AUTOMOTIVE GRADE

CS452/453

2.4A/4.4A Injector Solenoid Driver

Description

The CS452/453 is a monolithic integrated circuit designed for medium current solenoid driver applications. Its typical function is to supply full battery voltage to fuel injector(s) for rapid current rise, in order to produce positive injector opening.

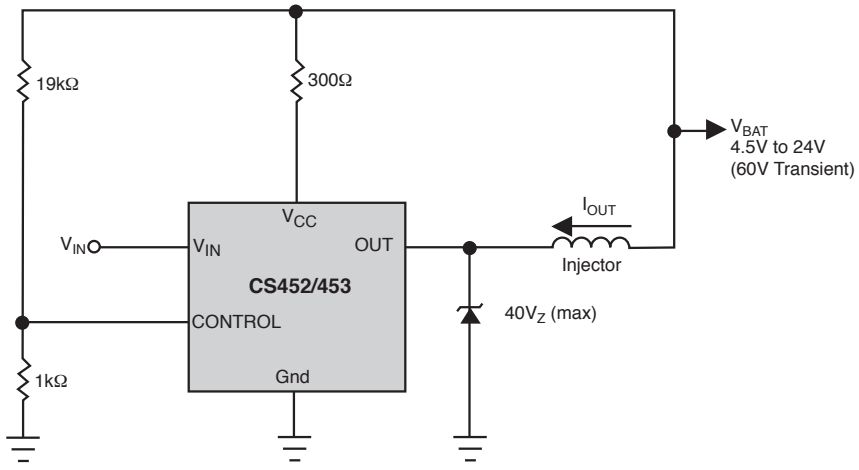
When load current reaches a preset level (2.4A for CS452, or 4.4A for CS453), the injector driver reduces the load current by a 4:1 ratio and operates as a constant current source. This condition holds the injector open and reduces system power dissipation.

Other solenoid or relay applications can be equally well served by the CS452/453. Two high impedance inputs are provided which permit a variety of control options and can be driven by TTL or CMOS logic.

Absolute Maximum Ratings

Power Supply Voltage (V_{CC}) 24V
V_{IN} ..... -6.0 to 24V
Control ..... -6.0 to 24V
Peak Transient Voltage (46V Load Dump) 60V
Internal Regulator Current 50mA
Junction Temperature Range ..... -40°C to +150°C
Operating Temperature Range (Tab Temperature) ..... -40°C to +125°C
Storage Temperature Range ..... -65°C to +150°C
Lead Temperature Soldering
Wave Solder (through hole styles only) ... 10 sec. max, 260°C peak

Typical Application Diagram

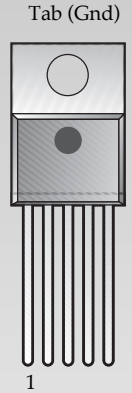


Features

- **Microprocessor Compatible Inputs**
- **On-Chip Power Device 2.4A Peak, Typical CS-452 4.4A Peak, Typical CS453**
- **Low Thermal Resistance To Grounded Tab**
- **60V Peak Transient Voltage**
- **Low Saturation Voltage**
- **Operates Over a 4.5V to 24V Battery Range**

Package Options

5 Lead TO-220



1 V_{IN}
2 CONTROL
3 Gnd
4 OUT
5 V_{CC}

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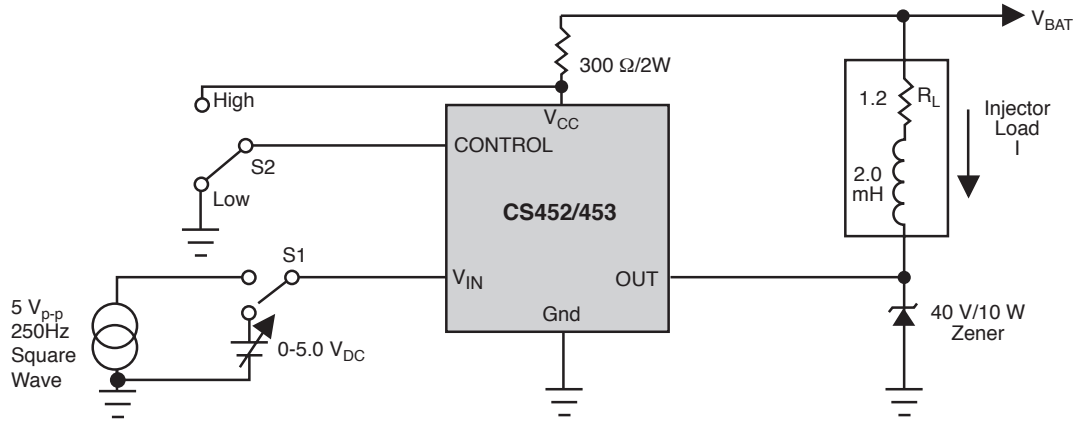
Electrical Characteristics: V_{BAT}= 12 V_{DC}, T_A = 25°C, test circuit of Test Circuit diagram, unless noted

CHARACTERISTIC		MIN	TYP	MAX	UNIT
Output Peak Current (I_{pk})	CS452	1.7	2.4	2.9	A
	CS453	3.6	4.4	5.2	A
Output Sustaining Current (I_{sus})	CS452	0.50	0.60	0.70	A
	CS453	0.95	1.12	1.25	A
$V_{(BR)CEO(sus)}$ @ 1mA		42	50		V
Output Voltage in Saturated Mode					
CS452 @ 1.5A			1.2		V
CS453 @ 3.0A			1.6		V
Internal Regulated Voltage	(@V_{CC}, Test Circuit diagram)		6.9		V
Input "on" Threshold Voltage			1.4	2.0	V
Input "off" Threshold Voltage		0.7	1.3		V
Input "on" Current					
@ V_{IN} = 1.4V_{DC}			35		µA
@ V_{IN} = 5.0V_{DC}			220		µA
CONTROL "on" Threshold Voltage		1.2	1.5	1.8	V
CONTROL Current					
CONTROL = 0.8V_{DC}			-5	-50	µA
CONTROL = 5.0V_{DC}			1.0		µA
Input Turn On Delay (t_l)			0.5	1.0	µs
I_{pk} sense to I_{sus} delay (t_p)			60		µs
CONTROL Signal Delay (t_t)			15		µs
Input Turn Off from Saturated Mode Delay (t_s)			1.0		µs
Input Turn Off from Sustain Mode Delay (t_d)			0.2		µs
Output Voltage Rise Time (t_v)			0.4		µs
Output Current Fall Time (t_f) 4.0A			0.6	1.0	µs

Package Lead Description

PACKAGE LEAD #	LEAD SYMBOL	FUNCTION
TO-220		
1	V_{IN}	Switches the injector driver on and off.
2	CONTROL	Acts to disable OUT when high.
3	Gnd	Ground connection.
4	OUT	Output Drive current.
5	V_{CC}	Supply voltage to IC. V_{CC} is connected to V_{BAT} through a series resistor (300Ω typ.)

Test Circuit



Circuit Description

Inductive actuators such as automotive electronic fuel injectors, relays, solenoids and hammer drivers can be powered more efficiently by providing a high current drive until actuation (pull-in) occurs and then decreasing the drive current to a level which will sustain actuation. Pull-in and especially dropout times of the actuators are also improved.

The fundamental output characteristic of the CS452/453 provides a low impedance saturated power switch until the load current reaches a predetermined high-current level and then changes to a current source of lower magnitude until the device is turned off. This output characteristic allows the inductive load to control its actuation time during turn-on while minimizing power and stored energy during the sustain period, thereby promoting a fast turn-off time.

Automotive injectors at present time come in two types. The large throttle body injectors have an inductance of about 2.0mH and an impedance of 1.2Ω and require the CS453 driver. The smaller type, popular worldwide, have an inductance of 4.0mH and an impedance of 2.4Ω and needs about a 2.0A pulse for good results, which can be met with the CS452. Some designs are planned which employ two of the smaller types in parallel. The inductance of the injectors are much larger at low current, decreasing due to armature movement and core saturation to the values above at rated current.

Operating frequencies range from 5.0Hz to 250Hz depending on the injector location and engine type. Duty cycle in some designs reaches 80%.

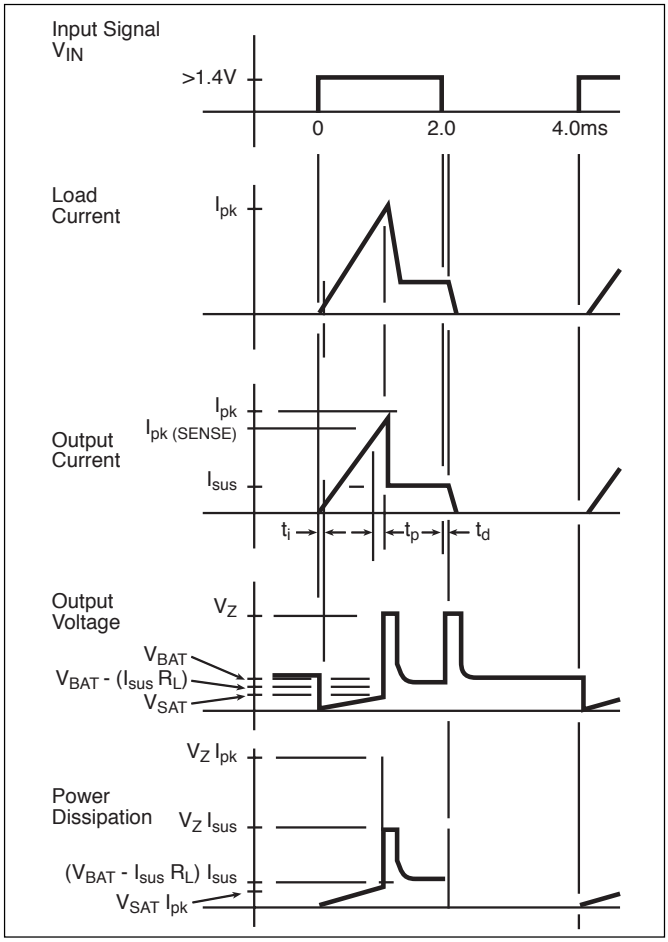
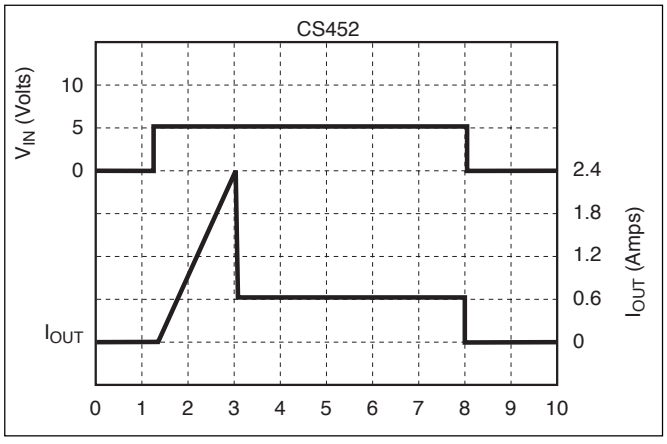
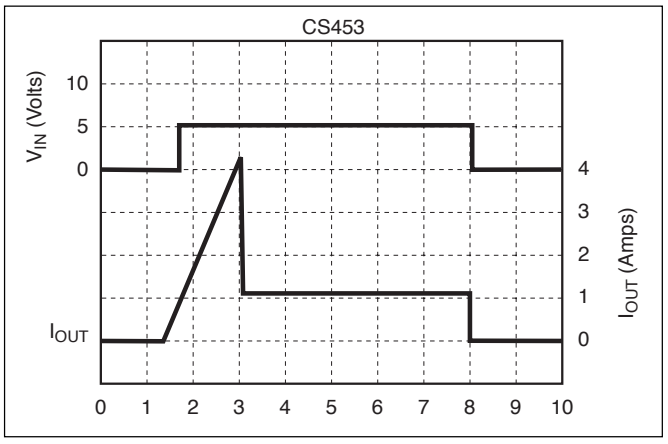


Figure 1. Operating Waveforms (Max. Frequency 250Hz, CONTROL Grounded)

Timing Diagrams

Input Voltage and Output Current vs. Time





Application Information

The CS452/453 is provided with an input lead (V_{IN}) which turns the injector driver "on" and "off". This lead has a nominal trip level of 1.4V and an input impedance of 20kΩ. It is internally protected against negative voltages and is compatible with TTL and most other logic.

There is also a control lead (CONTROL) which if held low or grounded, permits the device to operate in saturation to $I_{pk(sense)}$, where it will switch to I_{sus} automatically. If CONTROL is brought high (>1.5V), the output drive stage is turned off, regardless of what state the input (V_{IN}) is at, and the output current goes to zero.

Figure 1 shows the operating waveforms for the simplest mode; i.e., with CONTROL grounded. When the driver is turned on, the current ramps up to the peak current sense level, where some overshoot occurs because of internal delay. The CS452/453 then reduces its output to I_{sus}. The fall time of the device is very rapid (≤1.0μs), but the decay of the load current takes 150 to 220 μs, while dumping the load energy into the protection Zener clamp.

It is essential that the Zener voltage be lower than the $V_{(BR)CEO(sus)}$, but not so low as to greatly stretch the load current decay time. Without the zener, the discharge of the load energy would be totally into the CS452/453, which, for the high current applications, could cause the device to fail.

Also in figure 1 is the graphically derived instantaneous power dissipation of the CS452/453. It shows that, for practical purposes, the worst case dissipation is less than (I_{sus}) (V_{BAT}) (duty cycle).

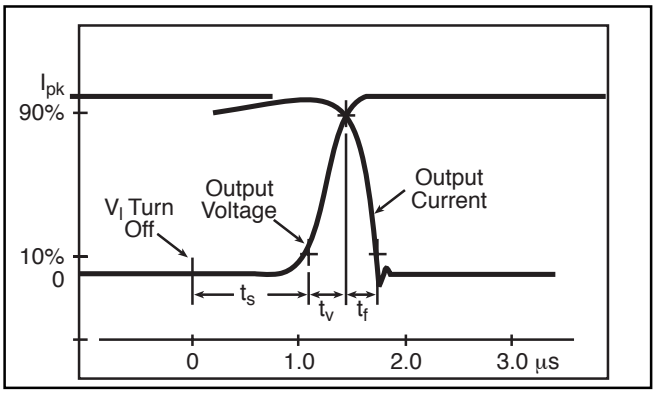


Figure 2. Switching Waveforms (Expanded Time Scale)

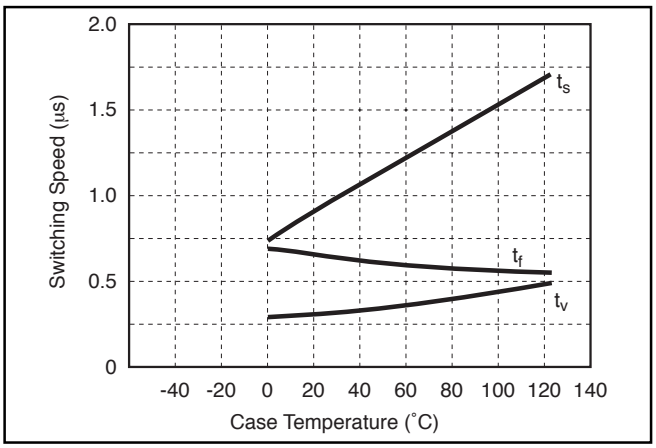


Figure3. Switching Speed vs. Temperature

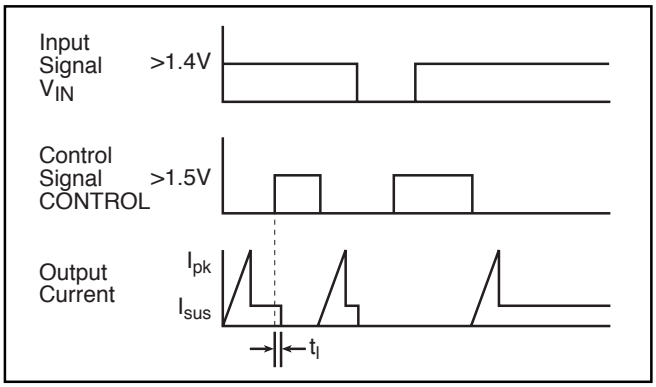


Figure 4. Application of CONTROL

Provided in Figures 2,3, and 4 are definitions of the switching intervals specified in the Electrical Characteristics. Figure 3 shows that the critical switching parameters stay under control at elevated temperatures.

In those applications where high voltage transients may occur while the output lead (OUT) is in the I_{sus} mode, excessive instantaneous power dissipation may occur, causing device failure. When this condition occurs, the control lead (CONTROL) can be used to shut off the output stage in order to protect the CS452/453. As long as CONTROL is in the high state (>1.5 volts, typ.), the output will remain off. One method of sensing the supply voltage and controlling CONTROL is to use a resistor divider between the supply voltage and ground with CONTROL connected to the resistor divider (see Typical Application diagram).

Another application option of the control lead is to use it to accomplish an enable/disable function. Since CONTROL is compatible with TTL and CMOS logic levels, a logic low will enable the output, and allow it to follow the input signal at V_{IN}. If CONTROL is held at a logic high, the output will be disabled regardless of the state of the input signal.

If the control function is not being used in the application, it must be grounded or otherwise placed in a logic low state. If CONTROL is left open, the output stage will remain off.

The output current in the I_{sus} mode should be oscillation free. There is a possibility that in a given application, the output current could oscillate for a small fraction of parts. If this was to occur, the remedy is place a capacitor from OUT to Ground. The value of the capacitor should not exceed 0.01μF.

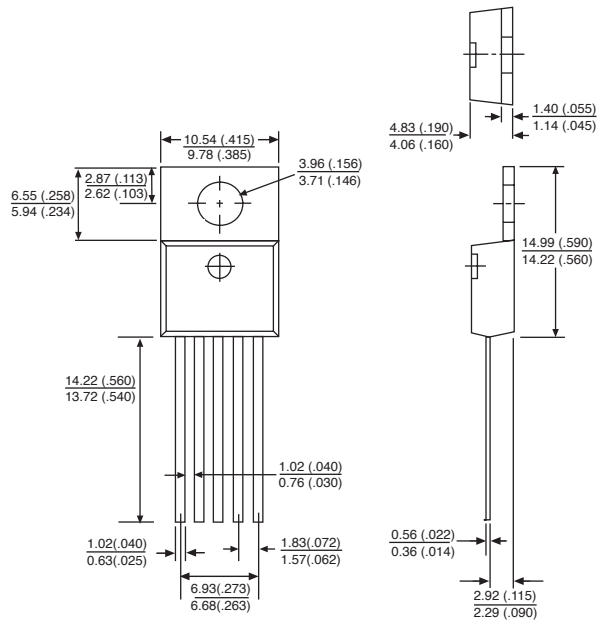
Package Specification

PACKAGE DIMENSIONS IN mm (INCHES)

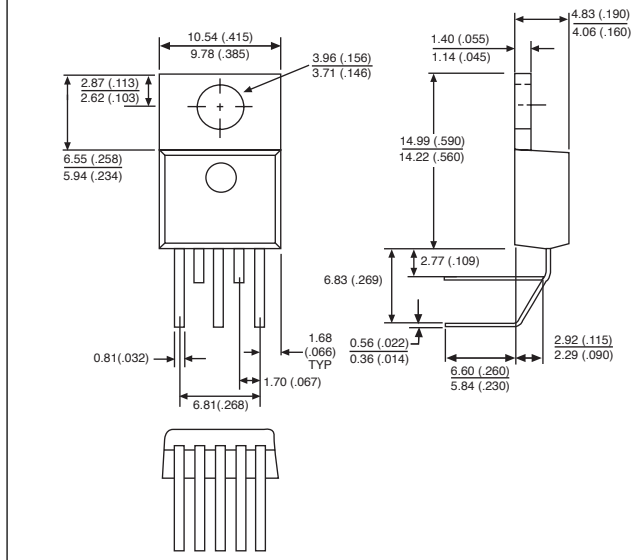
PACKAGE THERMAL DATA

Thermal Data		5 Lead TO-220	
$R_{\Theta JC}$	typ	2.6	°C/W
$R_{\Theta JA}$	typ	50	°C/W

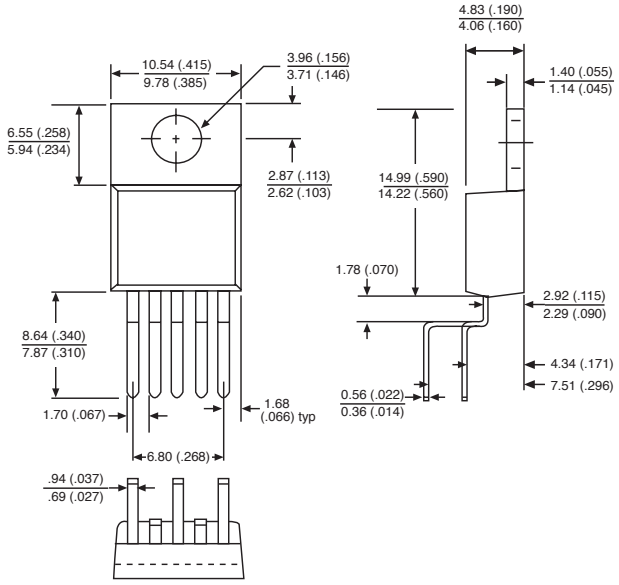
5 Lead TO-220 (Straight)



5 Lead TO-220 (Horizontal)



5 Lead TO-220 (Vertical)



Ordering Information

Part Number	Description
CS452GT5	5 Lead TO-220 Straight
CS452GTVA5	5 Lead TO-220 Vertical
CS452GTHA5	5 Lead TO-220 Horizontal
CS453GT5	5 Lead TO-220 Straight
CS453GTVA5	5 Lead TO-220 Vertical
CS453GTHA5	5 Lead TO-220 Horizontal

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