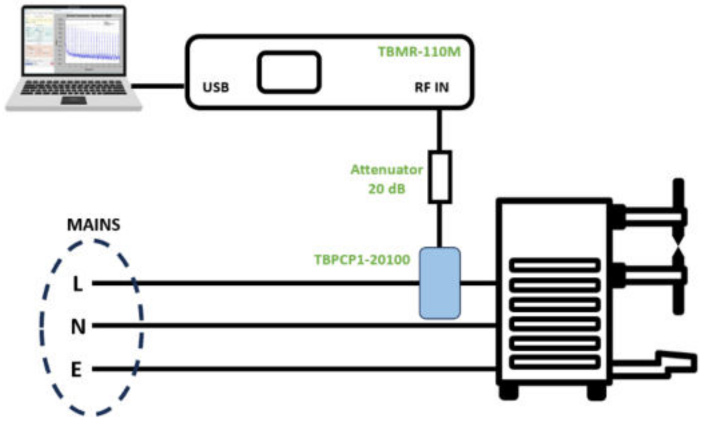
# 1. Introduction

This paper describes how to use the equation feature in the TBMR-110M spectrum analyzer application. A spot welder´s transformer is tested for mains harmonics during the welding operation. The transformer´s main line is routed through the aperture of a Tekbox RF Pulse Current Monitoring Probe. A suitable equation is used to convert the voltage at the probe's output into current units, which is then displayed on the diagram.

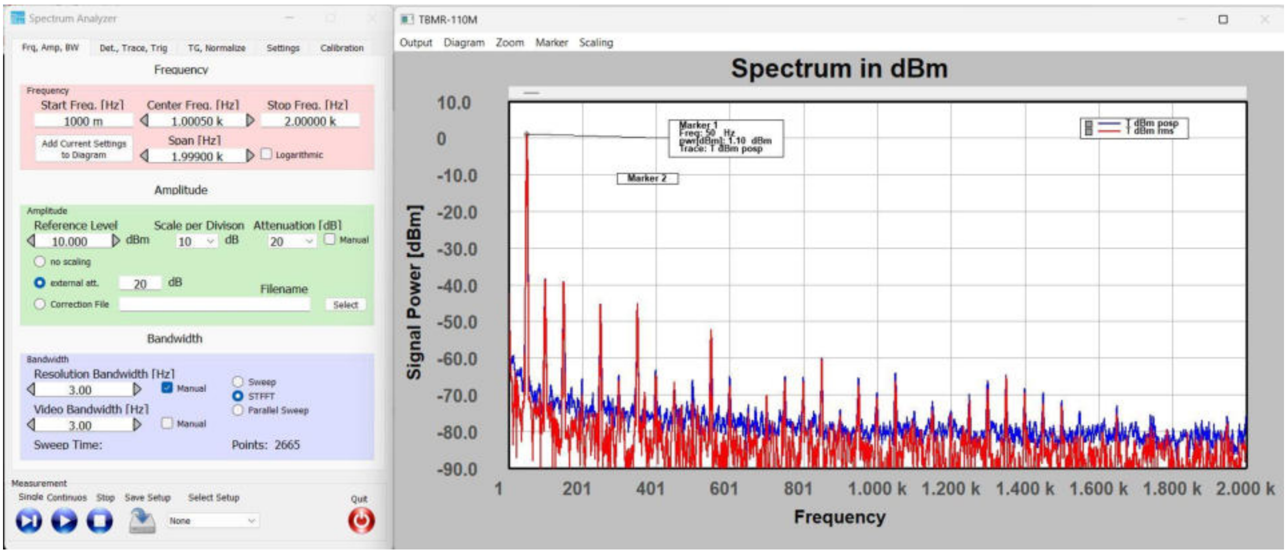
# 2. Spot-welding transformer – primary current measurement




The transformer's main line is routed through the aperture of the TBPCP1-20100 RF Pulse Current Monitoring Probe. The probe has a 3dB bandwidth between 20 Hz and 100 MHz and a transimpedance of -20 dBΩ in a 50 Ohm system. A 20 dB attenuator is connected between the probe output and the TBMR-110M RF input.

Based on the transformer datasheet, the primary current is approximately 2 A, which converts to 126 dBµA. Adding a transimpedance of -20 dBΩ gives a probe output voltage of 106 dBµV, or -1 dBm. This is well within the acceptable RF input power range. Nonetheless, a 20 dB attenuation is included to provide protection against any current transients when turning on and off the welder. Furthermore, the calculation assumes a sinusoidal current, which may not be the case when in operation.

The TBMR-110M in spectrum analyzer mode is set to a span from 1 Hz to 2 kHz, Gain is set to 0and scaling is set to 20 dB to account for the external attenuator. RMS and Positive Peak Detector are turned on and the resolution bandwidth is set to 3 Hz:




The amplitude of the 50 Hz tone is 1.1 dBm, which corresponds well with the initial estimation.

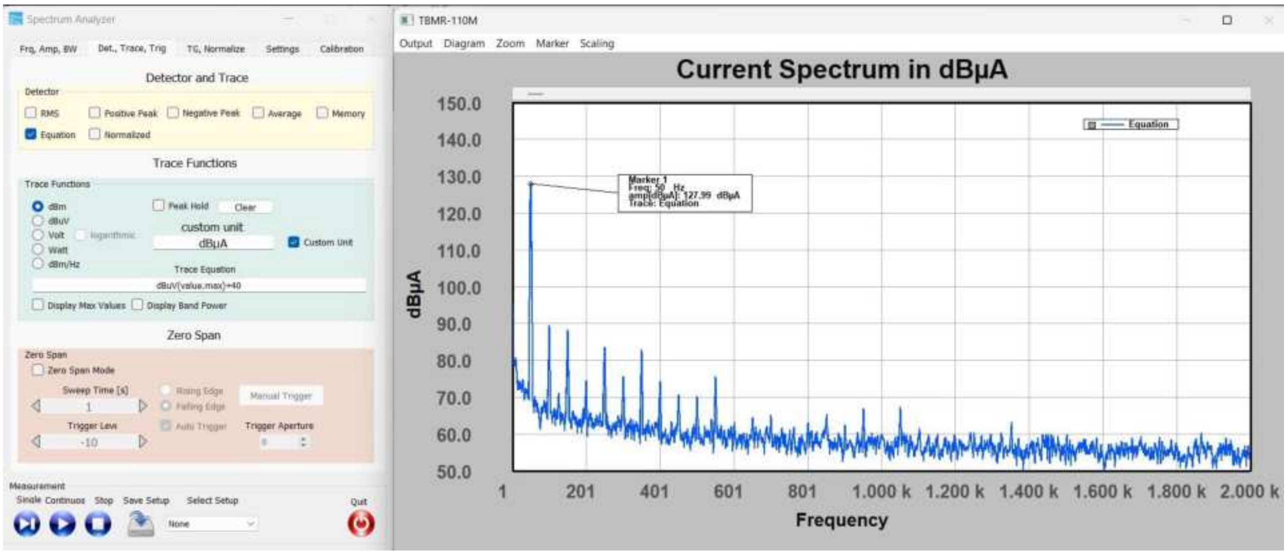
The next step is to convert the measurement result to current.

I [dBµA] = Probe voltage [dBµV] – Transimpedance [dBΩ] + Attenuation dB]
I [dBµA] = Probe voltage [dBµV] + 40 dB

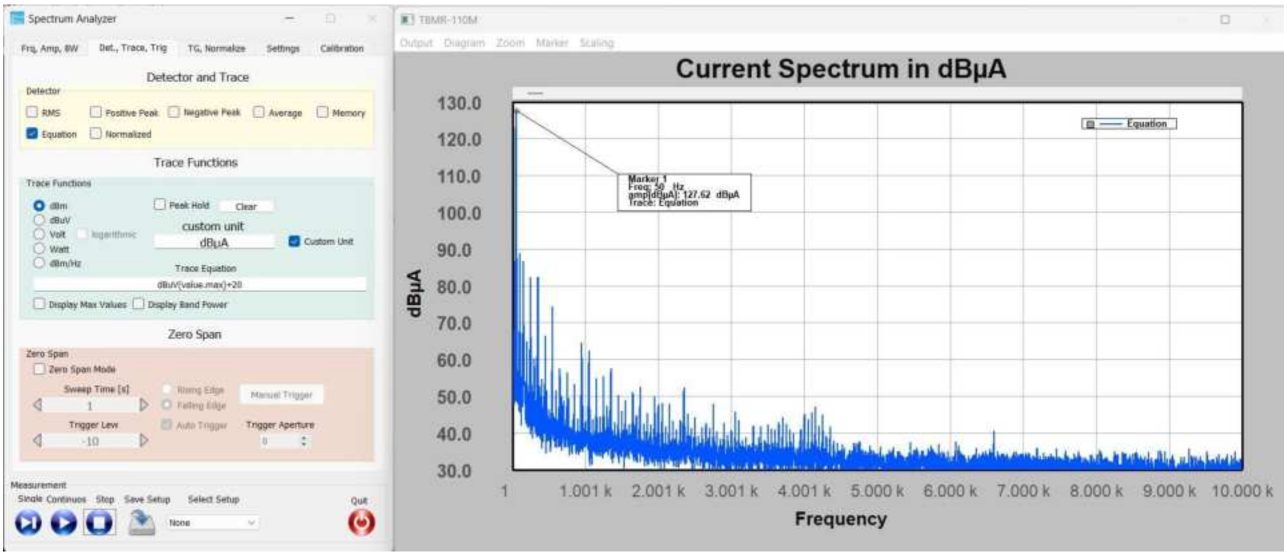
We use the peak detector value in [dBµV] as input data and enter following trace equation:

**dBµV(value.max) + 40**

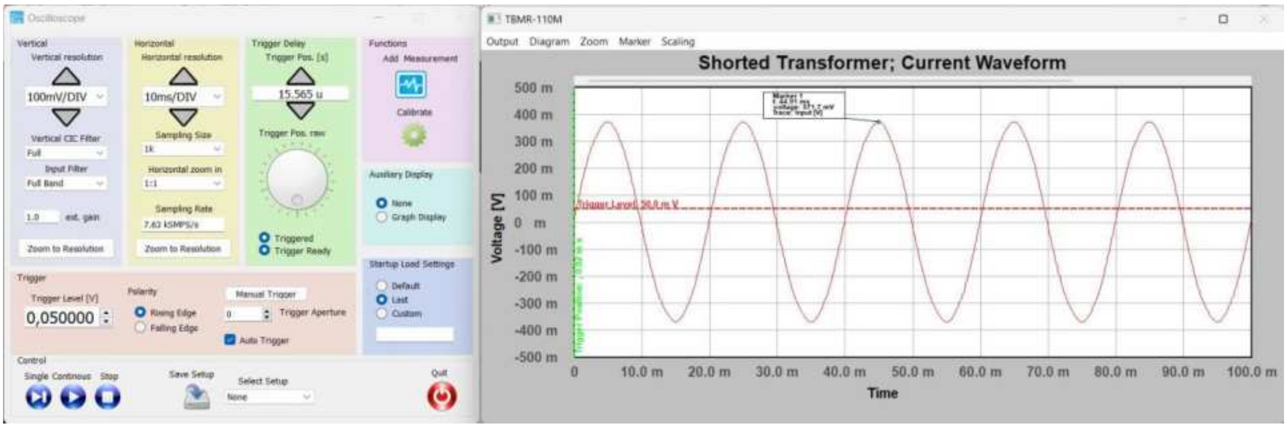
We turn off the RMS and Positive Peak detectors and enable the Equation trace on. We enter dBµA as custom unit for the diagram´s Y-Axis label.




Next we´ll examine the spectrum from 1 Hz to 10 kHz. To increase  dynamic range, we remove the 20 dB attenuator.
The trace equation must be changed to **dBµV(value.max) + 20**



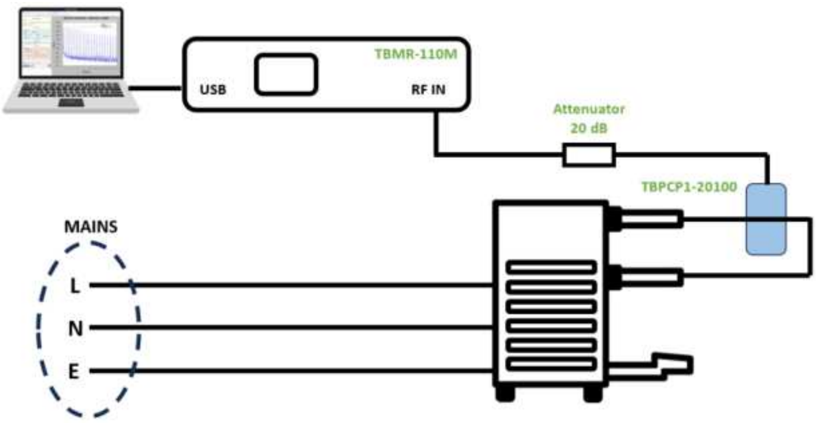

Next we switch to the oscilloscope mode to examine the primary current in the time domain:



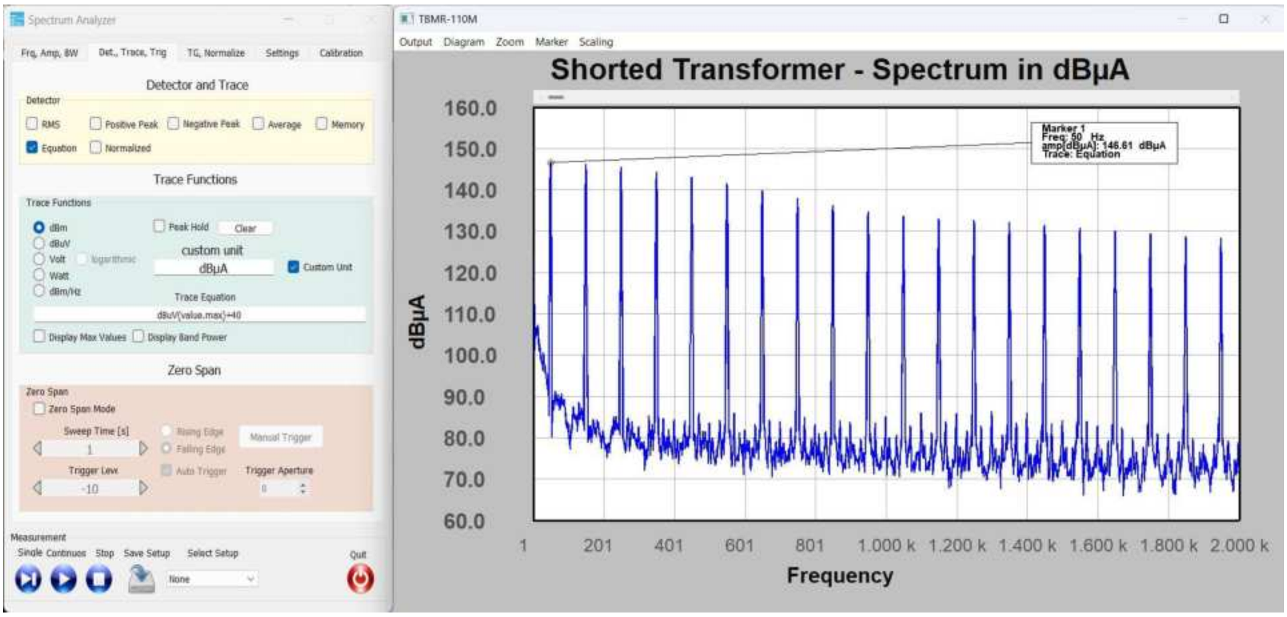
Time domain, attenuator still removed.

## 3. Spot-welding transformer – secondary current measurement

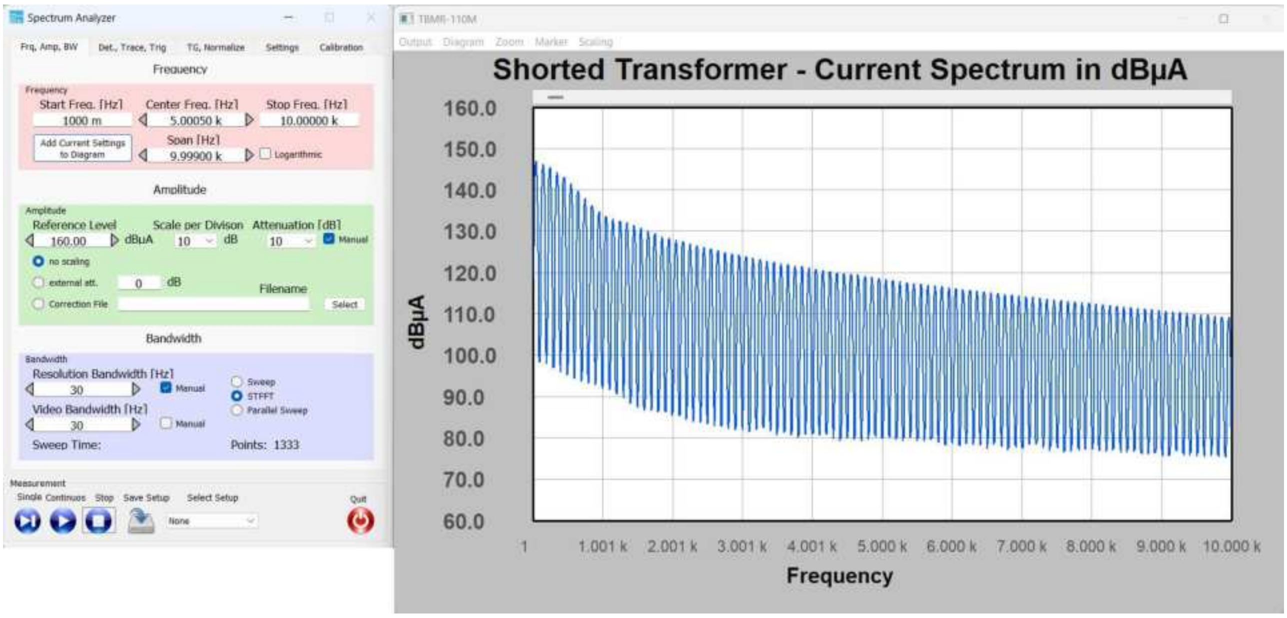
Next we look at the secondary current:




The electrodes are removed and a 3m long copper cable with a diameter of 5mm diameter is utilized to comfortably insert the current probe. We re-insert the 20 dB attenuator, because the secondary current is significantly higher than the primary current.



The measurement result is astonishing. The secondary current is significantly higher, 146.6 dBµA, which equates to 21.4 A and which is expected. However, the current spectrum has extremely high harmonic content.




The harmonics spectrum of the secondary current up to 10 kHz


Secondary current harmonics up to 60 kHz!

Next we examine the secondary current in the time domain:


The output current is highly non-linear. This comes as no surprise, after measuring the spectrum.

## 4. Summary

During operation, the secondary side of a simple spot-welding transformer can be considered shorted. The current spectra of the transformer´s mains side and the secondary side differ dramatically.

The spectrum and waveform of the current of the secondary side shows all characteristics of a highly saturated transformer core. The current on the primary side remains sinusoidal during operation.

This implies that the inductance of the primary winding is large enough to suppress higher order current harmonics, even when saturated.

| Version | Date | Author | Changes |
|---|---|---|---|
| V 1.0 | 21.04.2024 | Mayerhofer | Creation of the document |
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