Application Hint 18

Powering the IntelDX4™ Processor

By Bob Wolbert

General Description

The IntelDX4™ Processor and IntelDX4 Processor "OverDrive™" microprocessors are upgrades to the popular 486 microprocessor and share the same basic pinout.[1] A computer motherboard may be designed that accepts either processor, allowing the end user to initially use the lower cost 486 and later upgrade to the IntelDX4 Processor by simply replacing ICs. There is a catch: the IntelDX4 Processor operates from a 3.3V supply[2,3]. Pin S4 on the IntelDX4 Processor, VOLDET (voltage detect), is grounded to indicate the 3.3V processor is installed. This pin is either not connected or pulled high on 486 processors. Using this indicator, we can design a power control system that insures the proper voltage is applied to the processor.

This note describes a circuit that reads VOLDET from a IntelDX4 Processor-series processor and automatically determines whether to supply 5V or 3.3V. It operates from a single +5V ± 5% power supply and produces 3.3V output with a low drop-out linear regulator.

Circuit Discussion

Our goal is to provide the proper supply voltage to the microprocessor. We begin by determining what is the proper voltage. Intel has assigned IntelDX4 Processor pin S4 to "VOLDET". This pin position, unassigned on the 486, is internally bonded to ground on the IntelDX4 Processor. A pull-up resistor connected from VOLDET to a system supply will allow differentiation between the grounded IntelDX4 Processor and the open-circuited or logic high 486.

Our next consideration is to provide switched +5V from the main supply when a 486 is used. A low ON resistance switch will work. Micrel's MIC5014 high side MOSFET driver and a medium sized N-channel power MOSFET is ideal.

Now, we must produce a clean 3.3V source. The Intel IntelDX4 Processor requires up to 1.25A at 3.3V. The Intel IntelDX4 Processor OverDrive™ needs up to 3A. The 1.5A Micrel MIC29150-3.3 easily supplies the IntelDX4 Processor, and the MIC29300 is perfect for suppling the IntelDX4 Processor OverDrive™.

Finally, we put the blocks together and iron out interfacing. Figure 1 shows the power system block diagram.

Details

The schematic diagram for the power control block appears as Figure 2. With a 486 processor installed, the pull-up resistor, R1, pulls the MIC5014 input pin high, enabling the MOSFET driver. An internal charge pump voltage multiplier charges the power MOSFET (Q1) gate and supplies +5V V_{CC} to the processor. Voltage to the processor is V_{CC} minus a voltage drop determined by processor supply current times MOSFET ON resistance. The MOSFET size is determined by the maximum allowable voltage drop:

$$R_{MOSFET\ ON} = (V_{CC\ (S)\ MIN} - V_{CC\ (P)\ MIN}) / I_{CC}$$

Where: $V_{CC\ (S)\ MIN}$ is the minimum supply voltage from the power source

$V_{CC\ (P)\ MIN}$ is the minimum operating voltage for the processor

I_{CC} is the peak processor operating current

Assuming a 5V ±5% supply and a 486 rated for ±10% supply tolerance, the MOSFET ON resistance is:

$$R_{MOSFET} = (4.75 - 4.50) / I_{CC} = 0.25V / I_{CC}$$

Or 250 milliohms for a 1A load. A MOSFET with 0.25Ω or lower ON resistance will work.

Providing 3.3V from a nominal 5V supply is an easy matter using Micrel's low drop out linear regulators. These regulators need only one external component for operation, an

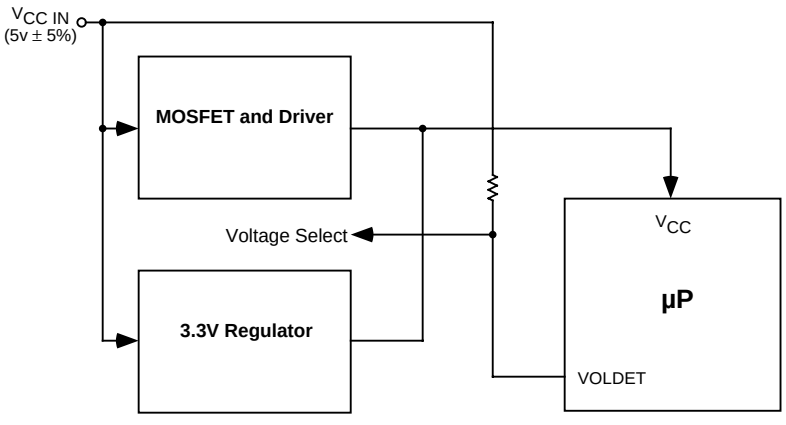

Figure 1. Block diagram for an auto-select voltage block for powering a computer motherboard that uses either 486 or IntelDX4 Processor microprocessors. VOLDET signals the MOSFET and Driver block and the 3.3V Regulator block whether the 5V 486 or the 3.3V IntelDX4 Processor is installed. The end user can upgrade his microprocessor without worrying about supply voltage jumpers.

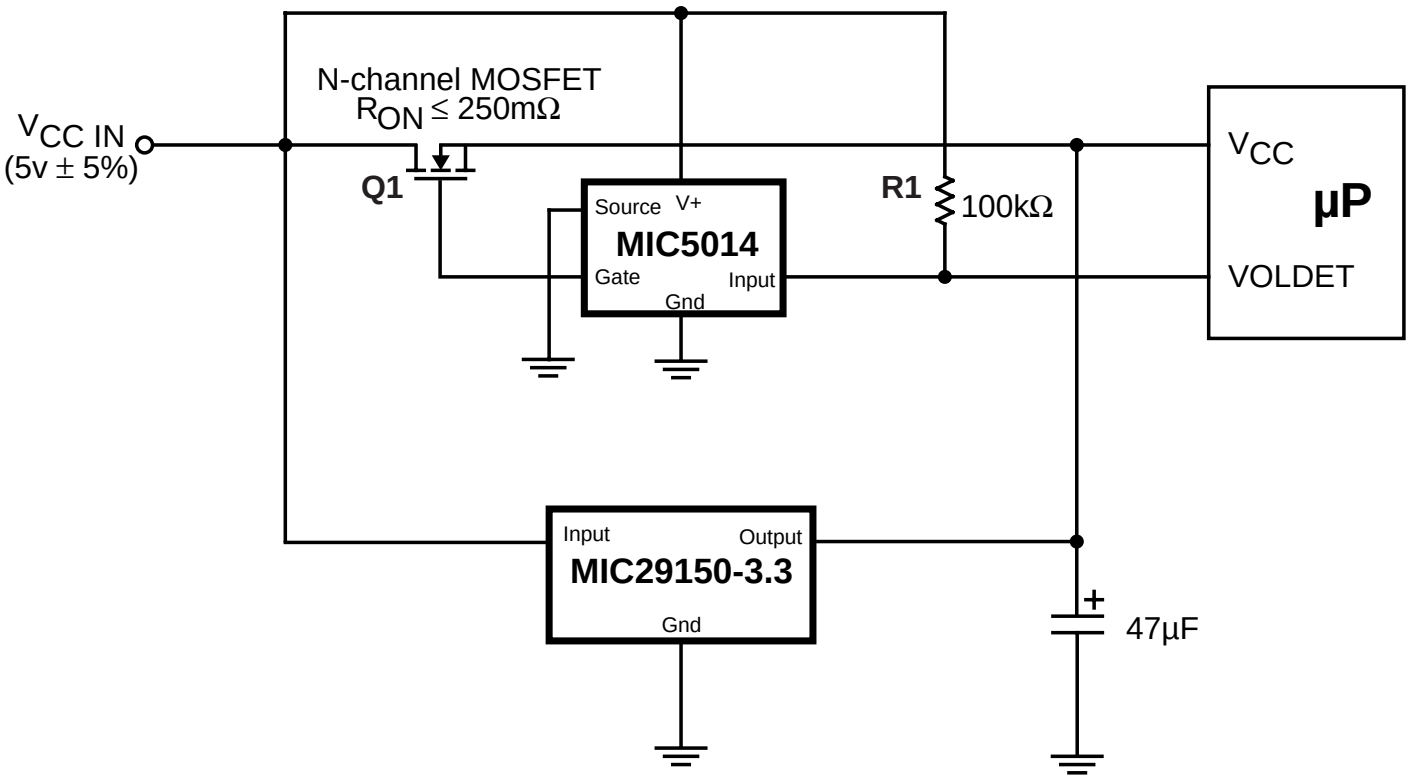

Figure 2. Complete schematic for an automatic voltage selection switch using the IntelDX4 Processor VOLDET pin.

output filter capacitor. Micrel's Super ßeta PNP™ LDOs are ideal for this application for other reasons as well. Unlike other regulators, Micrel's LDOs operate with drop-out voltages of 300mV–often less. This is important when we consider worst case tolerances: The "5V" supply can be as low as 4.75V and still be within its specification. The MIC29150-3.3 output may be as high as 3.366V under worst case conditions. This gives us a worst case available drop out voltage of only 1.384V (4.75V – 3.366V) . This is well within the 300mV typical performance of Micrel's LDOs as well as comfortably within the 600mV guaranteed maximum (over the full operating temperature range) specification. No NPN-pass element linear regulator can approach this performance. Additionally, Micrel LDOs feature "reverse battery" protection. This is like an ideal diode in series with the regulator that prevents reverse current flow caused either by a negative input voltage *or a higher voltage present on the regulator output.* This feature lets us connect the 3.3V LDO directly in parallel with the 5V switch to the microprocessor V_{CC}. If the 5V supply is disabled, the LDO will source 3.3V. When the 5V supply is enabled, it will reverse bias the "diode" in the LDO output and effectively shut off the regulator. This means a simple three terminal LDO can be employed.

"Green" systems conserve power when full performance is not needed. The IntelDX4 Processor implements "green" features, powering down to only a few hundred milliamperes in sleep mode. It reawakens in less than a microsecond and draws full power. Proper operation under these conditions requires a low inductance, low effective series resistance (ESR) capacitor. Generally, this is best implemented by paralleling the regulator filter capacitor with a small (0.1µF to 2.2µF) capacitor.

If other output voltages are required, Micrel's adjustable MIC29152 and MIC29302 are available and allow the designer to select any output voltage from 1.24V to the maximum rating of the device. Please refer to Application Hint 19 for further discussion of adjustable regulator applications.

At the 1.25A IntelDX4 Processor level, thermal considerations are not difficult; however at the 3A level of the IntelDX4 Processor OverDrive, proper heat sinking is essential. For full details on heat sinking Micrel LDOs in this application, refer to Micrel Application Note 9, "Design Considerations for 5V to 3.3V Pass Regulators".

Notes

NOTE 1: Intel™, IntelDX4™, and OverDrive™ are trademarks of Intel Corp.

NOTE 2: The IntelDX4 Processor accepts logic inputs as high as 5.3V when operating in a mixed-V_{CC} environment.

NOTE 3: The IntelDX4 Processor uses a nominal 3.3V supply. However, Intel has reserved the right to supply devices that run on other voltages (for example, one batch might require 3.6V, the next, 3.45V). Micrel recommends using an adjustable regulator (MIC29152 or MIC29302) until this situation is resolved. Refer to Application Hint 19 for further details.