Applying the STK11C88, STK15C88 and STK16C88 32K x 8 nvSRAM

Abstract

Simtek Corporation's family of high speed 256 kilobit nonvolatile Static Random Access Memories includes the STK15C88 *AutoStore*™ and STK11C88 Software Store and STK16C88 *AutoStorePlus*™ devices. All three memories have industry-standard 32K x 8 architectures and pin-outs (Figure 1), and are drop-in replacements for many standard SRAM and BatRAM products. As with all Simtek nvSRAM products, the STK11C88, STK15C88 and STK16C88 do not require batteries or other power sources to maintain nonvolatility for a guaranteed minimum of 100 years, even at high temperatures.

The STK15C88 *AutoStore*™ and STK16C88 *AutoStorePlus*™ memories both automatically *STORE* the SRAM data into EEPROM upon power loss, and require no external power storage components such as batteries or capacitors. They are available in speeds of 20, 25, 35, and 45 nanoseconds.

The STK11C88 Software Store memory is designed for safe storage of data under processor control. The STK11C88 virtually eliminates the danger of inadvertent data loss due to human error or electronics failure. It is ideally suited for applications that would normally require the combination of high speed SRAM and EEPROM, and performs both functions in one package. The resultant savings in board space, glue logic (parts count), and power consumption helps to reduce costs and increase packaging density. The STK11C88 is available in 20, 25, 35, and 45 nanosecond versions, and can be interfaced to most standard microprocessors without interface logic or memory wait states.

Both memories automatically *RECALL* nonvolatile data into the SRAM portion of the chip at power-up without processor intervention or external control. Simtek's family of nonvolatile memories give the product development engineer the ability to design modern embedded and state machines without the worry of data loss or corruption due to power failure.

SRAM Operations

The STK11C88, STK15C88 and STK16C88 nvSRAM memories are identical in the operation of their RAM front ends, and look to the design engineer like industry standard 32K x 8 fast SRAMs.

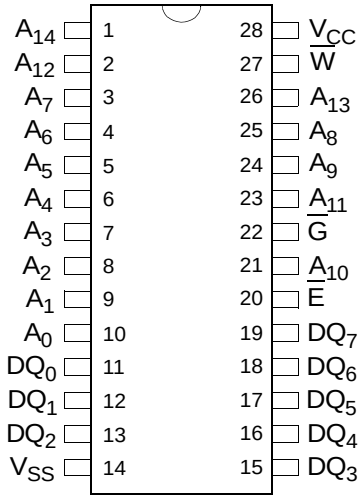

Figure 1
STK11C88/STK15C88/STK16C88 Pin-Out

The three control lines, Write Enable ($\overline{W}$), Chip Enable ($\overline{E}$), and Output Enable ($\overline{G}$) are utilized in the same manner as a standard SRAM. This front end functional equivalency allows improvements to be made to old designs without PWB (Printed Wiring Board) or control logic changes. The ability of Simtek's nvSRAM devices to run at processor bus speeds eliminates the need for wait states, bus control logic, or specialized decoder circuitry. This combination of speed and versatility in one package serves to simplify board layout and reduce device count.

SRAM Reads are performed whenever $\overline{E}$ and $\overline{G}$ are low and $\overline{W}$ is high. The output data on lines DQ_0 - DQ_7 corresponds to the address specified on pins A_0 - A_{14}.

SRAM Writes are performed whenever $\overline{E}$ and $\overline{W}$ are low. The data on pins DQ_0 - DQ_7 will be written into memory at the location specified by the address present on lines A_0 - A_{14}. The $\overline{G}$ (Output Enable)

line should preferably be held high during the entire Write cycle to avoid bus contention on the data lines.

The STK11C88, STK15C88 and STK16C88 are high speed memories and therefore must have a high frequency bypass capacitor of approximately 0.1µF connected between V_{CC} and ground. As with all high speed CMOS integrated circuits, careful routing of power, ground and signals will help to reduce noise induced problems.

STK11C88 Nonvolatile Operations

nvSRAM Store

The STK11C88 is a member of Simtek's "Software Store" nvSRAM family, and is designed for easy in-circuit programmability. Data that has been written to the STK11C88's SRAM is Stored to nonvolatile memory by reading six specific SRAM addresses in sequence. The Store operation is completely autonomous from that point, and requires no processor support nor external glue logic to complete. Once the *STORE* process is initiated, the STK11C88 is disabled and no SRAM accesses are allowed until the Store operation is completed (<10 ms). It is important that Read operations be used instead of Writes. SRAM Writes will invalidate the sequence. The following address sequence is used to start a memory *STORE* operation:

1. Read Address 0E38H
2. Read Address 31C7H
3. Read Address 03E0H
4. Read Address 3C1FH
5. Read Address 303FH
6. Read Address 0FC0H (Initiate *STORE* Cycle)

The chance of inadvertently reading the correct six addresses in sequence, and accidentally corrupting the data Stored in the STK11C88's nonvolatile section, is less than 1 chance in 10^{25}.

nvSRAM Recall

STK11C88 data is Recalled from nonvolatile memory to SRAM during power-up. A *RECALL* is automatically initiated when internal circuitry senses VCC levels rising above approximately 4.25 volts (V_{SWITCH}). Embedded processor wake-up sequences (power-on reset), should be delayed for a minimum of 550µs ($t_{RESTORE}$) after V_{SWITCH} to assure that data is completely recalled and to allow the system to stabilize before attempting nvSRAM accesses.

Data can also be recalled under software control in a manner similar to the *STORE* operation. Six addresses are read in sequence to initiate the transfer from nonvolatile memory to SRAM. The following address sequence is used to start a memory *RECALL*:

1. Read Address 0E38H
2. Read Address 31C7H
3. Read Address 03E0H
4. Read Address 3C1FH
5. Read Address 303FH
6. Read Address 0C63H (Initiate Recall Cycle)

It takes a maximum of 20µs for data that was Stored in nonvolatile memory to be Recalled to SRAM.

STK15C88 Nonvolatile Operations

The STK15C88 is very similar in operation to the STK11C88. Its software *STORE* and *RECALL* operations, and its power-up *RECALL* capabilities are identical. The STK15C88 adds the capability of Simtek's *AutoStore*™ technology that allows it to sense power loss and *STORE* data to nonvolatile memory autonomously without external circuitry or processor intervention. As with the STK11C88, once data is stored into nonvolatile memory, no batteries, capacitors or external power sources are required to safely maintain the data for a minimum of 10 years. The only requirement for full *AutoStore*™ operation is that power supply voltage remain above 3.6 volts for a minimum of 10ms after V_{SWITCH} (approximately 4.25 volts, see Figure 2).

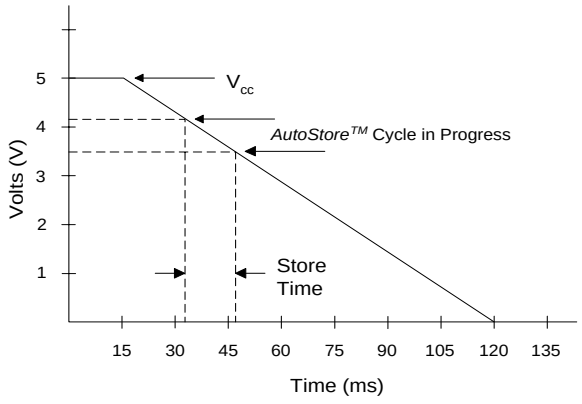

Figure 2:
STK15C88 *AutoStore*™ Vcc Requirements

Even if the design engineer cannot guarantee the 10ms power supply voltage requirement, it is still possible to use the STK15C88 in many applications.

The addition of a low forward voltage drop diode, and a 100µF capacitor will supply the energy necessary for the *STORE* operation to complete independent of the Power Supply decay characteristics (Figure 3). The optional resistor on $\overline{W}$ prevents accidental writes to the SRAM in systems whose power supply is unreliable on power-up above V_{SWITCH}. Note that this alternate configuration effectively raises the V_{SWITCH} level by the diode drop V_f.

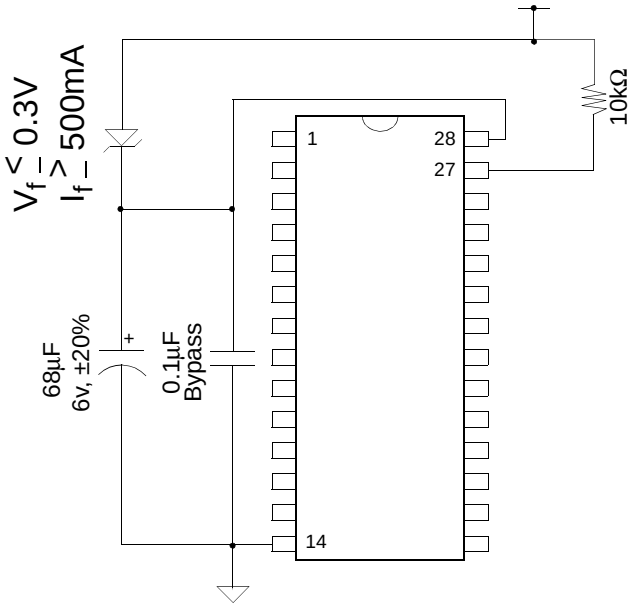

Figure 3
Alternate STK15C88 *AutoStore*™ Implementation

STK16C88 Nonvolatile Operations

The STK16C88 is a close relation to the STK15C88. Its software *STORE* and *RECALL* operations, and its power-up *RECALL* capabilities are identical. The *AutoStorePlus*™ feature of the STK16C88 provides automatic *STORE* of SRAM data to EEPROM on power-down that is independent of the power supply decay rate. The *AutoStorePlus*™ is initiated 1µs after the detection of power failure (the transition through V_{SWITCH}) and does not depend upon the power supply to complete the *STORE* cycle. It is the ideal standard pin-out solution in systems whose power supply decays very quickly. To a design engineer who cannot guarantee the 10ms required by the STK15C88 to execute a *STORE* on power-down, the STK16C88 is a simpler solution requiring no additional components.

Applications

Simtek's family of nvSRAMs is the ideal complement to many of today's most advanced technologies. By increasing the level of integration, designs can be achieved that are smaller (more compact), lower in power, higher reliability, lower cost, and much higher performance than possible just a few years ago.

FPGA/PGA

Many manufacturers of programmable gate arrays require high speed nonvolatile memory to load configuration table data into their programmable arrays. Combining the high speed and density of Gate Array devices from Xylinx and Altera, with the advanced capability of the Simtek 32K x 8 family of nonvolatile memories, opens the door to many new embedded applications. Adaptive security systems, video/telecom Digi-Cypher, and automotive theft protection and recovery systems are just a few of the potential applications for embedded PGA/ nvSRAM systems (Figure 4).

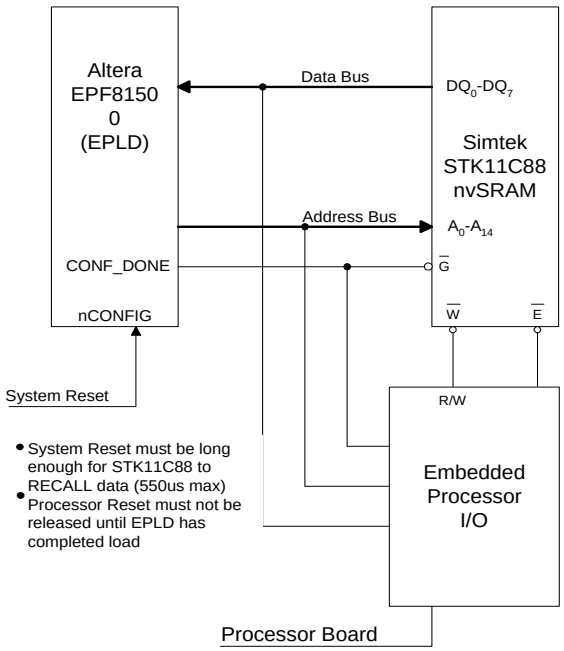

Figure 4
Altera EPF81500 EPLD in a parallel load configuration with the SIMTEK STK11C88 256K “Fast” nvSRAM

By using a single STK11C88 nvSRAM to parallel load configuration data to an Altera EPLD, and by using the same memory as a fast SRAM for processor scratch pad RAM memory, the design engineer can realize a significant reduction in parts count and cost. At system power-up, the EPF81500 is held in a

reset condition for a minimum of 550µs after V_{CC} reaches V_{SWITCH} (about 4.25V). This allows sufficient time for the STK11C88 to Recall data from its nonvolatile memory into SRAM. After system reset is released the EPF81500 will request data from the STK11C88 (pull CONF_DONE line low) and begin sending addresses in a sequential count up or count down manner. After data is loaded into the EPLD, it will release the CONF_DONE line allowing the STK11C88 to be accessed by the embedded microprocessor. It is required that the microprocessor be held in reset until the EPF81500 is finished loading. This simple approach solves the problem of needing both fast SRAM scratch pad memory and nonvolatile memory to load the Altera device.

nvSRAM and TI-TMS320C52

Use of Simtek's 256K parts allows the TMS320C52 to run at its fully rated 80 megahertz with no wait-states. This design approach also assures that all calculated or measured control variables are saved in the event of power failure. No glue logic or interface components are required for systems of up to 96K words of nonvolatile memory, and only minimal external logic for systems of up to 192K words. This compact, efficient memory design simplifies PCB layout, improves system reliability, and reduces cost. Since memory data is safe when power fails, short VCC drop-outs will not necessarily result in loss of control or require system re-boot. If the on-board real-time clock maintains nonvolatile elapsed time knowledge, recovery may be possible without loss of control or unstable operation.

Use of the STK11C88 for program memory guarantees that control code will not be lost during power dropouts, but still allows code changes to be made in-circuit without special equipment or hardware modifications. This is of special value in applications such as security systems where periodic updates to password files or access lists are required, but where nonvolatility is a necessity (Figure 5).

Conclusion

Applications for Battery Backed RAM are limited by the temperature range over which batteries operate reliably. Lithium batteries have shortened life spans at high temperature and electro-chemical inefficiencies at low temperature. Battery Backed RAMs are also slower than nvSRAMs, and therefore are not suited to many high performance embedded processor applications. Use of Simtek's family of nonvolatile SRAMs efficiently replaces Battery Backed RAM, and results in higher reliability and higher performance products. The "C88" nvSRAM family also replaces the combination of SRAM and EEPROM presently used in many stand-alone applications to get around Battery Backed RAM's inherent limitations. The resulting savings in board space, power, and cost makes the nvSRAM an attractive design option.

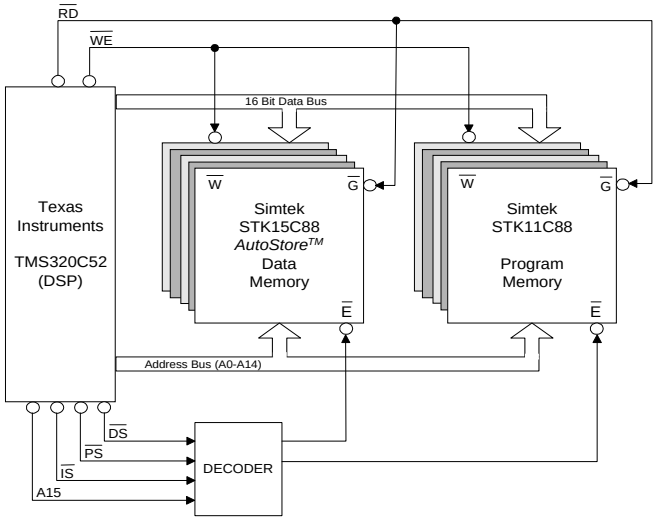

Figure 5
High Performance Embedded DSP System Using the TMS320C52 with the Simtek STK11C/15C88

Simtek's nvSRAMs also have many advantages over fast FLASH memory, including a single byte write, single operating voltage (5V), faster access times, and unlimited SRAM Write cycles. nvSRAMs also have the ability to perform Store operations autonomously without processor intervention or the requirement to run FLASH store algorithms. This results in less processor overhead, reduced parts count and higher product reliability.

The Simtek "C88" family of nonvolatile memories is fast, versatile, and cost effective for many types of modern high performance designs. The combination of speed and nonvolatility in one package allows high technology processing engines to operate at their full potential. The added advantage of remote programmability without the need to modify hardware, simplifies field upgrades and lengthens product lifetimes.