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Measuring ESU Peak Voltages

Demands of the modern ESU PM procedure

Electro-Surgical Units (ESU) are Medical Devices that are constantly evolving with new innovative modes used in surgery. To ensure the safety of medical professionals and patients, Preventive Maintenance (PM) procedures are also evolving and adapting to these new ESU technologies.

Biomedical teams from manufacturers, service companies, and hospitals require an accurate and capable ESU Analyser to perform such PM procedures.

Today, there are some ESU testing procedures that require engineers to record peak voltage (**Vpeak**) readings on cut or coag outputs and compare them with limits provided by the manufacturers.

Some ESU Analysers on the market measure only **peak-to-peak voltages** (**Vpeak-to-peak**). Careful choice of the ESU Analyser needs to be made to ensure manufacturers' required testing can be performed properly.

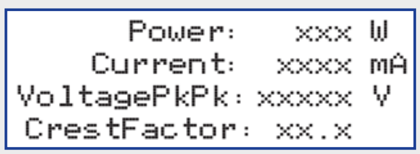

Figure 1: Display shown by a competing ESU analyser; Vpeak-to-peak is labelled as VoltagePkPk.

"Vpeak-to-peak" is the total voltage between the negative peak and the positive peak, while "Vpeak" is the voltage between the zero volt line and the largest peak of the signal, which could be on the positive or the negative part of the curve.

The following drawing shows the difference between "Vpeak" and "Vpeak-to-peak":

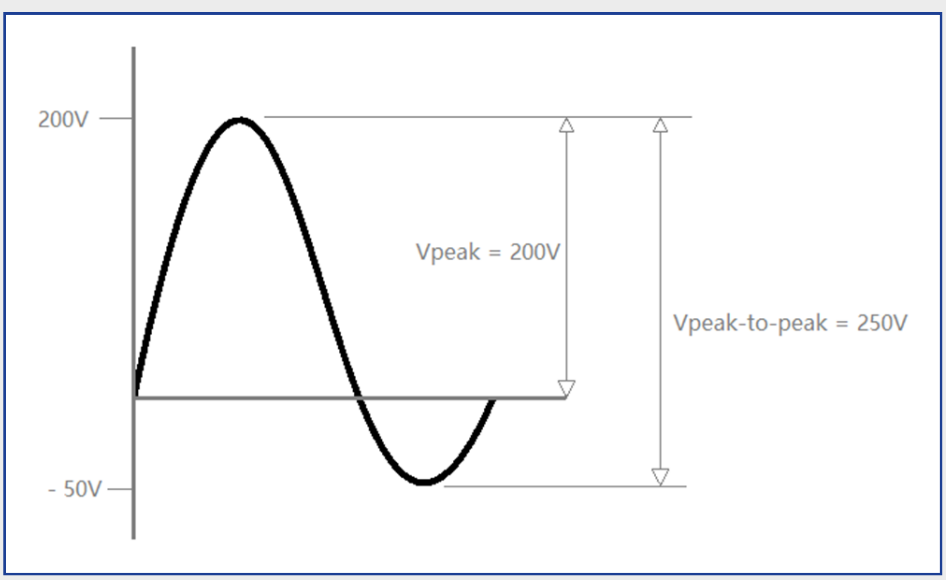

Figure 2: Vpeak vs Vpeak-to-peak for an asymmetric sinewave.

A story of Symmetric or Asymmetric ESU waveforms...

We must consider that ESUs output waveforms can be symmetric or asymmetric.

For symmetrical output waveforms, ESU Analysers can obtain the Vpeak of the ESU by measuring the Vpeak-to-peak voltage and dividing the result by 2. Alternatively, the analyser may simply display the Vpeak-to-peak measurement and then the engineer will have to manually calculate the Vpeak value.

For asymmetrical output waveforms, however, the above method would provide the wrong results and should be avoided. The correct way to measure Vpeak for asymmetric waveforms is to measure only the largest positive or negative part of the output waveform (whichever is greater).

Datrend's vPad-RF ESU Analyser measures both the Vpeak-to-peak and Vpeak independently as these values may not relate to each other.

On the vPad-RF display captured below, we can easily see that the ESU waveform is asymmetric and, as expected, the Vpeak measurement does not correspond to half of the Vpeak-to-peak value.

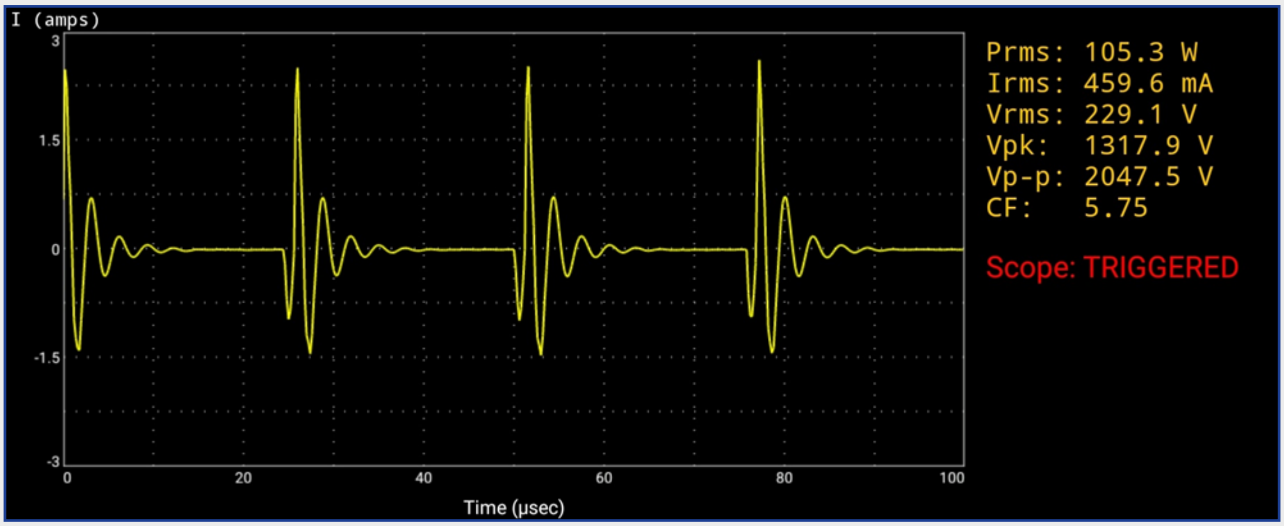

Figure 3: Screenshot of vPad-RF app displaying an ESU waveform.

The output waveforms of many modern ESU's are asymmetrical. Measuring these waveforms is more complex and requires special considerations.

In these cases, the 'easy method' where we measure the Vpeak-to-peak voltage and divide the result by 2 (as in the case when the output waveform is symmetrical), simply will not work. It could significantly underestimate the Vpeak values.

This is a big mistake to be making when you are trying to test an ESU to ensure it passes its own safety requirements. The engineer could be confirming the ESU is within specifications and putting the device back to service, when in fact the device could have failed the manufacturer's requirements and would have put the patient's safety at risk.

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A story of accuracy...

We must also consider the capability of the ESU Analyser to determine the voltage.

Accuracy of Datrend's vPad-RF is ±(1% +10V) for Vpeak measurements, but be aware that other ESU testers could be ±(10% +50V)!

This means a test at 2,500V using other ESU testers could be inaccurate by up to 300V (which is 10% of 2500V plus 50V). At 250V, such testers may be inaccurate by up to 75V (which is 10% of 250V plus 50V). Is it acceptable to measure high voltage with 12% error (2500V ±300V)? Is it acceptable to measure lower voltages with 30% error (250V ±75V)? You must consider what the manufacturer of the ESU is asking for to ensure accurate measurements are made.

Compare that to Datrend's vPad-RF: at 2500V, the error is under 1.5% (or ±35V); and at 250V, the error is only 5% (or ±12.5V).

So how is Vpeak measured?

There are two methods of measuring Vpeak:

The 1st method uses an oscilloscope and manually captures a signal of the output. This waveform can then be measured with cursors placed on the highest or lowest point to measure Vpeak in relation to the zero-volt line.

This requires a good scope, but more importantly, we need to appreciate the output of the ESU is not ground referenced, so we should not be grounding the patient return or neutral output of the ESU to the scope. The vast majority of modern ESUs are F Type. Therefore, we need a floating interface, and with such high voltages as well as high frequencies present, it needs to be a differential oscilloscope probe of the highest performance and safety.

Such high voltage probes do exist but have a high price of around $3500 USD, which adds significantly to the cost to the equipment required to perform the test properly.

The 2nd method relies on the internal workings of the ESU Analyser to determine Vpeak. Some can do this measurement, some cannot, some perform it correctly, some do not.

Take our case. We need to deduce the voltage from the resistance and the current (***as most modern ESU Analysers measure current, not voltage***). Ohm's Law, V = I x R, can be helpful to obtain the voltage.

But at a typical ESU signal of 450KHz, the radio-frequency characteristics of the load can add more complications!

A load at DC is "X" Ω, but at 450KHz we may no longer be dealing with resistance, but impedance (Z). This causes all kinds of effects; it can make accurate readings difficult to obtain. The load at 450KHz could be "X" Ω +/- some other "resistance", which may either be a capacitive or inductive reactance.

So, V = I x Z, not R.

And remember... Z changes with frequency.

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The challenge does not end there, because when applying a 2500V @ 450Khz into an ESU Analyser can cause other effects. The analyser needs to be correctly designed to safely withstand the high power and high voltage that the ESU may produce, while at the same time protecting the sensitive measuring circuits inside the analyser.

At Datrend Systems, we have considered these challenges very carefully.

Datrend has designed a special test tool that takes into consideration the high voltage and also the impedance of the test circuit. With this tool, vPad-RF correctly measures Vpeak, so you can confirm with confidence that the modern ESU you are testing is functioning correctly and safely.

Datrend's test tool reduces the cost of the special equipment required to a fraction of the cost of a high-voltage differential oscilloscope probe. The overall package is cheaper and gives more accurate results than any other analyser on the market.

Click here to learn more about the vPad-RF.

vPad-RF is just one of the modern analysers available from Datrend Systems, contact us at Sales@Datrend.com to learn more about our full-line of Biomedical Test Instrumentation and Solutions.

vPad-RF is the complete ESU Analyser!