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# Output Ripple Measurement Methods for DC-DC Converters

## ABSTRACT

Measuring output voltage ripple can be a quick way to evaluate the performance of modern power converters and low dropout (LDO) devices. Different measurement methods may lead to the opposite evaluation results of the output ripple. How to obtain accurate ripple values becomes the most important part in ripple measurement. This design tip will introduce the practical method of output ripple voltage measurement to check the performance of DC-DC power converters. The voltage ripple will be briefly explained first, followed by the waveform comparison between the conventional long measurement loop technique and the tip and barrel minimizing measurement loop technique. Finally, three practical measurement tips and the conclusion will be provided.

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## 1. INTRODUCTION

Modern electronic applications usually contain embedded computing and wireless connectivity functions, and these circuits often have high pulsating and heavy loading behaviors, while requiring low input voltage ripples. A new generation of DC-DC converters will therefore be required to have faster transient responses and to maintain stable output voltage under the fast fluctuating load conditions, and their lower output ripples should be as good or even better, compared to LDO regulators. For evaluating the output voltage ripple of these converters, it is important to understand the better measurement method, which may not couple lots of noises to the measurement waveform.

When measuring the output ripple, different measuring methods may collect different amount of noises, shown on the waveform, and thereby the output ripple performance of the converter may be underestimated. Figure 1 shows that noise component superposed on the actual output ripple, which causes the measured output ripple larger than the actual one. This is quite common when using the conventional method, directly connecting a common passive oscilloscope probe to the output terminal. The reasons why measurement inaccuracies occur and the techniques to solve this problem will be introduced in the next section.

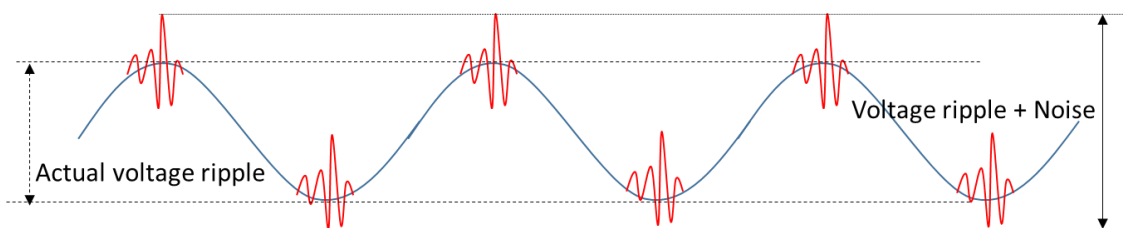


FIGURE 1 : VOLTAGE RIPPLE AND NOISE COMPONENT ARE SUPERPOSED IN MEASUREMENT

## 2. MEASURE THE OUTPUT VOLTAGE RIPPLE

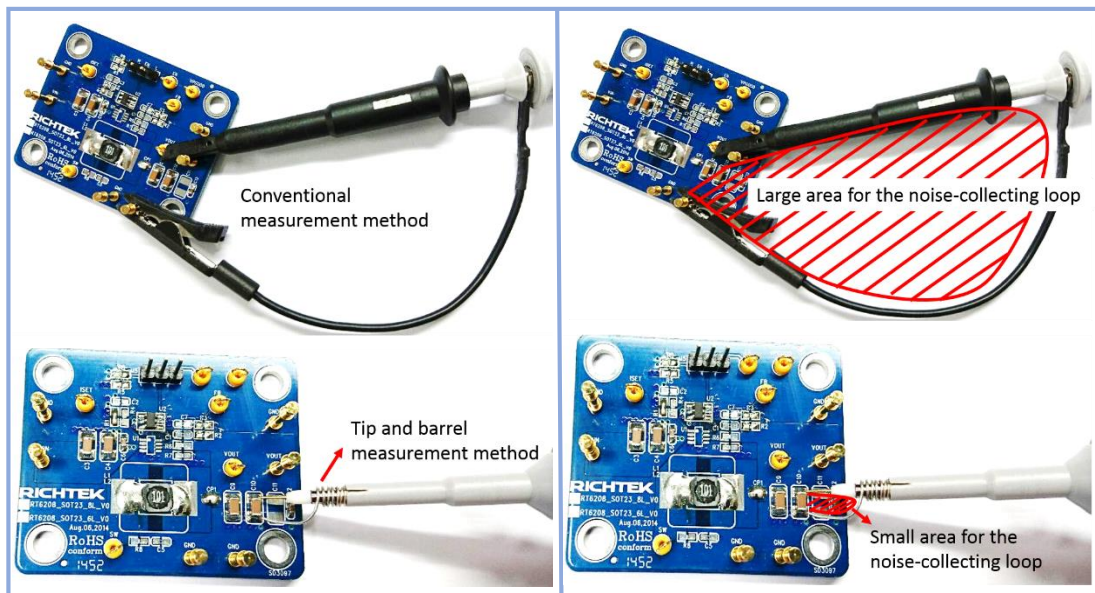


FIGURE 2 : CONVENTIONAL METHOD V.S. TIP AND BARREL METHOD

The conventional connection with large measurement loop cannot obtain the ripple voltage of switching converters accurately, because the long ground wire and the tip jack may form a loop antenna to collect the noises around the environment. The noises are superposed to the output voltage ripple, which makes all the measurement results incorrect.

In order to obtain actual output voltage ripple, it is imperative to minimize the measurement loop during the measurement set-up. The tip and barrel measurement method is one of the most recommended accurate measurement method, which is well-known for its easy-to-use with a smaller measurement loop. Using this method, a smaller noise-collecting loop can be easily achieved.

Note that the measurement points may also affect output ripple measurement results, so the second thing to consider is to choose the measurement points which can minimize the noise-collecting loop. Typically, the proper measurement points are across the output capacitor soldering pads. The closer measurement points to the capacitor, the less noise will be collected during measurement. Figure 2 shows the tip and barrel measurement method is applied across the output capacitor, while the conventional method applied on the output terminal. The area formed by the noise-collecting loop of the conventional method is much larger than that of the tip and barrel method, which explains why lots of noises appear on the waveform, using the former method.

Last but not the least is to choose an acceptable oscilloscope sampling bandwidth according to the applications. With the three aforementioned tips, to accurately measure output ripple voltage can be quite easy to achieve.

Figure 3 shows the comparison of the conventional long measurement loop method on the output terminal and the tip and barrel measurement directly on the output capacitor at different oscilloscope sampling bandwidth settings. The result shows that with the conventional long measurement loop method the waveform contains lots of noise and huge ripples, while with the tip and barrel measurement method, which shortens the measurement loop, the output waveform is cleaner and thus the accurate output ripple can be measured.

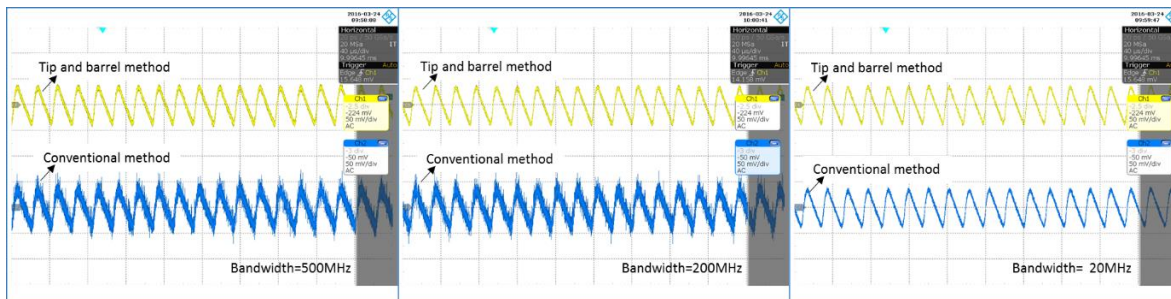


FIGURE 2 : DIFFERENT MEASUREMENT METHODS WITH 20MHZ TO FULL (500MHZ) BANDWIDTH SETTINGS

### 3. SUMMARY/PRACTICAL TIPS

#### Minimize the measurement loop

When measuring output voltage ripple for DC-DC converters, the measurement loop area plays an important role in the noise collection. Keep in mind to always consider to minimize the loop area. And the tip and barrel method can minimize the noise effects on the ripple measurement value.

#### Chose the proper measurement points

Make sure the loop area is small enough for the measurement. Normally, choose the measurement point as near the output capacitor as possible, and make the connection as low impedance as possible. The closer measurement point to the capacitor, the less noise will be collected during the measurement.

#### Set the acceptable sampling bandwidth

For different applications, how the critical load is sensitive to the noises, caused by the converter output ripple may vary. For noise-sensitive applications, like high-resolution analog-to-digital converters (ADC) or audio applications, it is recommended to measure output ripple at full bandwidth, while for noise-insensitive applications, the sampling bandwidth of 20MHz may be chosen. Note that background noises still need to be checked at the full oscilloscope sampling bandwidth, so that the output ripple may not be measured inaccurately.

### 4. CONCLUSION

The tip and barrel method to measure the output voltage ripple for DC-DC converters is less noise-collecting and is easy to implement to obtain accurate data. Together with choosing an acceptable oscilloscope sampling bandwidth for the applications and proper measurement points, accurate measurement can be easily achieved. It is excellent for performing a quick check for most DC-DC converters.

**Next Steps**

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