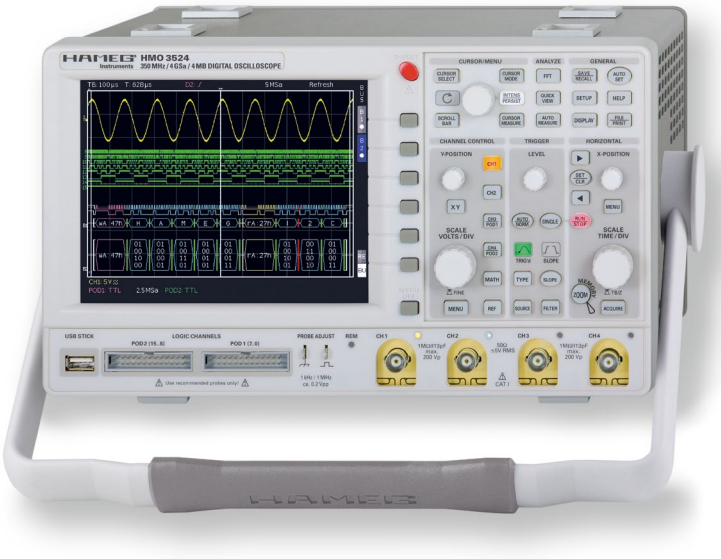
HAMEG Oscilloscopes

Measurement of power and energy using the combined mathematical functions of the oscilloscope

The new series of Digital Storage Oscilloscopes HMO352x/2524 of HAMEG Instruments features a deep acquisition memory of 2 MB per channel, a sampling rate of up to 4 GSa/s and a bandwidth of 350 MHz. These specifications recommend these instruments for the analysis of dynamic switching signals in power circuits, e.g. inside mains power supplies. Additionally, the HMO series offers special analysis and setting functions required for power and energy analysis. HAMEG also offers optional accessories such as difference amplifier probes (e.g. the type HZ115, specified for up to 1000 Vrms and up to 30 MHz), passive high voltage probes (e.g. the type HZ53 100 : 1, specified for up to 1200 Vrms and 100 MHz) and a DC/AC current probe (e.g. the type HZO50, specified for up to 20 Arms and up to 100 kHz) in order to allow the safe isolated measurement of signals with the oscilloscope.



In power supplies quite often signals have to be measured which are neither referenced to earth nor the housing. Frequently, the oscilloscope is powered via an isolation transformer and a standard passive probe is used. This procedure is highly risky:

- ❑ The oscilloscope housing's potential will be undefined which may endanger the life of the operator.
- ❑ The isolation of an oscilloscope's power supply, as a rule, will not be designed for any voltages which may occur in such a setup and may hence be destroyed.
- ❑ Due to the fact that all input channels of an oscilloscope have a common ground only the channel may be used to which the passive probe is connected.
- ❑ The test object will be loaded with the capacity of the oscilloscope housing resp. the isolation transformer which may cause the destruction of fast switching circuits.

The safest und best method from the measurement standpoint to eliminate these potential hazards is the use of a galvanically isolated difference amplifier probe which offers the possibilty of isolated measurements within circuits. However, even the best difference amplifiers always display a small residual offset error. This means that there will always remain a small offset error in the measurement. The HMO offers compensation by software. In order to perform the compensation, turn on both instruments for at least some minutes to allow the temperature drift to settle, with the input terminals of the difference amplifier probe shorted together and the desired attenuation selected (100 : 1 in this example). Then use the AUTO measurement function of the HMO to measure the average of the channel to which the difference amplifier probe is connected, this will reveal the offset. In this example the offset error is appr. 150 mV. Use the vertical menu of the channel (in this example channel 2 is used) to compensate the error by selecting the appropriate DC offset value as shown in figure 1.

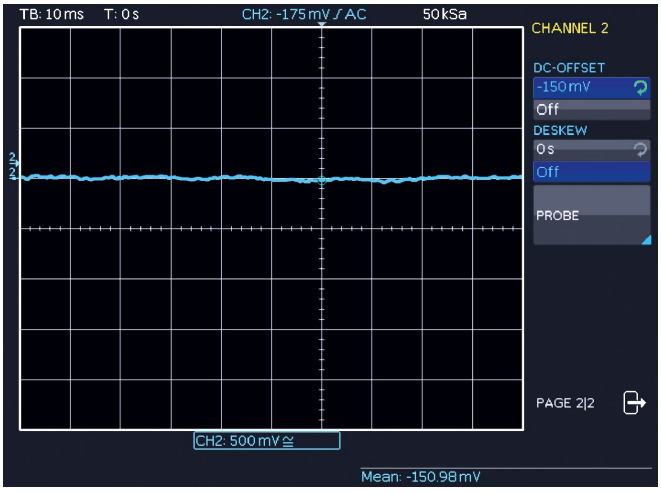


Fig. 1: Offset compensation in the vertical menu.

If fast switching signals are to be measured or, e.g., the power in the moment of switching, the different signal delays of the various voltage and current probes have to be considered. This is exactly possible by using a signal source which delivers coincident voltage and current outputs. The same procedure used for the compensation of the voltage offset is applicable to the time offset (see figure 1) in order to compensate for any difference in the delays of voltage and current probes.

These basic preliminary operations are necessary in order to obtain precise measurement results. Now the mathematical functions have to be selected which are required for the power and energy curves' display. The HMO series offers 5 sets of formulas, up to 5 equations may be entered in each. The most important mathematical analyses will be assigned to the 5 sets of formulas which can be quickly called without the need to enter the equations each time anew. Sets of formulas may also be stored on a USB stick in order to save them or to make them available to other HMO users. In this example, the energy curve of a cycled load of a power supply shall be displayed. The voltage across the load is measured with an active difference probe (including the offset compensation), the load current with a current probe connected to channel 1.

The first task will now be entering the current probe factor (100 mV/A). Formula set 1 will be called, and equation MA1 will be defined. Channel 1 will be multiplied by a constant (0.1) and assigned the unit A (Ampere). This will ensure that the scaling and the units displays will be correct as well with cursor as with auto measurements.

Fig. 2: Definition of a current equation

Now a new equation will be entered into formula set 1 and adjusted so that the result of the equation „Current" and the channel 2 will be multiplied, this will yield the power curve. Subsequently, another equation is added to the formula set which is defined as the integral of the equation „Power".

Now all definitions are complete, and the results can be displayed and analyzed further. The following figure shows

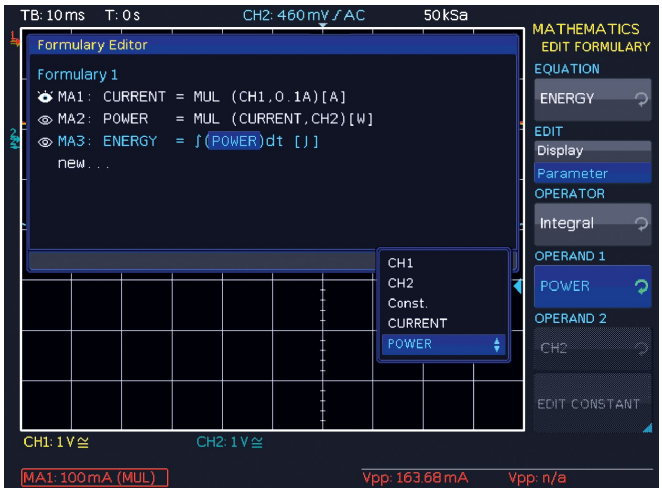


Fig. 3: Definition of the energy equation.

all 3 equations of the formula set, the newly scaled current curve is displayed above channel 1. Its shape is identical to channel 1, but it contains the current probe scale factor and unit Ampere. The mathematical curve in the middle is the power curve and it represents the instantaneous power. The lowest mathematical curve is the energy curve, the integral of the power curve. The peak current and the peak power were obtained by using the auto measurement functions, both are correctly scaled and display the correct units Ampere and Watt. Additionally, cursor measurements may be performed on the curves in order to determine the values of voltage, current, power, and energy at any arbitrary point of the measured and calculated signals.

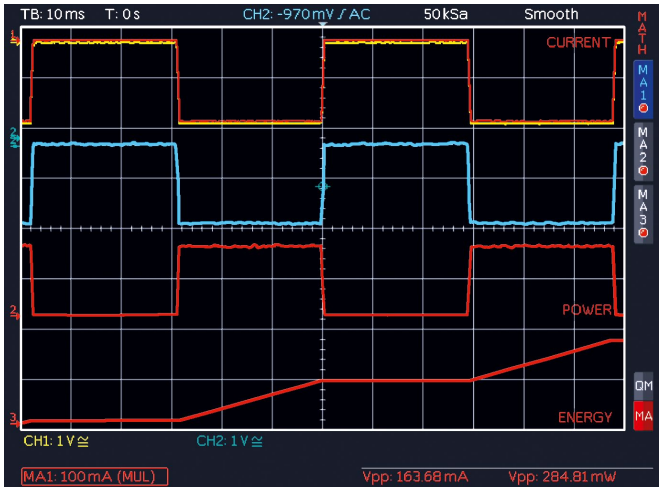


Fig. 4: Display of input and analyzed functions.

Summary:

Digital Storage Oscilloscopes are very well capable of measuring the instantaneous power and energy of electronic subassemblies or switched mode power supplies. The measurement features are supported by the right accessories such as difference amplifier probes and current probes. The oscilloscopes should offer the following functions:

- ❑ Vertical offset compensation for active probes.
- ❑ Compensation of differences in signal delay between channels if dissimilar probes such as voltage and current probes are used.
- ❑ Combined mathematical functions e.g. in order to calculate the energy curve.

As shown the HAMEG HMO series oscilloscopes feature all these functions, it was also shown that these oscilloscopes together with the associated accessories deliver a precise and comfortable power and energy analysis.

Check list for correct power measurements with an oscilloscope:

- ❑ A difference amplifier probe with suitable measuring ranges.
- ❑ A current probe or shunt with a range and a rise time to suit the currents encountered.
- ❑ The voltage offset of the difference amplifier probe was compensated in the oscilloscope.
- ❑ The different signal delays in the voltage and current paths were compensated in the oscilloscope, so both voltage and current signals will be correctly displayed.
- ❑ The oscilloscope is able to perform concatenated mathematical operations in order to multiply the voltage and current curves and to derive the integral of the product.