

Automotive Electronic Circuits

In Brief . . .

Motorola Analog has established itself as a global leader in custom integrated circuits for the automotive market. With multiple design centers located on four continents, global process and assembly sites, and strategically located supply centers, Motorola serves the global automotive market needs. These products are key elements in the rapidly growing engine control, body, navigation, entertainment, and communication electronics portions of modern automobiles. Though Motorola is most active in supplying automotive custom designs, many of yesterday's proprietary custom devices have become standard products of today, available to the broad base manufacturers who support this industry. Today, based on new technologies, Motorola offers a wide array of standard products ranging from rugged high current "smart" fuel injector drivers which control and protect the fuel management system through the rigors of the underhood environment, to the latest SMARTMOS™ switches and series transient protectors. Several devices are targeted to support microprocessor housekeeping and data line protection. A wide range of packaging is available including die, flip-chip, and SOICs for high density layouts, to low thermal resistance multi-pin, single-in-line types for high power control ICs.

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Automotive Electronic Circuits

Table 1. Voltage Regulators

Function	Features	Suffix/Package	Device
Low Dropout Voltage Regulator	Fixed and adjustable positive output voltage regulators which maintain regulation with very low input-to-output voltage differential.	Z/29, T/221A, T/314D, TH/314A, TV/314B, DT/369A, DT-1/369, D2T/936, D2T/936A, D/751	LM2931 Series
Low Dropout Voltage Regulator	Low voltage differential regulator featuring dual positive 5.0 V outputs; switched currents in excess of 750 mA and 10 mA standby current. Fixed quiescent current is less than 3.0 mA.	T/314D, TH/314A, TV/314B, D2T/936A	LM2935
Low Dropout Voltage Regulator	Positive 5.0 V, 500 mA regulator with on-chip power-up-reset circuit with externally programmable delay, current limit, and thermal shutdown.	T/314D, TV/314B	MC33267
Low Dropout Voltage Regulator	Positive 3.3 V, 5.0 V, 12 V, 800 mA regulator.	D/751, DT/369A	MC33269

Table 2. Electronic Ignition Circuits

Function	Features	Suffix/Package	Device
Electronic Ignition Circuit	High energy variable dwell electronic ignition control circuit used in 12 V battery systems using a variable reluctance sensor; drives external Darlington used to control coil current, dwell and spark energy are externally programmed. "Bumped" Flip-Chip die are for inverted mounting to substrate.	P/626, D/751, Flip-Chip	MC3334, MCCF3334
Electronic Ignition Circuit	Differential input, high energy ignition control circuit used in 12 V battery systems; drives external Darlington used to control coil current, internal zener for flyback protection of external Darlington, three external capacitors used to program RPM adaptive coil current dwell and charge times, coil current limiting, and engine push starting capability. "Bumped" Flip-Chip die are for inverted mounting to substrate.	DW/751G, Flip-Chip	MC33093, MCCF33093
Electronic Ignition Circuit	Single-ended input, high energy ignition control circuit used in 12 V battery systems; drives external Darlington used to control coil current, internal zener for flyback protection of external Darlington, three external capacitors used to program RPM adaptive coil current dwell and charge times, coil current limiting, and engine push starting capability. "Bumped" Flip-Chip die are for inverted mounting to substrate.	DW/751G, Flip-Chip	MC33094, MCCF33094
Electronic Ignition Circuit	Reluctance or Hall Sensor input, high energy ignition control circuit used in 12 V battery systems; drives external Darlington used to control coil current, internal zener for flyback protection of external Darlington, spark advance, RPM detect, coil current dwell, and coil current limiting. "Bumped" Flip-Chip die are for inverted mounting to substrate.	DW/751G, Flip-Chip	MC79076, MCCF79076

Table 3. Low- and High-Side Switches

Function	Features	Suffix/Package	Device
Low-Side Protected Switch	Single low-side switch; 5.0 V CMOS compatible input, 1.0 A maximum current rating, with overcurrent, overvoltage, and thermal protection. Ideally suited for instrument panel use.	T/221A, T-1/314D, DW/751G	MC3392
Half-Amp High-Side Switch	Controls loads from positive supply side of load in 12 V battery systems; TTL compatible input control, output current limiting, thermal shutdown, reverse battery protection, ± 100 V transient protection.	T/314D, DW/751G	MC3399
Quad Fuel Injector Driver	Four low-side switches with parallel CMOS compatible input control, ≤ 7.0 mA quiescent current, $0.25 \Omega R_{DS(on)}$ at 25°C, individual internal per output current limiting and 65 V inductive flyback protection, fault reporting of open and shorted loads, overvoltage duration shutdown with automatic recovery.	T/821D, TV/821C	MC33293A
Basic Octal Serial Switch	Eight low-side switches incorporating Serial Peripheral Interface (SPI) protocol using an 8-bit CMOS compatible input control word, serial fault reporting, overvoltage detection and shutdown, ≤ 2.0 mA total operational quiescent current, and $\leq 25 \mu\text{A}$ sleep state supply current; outputs have individual $1.0 \Omega R_{DS(on)}$ at 25°C, 1.0 A minimum current limiting, thermal shutdown, and 55 V inductive flyback protection.	DW/751E	MC33291
Octal Serial Switch	Eight low-side switches incorporating Serial Peripheral Interface (SPI) protocol using an 8-bit CMOS compatible input control word, serial fault reporting, overvoltage detection and shutdown, ≤ 4.0 mA total operational quiescent current, and $\leq 50 \mu\text{A}$ sleep state supply current; outputs have individual $0.45 \Omega R_{DS(on)}$ at 25°C, 3.0 A minimum current limiting, thermal shutdown, and 55 V inductive flyback protection.	P/738, DW/751E	MC33298
Dual High-Side Switch	Two high-side switches incorporating parallel CMOS compatible input control, overvoltage shutdown, ≤ 300 mA sleep state current with chip enable; each output switch has $0.25 \Omega R_{DS(on)}$ at 25°C with internal charge pump, 3.0 A minimum current limiting, output status reporting of output ON and OFF open load detection, short to ground shutdown protection with automatic retry, and short to supply detection. Fault interrupt output is available for system interrupt use.	DW/751E	MC33143

Table 4. Alternator Regulators

Function	Features	Suffix/Package	Device
Alternator Regulator	Provides load response control, duty cycle limiting, under/overvoltage and phase detection, high-side external MOSFET field current control, voltage regulation in 12 V alternator systems.	DW/751D	MC33092
Integral Alternator Regulator	Constant frequency with variable duty cycle circuit used with an external Darlington device to monitor and control the field current in 12 V alternator charging systems. Circuit reports overvoltage and stopped engine (broken belt) conditions, and adjusts charge rate to compensate for changes in ambient temperature. "Bumped" Flip-Chip die are for inverted mounting to substrate.	D/751A, Flip-Chip	MC33095, MCCF33095

Table 5. Communication Bus Circuits

Function	Features	Suffix/Package	Device
ISO 9141 L & K-Line Serial Link Transceiver	Two-wire asynchronous serial communication interface (SCI) to a microcontroller for one-wire car diagnostic systems (DIA), for 12 V battery systems; receive and transmit data, and L-line output to microcontroller are 5.0 V CMOS compatible, both ISO 9141 K- and L-lines of bus are available. Enhanced K-line data rates up to 200 k Baud, short to ground protection of bus K-line input, thermal shutdown protection. Battery terminal will sustain 40 V dc.	D/751A	MC33199
ISO 9141 K-Line Serial Link Transceiver	Two-wire asynchronous serial communication interface (SCI) to a microcontroller for one-wire car diagnostic systems; for 12 V battery systems, I/O lines to microcontroller are 5.0 V CMOS compatible, ISO 9141 K-line of bus available, greater than 50 k Baud rates, 1.0 A short to ground current limit of bus K-line input, 35 mA ISO K-line data current sinking, thermal shutdown protection, 45 V battery load dump, and 40 V dc K-line capability.	D/751, P/626	MC33290

Table 6. Special Function Circuits

Function	Features	Suffix/Package	Device
High-Side T MOS Driver	Control circuit used to drive and protect generic external N-channel power MOSFETs in high-side switching applications; 5.0 V CMOS compatible input control, internal charge pump, externally programmed to protect power MOSFET, shorted load protection, and MOSFET overcurrent fault reporting.	P/626, D/751	MC33091A
MI-Bus Interface Stepper Motor Controller	High noise immunity serial communication MI-Bus protocol circuit used to control relay drivers and motors in harsh environments. Four phase signals drive two phase motors in either half of full-step modes; bus error, motor fault, and over temperature detection.	DW/751G	MC33192
Peripheral Clamping Array	Protects up to six MPU I/O lines against voltage transients; V_{CC} +1.0 V positive clamping, -0.3 V negative clamping.	*626, D/751	TCF6000
Direction Indicator	Turn signal flasher circuit detects defective lamps and protects against overvoltage in automotive 12 V battery flasher applications; on-chip relay driver, 20 m Ω shunt requirement, minimum modification required to replace UAA1041B in applications not requiring short circuit detection.	D/751, P/626	MC33193
Wash Wiper Timer	Standard wiper timer control circuit for use in driving wiper motor relay in 12 V battery systems; can perform intermittent, after-wash, and continuous wiper timer functions.	D/751, P/626	MC33197A

* No Suffix

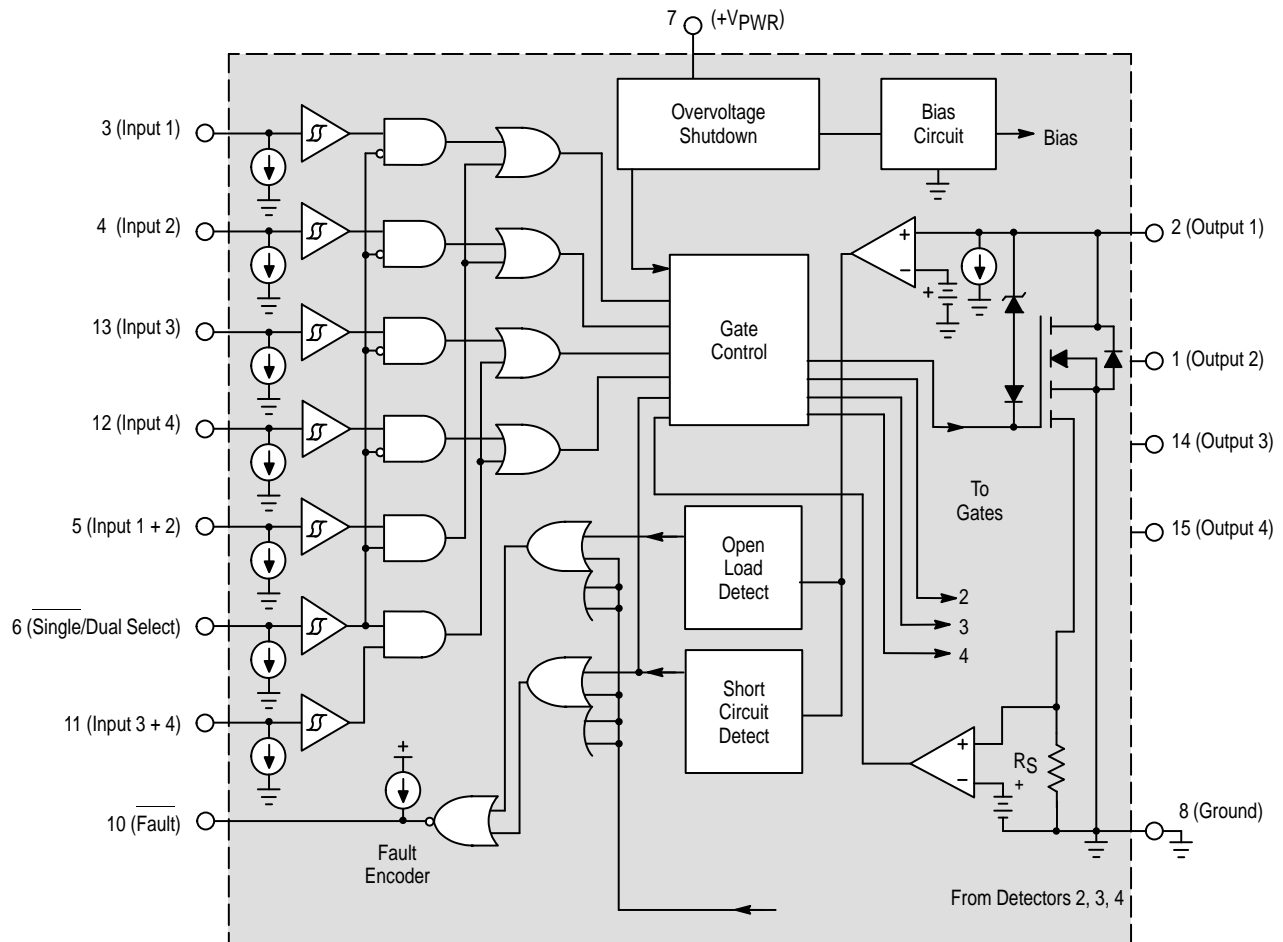
Quad Fuel Injector Driver

MC33293AT, MC33293ATV

$T_J = -40^\circ$ to $+150^\circ\text{C}$, Case 821D, C

The MC33293AT is a monolithic quad low-side switching device having CMOS logic, bipolar/CMOS analog circuitry, and DMOS power FETs. All inputs are CMOS compatible. Each independent output is internally clamped to 65 V, current limited to ≥ 3.0 A, and has an $r_{DS(on)}$ of $\leq 0.25 \Omega$ with $V_{PWR} \geq 9.0$ V and may be paralleled to lower $r_{DS(on)}$. Fault output reports existence of open loads (outputs "On" or "Off"),

shorted loads, and over temperature condition of outputs. A shorted load condition will shut off only the specific output involved while allowing other outputs to operate normally. An overvoltage condition will shut off all outputs for the overvoltage duration. A single/dual mode select pin allows either independent input/output operation or paired output operation.



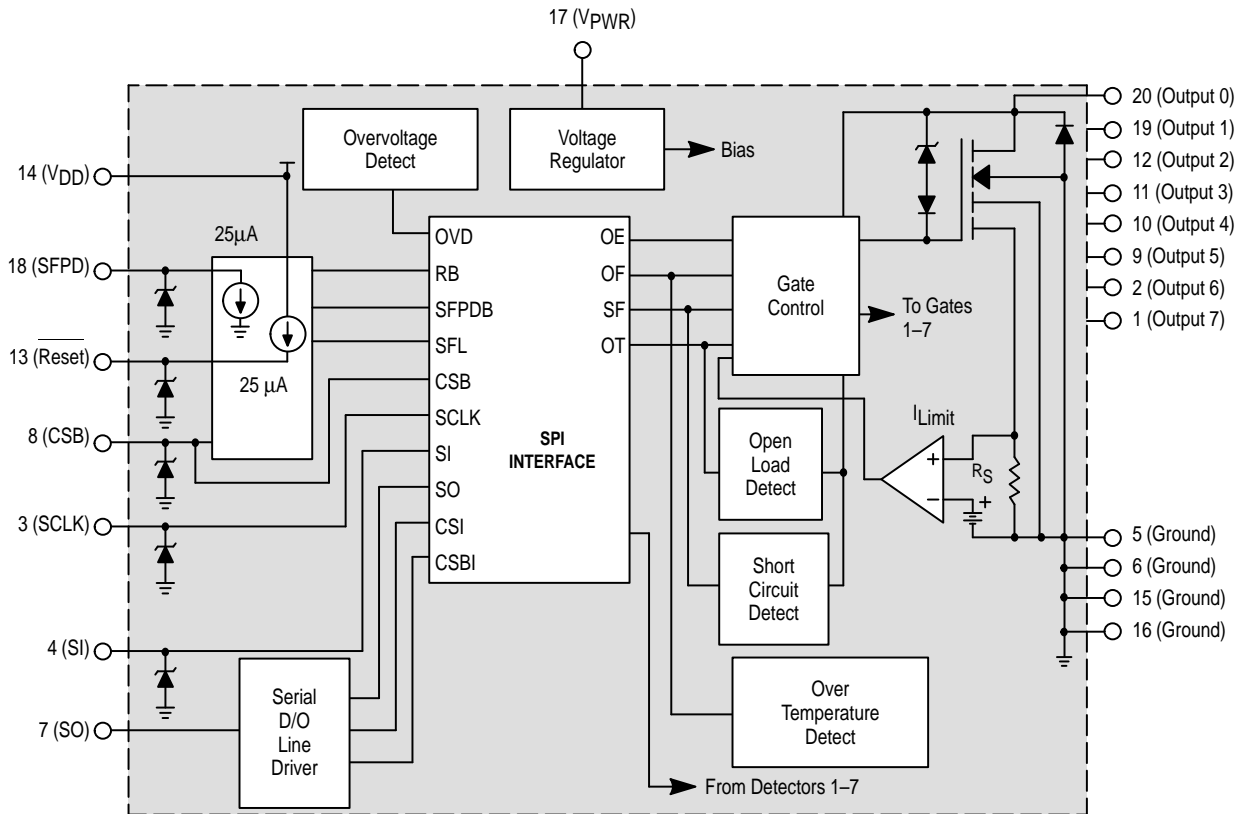
Octal Serial Switch

MC33298P, MC33298DW

$T_J = -40^\circ$ to $+150^\circ\text{C}$, Case 738, 751E

The MC33298 is a monolithic eight output low-side switch with 8-bit serial input control. Incorporates CMOS logic, bipolar/CMOS analog circuitry, and DMOS power FETs. All inputs are CMOS compatible. It is designed to interface to a microcontroller and switch inductive or incandescent loads.

Each independent output is internally clamped to 55 V, current limited to ≥ 3.0 A, and has an $r_{DS(on)}$ of $\leq 0.45 \Omega$ with $V_{PWR} \geq 9.0$ V. This device has low standby current, cascadable fault status reporting, output diagnostics, and shutdown for each output.



Dual High-Side Switch

MC33143DW

$T_A = -40^\circ$ to $+125^\circ\text{C}$, Case 751E

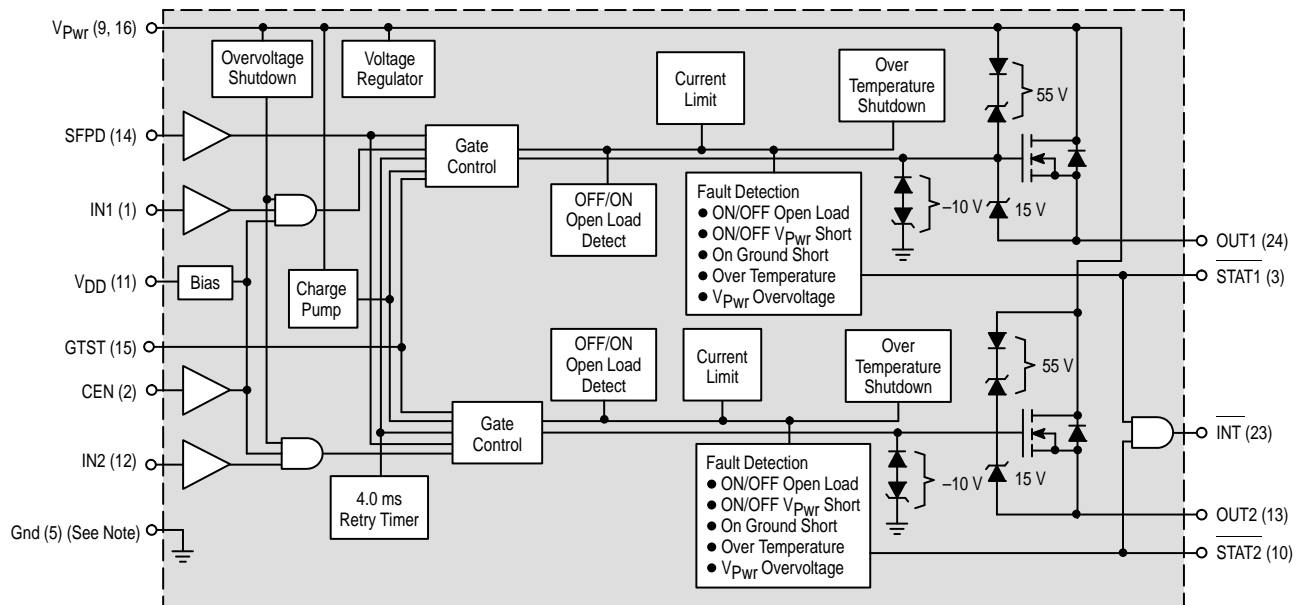
The MC33143 is a dual high-side switch designed for solenoid control in harsh automotive applications, but is well suited for other environments. The device can also be used to control small motors and relays as well as solenoids. The MC33143 incorporates SMARTMOS™ technology, with CMOS logic, bipolar/MOS analog circuitry, and DMOS power outputs. An internal charge pump is incorporated for efficient gate enhancement of the internal high-side power output devices. The outputs are designed to provide current to low impedance solenoids. The MC33143 provides individual output fault status reporting along with internal Overcurrent and Over Temperature protection. The device also has Overvoltage protection, with automatic recovery, which “globally” disables both outputs for the duration of an Overvoltage condition. Each output has individual Overcurrent and Over Temperature shutdown with automatic retry recovery. Outputs are enabled with a CMOS logic high signal applied to an input to providing true logic control. The outputs, when turned on, provide full supply (battery) voltage across the solenoid coil.

The MC33143 is packaged in an economical 24 pin surface mount power package and specified over an operating voltage of $5.5\text{ V} \leq V_{PWR} < 26\text{ V}$ for $-40^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$.

- Designed to Operate Over Wide Supply Voltages of 5.5 V to 26 V

- Dual High-Side Outputs Clamped to -10 V for Driving Inductive Loads
- Internal Charge Pump for Enhanced Gate Drive
- Interfaces Directly to a Microcontroller with Parallel Input Control
- Outputs Current Limited to 3.0 A to 6.0 A for Driving Incandescent Loads
- Chip Enable “Sleep Mode” for Power Conservation
- Individual Output Status Reporting
- Fault Interrupt Output for System Interrupt Use
- Output ON or OFF Open Load Detection
- Overvoltage Detection and Shutdown
- Output Over Temperature Detection and Shutdown with Automatic Retry
- Sustained Current Limit or Immediate Overcurrent Shutdown Output Modes
- Output Short to Ground Detection and Shutdown with Automatic Retry
- Output Short to V_{PWR} Detection

Simplified Internal Block Diagram



NOTE: Pins 5, 6, 7, 8, 17, 18, 19 and 20 should all be grounded so as to provide electrical as well as thermal heatsinking of the device.

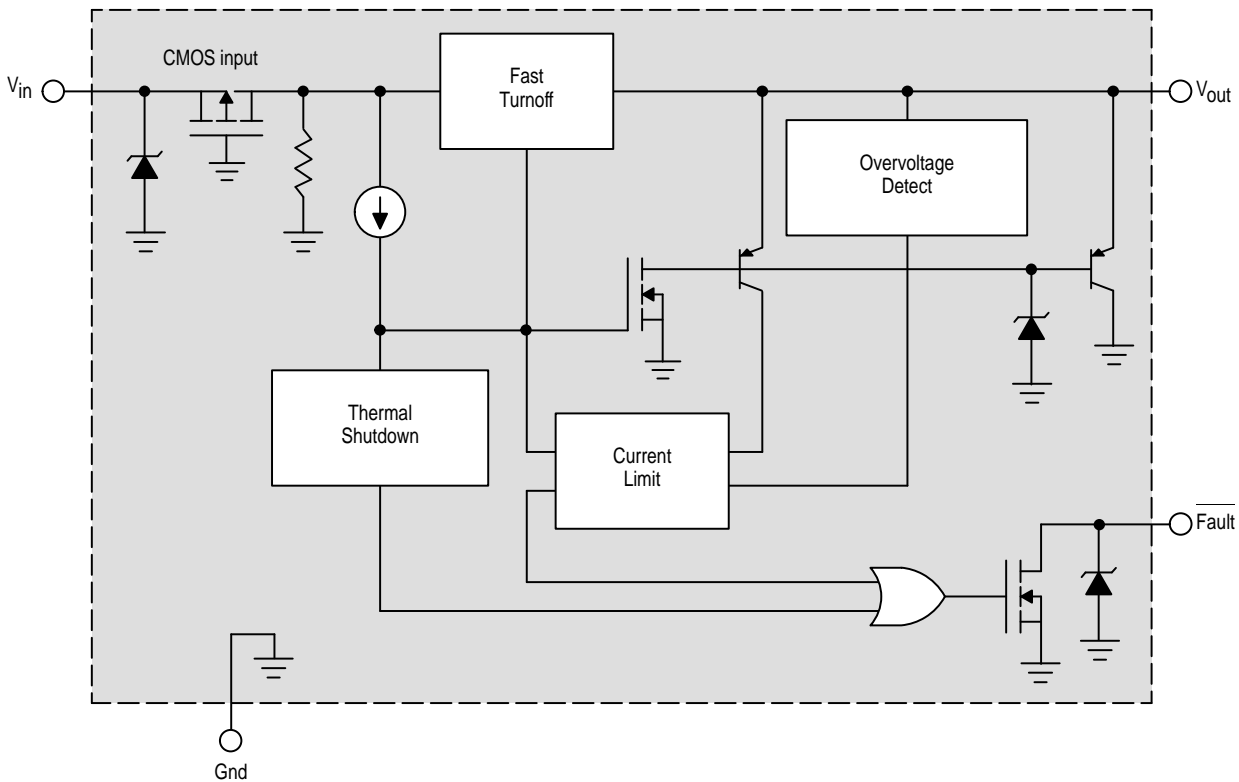
Low Side Protected Switch

MC3392T, T-1, DW

$T_J = -40^\circ$ to $+150^\circ\text{C}$,
Case 221A, 314D, 751G

Single low side protected switch with fault reporting capability. Input is CMOS compatible. Output is short circuit protected to 1.0 A minimum with a unique current fold-back feature. Device has internal output clamp for driving inductive loads with overcurrent, overvoltage, and thermal protection. When driving a moderate load, the MC3392 performs as an

extremely high gain, low saturation Darlington transistor having a CMOS input characteristic with added protection features. In some applications, the three terminal version can replace industry standard TIP100/101 NPN power Darlington transistors.



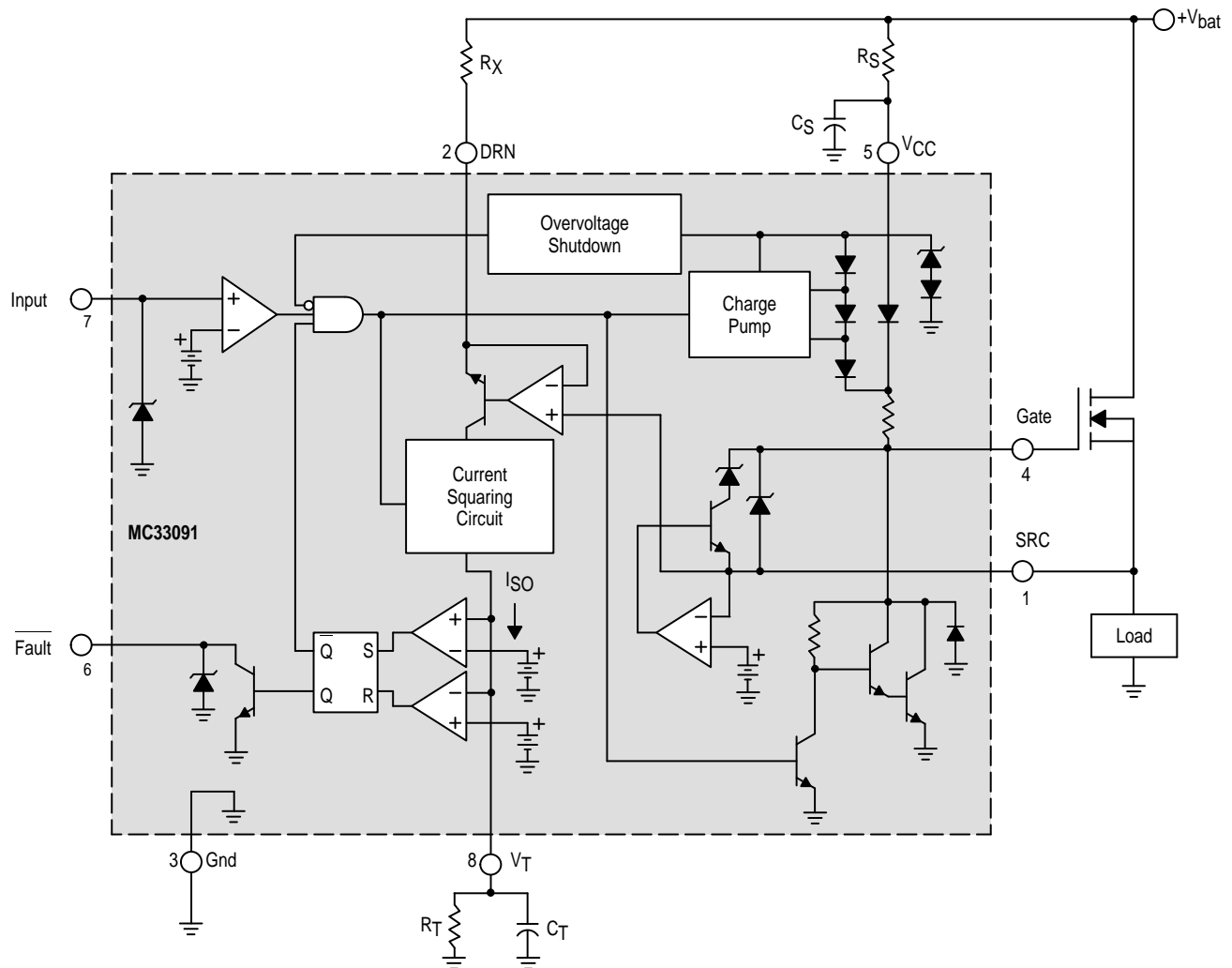
High Side TMOS Driver

MC33091AP, AD

$T_J = -40^\circ$ to $+150^\circ\text{C}$, Case 626, 751

Offers an economical solution to drive and protect N-channel power TMOS devices used in high side switching configurations. Unique device monitors load resulting V_{DS} . TMOS voltage to produce a proportional current used to drive an externally programmed over current timer circuit to protect the TMOS device from shorted load conditions. Timer can be programmed to accommodate driving incandescent loads.

Few external components required to drive a wide variety of N-channel TMOS devices. A Fault output is made available through the use of an open collector NPN transistor requiring a single pull-up resistor for operation. Input is CMOS compatible. Device uses $\leq 3.0 \mu\text{A}$ standby current and has an internal charge pump requiring no external components for operation.

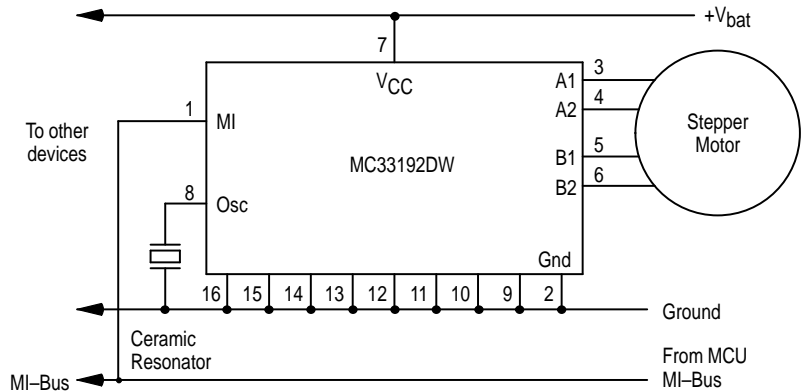


MI-Bus Interface Stepper Motor Controller

MC33192DW

$T_J = -40^\circ$ to $+100^\circ\text{C}$, Case 751G

Intended to control loads in harsh automotive environments using a serial communication bus. Can provide satisfactory real time control of up to eight stepper motors using MI-Bus protocol. Use of MI-Bus offers a noise immune system solution for difficult applications involving relays and motors. The stepper motor controller provides four phase signals to drive two phase motors in either half of full-step modes. Designed to interface to a microprocessor with minimal amount of wiring, affording an economical and versatile system.



Automotive Direction Indicator

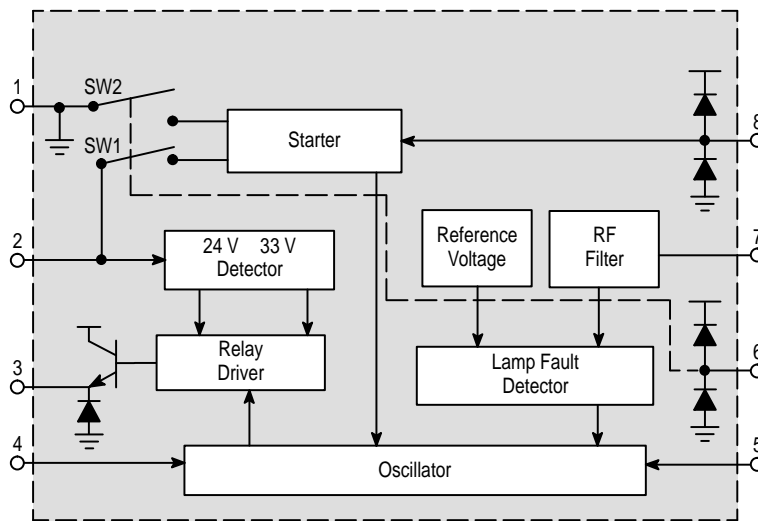
MC33193P, D

$T_A = -40^\circ$ to $+125^\circ\text{C}$, Case 626, 751

The MC33193 is a new generation industry standard UAA1041 "Flasher". It has been developed for enhanced EMI sensitivity, system reliability, and improved wiring simplification. The MC33193 is pin compatible with the UAA1041 and UAA1041B in the standard application configuration as shown in Figure 9, without lamp short circuit detection and using a 20 mΩ shunt resistor. The MC33193 has a standby mode of operation requiring very low standby supply current and can be directly connected to the vehicle's battery. It includes a RF filter on the Fault detection pin (Pin 7)

for EMI purposes. Fault detection thresholds are reduced relative to those of the UAA1041 allowing a lower shunt resistance value (20 mΩ) to be use.

- Pin Compatible with the UAA1041
- Defective Lamp Detection Threshold
- RF Filter for EMI Purposes
- Load Dump Protection
- Double Battery Capability for Jump Start Protection
- Internal Free Wheeling Diode Protection
- Low Standby Current Mode



Automotive Wash Wiper Timer

MC33197AD

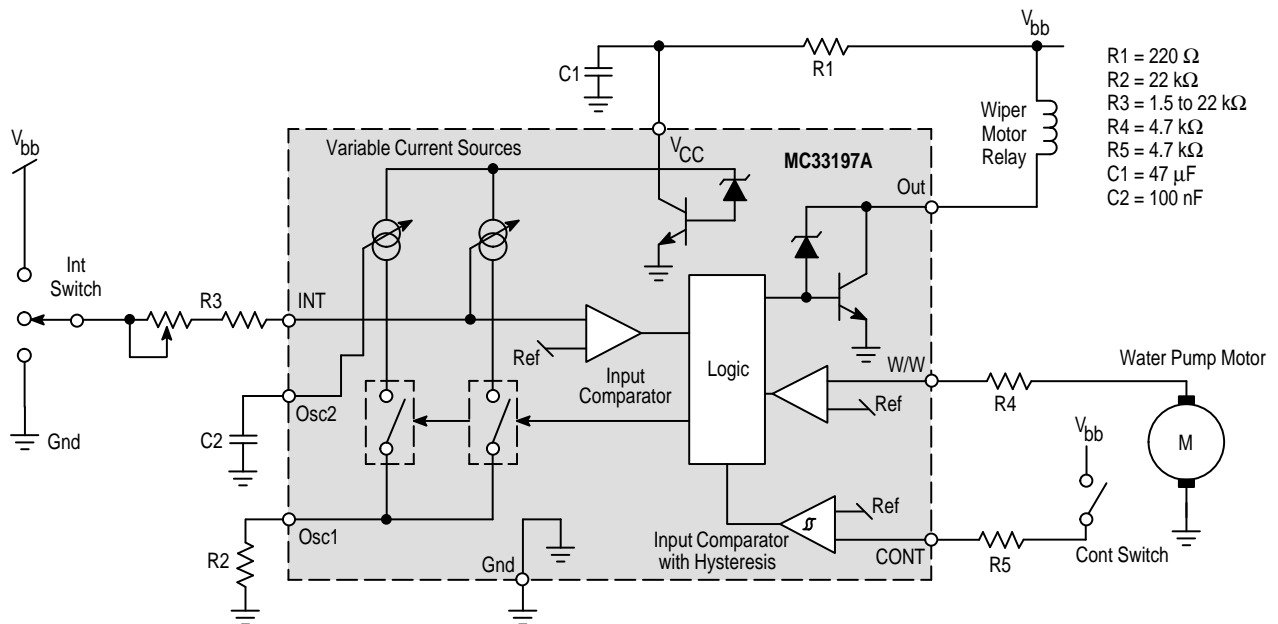
$T_A = -40^\circ$ to $+105^\circ\text{C}$, Case 751

MC33197AP

$T_A = -40^\circ$ to $+125^\circ\text{C}$, Case 626

The MC33197A is a standard wiper timer control device designed for harsh automotive applications. The device can perform the intermittent, after wash, and continuous wiper timer functions. It is designed to directly drive a wiper motor relay. The MC33197A requires very few external components for full system implementation. The intermittent control pin can be switched to ground or V_{bat} to meet a large variety of possible applications. The intermittent timing can be fixed or adjustable via an external resistor. The MC33197A is built using bipolar technology and parametrically specified over the automotive ambient temperature range and 8.0 to 16 V supply voltage. The MC33197A can operate in both front and rear wiper applications.

- Adjustable Time Interval of Less Than 500 ms to More Than 30 s
- Intermittent Control Pin Can Be Switched to Ground or V_{bat}
- Adjustable After Wipe Time
- Priority to Continuous Wipe
- Minimum Number of Timing Components
- Integrated Relay Driver With Free Wheeling Protection Diode
- Operating Voltage Range From 8.0 to 16 V
- For Front Wiper and Rear Wiper Window Applications



Automotive ISO 9141 Serial Link Driver

MC33199D

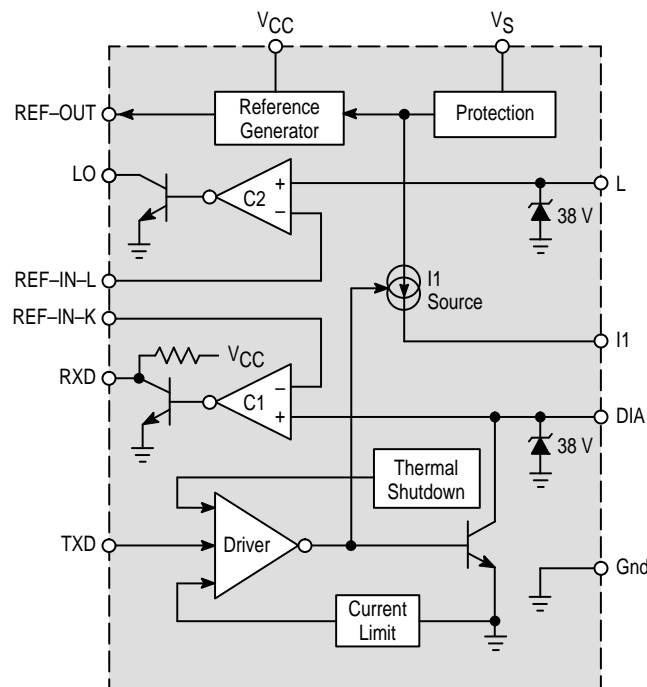
$T_A = -40^\circ$ to $+125^\circ\text{C}$, Case 751A

The MC33199D is a serial interface circuit used in diagnostic applications. It is the interface between the microcontroller and the special K and L Lines of the ISO diagnostic port. The MC33199D has been designed to meet the "Diagnosis System ISO 9141" specification.

The device has a bi-directional bus K-Line driver, fully protected against short circuits and over temperature. It also includes the L Line receiver, used during the wake up sequence in the ISO transmission.

The MC33199 has a unique feature which allows transmission baud rate up to 200 k baud.

- Electrically Compatible with Specification "Diagnosis System ISO 9141"
- Transmission Speed Up to 200 k Baud
- Internal Voltage Reference Generator for Line Comparator Thresholds
- TXD, RXD and LO Pins are 5.0 V CMOS Compatible
- High Current Capability of DIA Pin (K-Line)
- Short Circuit Protection for the K-Line Input
- Over Temperature Shutdown with Hysteresis
- Large Operating Range of Driver Supply Voltage
- Full Operating Temperature Range
- ESD Protected Pins



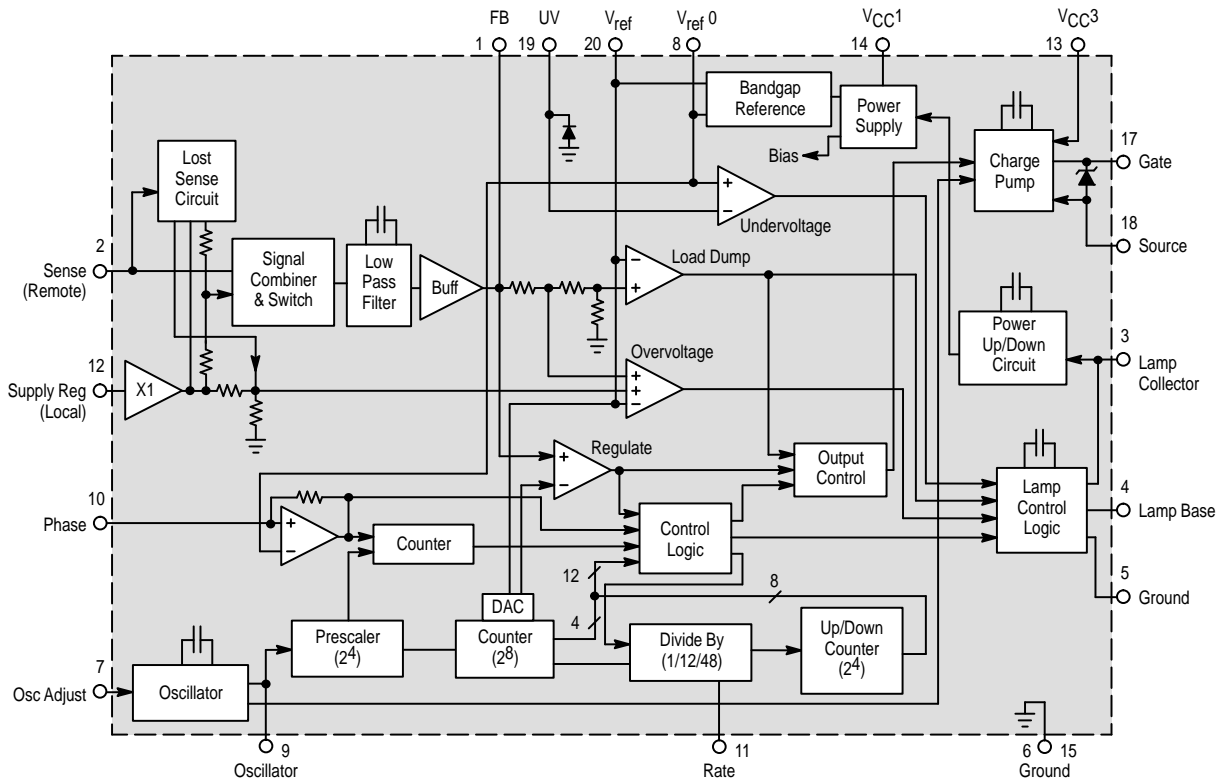
Alternator Voltage Regulator

MC33092DW

$T_J = -40^\circ$ to $+125^\circ\text{C}$, Case 751D

Provides voltage regulation and load response control in diode rectified 12 V alternator charging systems. Provides externally programmed load response control of the alternator output current to eliminate engine speed hunting and vibration due to sudden electrical loads. Monitors and compares the

system battery voltage to an externally programmed set point value and pulse width modulates an N-channel MOSFET transistor to control the average alternator field current. In addition, has duty cycle limiting, under/overvoltage and phase detection (broken belt) protective features.



ISO Serial Link Interface

MC33290D, P

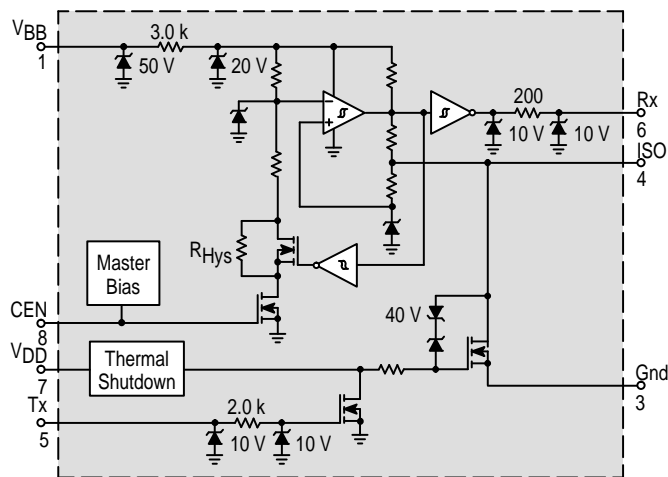
$T_A = -40^\circ$ to $+125^\circ\text{C}$, Case 751, 626

The MC33290 is a serial link bus interface device designed to provide bi-directional half-duplex communication interfacing in automotive diagnostic applications. It is designed to interface between the vehicle's on-board microcontroller and systems off-board the vehicle via the special ISO K-line. The MC33290 is designed to meet the "Diagnostic Systems ISO9141" specification. The device's K-line bus driver's output is fully protected against bus shorts and over temperature conditions.

The MC33290 derives its robustness to temperature and voltage extremes from being built on a *SMARTMOS*[™] process, incorporating CMOS logic, bipolar/MOS analog circuitry, and DMOS power FETs. Though the MC33290 was principally designed for automotive applications, it is suited for other serial communication applications. It is parametrically specified over an ambient temperature range of $-40^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ and $8.0\text{ V} \leq V_{\text{Bat}} \leq 18\text{ V}$ supply. The economical 8 pin

DIP and SO-8 surface mount plastic packages make the MC33290 very cost effective.

- Designed to Operate Over Wide Supply Voltage of 8.0 to 18 V
- Ambient Operating Temperature of -40°C to 125°C
- Interfaces Directly to Standard CMOS Microprocessors
- ISO K-Line Pin Protected Against Shorts to Ground
- Thermal Shutdown with Hysteresis
- Maximum Transmission Speeds in Excess of 50 k Baud
- ISO K-Line Pin Capable of High Currents
- ISO K-Line can be Driven with up to 10 nF of Parasitic Capacitance
- 8.0 kV ESD Protection Attainable with Few Additional Components
- Standby Mode: No V_{Bat} Current Drain with V_{DD} at 5.0 V
- Low Current Drain during Operation with V_{DD} at 5.0 V



Basic Octal Serial Switch with Serial Peripheral Interface I/O

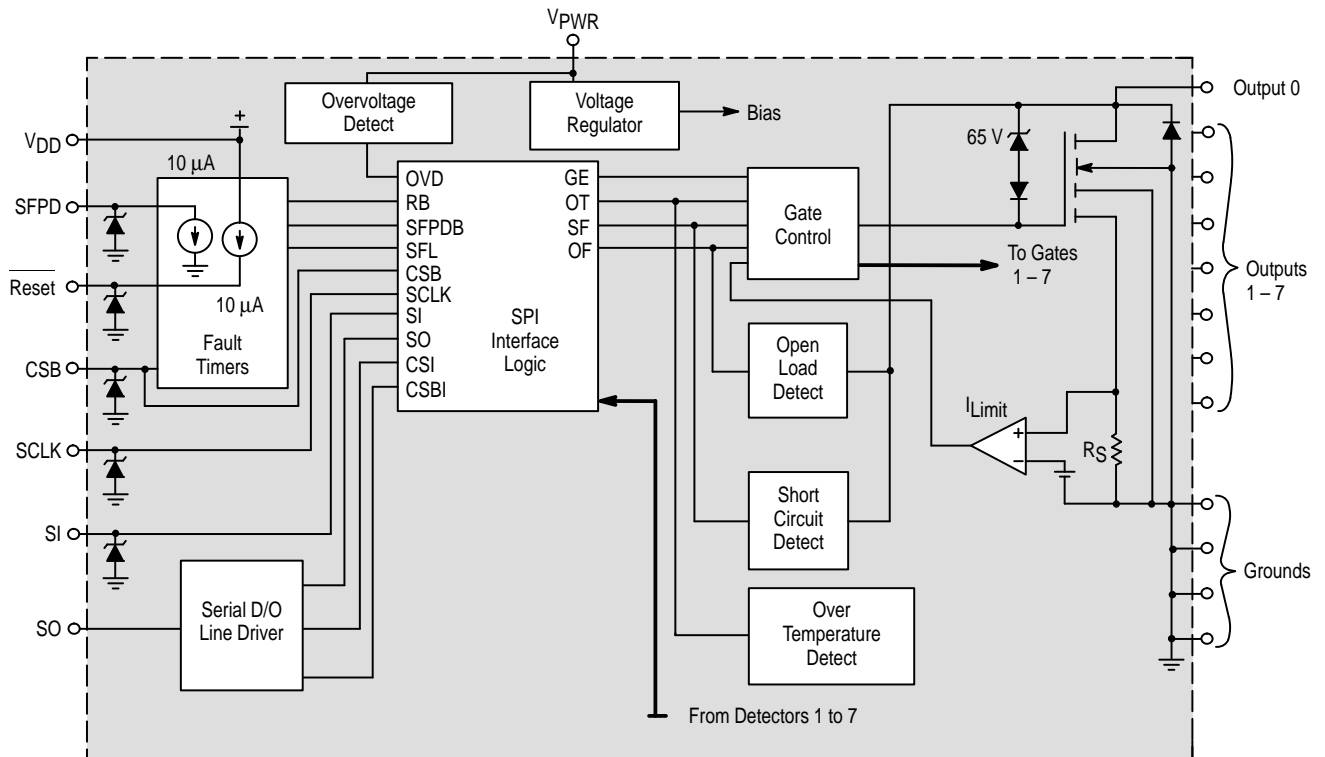
MC33291DW

$T_A = -40^\circ$ to $+125^\circ\text{C}$, Case 751E

The MC33291 is an eight output low side power switch with 8 bit serial input control. The MC33291 is a versatile circuit designed for automotive applications but is well suited for other environments. The MC33291 incorporates SMARTMOS™ technology, with CMOS logic, bipolar/MOS analog circuitry, and DMOS power MOSFETs. The MC33291 interfaces directly with a microcontroller to control various inductive or incandescent loads. The circuit's innovative monitoring and protection features are: very low standby current, SPI cascadable fault reporting, internal 55 V clamp on each output, output specific diagnostics, and independent shutdown of outputs. The device is parametrically specified over an ambient temperature range of $-40^\circ\text{C} \leq T_A \leq 125^\circ\text{C}$ and $9.0\text{ V} \leq V_{PWR} \leq 16\text{ V}$ supply. The economical SO-24 wide body surface mount plastic packages makes the MC33291 very cost effective.

- Designed To Operate Over Wide Supply Voltage of 5.5 V to 26.5 V
- Interfaces Directly with Microprocessor using 8 Bit SPI I/O Protocol to 3.0 MHz

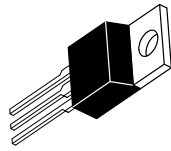
- 1.0 A Peak Current Outputs with Maximum $R_{DS(on)}$ of $1.4\ \Omega$ at $T_J = 150^\circ\text{C}$
- Outputs Current Limited to 1.0 – 3.0 A for Switching Incandescent Loads
- Output Voltages Clamped to 55 V during Inductive Switching
- Maximum Sleep Current (I_{PWR}) of $25\ \mu\text{A}$ with Reset Low
- Maximum of 4.0 mA I_{DD} during Operation
- Maximum of 2.0 mA I_{PWR} during Operation with All Outputs ON
- Open Load Detection (Outputs OFF)
- Overvoltage Detection and Shutdown
- Outputs have Independent Over Temperature Detection and Shutdown
- Output Mode Programmable for Sustained Current Limit or Shutdown
- Independent Output Short Circuit Detect and Latch-Off for Every Write Cycle
- Designed for -40°C to $+125^\circ\text{C}$ Ambient Temperature Operation



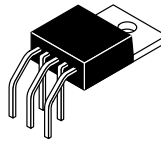
Automotive Electronic Circuits Package Overview



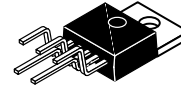
CASE 29
Z SUFFIX



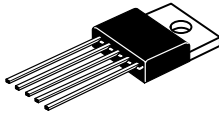
CASE 221A
T SUFFIX



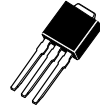
CASE 314A
TH SUFFIX



CASE 314B
TV SUFFIX



CASE 314D
T, T-1 SUFFIX



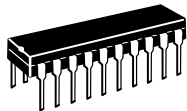
CASE 369
DT-1 SUFFIX



CASE 369A
DT SUFFIX



CASE 626
P, NO SUFFIX



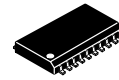
CASE 738
P SUFFIX



CASE 751
D SUFFIX



CASE 751A
D SUFFIX



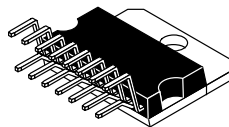
CASE 751D
DW SUFFIX



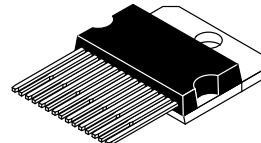
CASE 751E
DW SUFFIX



CASE 751G
DW SUFFIX



CASE 821C
TV SUFFIX



CASE 821D
T SUFFIX



CASE 936
D2T SUFFIX



CASE 936A
D2T SUFFIX