load is switched on. This inrush current can cause transients on the main power supply disturbing circuitry supplied by it.

The simplest method of limiting the inrush current is to control the slew rate of the MOSFET switch. This can be done with external R/C circuits, but this approach can occupy significant PCB area, and involves other compromises in performance. The slew rate control driver IC FDG901D is specifically designed to interface low voltage digital circuitry with power MOSFETs and reduce the rapid inrush current in load switch applications. The IC limits inrush current by controlling the current, which drives the gate of the P-Channel MOSFET switch.

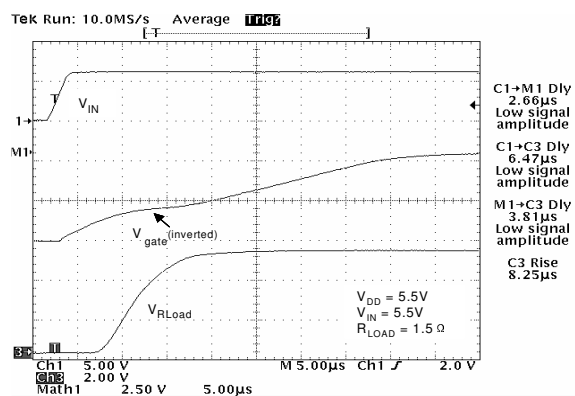
The control input is a CMOS compatible input with a minimum high input voltage of 2.55V with a power rail voltage of 6V. Therefore, it is compatible with any CMOS logic voltages between 2.55V and 5V and under these conditions there is no additional configuration required.

The Slew Rate Control Driver (FDG901D) is designed to give a programmed choice of one of three steady  $dv/dt$  states on the output during turn-on. To change the  $dv/dt$  value, the user needs to use the Slew Rate Control Pin (Pin 2). To utilize the smallest current setting (10 nA) from the IC, a voltage equal to  $V_{DD}$  must be applied to the Slew Rate Control Pin 2. To use the next higher current setting (~1μA) a voltage equal to Ground must be applied to Pin 2. To achieve the highest current setting (~80μA) or obtain a faster switching speed, the Slew Rate Pin2 must be open (floating). A higher value of capacitance will result in a slower switching rate. To determine the switching times of each setting use the simple equation:

$$t = \frac{Q_g}{I_G}$$

where  $Q_g$  is the Gate charge in nC for a given MOSFET and  $I_G$  is the gate current controlled by the slew rate pin.

Below is a captured image from an oscilloscope depicting the device response. The FDG901D was connected to control an FDG258P P-Channel DMOS. The Slew Rate control pin was set to open (floating state).



**Circuit waveforms for an FDG901D controlling a P-Channel FDG258P MOFET**





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