Keeping the best audio quality in mobile phone by managing voltage drops created by 217 Hz transients

Source of major noise

Whatever the protocol used by a mobile phone, GSM or TDMA, RF transmitter switching creates the most notorious noise for the power supply. The RF power amplifier switches on and off at a rate of 217 Hz. At each of these events, a high current (up to 1.7A) is drawn from the power supply, creating a sudden voltage drop on the battery equivalent serial resistance (ESR) reaching up to 500 mV.

For a System-on-Chip (SoC) embedding high-resolution audio converters with audio amplifiers, or for a high sensitivity MEMS, such an amplitude jeopardizes the overall performance of the SoC(s). More specifically, the audio quality may be deeply altered by audible buzz sounds.

Such a noise is particularly audible as it is not random. Indeed, noises with amplitudes as low as 10 µV can be heard if they occur at a fixed rate of recurrence. They could be even much more disturbing than a random noise of higher amplitude, which will be considered as a background noise.

The best choice for preventing GSM noise from degrading audio quality is to place a Linear Regulator (LR) with very Low Drop-Out (LDO) and Output Noise to supply directly the audio amplifier from the Lithium-Ion battery. Such LDO linear regulator is then used as a clean-up or filtering module for the amplifier power supply.

The usual key criterion to select the best LR to prevent GSM noise is the capability of the LR to reject noise from the input voltage, expressed as Power Supply Rejection Ratio. But PSRR figures should also be pondered with the LR transient responses and drop-out characteristics.

Power Supply Rejection Ratio

The Power Supply Rejection Ratio is the ability of the regulator to maintain its output voltage as its input voltage varies. PSRR must be specified over some frequency range, certainly including the critical 217 Hz, and for the maximum output current for which the regulator is designed. Indeed, the capacity of rejection must be ensured even when the regulator is the most solicited (drop-out is maximal).

Usually, PSRR performances are specified at 10 kHz and may not be appropriate to reflect the expected rejection of noise at 217 Hz.

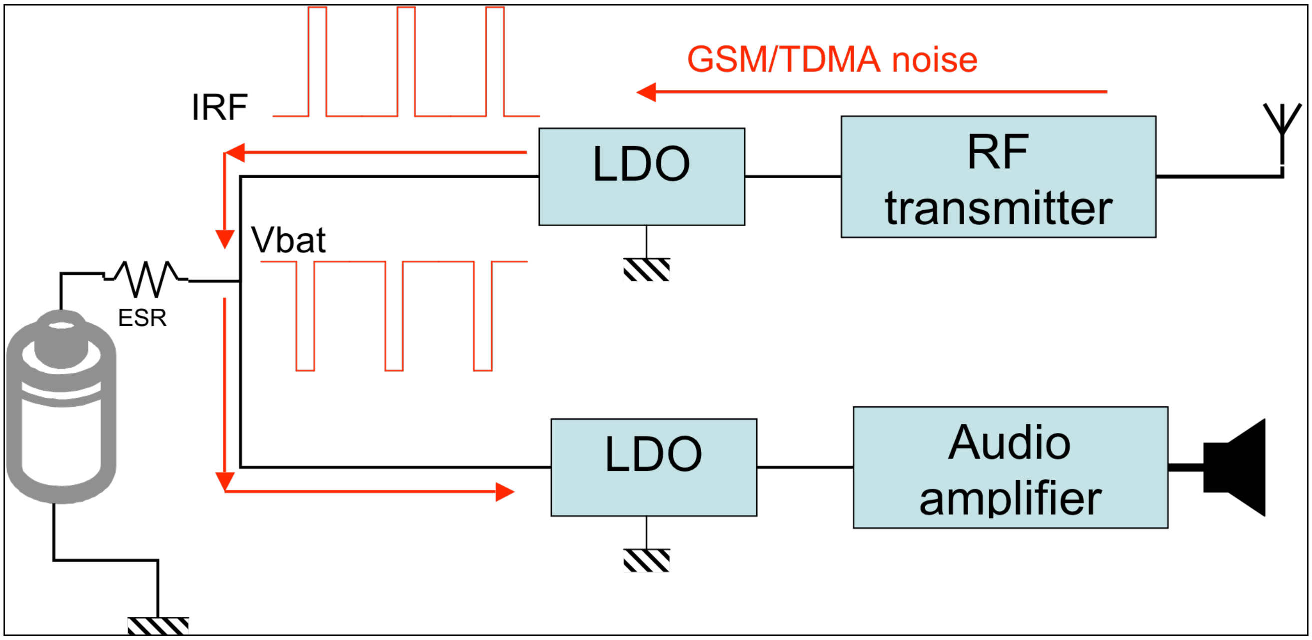

Figure 1 TDMA noise propagation in a typical Li-Ion battery powered device

The first conclusion is that the PSRR specification must be analyzed over a complete frequency range to compute the sensitivity of the regulator to any possible noise source, including 217 Hz.

Transient response and drop-out

The PSRR is not the only specifications ensuring that no noise will be heard on the audio output. The transient response characteristic of the LR, thus the capacity of the voltage regulator to maintain the output voltage at the desired regulated value, under sudden supply or load change, also is critical.

Let us convey some important statements.

Assuming Vin stands for input voltage, Vout stands for output voltage, Voutreg stands for regulated output voltage :

Vdrop = minimum drop-out of the regulator (minimum difference between Vin and Vout)

- The LR is designed to maintain a fixed output voltage, with a high PSRR, for a varying input voltage
- When Vin > Voutreg + Vdrop, the LR performs normally and regulates the output voltage with a 70 dB PSRR for example
- When Vin < Voutreg + Vdrop, the LR does not regulate the output anymore and Vout = Vin-Vdrop, the PSRR is 0 dB as the output voltage follows the input voltage

Therefore a LR exhibits a high PSSR only when the condition Vin > Voutreg + Vdrop is satisfied.

Let us consider a case depicted in Figure 2 where the LR is making the interface between a Lithium-Ion battery delivering 3.6 V and an analog block requiring a regulated 2.8 V supply. The figure shows how a 500 mV transient on the battery voltage is transferred to the LDO output depending on the effective drop-out of the linear regulator.

In Figure 2, the LR n°1 (in blue plain line) has a drop-out of less than 100 mV and therefore keeps on regulating, while the n°2 (in red doted line) cannot stand such voltage drop as it requires a minimum of 400 mV of difference (drop-out) between the input and the output voltage.

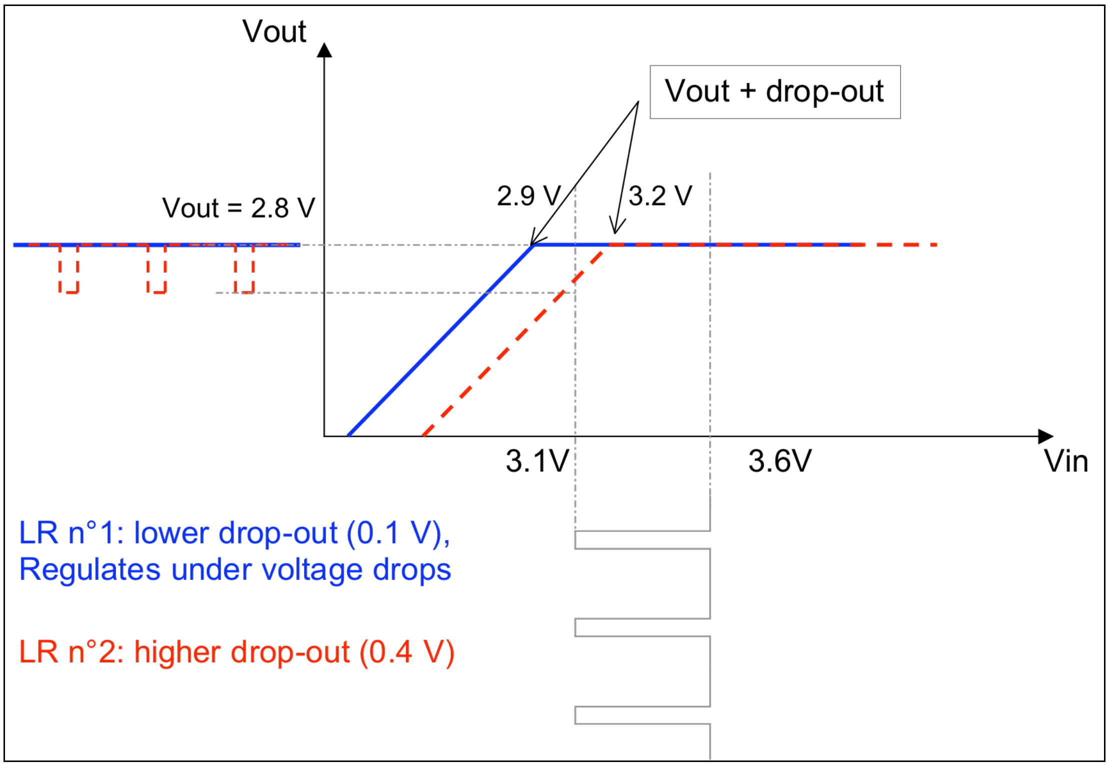

Figure 2 Relationship between dropout and effective noise rejection of a linear regulator

The second conclusion is that the demand for a linear regulator with very low drop-out is even more critical as the battery voltage decreases over time, down to 2.9 V for instance. It is important to maintain regulation over the full range of the battery voltage and this leads to the conclusion that the better the drop-out is, the better the battery runtime will be.

Misleading PSRR specification

It is not rare to see a LR specified with a 400 mV drop-out voltage. Even if such a LR is specified for a PSRR of 85 dB, it will not be able to filter any noise if the input voltage is lower than 3.0 +

0.4 = 3.4 V (case of regulator n°2 on Figure 2) and it will then demonstrate a PSRR of 0 dB in this case!

See the case on Figure 2, where the residual TDMA noise present at the regulator n°2 output with several hundreds of mV and cannot be predicted using the PSRR figure!

The third conclusion is that the effective dropout must be considered as well to evaluate the residual noise at the linear regulator output.

To be useful for a SoC integrator willing to compare two linear regulators, the drop-out must be given at the maximum current. This ensures that the LR is properly calibrated to drive the given load and reject properly the noise from the input voltage in all operating conditions.

Such embedded LR with high performances are currently provided by Dolphin Integration as an extension to its famous product line of embedded high resolution audio CODECS. With such solutions, the Company's customers may benefit from a higher audio quality over a longer time and a better immunity to the noise on PCB power supplies.

For more information, visit our website at www.dolphin-ip.com/jazz

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