Comparing the Am186™EM and Am186ER Microcontrollers

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This white paper outlines the issues that need to be considered in comparing an Am186™ER microcontroller to the Am186EM microcontrollers. The Am186ER controller has a very similar feature set to the Am186EM controller, with the additional integration of 32 Kbyte of RAM. The package mechanicals, number of pins and pin order are the same. In order to cost-effectively integrate the RAM, the .35 µ CS34 process was used. The shift to .35 µ also requires the integrated analog PLL to be changed and for the power supply to shift to 3.3 V.

This document should be used as a checklist of issues and is not a substitution for either product manual. All issues are also relevant to the Am188™ER in an Am188EM system.

Vcc power plane

One of the major functional changes from the Am186EM to the Am186ER microcontroller is the change from 5 V +/- 10% V_{CC} (Am186EM) to 3.3 V +/- 0.3 V (Am186ER). This requires either the entire board to switch to 3.3 V or the processor to be on a separate power plane with that power plane connected to either 5 V (Am186EM) or 3.3 V (Am186ER).

Input/output voltages

The Am186ER microcontroller will accept inputs up to 2.6 V over the V_{CC} (i.e., the Am186ER is 5-V tolerant). The Am186ER controller will drive outputs to TTL levels, but the maximum V_{OH} is limited to the 3.3-V V_{CC}. The maximum input voltages of X1 and X2 are limited to Vcc. This requires that the clock input circuit either be a crystal or limited to the 3.3-V Vcc.

Power consumption

The Am186ER microcontroller power consumption is significantly less than the Am186EM. Much of this is due to the switch from 5 V to 3.3 V (~56%). The total system

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power consumption is further reduced by the integration of the RAM into the Am186ER controller.

Clocking - modes

On the Am186EM microcontroller, the default clocking is 1x the system frequency (e.g., 40 MHz in, 40 MHz out) and the PLL is engaged. On the Am186ER controller, the default clocking is 4x the system frequency (e.g., 10 MHz in, 40 MHz out) and the PLL is engaged. The 4x mode is only valid in the range of 32 MHz to 40 MHz. For Am186ER operation between 16 and 40 MHz, the 1x mode (e.g., 25 MHz in, 25 MHz out) with PLL enabled, or the divide by 2 mode (e.g., 50 MHz in, 25 MHz out) with PLL disabled options are available. For Am186ER controller operation below 16 MHz, the divide by 2 mode with PLL disabled option should be used. S6 and UZI are used to select between the clocking modes during Reset.

Clocking - mode selection

On the Am186EM microcontroller, all mode selections made at Reset require the mode select signals to be held valid for 3 clocks after Reset negates. On the Am186ER controller, this is still true for all mode selects other than the clock select lines. For the clock select lines, the amount of time the CLKSEL0 and CLKSEL1 must be held valid after Reset depends on the clocking mode being selected. For 1x and divide by 2 modes, the CLKSEL0 and CLKSEL1 must be held valid for 3 clocks after Reset negates. For 4x mode, the CLKSEL0 and CLKSEL1 must be held valid for 5 clocks after Reset negates.

If an external pull-down resistor is used to select the clocking mode, there is no change required between the two clocking modes. CLKSEL0 and CLKSEL1 will remain in high impedance until 6-1/2 clocks after Reset negates. The pull-down resistor will keep these signals valid until the Am186ER microcontroller begins to drive alternate signals (S6 and UZI).

Clocking - crystal

When using a crystal with the Am186ER controller, the values of the capacitors connected to X1 and X2 are the same as those in the Am186EM. The crystal is connected directly to X1 and X2. The maximum ESR of the crystal to the Am186ER controller is increased to 60Ω. This allows the 40Ω maximum ESR of the crystal to the Am186EM to also be used for the Am186ER microcontroller.

Clocking - oscillator

On the Am186EM microcontroller, using an oscillator requires connecting the oscillator to X1 and leaving X2 floating. On the Am186ER controller, the oscillator is still connected to X1, but X2 must be grounded. On the Am186ER, X1 is limited to a maximum input voltage of Vcc.

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Processor revision level register

The PRL register is changed between the Am186EM and Am186ER microcontrollers. In addition, the Am186ER microcontroller's PLL also indicates if the part is a 186 or 188.

New peripheral control block register

On the Am186ER microcontroller, the internal chip select register is added to the PCB with an offset of 0ACH. On the Am186EM controller, this was an unimplemented register. Access to this location in the PCB on the Am186EM controller will have no effect.

Internal RAM - address space

On the Am186ER microcontroller, the integrated 32 Kbyte of RAM can be used to replace external RAM in many systems. To use the internal RAM on the Am186ER, the internal chip select register needs to be accessed to set the internal RAM enable bit (RE) and select the base address of the internal memory (BA19-BA15). The internal memory address space can overlap the peripheral control block address space. The internal memory address space should only overlap any external chip select address space if the external chip select has no wait states and ignores external ready. Writing to the chip select register associated with any chip select other than the internal memory chip select enables that chip select, creating the potential for contention if the internal memory is located in the same address space.

Show reads

The addresses and data for writes to internal memory are externally visible on the address/data bus. An option exists to have internal memory reads be externally visible on the address/data bus. If this show read option is enabled, then the internal memory data is driven onto the address/data bus during T3 and held through T4.

Signals that have changed

The following are the list of signals that have changed from the Am186EM to the Am186ER microcontroller:

X1, X2	- New oscillator mode, input voltage
S6, UZI	- New clocking modes
S1/IMDIS	- Internal RAM disable
S0/SREN	- Show internal RAM cycles
AD0-AD15	- Show reads from internal RAM (optional)

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Timing parameters

On the Am186ER microcontroller, all timing parameters are measured at $V_{CC}/2$ with 50 pF loading on CLKOUTA unless otherwise noted. All output test conditions are with C_L= 50 pF. For switching tests, V_{IL} = 0.3v and V_{IH} = Vcc - 0.3V. On the Am186EM controller, all timing parameters are measured at 1.5 V with 50 pF loading on CLKOUTA unless otherwise noted. All output test conditions are with C_L= 50 pF. For switching tests, V_{IL} = 0.45v and V_{IH} = 2.4 V, except at X1 where $V_{IH} = V_{CC}$ - 0.5V. This change in how the timing parameters are measured should not change the timing specifications.

Programmable I/O pull-ups/pull-downs

The programmable I/O have a mode which engages an internal pull-up or pull-down. On the Am186EM controller, this is equivalent to approximately a 10 KΩ resistor. On the Am186ER controller, these pull-ups/pull-downs are momentarily actively driven and then maintained high or low with an internal resistor approximately equivalent to 100 KΩ resistor. This means a reduction in the current and a faster rise/fall time to switch high/low when entering Reset.

Faster edge rates

The Am186ER controller is in the faster 0.35 µ CS34 process, causing faster switch times on many of the signals. These faster edges may cause termination problems in some systems with long traces or poor layout.

Chip select register protection

The Am186EM microcontroller enables the chip selects with a read or write access to the chip select register. The one exception is the UCS, which is enabled on Reset. The Am186ER controller also has the UCS enabled on Reset, but the other chip select registers (except the internal chip select) are enabled only with a write to the chip select register. The internal chip select is enabled with a bit in the register. Since code should only be enabling a chip select by writing to the chip select register, this should not change existing Am186EM microcontroller code.

Conclusion

The Am186ER microcontroller is pin-compatible with the Am186EM microcontroller. The differences described above are minor enough that it would be possible to develop a board to accept either part.

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