A Virtual Instrument For Remote Monitoring Of Electromagnetic Field

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*Abstract-*The paper presents a virtual instrument completely based on LabVIEW for remote monitoring of electromagnetic field across the local area network or Internet environment. As our primary intention was to implement a virtual instrument able to measure and display directly the E-field strength values, the access to the instrument is simply performed via the LabVIEW built-in web server.

I. Introduction

Sometimes is necessary to study the electromagnetic field focused on its critical points. We developed an instrument for remote monitoring of electromagnetic field using LabVIEW graphical development environment. As shown in Figure 1, the main constitutive parts of the system are a spectrum analyzer, able to acquire EMF sensor signals and a GPIB interfaced computer running the virtual instrument for electromagnetic field monitoring. Further, the access to the instrument becomes available via the LabVIEW built-in web server.
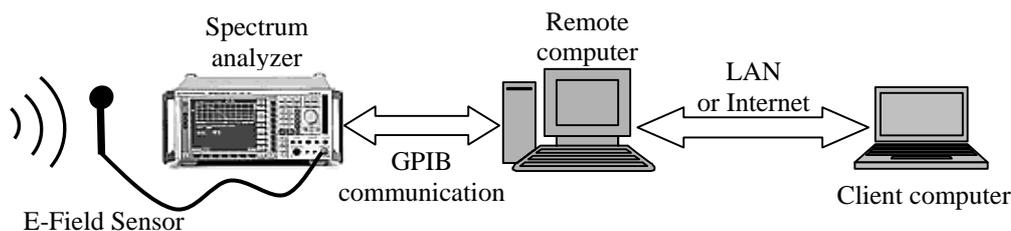

Figure 1. Measurement architecture

II. Virtual instrument description

The virtual instrument remotely communicates with the 2398 spectrum analyzer through direct connection, using the GPIB communication format. The interaction with the VI is performed through the LabVIEW built-in web server. In VI development, our basic idea was to achieve two targets:
1. the implementation of the most important functions of the spectrum analyzer, using GPIB commands;
2. the direct calculation and display of the electric field values;

Taking into account these considerations, we performed the instrument allowing the user to switch the four coupled functions (resolution bandwidth, video bandwidth, sweep time and input attenuation) between Auto mode and Manual mode. Optionally, in Manual mode the values of these parameters are selected through proper controls located on the front panel of VI.

The AUTOCPL function will determine the spectrum analyzer to automatically set the resolution bandwidth, video bandwidth and sweep time parameters to the optimum values so frequency and level measurement errors do not occur and received data from analyzer is correct [1]. Figure 2 presents two measurement examples with the resolution bandwidth automatically fixed at 300 kHz and manually fixed at 30 kHz.

The observation frequency of the spectrum analyzer is set in either of two modes: Start – Stop Mode or Centre – Span Mode. A front panel control allows the settlement of the full frequency span.

The received data from analyzer represents the power. The available data formats could be decimal number format (ASCII code) or binary format [2]. The ASCII strings appear as numeric values and these values has been used for further processing.
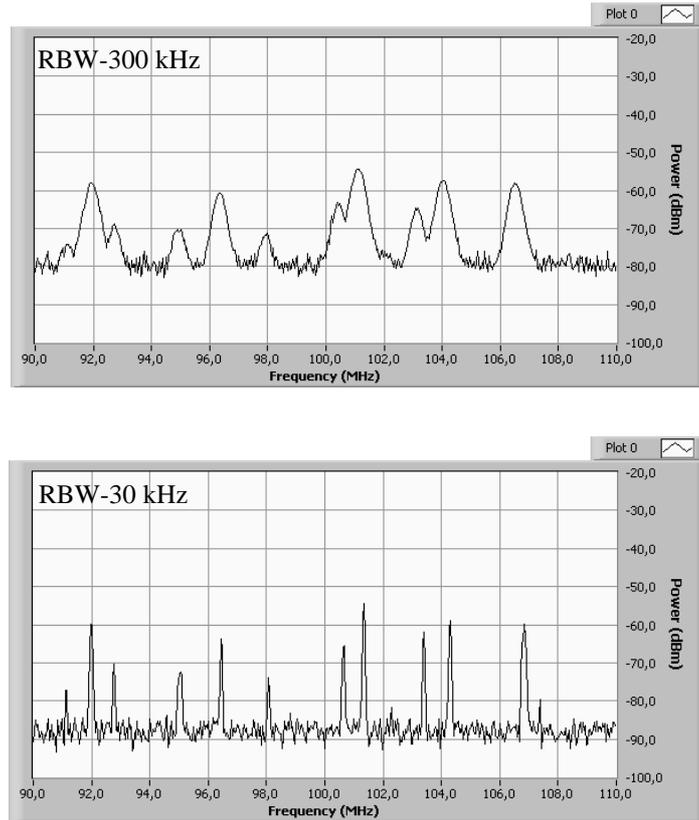
Figure 2. The power (in units of dBm) with the resolution bandwidth
fixed at 300 kHz (auto) and 30 kHz (manually)

The acquired trace is represented by 500 points and the amplitude mode and scale are logarithmic. If the reference level is changed (upper value on Y-axis), the trace is displaced on the graph accordingly to new value. The VI displays the current trace of the spectrum analyzer and also shows the frequency where the power peak level occurs (peak frequency) and the peak level for the displayed trace.

For direct calculation and display of E-field strength, it was necessary to implement the E-field probe performance factor in terms of frequency. The performance factor is defined as the ratio of the field presented to the probe to the voltage developed by the probe at its BNC connector [3].

$$PF[dB] = 20\lg\left(\frac{E}{U}\right) \qquad (1)$$

For testing the VI, we used a 50 Ω near-field ball probe, model 904, from EMC Test Systems, covering the frequency interval from 100 kHz to 500 MHz. Obviously, if other type of probe is desired, the VI will change too, the LabVIEW environment being very flexible in this way.
The voltage developed by the probe is calculated with the following formula [4]:

$$U[dB\mu V] = P[dBm] + 107 \text{, for } R = 50\Omega \qquad (2)$$

The field amplitude is obtained by adding the performance factor to the measured voltage:

$$E[dB\mu V / m] = U[dB\mu V] + PF[dB] \qquad (3)$$

To obtain the strength of electric field in units of dBμV/m, the VI search for all performance factor values (PF) within frequency interval specified by user and computes the E-field strength with relation (3).
Knowing the values of E-field strength in dBμV/m, the basic conversion to the units of V/m has been performed by using the following formula:

$$E[V / m] = 10^{\frac{E[dB\mu V / m]}{20}} \cdot 10^{-6} \qquad (4)$$

The user is able to measure and display both power in dBm and E-field strength in dBμV/m or V/m.

For these quantities are also available the peak frequency and the peak levels. Figure 3 shows two measurement examples, the frequency span being from 90 MHz to 110 MHz. The maximum power peak displayed by the virtual instrument is -55.51 dBm corresponding to a 101.1 MHz frequency. For this power, the calculated E-field strength is 108.90 dBμV/m or 0.279 V/m.
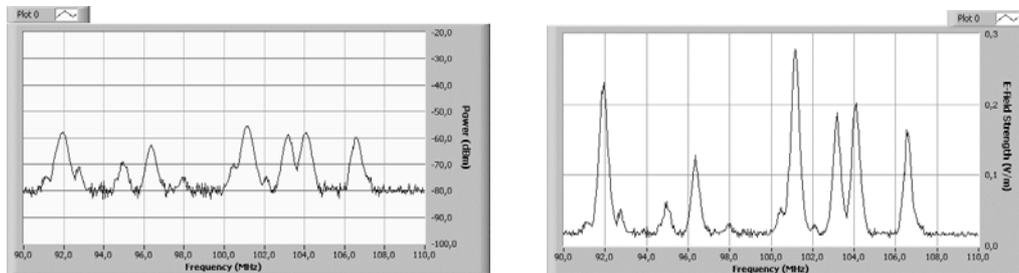

Figure 3. The power in units of dBm and the E-field strength in units of V/m

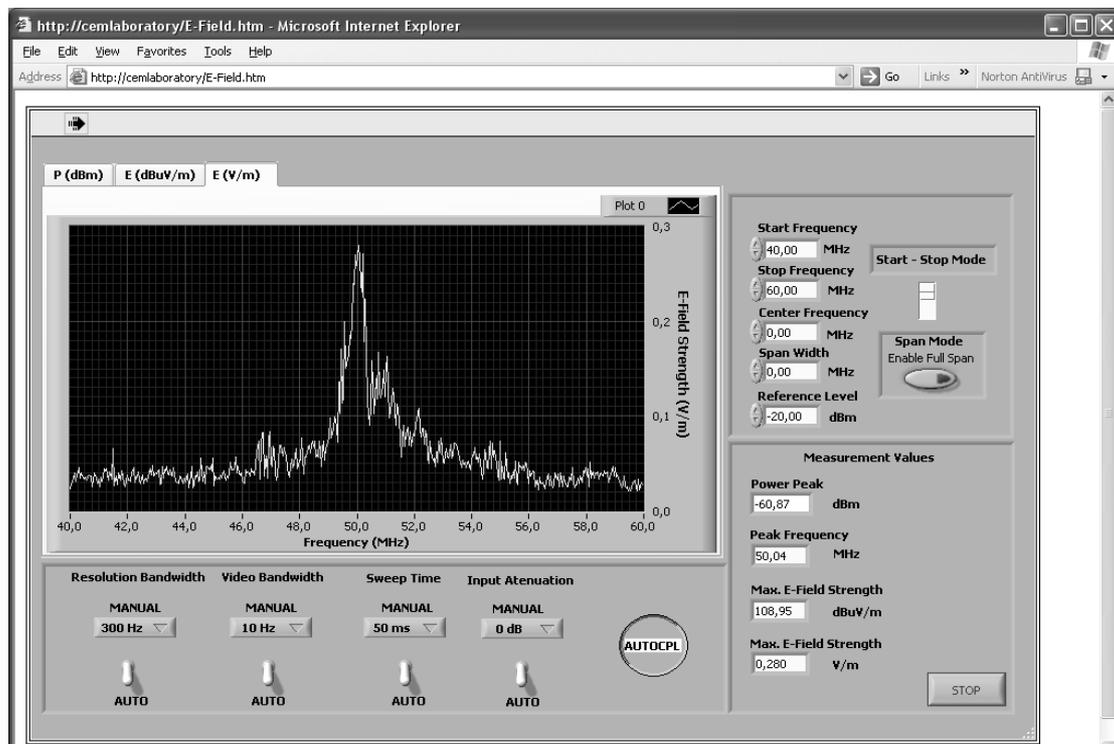Figure 4 presents the front panel of the VI embedded in a web page.

Figure 4. The front panel of the VI embedded in a web page

To perform in situ electric field measurements, the best connectivity solution is to use a laptop. A USB/GPIB converter (a simple cable with a GPIB plug on one end and a USB plug on the other that provides a direct connection from the USB port on PC to GPIB instruments) is the fastest and easiest way to connect instruments to a PC.

The USB/GPIB Interface is a best fit for R&D and small system applications where high system throughput is not important. Even though it offers high throughput with large block transfers (like spectrum analyzer trace downloads), its small-block transfer rates are slower than a typical GPIB interface due to the first byte latency of the USB. This interface offers ease of use and flexibility, and it can be easily shared [5].

III. Conclusions

The here presented paper describes a LabVIEW instrument for remote monitoring of electromagnetic field. The VI basically incorporates the most important functions of a spectrum analyzer into an easy to use interface. Moreover, being able to determine and display directly the strength of electric field, it can be successfully used to inform the public about the electromagnetic radiation levels especially in radio frequency domain.

Acknowledgements

References

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