



# 2.4A/4.4A Injector Solenoid Driver

## Description

The CS-452/453 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 CS-452, or 4.4A for CS-453), the injector driver reduces

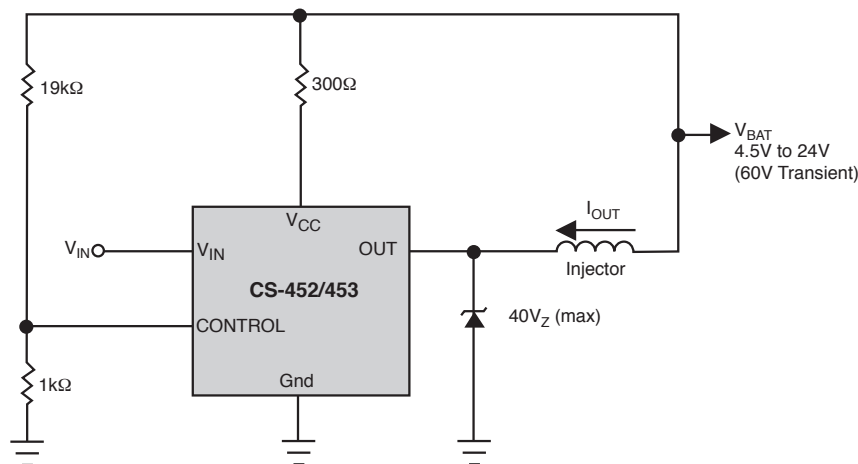
the load current by a 4:1 ratio and operates as a constant current source. This condition holds the injector open and reduces system power dissipation.

Other solenoid or relay applications can be equally well served by the CS-452/453. 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



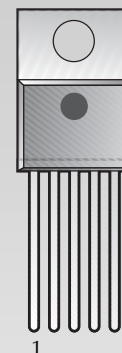
## Features

- Microprocessor Compatible Inputs
- On-Chip Power Device  
2.4A Peak, Typical CS-452  
4.4A Peak, Typical CS-453
- Low Thermal Resistance To Grounded Tab
- 60V Peak Transient Voltage
- Low Saturation Voltage
- Operates Over a 4.5V to 24V Battery Range

## Package Option

5 Lead TO-220

Tab (Gnd)



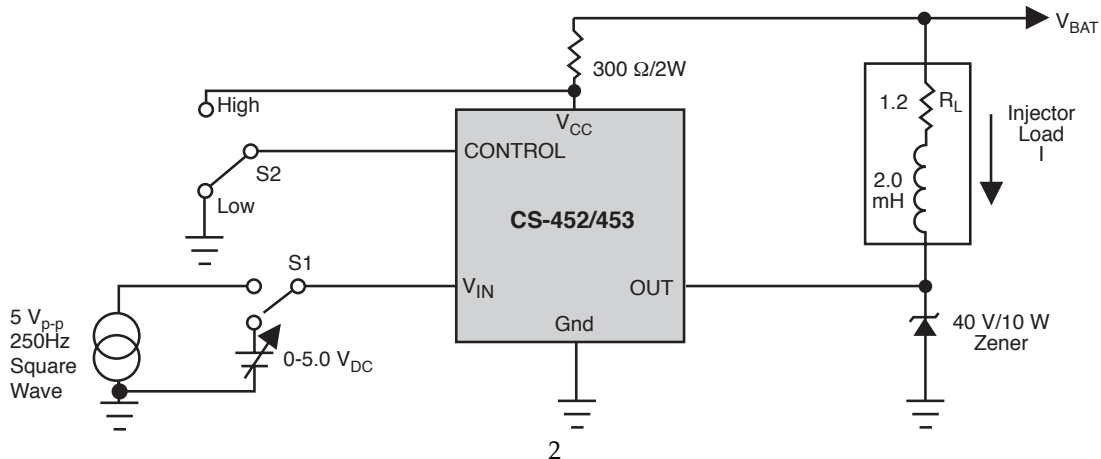
- 1  $V_{IN}$
- 2 CONTROL
- 3 Gnd
- 4 OUT
- 5  $V_{CC}$

**Electrical Characteristics:  $V_{BAT}=12V_{DC}$ ,  $T_C=25^\circ C$ , test circuit of Test Circuit diagram, unless noted**

CHARACTERISTIC		MIN	TYP	MAX	UNIT
Output Peak Current ( $I_{pk}$ )	CS-452	1.7	2.4	2.9	A
	CS-453	3.6	4.4	5.2	A
Output Sustaining Current ( $I_{sus}$ )	CS-452	0.50	0.60	0.70	A
	CS-453	0.95	1.12	1.25	A
$V_{(BR)CEO(sus)}$ @ 1mA		42	50		V
Output Voltage in Saturated Mode					
	CS-452 @ 1.5A		1.2		V
	CS-453 @ 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		$\mu A$
	@ $V_{IN} = 5.0V_{DC}$		220		$\mu A$
CONTROL "on" Threshold Voltage		1.2	1.5	1.8	V
CONTROL Current					
	CONTROL = $0.8V_{DC}$		-5	-50	$\mu A$
	CONTROL = $5.0V_{DC}$		1.0		$\mu A$
Input Turn On Delay ( $t_i$ )			0.5	1.0	$\mu s$
$I_{pk}$ sense to $I_{sus}$ delay ( $t_p$ )			60		$\mu s$
CONTROL Signal Delay ( $t_l$ )			15		$\mu s$
Input Turn Off from Saturated Mode Delay ( $t_s$ )			1.0		$\mu s$
Input Turn Off from Sustain Mode Delay ( $t_d$ )			0.2		$\mu s$
Output Voltage Rise Time ( $t_r$ )			0.4		$\mu s$
Output Current Fall Time ( $t_f$ ) 4.0A			0.6	1.0	$\mu s$

**Package Lead Description**

PACKAGE LEAD #	LEAD SYMBOL	FUNCTION
<b>TO-220</b>		
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 (300 $\Omega$ 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 CS-452/453 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 CS-453 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 CS-452. 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%.

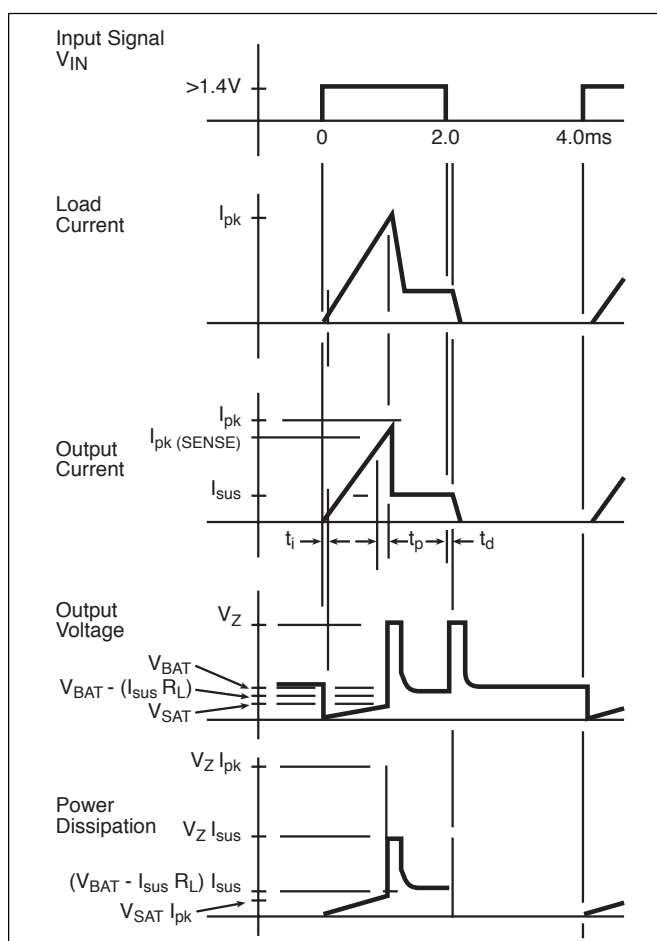
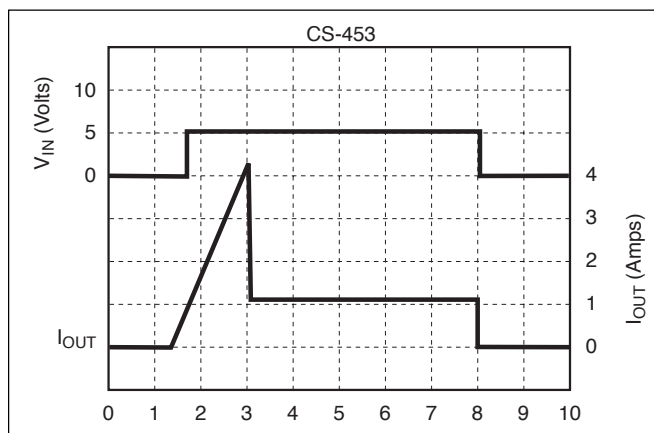
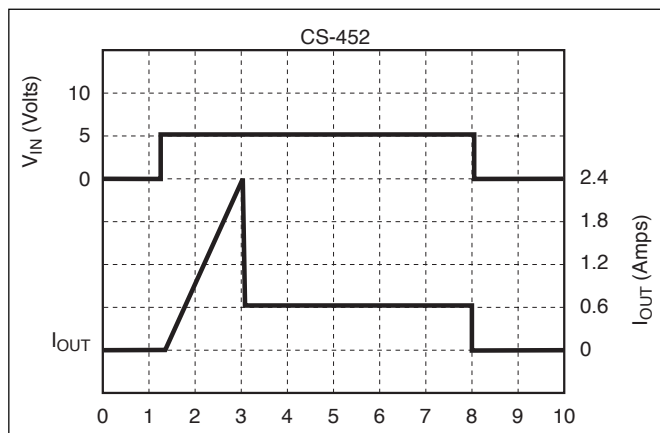


Figure 1. Operating Waveforms (Max. Frequency 250Hz, CONTROL Grounded)

## Timing Diagrams

### Input Voltage and Output Current vs. Time



The CS-452/453 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 20k $\Omega$ . 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 CS-452/453 then reduces its output to  $I_{sus}$ . The fall time of the device is very rapid ( $\leq 1.0\mu s$ ), but the decay of the load current takes 150 to 220  $\mu s$ , 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 CS-452/453, 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 CS-452/453. It shows that, for practical purposes, the worst case dissipation is less than ( $I_{sus}$ ) ( $V_{BAT}$ ) (duty cycle).

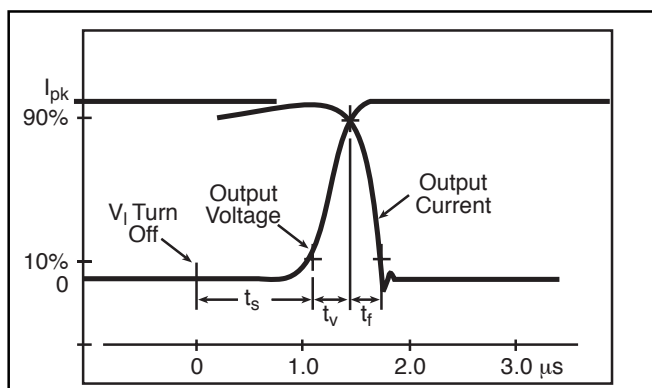


Figure 2. Switching Waveforms (Expanded Time Scale)

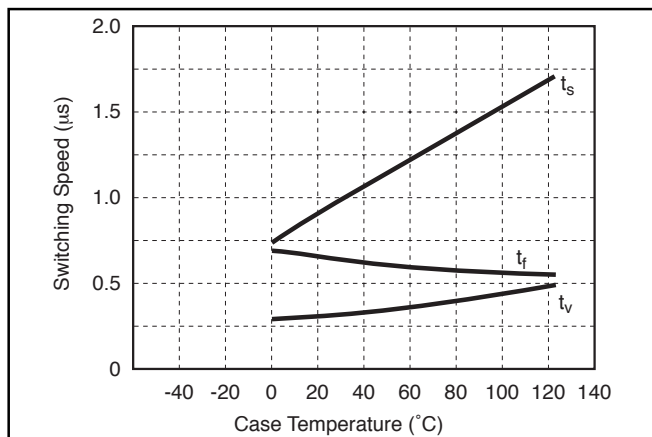


Figure 3. Switching Speed vs. Temperature

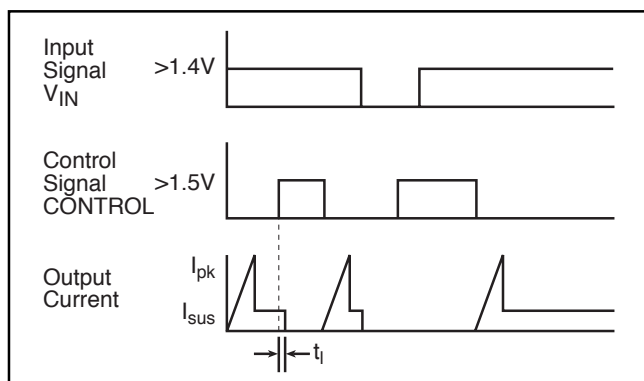


Figure 4. Application of CONTROL

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 CS-452/453. 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 0.01 $\mu F$ .

# Package Specification

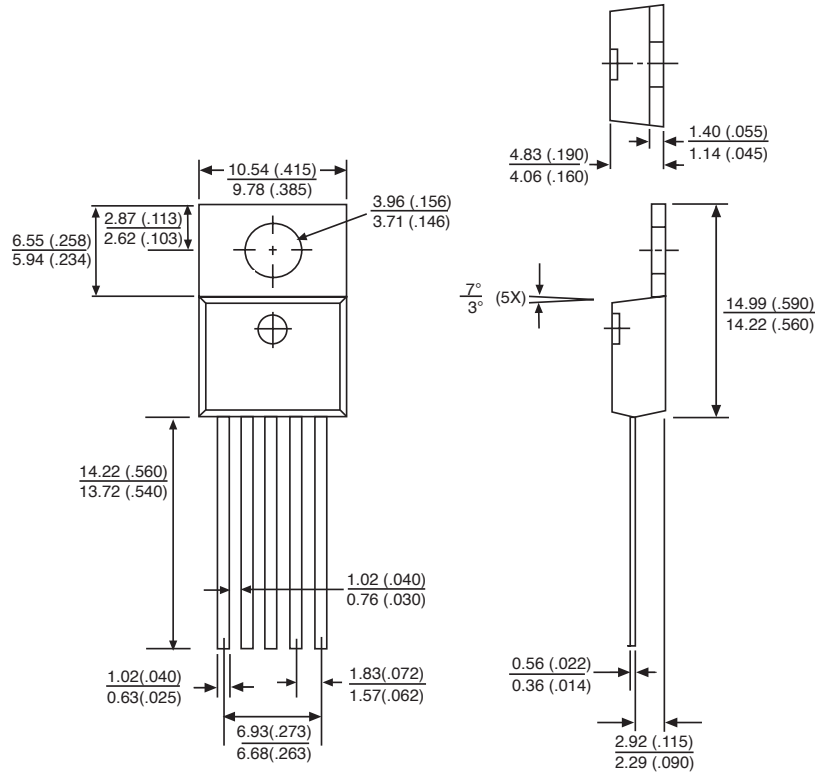
CS-452/453

## PACKAGE DIMENSIONS IN mm (INCHES)

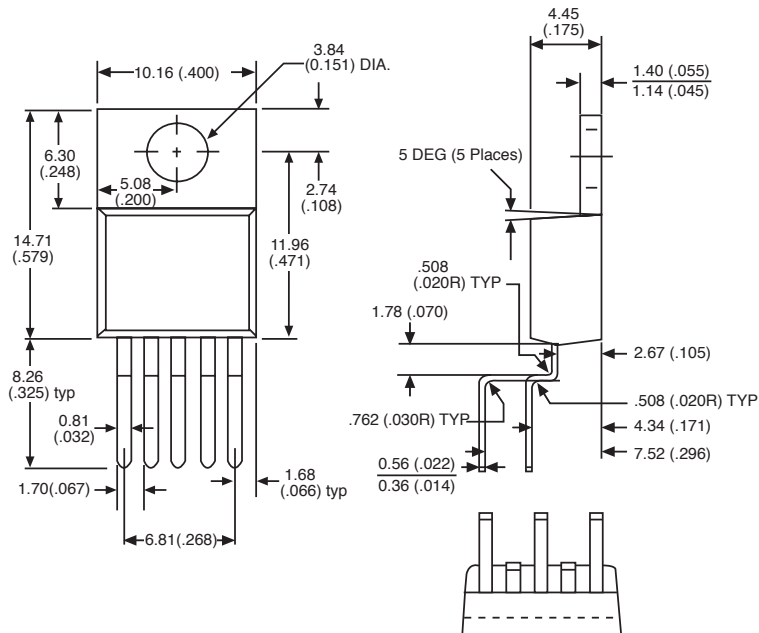
## PACKAGE THERMAL DATA

Thermal Data		5 Lead TO-220	
$R_{\theta JC}$	typ	2.6	$^{\circ}\text{C/W}$
$R_{\theta JA}$	typ	50	$^{\circ}\text{C/W}$

## 5 Lead TO-220 (Straight)

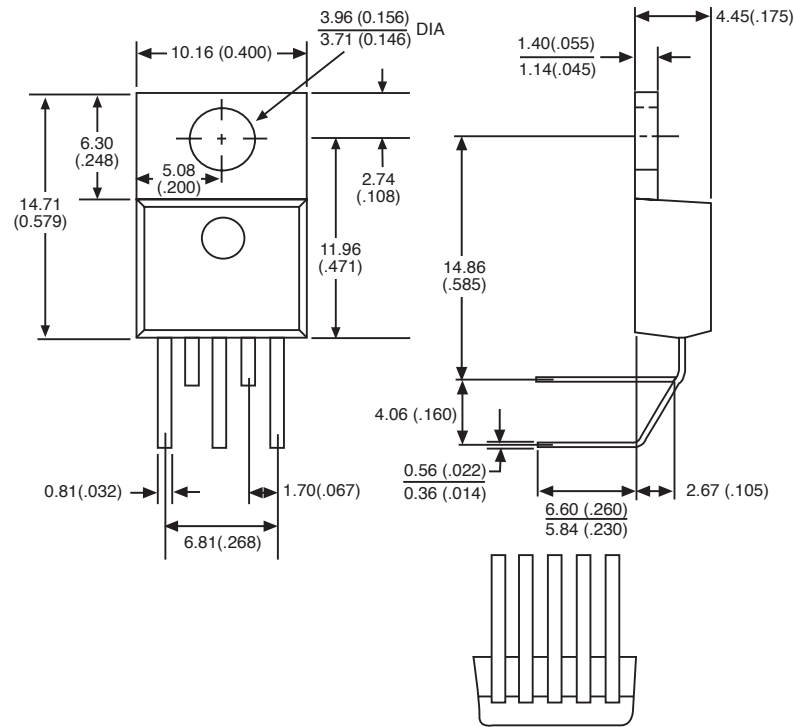


## TO-220 (Vertical)



## Package Specification: continued

## 5 Lead TO-220 (Horizontal)



## Ordering Information

Part Number	Description
CS-452T	5 Lead TO-220 Straight
CS-452TV	5 Lead TO-220 Vertical
CS-452TH	5 Lead TO-220 Horizontal
CS-453T	5 Lead TO-220 Straight
CS-453TV	5 Lead TO-220 Vertical
CS-453TH	5 Lead TO-220 Horizontal

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