AN2257

Choosing the Right EERAM VCAP Capacitor

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INTRODUCTION

This application note provides guidelines for both selecting and placing a VCAP capacitor (CVCAP) for the devices enumerated below (see EERAM Part Numbers).

EERAM Part Numbers

Device	
47C04	48L256
47L04	48L512
47C16	48L640
47L16	48LM01
47L64	

AUTOSTORE

This application note assumes the EERAM device will utilize the EERAM AutoStore function for automatic backup of the SRAM data to EEPROM on system power loss or system brown-out. The AutoStore function is optional on some devices. If used for any automatic EEPROM backups, then this application note applies.

To enable AutoStore on the 47X04 and 47X16 devices, set the ASE (AutoStore Enable) bit in the STATUS register to '1'. To enable AutoStore on the 48L640, 48L256, 48L512 and 48LM01 devices, set the ASDIS bit in the STATUS register to '0'. In the 47L64 device, AutoStore is always enabled.

Install a capacitor connected between the VCAP pin and ground, as seen in Figure 1 (I^2C) or Figure 2 (SPI). The rest of this document discusses how to choose this capacitor. If the AutoStore is enabled and if the SRAM array has been modified, then the AutoStore function begins using the VCAP voltage as a temporary power source.

FIGURE 1: TYPICAL I^2C APPLICATION

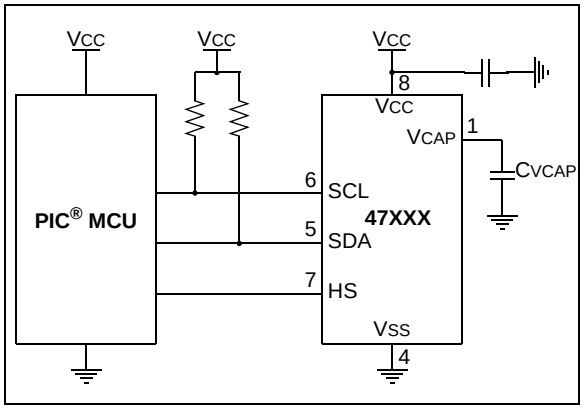
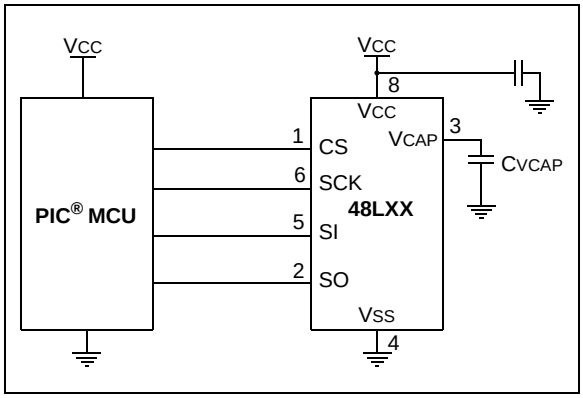
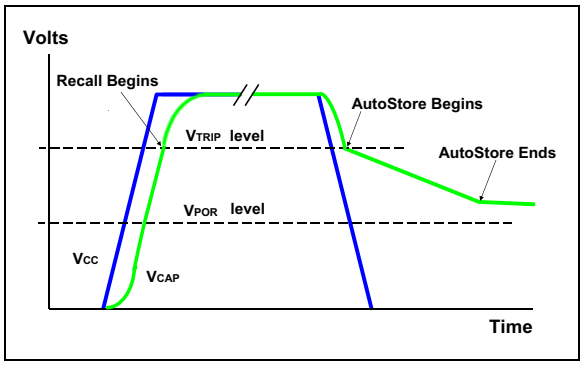


FIGURE 2: TYPICAL SPI APPLICATION



As seen in Figure 3, after power is applied to the VCC pin, the voltage across the VCAP capacitor also rises. A switch inside the device connects the VCAP pin to the VCC pin on power-up. As the voltage at VCAP increases and passes the VTRIP level, the Recall function begins, powered by VCC, where the EEPROM data is copied into the SRAM array. The time for the recall is very brief, taking less than 10 ms. While the VCC voltage remains in the normal operating range, the internal switch stays on, keeping the VCAP voltage at VCC level.

FIGURE 3: AUTOSTORE VOLTAGES



When power is removed and VCC falls, VCAP voltage will fall as well, but when the internal power rail falls below VTRIP, the device automatically disconnects the switch between VCAP and VCC, and this allows the capacitor to provide the power, independent of VCC, for the duration of the AutoStore.

VCAP SELECTION

It is important to select a capacitor that will provide enough energy to finish the AutoStore operation without any loss of data. It also should not be too large as this may take longer to charge up when VCC is applied and could increase cost. The capacitor needs to be rated for the voltage and temperature expected in the application, and it needs to be specified so that changes in capacity due to age, temperature or voltage do not prevent a successful AutoStore over the full lifetime of the application.

CAPACITY REQUIREMENTS

The data sheets show the required minimum capacitance values to be used for the various EERAM devices. The devices were characterized across the entire specified operating range using these minimum values to ensure they would work reliably. But, these values are for the actual capacitance available to the device, not the rated capacitance of any particular capacitor.

The rated value and the actual capacitance value of different types of capacitors can differ greatly.

TOLERANCE

Part-to-part variations can cause problems in any production line. For the AutoStore operation, choosing a capacitor that has too little capacitance because of component variation could mean loss of data. It is important that this be taken into account when choosing a capacitor to be sure the minimum capacitance is still available under all operating conditions.

CAPACITOR TYPES

Multilayer Ceramic Capacitors (MLCCs)

MLCCs have unique particularities that must be taken into account. Certain ceramic chemistries, which are associated with the temperature codes as Y5V or Z5U, can exhibit significant capacitance loss as a function of operating voltage, known as the "DC bias" effect.

For this reason, it is recommended to use ceramic capacitors that are rated at least twice the minimum recommended capacitance value, and with a voltage rating of at least 10V. These will help to ensure that the ceramic capacitor is able to supply the power needed during the AutoStore operation.

Tantalum Capacitors

These capacitors offer the benefit of capacitance density, stability with temperature and little problem of aging. The tantalum capacitor works well with the EERAM device over the 100,000 (minimum) SRAM to EERAM back-up cycles and is the recommended choice for the EERAM VCAP. Since tantalum capacitor supply has been a concern in the past, we also recommend to reserve space in the footprint for an equivalent ceramic capacitor.

Aluminum Electrolytic Capacitors

While there are no aluminum capacitors listed in Table 1, primarily because of their height, an aluminum capacitor can be used with EERAM. These capacitors are low-cost but often have broad tolerance ranges and loss of capacitance due to aging. If this type is chosen, be sure that the minimum capacitance at the worst-case of tolerance and temperature over time is still enough to meet the minimum capacitance requirements.

OTHER CAPACITOR SPECIFICATIONS

Voltage Rating

As long as the voltage rating of the capacitor is above the absolute maximum voltage rating of the EERAM, then the voltage itself should not be a limiting factor. However, as found in the Multilayer Ceramic Capacitors (MLCCs), it can be beneficial to select capacitors with more than two times the expected applied voltage. A minimum capacitor voltage rating of 10V is recommended.

PCB Placement

The placement of the VCAP capacitor relative to the EERAM device is not critical, but as a good practice it should be kept close. The internal circuit in the EERAM uses a comparator to determine when to connect and disconnect the internal switches; it is not particularly sensitive, but it is still possible that significant external inductance in series with the VCAP could allow unexpected behavior. A distance of an inch (25 mm) or less is recommended. A standard 0.1 µF bypass capacitor is still required at the VCC pin, as close as possible, for reliable logic operation.

Cost

When evaluating BOM costs, discrepancies between expectation and reality can occur. One might expect that for a given type, voltage and package, a larger value capacitor would be more expensive than a lower value one. This is not always the case, as rarer parts will be more expensive.

For example, between the values of 10 µF and 22 µF, it is possible to find 15 µF or 18 µF capacitors, but these values may cost more than either of the other two more popular sizes. Since the EERAM can well tolerate a little more capacitance, it might be a better choice to select the lower-priced capacitor in the larger size. The selections in Table 1 were made on consideration of popularity (low cost) and dimensions.

CONCLUSION

When paired-up with appropriately sized capacitors, the EERAM device provides reliable and cost-effective data storage even when data is updated often and when power is lost suddenly and without warning. Choosing the right AutoStore capacitor means balancing physical characteristics to match the operating environment, while still providing enough energy storage to allow a complete and reliable store.

In this application note we have provided a list of acceptable capacitor sizes by EERAM device. The user can select one of the suggested capacitor types or choose a capacitor type that meets the minimum and maximum EERAM CVCAP specifications over temperature and time.

TABLE 1: RECOMMENDED VCAP CAPACITORS VALUES

EERAM Device	Minimum Specified Capacitance	Recommended Nominal Capacitance (10 VDC minimum rated)	Recommended Tantalum Capacitor	Recommended Ceramic Capacitor
47C04	3.5 µF	4.7 µF	4.7 µF	10 µF
47C16	5 µF	6.8 µF	6.8 µF	22 µF
47L04	5 µF	6.8 µF	6.8 µF	22 µF
47L16	8 µF	10 µF	10 µF	33 µF
47L64	22 µF	33 µF	33 µF	47 µF
48L640	22 µF	33 µF	33 µF	47 µF
48L256	47 µF	68 µF	68 µF	100 µF
48L512	47 µF	68 µF	68 µF	100 µF
48LM01	47 µF	68 µF	68 µF	100 µF

APPENDIX A: REVISION HISTORY

Revision A (August 2016)

Initial release of this document.

Revision B (April 2018)

Updated overall content to make the application note more understandable.

Note the following details of the code protection feature on Microchip devices:

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