

Application Note

## **Damping Factor (Q) computation for MIL-STD-461 CS116 signal with new TEMA3000 formulae function**

# Damping Factor (Q) computation for MIL-STD-461 CS116 signal with new TEMA3000 formulae function

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## 1 Summary

In previous TEMA3000 software versions, parameters computed by oscilloscope and screenshots were retrievable at the beginning of a test, at the end of the test, or for every impulse. These process parameters were displayed on computer's screen during the test and included automatically in the test report saving significant time with respect to monitoring and evaluation. The latest release of TEMA3000 software, as of S2 2022, complements these sophisticated functions with the capability to define formulae that include various parameters measured by an oscilloscope, and compute for each impulse even more parameters than those already available.

The ability of TEMA3000 to define formulae and hence automatically compute complex parameters based on measured ones allows many new possibilities, but this note will focus on automatic computation of damping factor (Q), as defined in MIL-STD-461, CS116 requirement.

## 2 Overview of the TEMA3000 formulae capability

Automatic measurement capabilities available with TEMA3000 and TEMA3000 DSO software module are "Take a screenshot", "Do a measurement" and starting with 4.9.0 version "Do advanced measurements". Each of the three actions can be selected by following the steps from figure 1:

Step 1: A Single Test is selected/defined, e.g. a CS116 test with MIL3000 or MIL-MG3 generators equipped with MIL3-10K10M module and connected to CN-BT6 coupler.

Step 2: After defining the Setup parameters (e.g. 1 MHz and 10 A level), the tab "DSO Trigger" (DSO: Digital Storage Oscilloscope) is selected;

Step 3: After defining a DSO and a suitable DSO setup, "Add" button is clicked. This will open the "Add a new DSO trigger" window;

Step 4: The timing of the DSO trigger is selected: "When test starts", "When test stops" or "On every impulse". For this application note, "On every impulse" is selected;

Step 5a: The desired "Action" can be either "Take a screenshot" or "Do a measurement". For "Do a measurement", limits and settings like unit of measurement can be defined before pressing OK to add the trigger to the single test or:

Step 5b: beside "Take a screenshot" or "Do a measurement" actions, a third action is available: "Do advanced measurements".

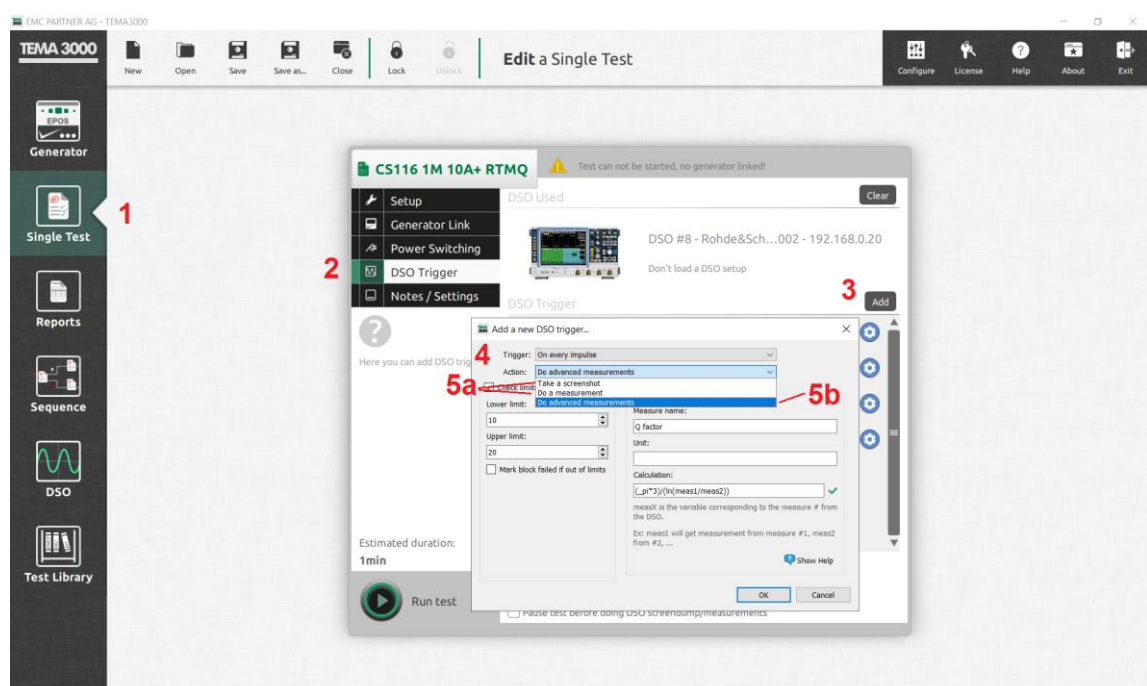


Figure 1. Steps needed for defining DSO triggers / measurements in TEMA3000.

Once the action 5b is selected, following settings can be performed: selection of automatic limits and setting lower and upper limits, name of the measure, measurement unit of applicable and the formula whose result will be displayed during the test and included automatically in the test report. The field "Calculation" can be filled in with a formula. The field/formula can include following:

- normal operators like "+", "-", "\*", "/";
- constants like "\_pi" (3.14) or "\_e" (2.718);
- brackets "(" and " )";
- functions like: "sqrt", "ln", "sum", etc. A complete list can be found in TEMA3000 help.
- variables: they are called "meas1", "meas2", etc. These variables are corresponding to automatic measurements that an oscilloscope performs and are predefined by operator.

In figure 2, three variables are pointed out:

- "meas1" – represents the current peak value measured by the oscilloscope on channel 1;
- "meas2" – represents the peak value of current measured by the oscilloscope on channel 1, but within the predefined gate/window (the gate has been set to measure the 4<sup>th</sup> peak, closest to 50 % of the 1<sup>st</sup> peak, necessary to compute damping factor);
- "meas3" – represents the automatic measurement of frequency by the oscilloscope within the predefined gate/window.

Taking into consideration the syntax available, the expression of damping factor Q can be written in TEMA3000 as follows:

Q expression in the standard	TEMA3000 expression of the formula
$Q = \frac{\pi(N-1)}{\ln(I_p/I_N)}$ <p>Where: Q = damping factor N = cycle number (for peak closest to 50 % decay)</p>	<p>Calculation: <math>(\_pi*3)/(\ln(\text{meas1}/\text{meas2}))</math></p> <p>Where: _pi = 3.14 constant N = 4 (MIL-MG3 peak 4 is closest to 50 % decay), hence _pi is multiplied with 3 (i.e. N-1) meas1 = automatically measured peak at 1<sup>st</sup> cycle meas2 = peak current at cycle closest to 50% decay</p>

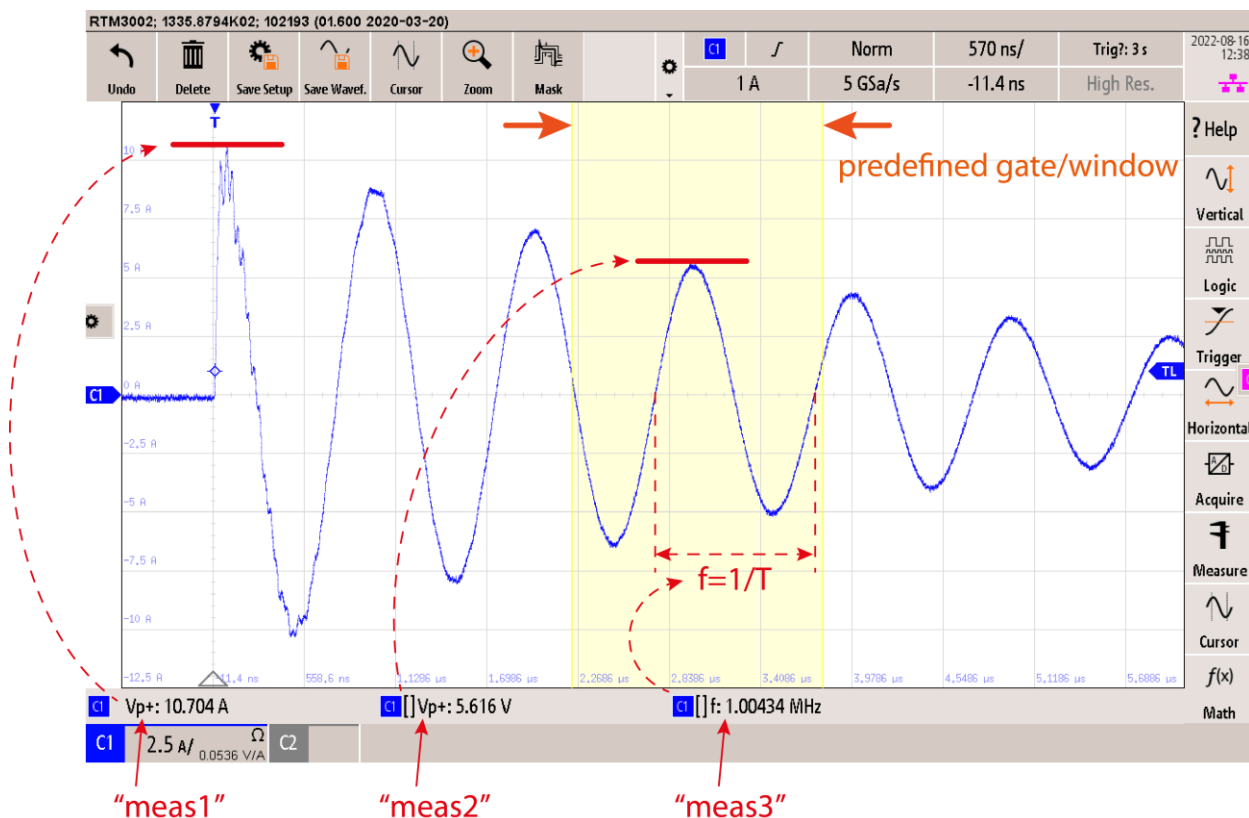


Figure 2. Definition of "meas1", "meas2" and "meas3" in oscilloscope's menu.

In figure 2, "meas1" corresponds to  $I_p$  and "meas 2" corresponds to  $I_N$  from MIL-STD-461G CS116.

The maximum number of “measx” variables depends on the oscilloscope model. For reference purposes, figure 3 exemplifies how “meas1” variable has been set in oscilloscope’s menu: “Measure” is activated, then Meas. Place 1 knob is ticked. “meas1” variable will correspond to Meas. Place 1 and will overtake its value whenever used in a formula. The type of measurement selected is Peak+, and it will be displayed as Vp+ in the down-left corner of the screen. Subsequently the source is selected (for “meas1” it is channel 1 of the oscilloscope), “Use Gate” is deactivated (for “meas2” and “meas3”, “Use Gate” will have to be activated) and “Statistics” as well.

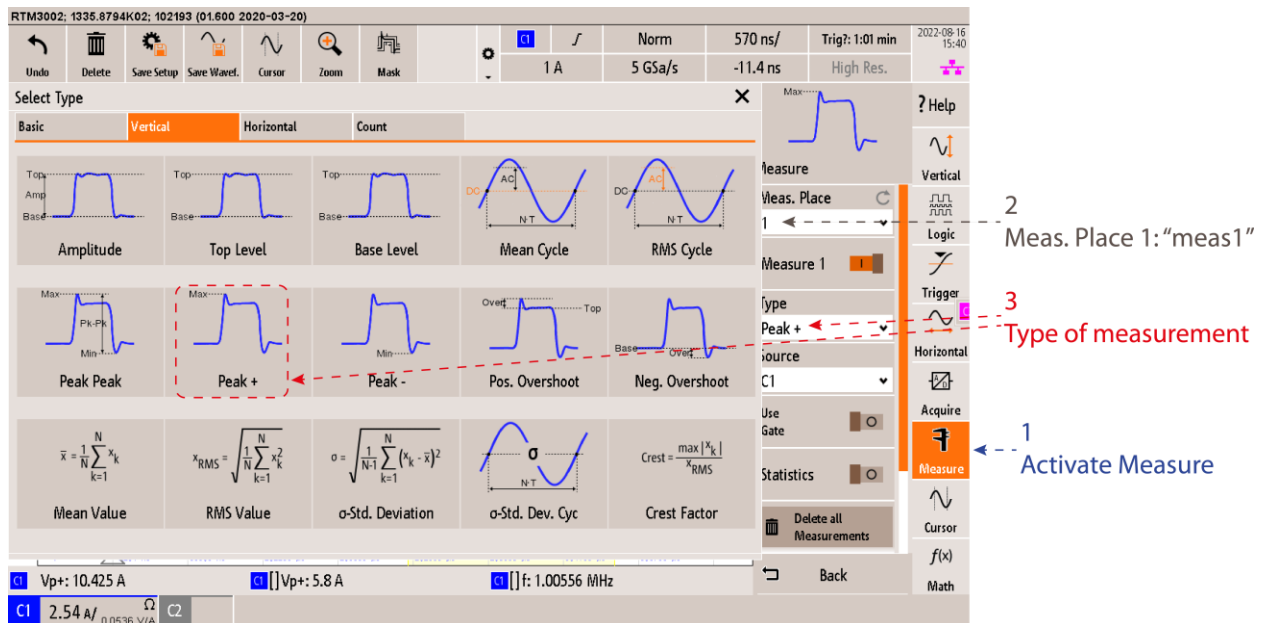


Figure 3. Definition of “meas1” automatic measurement in oscilloscope’s menu (R&S RTM3002 model).

In a similar manner, “meas2” will be set to measure peak 4 amplitude (for this oscilloscope model as Pk+ in the time gate/window described previously) and “meas3” will be set to measure the frequency within the same gate.

**Note:** menu structure and appearance might be slightly different for various oscilloscope models!

### 3 Required equipment, software and settings for automatic computation of damping factor in TEMA3000

#### 3.1 MIL-MG3 settings

In order to carry out a calibration with automatic damping factor calculation in TEMA3000, following setup must be selected:

MIL-MG3 is equipped with the plugin MIL3-10K10M, a **1-meter cable** is used to connect the plugin to **Input 1** of the coupler CN-BT6 (for 1 MHz signal). The coupler is placed in the VERI-MIL3 calibration fixture, and termination and high voltage attenuator are connected, and the cable together with the low-power 2 x 20 dB attenuators are connected to oscilloscope as below.

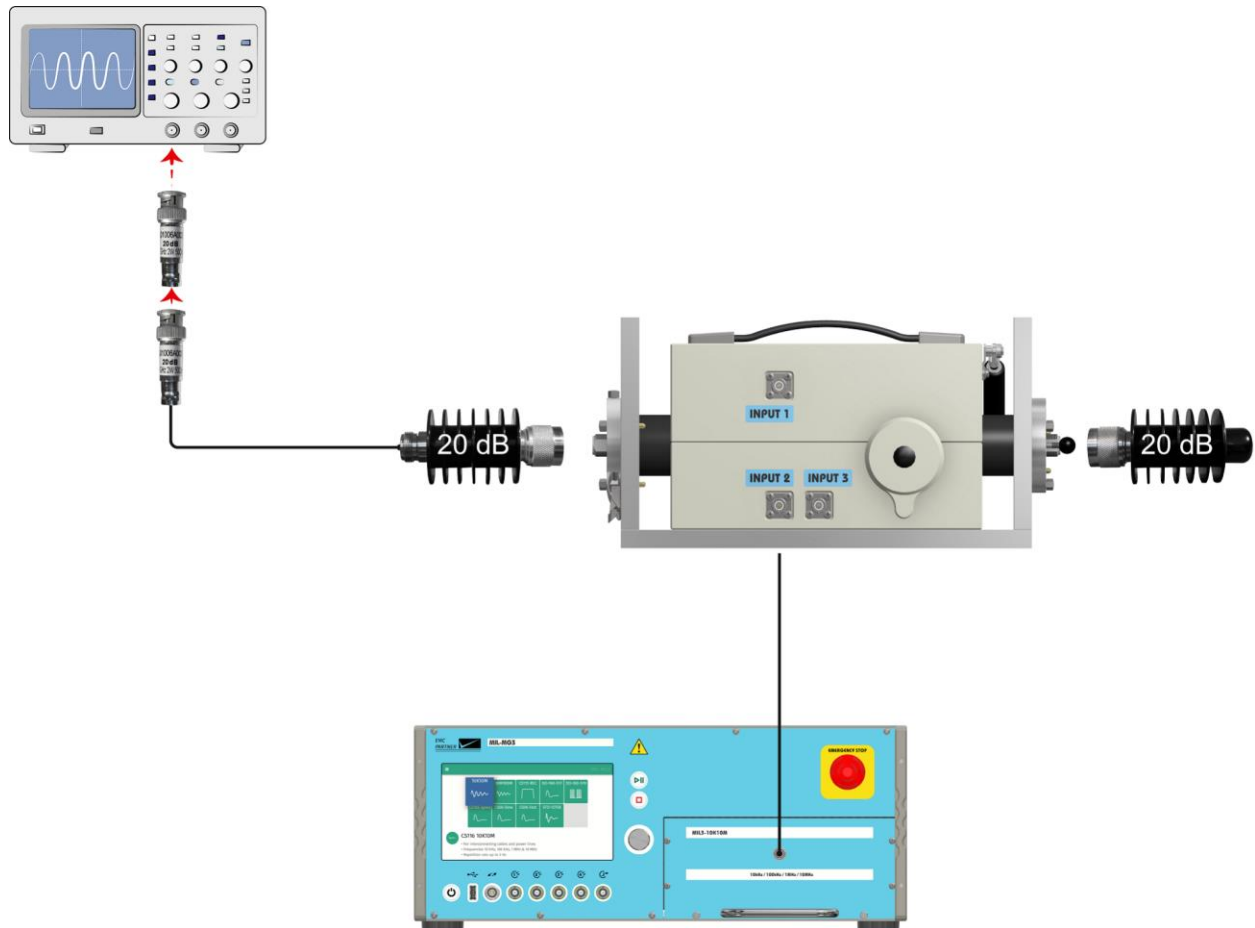


Figure 4. Setup for calibration with automatic damping factor, CS116 at 1 MHz.

### 3.2 Oscilloscope settings

Following settings are required in order to automate damping factor calculation:

Channel 1 active, input 50  $\Omega$ , probe factor as retrieved from VERI-MIL3 calibration report, measurement unit Amperes, scale 2.5 A/division, zero offset;

Time domain: 1  $\mu$ s/division or a similar value that allows displaying the waveform properly;

Trigger: normal, trigger level 2 A, trigger input Channel 1

Automatic measurements (function MEASURE or similar name) set as follows: measurement 1, that will be accessible in TEMA3000 as "meas1", for positive peak 1, measurement 2, that will be accessible in TEMA3000 as "meas2" for positive peak 4 (in order to set this, a gate/window must be activated with length > 1 period, that encompasses peak 4), and only for reference purposes, measurement 3 ("meas3") will measure the frequency within the gate/window defined previously for "meas2".

### 3.3 TEMA3000 Single Test definition

Communication between TEMA3000, MIL-MG3 and oscilloscope must be ensured.

In the "Single Test" menu, following settings are to be introduced:

New / Setup / Create / MIL-MG3 / CS116 10K10M

Waveform CS116 1MHz, Level 10 A, Polarity Positive, Test Time 50 s, repetition 5 s, Coupling Network CN-BT6.

After validating parameters and linking the generator unless already automatically linked, in the section DSO trigger, "Click to choose a DSO"/ Select the current DSO / "Learn new setup" and rename it/ eventually choose the setup.

The next step is to add DSO triggers. The first trigger to be added can be the calculation of damping factor Q. hence, select "Add", then "Trigger: On every impulse", "Action: Do advanced measurements" and "OK".

The fields that appear may be filled in as in figure 1. The automatic limit check has been set to minimum 10 and maximum 20 since the value of damping factor Q is defined in the standard as  $15 \pm 5$ .

Other triggers can be added, should this be required. In the report sample below, frequency has been added on the list of automatically measured parameters ("Do a measurement"), amplitude of first peak, and an automatic screen dump has been added as trigger as well.

After saving the single test and running the test, the test report will include automatic damping factor measurement as in the sample below.





Test Data								
Time	Impulse Number	Test Time	Level	Repetition	Q factor	f	Peak	DSO
Test started								
12:05:23.629	1	4 s	10.5 A	5 s	16.6747	1.00475 MHz	10.075 Amp	
12:05:28.630	2	9 s	10.5 A	5 s	16.4199	0.9994 MHz	10.075 Amp	
12:05:33.730	3	14 s	10.5 A	5 s	17.088	1.00198 MHz	10.025 Amp	
12:05:38.729	4	19 s	10.5 A	5 s	16.6747	1.00359 MHz	10.075 Amp	

Figure 5. Sample from TEMA3000 test report with automatic damping factor computation.

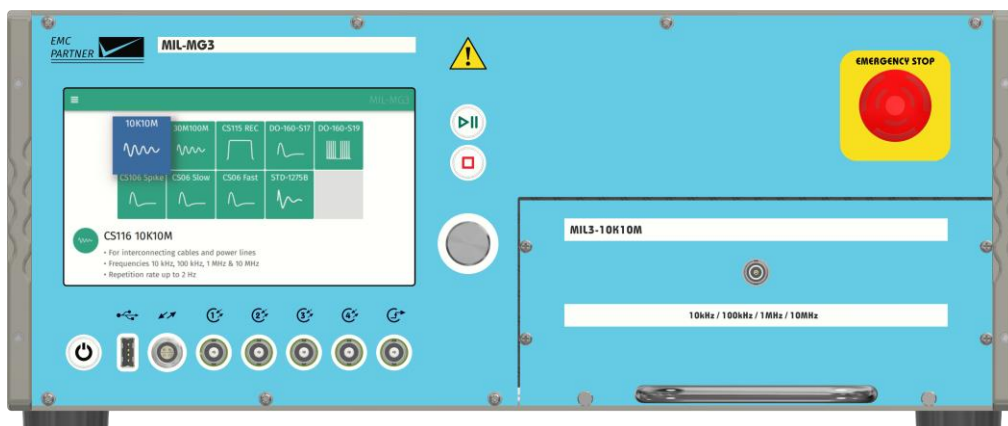
## 4 Conclusions

This application note presented an example of utilizing the new formulae/computation function available in TEMA3000 software with TEMA3000 DSO module. Damping factor computation is only one application that the new feature enables, the implementation is easy to configure and very flexible. It works with all oscilloscopes that are supported by TEMA3000 (Ethernet connection and compatible with VISA driver). For special measurements like the 4<sup>th</sup> peak of CS116 signal, the oscilloscope may require the gate/window capability, but this has also become widely available recently.

## 5 Relevant products

a) MIL-MG3 generator and accessories:

<https://www.emc-partner.com/downloads/brochures/8-military-test-system/file>



b) Any other EPOS / EPOS Orion generator that works with TEMA3000 and requires special reporting that may include computations based on formulae:

<https://www.emc-partner.com/downloads/brochures>

## 6 References

- [1] EMC PARTNER TEMA3000 user manual
- [2] [www.emc-partner.com](http://www.emc-partner.com)
- [3] MIL-STD-461G / 2015

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