Choosing the Right Linear Regulator for Your Application

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Technology Edge

Choosing the Right Linear Regulator for Your Application

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Linear regulators are often used as a band-aid by design engineers and are often chosen in later stages of the product development. The design engineer is concentrating more on how to make the complex BB or RF ASIC work, rather than the power/performance of the linear regulator that he or she may select.

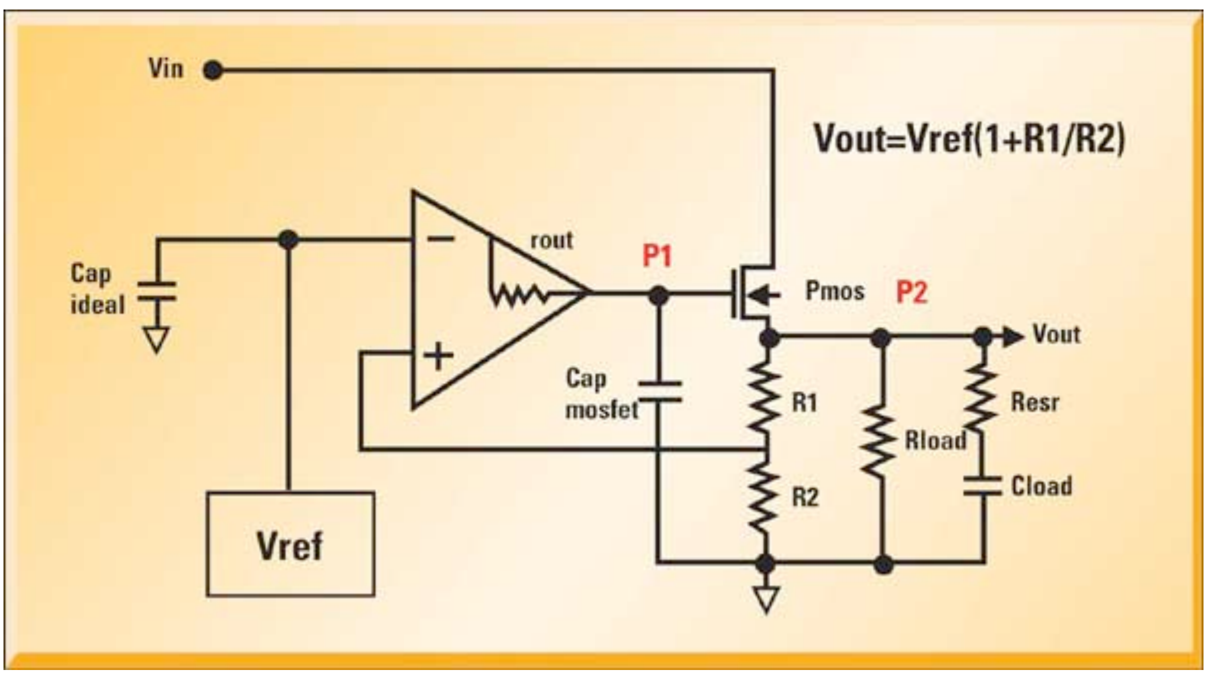
Linear regulators are often selected by the key specifications in the traditional bullet list than by the very critical core and performance characteristics that usually lay inside the cover of the datasheet. Specifications are very often misleading — what is advertised on the front sheet represents the key parameters, but has no value when not combined with other connecting parameters.

For instance, ground current is one of these parameters. This situation has developed because the competitive nature of the linear regulator market dictates that manufacturers of devices recognize the need to get the time restricted engineer to spend more than a passing glance at the device. Also, there is no true standardization in the way information is presented. Different scales, temperatures, and loads only cause confusion for the design engineer trying to compare parts.

Linear regulators — what are they?

The modern linear regulator provides many ingenious architectural fixes for challenging requirements. Essentially, a linear regulator is an operational amplifier and a pass transistor. The operational amplifier uses two points of reference — the internal band gap reference and a resistor divider chain on the output. During regulation, the voltage value of the resistors divider network provides feedback to the operational amplifier where it is compared with the band-gap reference.

Depending on the result, the pass transistor will turn on more or less current. This is a closed-loop system based around two main poles, these being the internal pole of the Error Amplifier/pass transistor and the external pole of the output current demand and ESR of the output capacitor. Manipulation of these two dominant poles affects the performance of the device and is a main contributor to the stability of the loop.



Understanding linear regulator classification

Increased efficiency is a constant demand from the design engineer. This translates into a reduction of the Iq and forward drop voltage. As manufacturers improve these figures of merit of the linear regulator, it has undesired side effects on other characteristics. General-purpose linear regulators are designed such that they can offer the best all-around performance possible. Characteristics which often oppose each other are weighted evenly. Package selection is primarily decided on cost and wide market acceptance.

Digital linear regulators

Digital linear regulators are designed to support the main digital cores of a system. Modern DSPs and microcontrollers have to work with rapid efficiency and often high current requirements.

Emerging markets that require wireless standards require large amounts of filtering. This puts tremendous strain on the digital processing cores in terms of software loading which translates into demanding and lightning-quick responses from the power management devices. These functions drive the main characteristics that are important for digital loads. Line and load regulation/ transients are primary functions. These parameters, though they are not often easy to find in the datasheets, are stated in two ways: percent deviation of V/I or actual V/I values. These should be referenced to a load current or change in input voltage.

Battery-operated and low-power

Systems have long periods of non-operation. Digital linear regulators are designed to go to sleep during these periods, but start up rapidly when needed. During the sleep mode all of the main operations of the linear regulator — including the band gap — are switched off. It is critical that fast turn-on times do not cause excessive overshoot. Overshoot and the ability of the linear regulator to cope with overshoot are linked to Iq. With decreasing Iq, it is a challenge to maintain or improve this.

What is needed is the ability to drive internal capacitance nodes rapidly and have available current to do it. As we further reduce the available current to drive this, the linear regulator’s ability to react is reduced.

Assuming that you do design a fast enough circuit and there is overshoot, one way to overcome this is by using a capacitor to dampen it. Consequently this makes the capacitance load higher and creates the demand for higher Iq.

Analog/RF linear regulators

Analog linear regulators are mainly driven around the air interface requirements. The air interface is the Achille’s heel of portable communications, as the signal is highly susceptible to noise and attenuation. So when considering an analog linear regulator, it is important that the device itself does not add further noise to the wanted signal and that it suppresses noise from other generating sources. Analog regulators need good noise figures which are measured in Vrms and suppression, which is PSRR (power supply rejection ratio), measured in dBs.

Noise reduction

The band-gap reference and the pass transistor are the main sources of noise. Adding an external bypass capacitor can reduce this noise, but this adds costs and increases form factor. It is possible within silicon to add internal capacitors to help, this as the noise at the transistor level is actually a combination of two factors: thermal noise and flicker noise. Electrons colliding against each other and also electrons being trapped in the Si02 level are the cause. PSRR is the ability of the device to suppress the unwanted noise generated by another regulating component or noise generator. This is particularly important in the analog environment, as analog IC devices are more susceptible to noise than digital.

The noise itself has a direct correlation to ground current as it is a factor of the drive to the transistors. The lower the drive current in the Mosfets, the worse the flicker and thermal noise. Lower drive translates once again into lower Iq.

So when selecting linear regulators, it is important to review the product details to evaluate the overall performance needed to your unique application.

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