

Introduction

For better or worse, automobile alarm systems are a fast-growing segment of the automotive aftermarket. This note briefly describes some of the more common systems, some ideas for future development, and how the MIC5010 family of high side MOSFET drivers can ease their design while improving performance and reliability.

Automotive Alarm Background

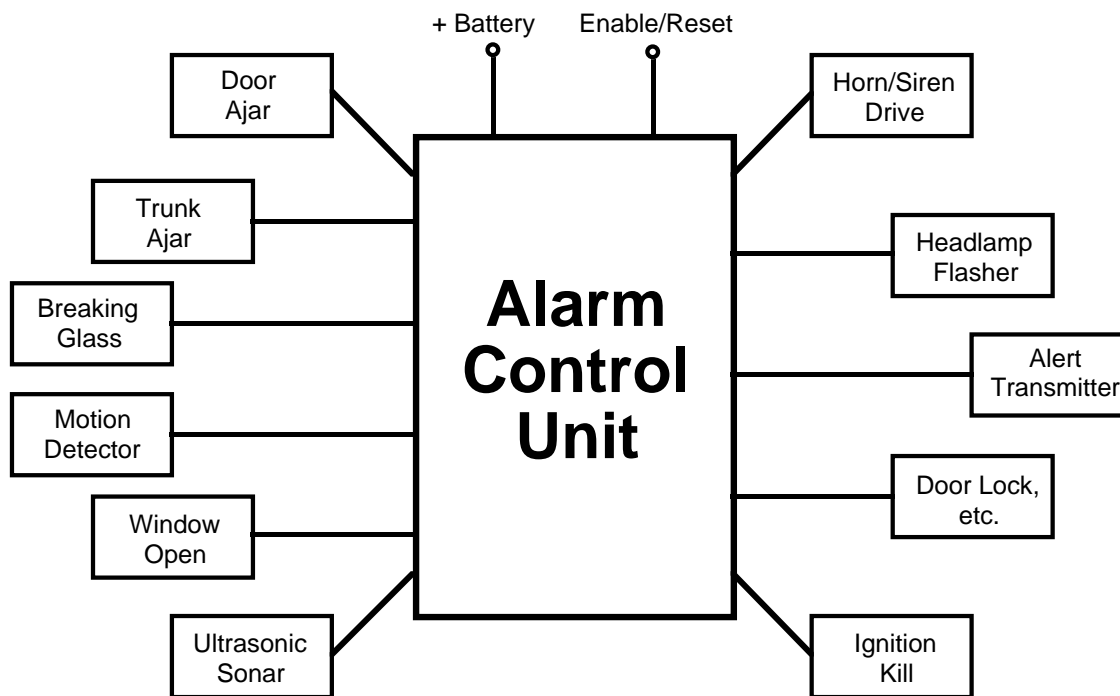
The typical automotive alarm system consists of three main blocks: sensors for intrusion detection, the control unit, and output devices for alerting passersby or disabling the vehicle.

Sensors vary from electronic ultrasonic intrusion detectors and audio devices (microphones and audio amplifiers) for vibration and glass breakage detection, through a mercury switch for motion detection, to electromechanical contact switches showing an open door, trunk or hood.

The control unit is the processing device. It enables and disables the sensors and output devices, and knows whether an input is expected or is cause for alarm.

Alarm system output devices range from simple, already installed standard automobile accessories such as the horn and headlamps, through accessory sirens, to more exotic systems such as an alerting transmitter or ignition "kill" switch. Some proposed systems have provisions for cellular telephone output for calling the authorities(!). "Help me! I'm being stolen.....! This is a recording....." Figure 1 shows a typical alarm system, including sensors, a control unit, and outputs, and Table 1 shows some typical inputs and actions.

Alarms have three main modes: disarmed, armed, and alert (or emergency). In disarmed mode, the alarm is transparent to the user. When armed, the control unit enables the sensors and awaits input. There are usually two types of alerts—one is immediate, triggered by breaking glass, for example; the



INPUT

OUTPUT

Figure 1. Automobile Alarm System Typical Block Diagram

Table 1. Alarm System Typical Input & Output

Input	Output (Set Mode)	Output (Emergency Mode)
Door Ajar Switch	Raise Window	Horn
Hood Ajar Switch	Lock Door	Flash Headlamps
Trunk Ajar Switch	Close & Lock Sunroof or Moonroof	Siren
Motion detector	Lights off (timer)	Pager/Alert Transmitter
Glass Breakage Detector (audio)	Close Convertible Top	Kill Ignition
Ultrasonic Detector	Enable Alarm	(Phone police)

other is delayed and occurs after a door is opened, allowing the owner time to disarm the system. Output devices are turned on, either immediately or after a reset delay.

Newer systems have an additional mode—a set mode, where the car is readied for safe parking. Upon initialization, the control unit checks the status of door locks, windows, sunroof/moonroof, convertible top, etc., and closes and locks each if necessary. Then normal alarm arming takes place.

Design Philosophy

Like most automotive products, several design goals are specified. Automobile alarms must be small in size, operate from the 12V negative ground battery system, have low standby current drain, operate over a wide temperature range, withstand reversed supply polarity and electrical load dumps, etc.

The control unit is designed for high reliability and low power consumption. CMOS logic is extensively employed. The output devices are moderate to high current drains, and require power switching devices. "High Side", or positive rail, switching is preferred due to the chassis negative ground electrical system.

Some systems use a single system board while others use distributed control, sense, and drive boards. If distributed, communications is provided through serial or 4 bit parallel data busses.

All systems require one or more power switches to cause or control actions in the "real" world by switching anywhere from 1 to 30 Amperes.

Load Switching

Switching 1A to 30A or so loads is non-trivial. Most present-day systems use relays for load control. Relays have several problems associated with their use (see Table 2). A far more ideal switch is the Power MOSFET, with its smaller size, lower cost, higher reliability, and minute drive requirements. Almost all automotive electrical systems have a negative chassis ground. Safety and this "common" point constraint requires that most electrical power switching be done in the positive path—"High-Side" switching is preferred. Thus, alarm system outputs should be high-side controlled. Using a Power MOSFET in the high-side mode requires the FET gate voltage be switched from a low level "OFF" state to an "ON" state where the gate is at a voltage higher than V_{CC} . Generating and controlling this high switching voltage has required large

amounts of external circuitry in the past, effectively restricting the Power MOSFET from the automobile. The MIC5010 High Side FET Driver family combines all necessary high side driving functions into a single IC package, and allows the economic and reliable introduction of DMOS to automotive electronics.

The MIC5010 FET Driver Family

The MIC5010 family of high- and low-side FET drivers is ideally suited to this application. Configured as a high side driver, the MIC5010 will take a CMOS control input and drive the gate of an N-Channel MOSFET above the positive supply. The low power MIC5010 family employs CMOS logic for compatibility and a charge-pump voltage tripler with internal capacitors for gate voltage generation. CMOS input compatibility guarantees proper termination for the controller logic, and the power MOSFET can be protected by adjustable current limiting, all controlled by the MIC5010 (or MIC5013). The relatively fast switching speed of the MIC5010 family of drivers reduces the power dissipation of the MOSFET by quickly transiting from the no current, high V_{DS} off state to the high current, low voltage ON state. The benefit is both increased reliability and little or no heat sinking required (depending on the size of power MOSFET employed).

The MIC5010 family has four members, the "full featured" MIC5010, with over-current limiting, fault detection, speed-up capacitor options, and an extra ENABLE input; the no-external-parts MIC5011; the dual driver MIC5012; and the MIC5013, offering over-current protection with fault signalling in an 8-pin package. Table 3 summarizes the features and differences between the variants.

Table 2. Switches for Alarm Outputs

Power MOSFET Advantages vs. Relays

- Extremely low drive current requirement
- Smaller size
- Lighter weight
- Non-mechanical (much longer life)
- No contact bounce
- Lower cost

Power MOSFET Advantages vs. PNP

- No fixed voltage drop
- Extremely low drive current requirement
- Larger Safe Operating Region

MIC5011

The lowest cost member of the 5010 family, the 8-pin MIC5011 requires no external components for high-side driving applications. As shown in Figure 2, when a logic HIGH is forced on the input, the oscillator and charge pump begin their voltage tripling action. The output charges the FET gate capacitor and turns on the FET. Standard Power MOSFETs are damaged if V_{GS} is greater than 20V, but are not fully on unless V_{GS} is around 10V. The internal 12.5V zener diode connecting the FET gate and source limits the voltage multiplication action so that V_{GS} is approximately 12.5V, a value that ensures low ON resistance as well as long FET life.

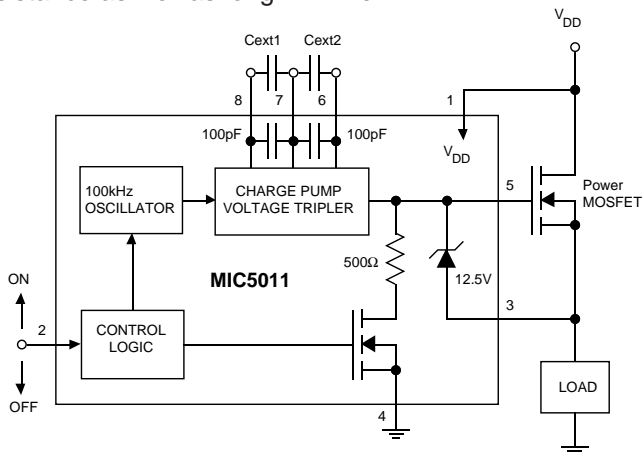


Figure 2. MIC5011 Block Diagram

Inductive loads, such as the horn or headlight relay, give many drivers problems. The MIC5011 takes inductive loads in stride, however, and a "catch" diode to clamp inductive flyback spikes is not even necessary (see Figure 3). As an inductive load is switched off, a negative flyback pulse is applied to the FET source. The MIC5011 holds the gate firmly near ground level, sourcing or sinking current as required. The resultant $+V_{GS}$ ($V_G=0$, V_S =negative) temporarily biases ON the FET and dissipates the spike (See Application Note 1, *MIC5011 Design Techniques*, for full details).

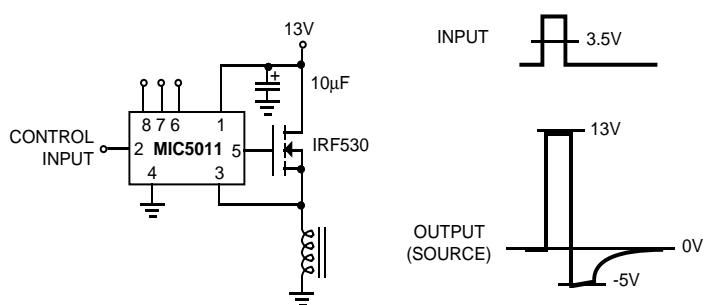


Figure 3. Inductive Spike Clamping

MIC5012

The MIC5012 is a dual version of the MIC5011. Two completely independent drivers control two loads from one 14-pin (16-pin surface mount) package. Operationally, each half of the MIC5012 is identical to the MIC5011.

MIC5013

When over-current protection is required, the 8-pin MIC5013 should be used. In a basic application, MIC5013 circuitry is similar to the MIC5011 or MIC5012. However, by adding four resistors, the MIC5013 can act as a circuit breaker; its output switches off if load current exceeds a user-determined value. As shown in Figure 4, the user has three design variables for limit selection, allowing a small sense resistor, R_S , for best efficiency. R_{TH} sets the internal voltage comparison threshold; current limit is inversely proportional to R_{TH} . R_1 and R_2 may be eliminated in many applications where the load is generally resistive and open loads are not expected. See the MIC5013 datasheet for full details on flexibly programming the current trip point.

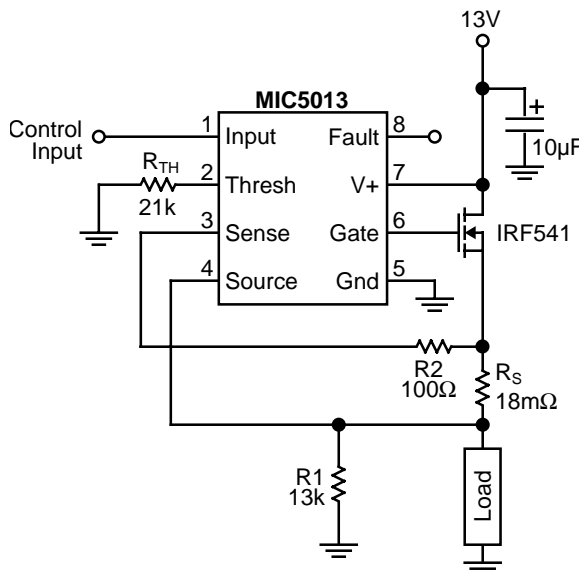


Figure 4. Current Protected Driver

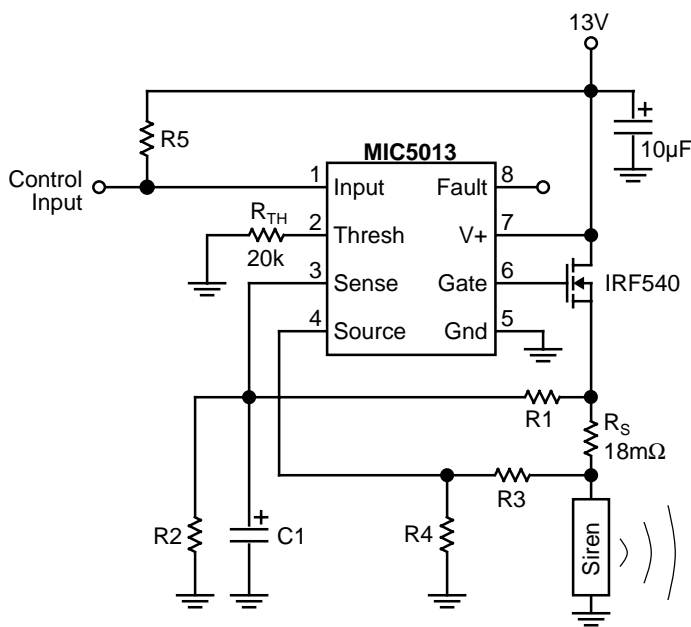
Automotive Alarm Hint: Remote Siren Drive with Automatic Shutdown

High security alarm systems provide an alert mechanism if the control unit is compromised. Figure 5 shows a circuit that :

- Is controlled by a single small gauge wire
- Is remotely mounted, perhaps under the hood
- **Will automatically switch ON if the control line is cut**
- Will reset itself after a time delay
- Requires only a MIC5013, a FET, and a few passive components

The circuit is built on a small board, and may be attached to the siren (or other output device) directly. The MIC5013 is configured with a direct battery line, ground and a single control line. If the alarm output unit is compromised by severing the control line, pull-up resistor R_S enables the MIC5013, which activates the FET, and the siren sounds.

Basically, the circuit operates in a standard current detect mode. The difference is that an additional capacitor, C_1 , begins to charge through R_1 as soon as the alarm activates.



Circuit sounds immediately upon Control Input triggering or Control Input disconnect (cut) and will reset after $t \approx 120$ seconds.

- R1 = 91kΩ
- R2 = R3 = 100 kΩ
- R4 = 68kΩ
- R5 = 470kΩ
- C1 = 100μF

Figure 5. MIC5013 Driver With Automatic Sound/Reset

As the voltage across C_1 exceeds the voltage on Pin 4 plus the V_{TH} set by R_{TH} , an over-current condition is simulated, and the output is shut down. Reset occurs with control line cycling or power interruption. This means that the siren will sound once, for a fixed amount of time, and then silence itself in accordance with some local laws and good engineering practice (not to mention preventing total battery discharge).

Because the MIC5013 takes almost no current in the OFF or standby modes (0.1μA, typical), both it and the driven FET can be directly connected to the battery.

Conclusion

The automotive alarm marketplace demands smaller and less expensive yet more reliable methods for output load drive and control. In alarm applications, where standby current drain is paramount, the low power MIC5010 series allows easy interface with low power CMOS logic control while providing all necessary drive control for small, efficient Power MOSFETs. For applications where the output devices are original equipment—horns and headlamps, for example—and the control unit drives the stock horn relay or headlamp relay, the MIC5011 or MIC5012 dual FET drivers are suggested. Where high current loads are directly driven, the protection offered by the MIC5013 is attractive.

The winning combination of MIC5010 drivers and Power MOSFET switches enables configuring a simple, hence reliable, and rugged alarm system.

Table 3. Comparing the MIC5010 Family Options

Device	Features
MIC5010	<ul style="list-style-type: none"> • Over Current Sensing • Fault Flag Output • 14-Pin DIP or Surface Mount Packages • Provision for Optional Speed-Up Capacitors • Over Current Enable Pin
MIC5011	<ul style="list-style-type: none"> • No External Components Required • Provision for Optional Speed-Up Capacitors • 8-Pin DIP or Surface Mount Packages
MIC5012	<ul style="list-style-type: none"> • Dual High Side Driver • No External Components Required • 14-Pin DIP or 16-Pin Surface Mount Packages
MIC5013	<ul style="list-style-type: none"> • Over Current Sensing • Fault Flag Output • 8-Pin DIP or Surface Mount Packages