ULDO provides a steady current for consumer electronics

Stable current supply is an essential element of high-quality electronic products. For consumer electronics, power management is a key requirement for the success of products. This article will introduce the high performance and high reliability CMOS ULDO for consumer electronics to understand the development trend of ULDO.

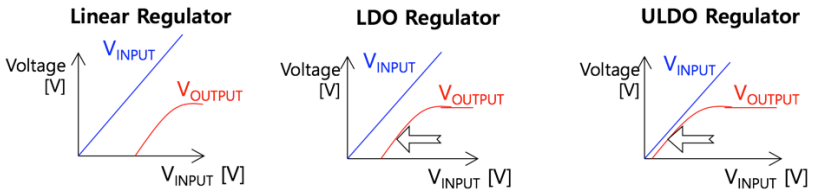
Low dropout provides better power conversion efficiency

Power management is also an important requirement for consumer electronics products to have stable power transmission, achieve low power consumption and noise under various load conditions, expect to use less space and have higher reliability. Therefore, a variety of power management IC, such as linear regulator, DC-DC converter, power controller and PMIC are developed and applied to meet the specific requirements of various application fields.

The common linear regulators in power management IC may be divided into standard linear regulators, low dropout regulators (LDO) and ultra-low dropout regulators (ULDO). The key difference among them is the dropout voltage characteristic required to maintain a steady output voltage. The dropout voltage is defined as the minimum output differential voltage to maintain a steady output voltage. From the point of view as power output, a linear regulator can also be regarded as a variable resistor.

When the output current changes, the internal control circuit of the linear regulator adjusts the on-resistance through the components. The adjustable on-resistance range defines the maximum operating current range (the operating output impedance range). For the standard linear regulator, the pass element is Darlington NPN or PNP output stage, with the differential pressure of up to 2V. The linear regulator cannot be applied to any application requiring low dropout, for example, generating a 3.3V voltage from a 3.6V battery supply. Most LDO/ULDO use NMOSFET or PMOSFET with appropriate size as the pass element for lower dropout voltage characteristics.

The important reason for a power circuit to pay attention to voltage drop is the power conversion efficiency. The low dropout performance of LDO can reduce the input voltage and achieve the desired power output. Due to lower power dissipation, higher power conversion efficiency and lower heating can be achieved. The above-mentioned three linear regulators require different minimum input voltages to achieve the same required output power. LDO/ULDO have low dropout and better power conversion efficiency, thus reducing the power consumption. Another advantage of low power consumption is low heat occurrence, which enables smaller package applications.



$V_{DROPOUT}$	2V	1.3V	0.5V
If an application circuit requires;			
V_{OUT}	3V	3V	3V
I_{OUT}	1A	1A	1A
P_{OUT}	3 W	3 W	3 W
The input should be;			
V_{IN}	Over 5 V	Over 4.3V	Over 3.5 V
P_{IN}	≈ 5 W	≈ 4.3 W	≈ 3.5 W
The Power Dissipation, PD [= $P_{IN} - P_{OUT} = (V_{IN} \times I_{IN}) - (V_{OUT} \times I_{OUT}) = (V_{IN} \times (I_{OUT}+I_{GND})) - (V_{OUT} \times I_{OUT})$] is;			
P_D	≈ 2 W	≈ 1.3 W	≈ 0.5 W
Efficiency	≈ 60%	≈ 70%	≈ 86%

*Figure **1**. Power Conversion Characteristics with respect to Dropout Voltage*

For ULDO, PMOSFET or NMOSFET used as pass element, which have the same effect but for different application purposes. PMOSFET LDO is a typical LDO structure. The on-resistance performance (dropout voltage performance) is proportional to V_{SG}, and higher V_{IN} is needed to obtain better on-resistance performance. Therefore, it is no problem to provide good dropout voltage performance when the output voltage is high. However, when the output voltage is low, the dropout voltage performance is limited by the minimum input voltage. Therefore, PMOS LDO is suitable for relatively high output voltage applications.

NMOSFET LDO has different operating mechanisms to overcome the limitation of low voltage conversion performance of PMOS LDO. Its on-resistance performance is also proportional to V_{IN}, resulting in higher V_{GS}, but V_{GS} can be changed according to V_{OUT}. Therefore, NMOS LDO has a separate voltage supply V_{BIAS}, which can be used in internal circuits to eliminate V_{IN} limitations in voltage drop performance when the output voltage is low. Even if the output voltage is low, it still maintains low dropout performance, and there is no minimum input voltage limit like PMOS LDO.

The general protection functions like output over-current protection (OCP) and over-temperature protection (OTP) are typical protection functions of LDO products recently. In addition, the most common demand for linear regulators in recent consumer electronics is the soft-start function, by increasing the voltage rise time on the load capacitor and by applying the internal soft-start circuit and /or programmable to reduce the charging rate of capacitor to reduce inrush current.

Another recent demand for consumer electronics from LDO is the automatic discharge function. When the LDO is turned off, the internal automatic discharge function provides a discharge path of the output load capacitor for stable power supply. Since the internal discharge path is connected through LDO, the automatic discharge function is helpful for the rapid operation of consumer electronics and the output voltage drops faster.

In addition, the PowerGood output is used as a power-on indicator for the load circuit. This signal indicates when the output voltage is suitable for reliable operation of the load circuit. The PowerGood output moves up or down with respect to the voltage level of the output voltage. Currently, the PowerGood signal is used not only for output power-on indication, but also for automatic power sequencing. The power sequence delay time (enable delay time) is easily programmed by an external RC delay circuit. As a result, the complex power sequence can be easily designed by simple wiring using PowerGood signals that provide design convenience for most consumer electronics.

In order to meet the demands of consumer electronics for linear regulators recently, the whole performance such as the power conversion performance of LDO, the additional function easily adapted to consumer electronics, and the reliability shall be carefully checked and verified. TAEJIN Technology Co., Ltd., has launched a series of CMOS ULDO products, including TJ9198, TJ4303, TJ4310, TJ4320, TJ4330, TJ2132, TJ2134, TJ5641, LM2C1117, etc. These products with low dropout (0.2V~0.4V), programmable soft start, external capacitor, output automatic discharge, supporting over-current and over-temperature protection, which have been verified by the industrial standards of reliability test specification. Some of these products have passed the certification of AEC-Q100, which can provide ULDO matching with PMOS and NMOS conducting devices. TAEJIN Technology has expertise in power management IC design and manufacturing based on mature research capabilities and the products have proven their value in a variety of consumer electronics over the years (including ultra-high-definition television, In-Vehicle Infotainment system, set top box, AV system, home theater, network, and sound bar, etc.), which are the best choice for related applications.