



APPLICATION NOTE 3951

## Power-Save Mode Reduces Power Consumption When Driving Relays

*Abstract: This application note discusses a relay driver, the MAX4822/MAX4824, with an internal power-save circuit that reduce overall power consumption. In a typical application, overall power savings ranges from 5.5% to 68.5%, depending on the type of relay used. Power-save mode also helps to reduce the size and cost of the power supply used to supply the relay coils. The overall result will be smaller and less-expensive systems.*

### Introduction

Certain types of equipment such as telecommunications or automated test equipment (ATE) often use multiple banks of relays to achieve nearly lossless switching of almost any kind of signal. In these products, many relay coils can be supplied from a single power supply, which must be large enough to drive all the coils simultaneously. In addition, the relays can be densely packed into a very small area, making power dissipation from the coils a design concern. Relays require a significantly higher voltage across the coil to become energized than to remain energized. Knowing this, it is possible to design a circuit that will reduce the drive current through the coil to save power. This application note discusses a relay driver device that features an internal power-save circuit to help reduce overall power consumption.

### The Power-Save Design Approach

The [MAX4822/MAX4824](#) relay drivers include a power-save feature that reduces the voltage across the driver a short time after the FET is first turned on. Initially, the output driver is a fully saturated FET that is turned completely on. After an adjustable timeout period, the voltage across the FET is regulated to a register programmable value. The timeout period is adjustable with an external capacitor (**Figure 1**).

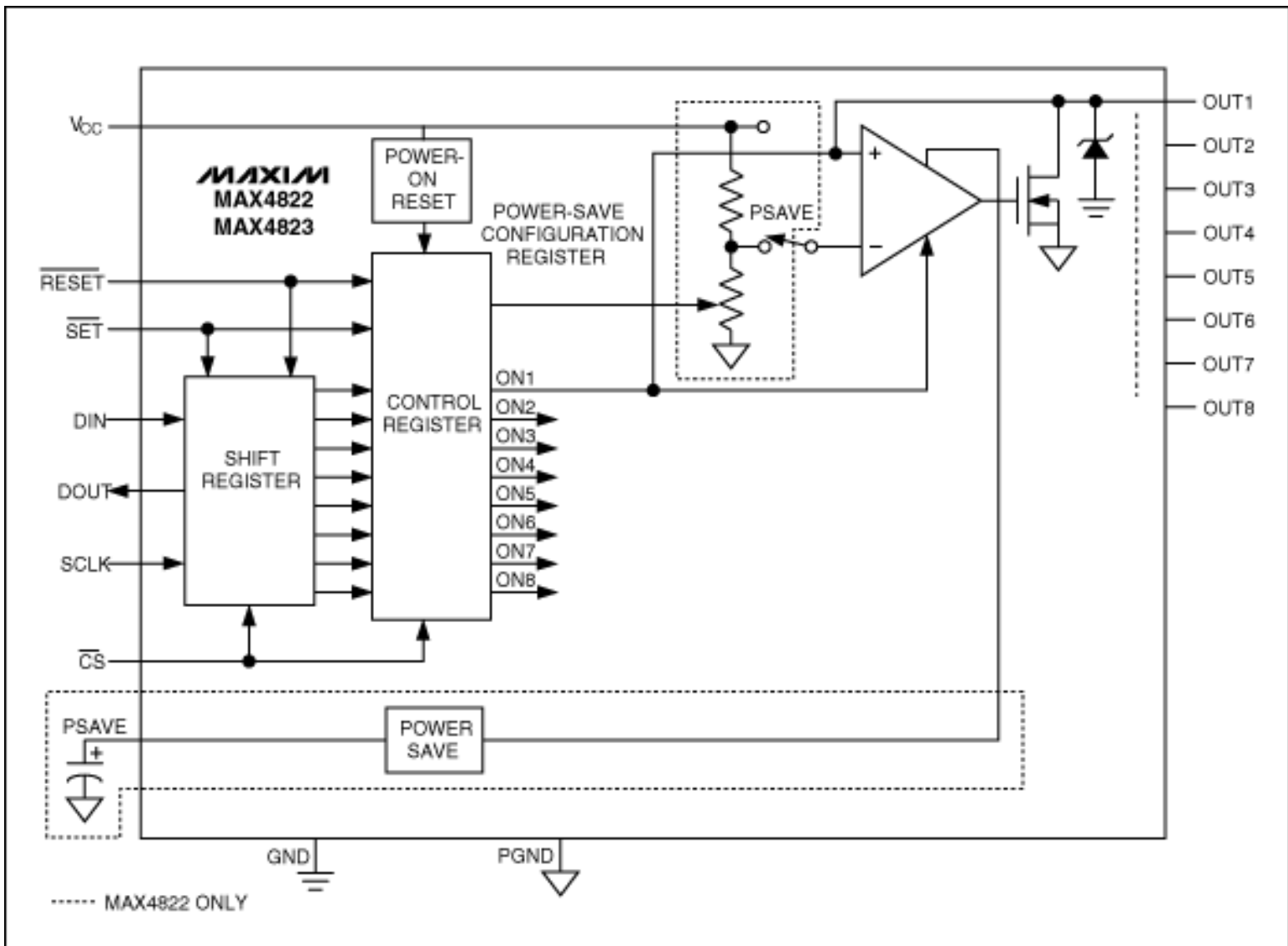


Figure 1. Functional diagram of the MAX4822.

The power-save feature reduces both the overall power dissipation in the relay coil and the power consumed from the supply. The output drivers of the devices have both an ON and an OFF state.

The ON state has two different states, called the "initial state" and the "power-save state." During the initial state, the output FET is fully saturated and turned completely on. After a timeout period set by the capacitor on the PSAVE pin, the device goes into its power-save state in which the voltage across the FET is regulated by use of a control loop.

To illustrate the savings in power-save mode, one can compare the power consumed in each of the two ON states. Consider, for example, a relay with a coil that has a 100Ω DC resistance and a system using a 5V supply. **Figure 2** shows the relay coil modeled as an ideal inductor with a resistance of  $R_{COIL}$ .

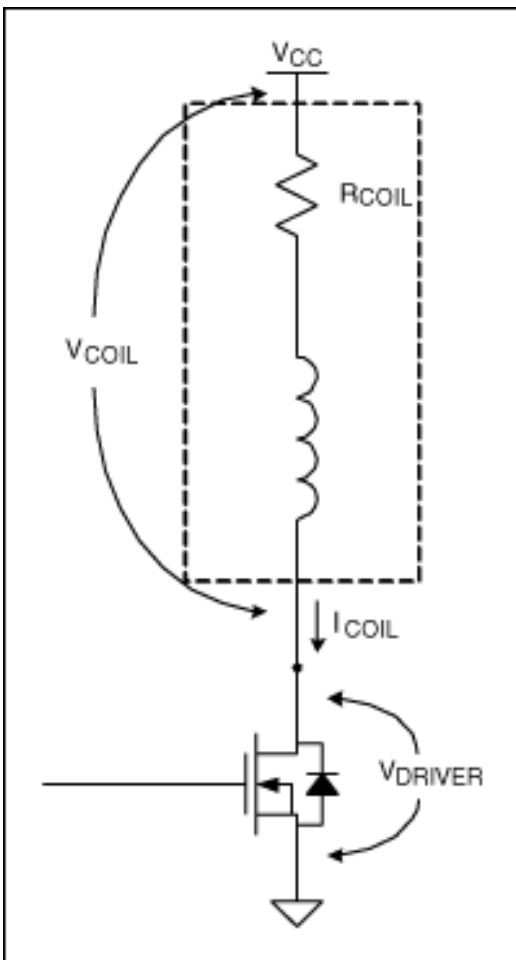


Figure 2. Model of a FET driving a relay coil. The coil is modeled as an ideal inductor with a series resistance of  $R_{COIL}$ .

During the initial state, the MAX4822/MAX4824 output resistance is  $5\Omega$ , max. Therefore, the power dissipated is found as:

$$I_{COIL} = 5V/105\Omega = 47.6mA$$

$$P_{COIL} = I_{COIL}^2 \times R_{COIL} = 47.6mA^2 \times 100\Omega = 0.227W$$

$$P_{DRIVER} = I_{COIL}^2 \times R_{DRIVER} = 47.6mA^2 \times 5\Omega = 0.011W$$

$$P_{TOTAL\_INIT} = 0.238W$$

The analysis of power dissipation is somewhat different during the power-save state. The power dissipated by the coil must first be quantified, and then the power dissipated by the driver is quantified. One then simply totals the values together.

During the power save state, the voltage at the FET output is regulated to some percentage of the supply voltage as set by an internal register. This means that the voltage called  $V_{DRIVER}$  in Figure 2 is regulated by the internal control loop. Returning to our example, assume that  $V_{DRIVER}$  is 50% (although the MAX4822/MAX4824 allow a range from 10% to 70%). Therefore, the power dissipation in the coil is found by:

$$V_{COIL} = 5V - (50\% \times 5V) = 2.5V$$

$$I_{COIL\_PS} = V_{COIL}/R_{COIL} = 2.5V/100\Omega = 0.025A$$

$$P_{COIL} = 2.5V \times 25mA = 0.0625W$$

To find the dissipation in the driver, remember that the current will be the same as the coil current:

$$I_{DRIVER\_PS} = 0.025A$$

$$V_{DRIVER} = 50\% \times 5V = 2.5V$$

$$P_{DRIVER} = 0.0625W$$

$$P_{\text{TOTAL\_PS}} = 0.125\text{W}$$

$$\text{SAVINGS} = 1 - P_{\text{TOTAL\_PS}}/P_{\text{TOTAL\_INIT}}$$

Therefore, in this example, power-save mode saves 47.5% when compared to the power consumed in the initial state.

There is an alternate equation for calculating the savings. Note that the information needed to calculate the power savings is already available once the current is known:

$$P_{\text{TOTAL\_PS}} = V_{\text{CC}} \times I_{\text{COIL\_PS}}$$

$$P_{\text{TOTAL\_INIT}} = V_{\text{CC}} \times I_{\text{DRIVER\_INIT}}$$

$$\text{SAVINGS} = 1 - I_{\text{COIL\_PS}}/I_{\text{DRIVER\_INIT}}$$

This alternate formula for the savings illustrates why the power-save mode actually saves power: the current drawn from the supply is reduced, while the supply voltage itself remains the same.

A table can be easily constructed to show the possible savings for each setting in the MAX4822/MAX4824. For this table,  $V_{\text{CC}} = 5\text{V}$ ,  $R_{\text{DRIVER}} = 5\Omega$ ,  $R_{\text{COIL}} = 100\Omega$ , as in the example above.

Driver Setting (n)	$V_{\text{DRIVER}}$	$V_{\text{COIL}}$	Savings (%)
10%	0.50	4.50	5.5
20%	1.00	4.00	16.0
30%	1.50	3.50	26.5
40%	2.00	3.00	37.0
50%	2.50	2.50	47.5
60%	3.00	2.00	58.0
70%	3.50	1.50	68.5

Notice that the savings possible increases with the setting in the driver. It is, however, important to note that for the highest setting, the voltage across the relay coil is only 1.5V which may not be enough to "hold" it in the ON position.

## Summary

The power-save feature of the MAX4822/MAX4824 relay drivers allows a significant reduction in the power consumed by monostable relays when in the ON state. In the example shown here, overall power consumption reduced by 47.5%. Testing shows that the savings can range from 5.5% to 68.5%, depending on the type of relay used. This power-save feature can also help to reduce the size and cost of the power supply that is supplying the relay coils, a step that results in smaller and less-expensive systems.

---

Application Note 3951: [www.maxim-ic.com/an3951](http://www.maxim-ic.com/an3951)

### More Information

For technical support: [www.maxim-ic.com/support](http://www.maxim-ic.com/support)

For samples: [www.maxim-ic.com/samples](http://www.maxim-ic.com/samples)

Other questions and comments: [www.maxim-ic.com/contact](http://www.maxim-ic.com/contact)

---

### Automatic Updates

Would you like to be automatically notified when new application notes are published in your areas of interest? [Sign up for EE-Mail™.](#)

---

**Related Parts**

MAX4822: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

MAX4824: [QuickView](#) -- [Full \(PDF\) Data Sheet](#) -- [Free Samples](#)

AN3951, AN 3951, APP3951, Appnote3951, Appnote 3951

Copyright © by Maxim Integrated Products

Additional legal notices: [www.maxim-ic.com/legal](http://www.maxim-ic.com/legal)