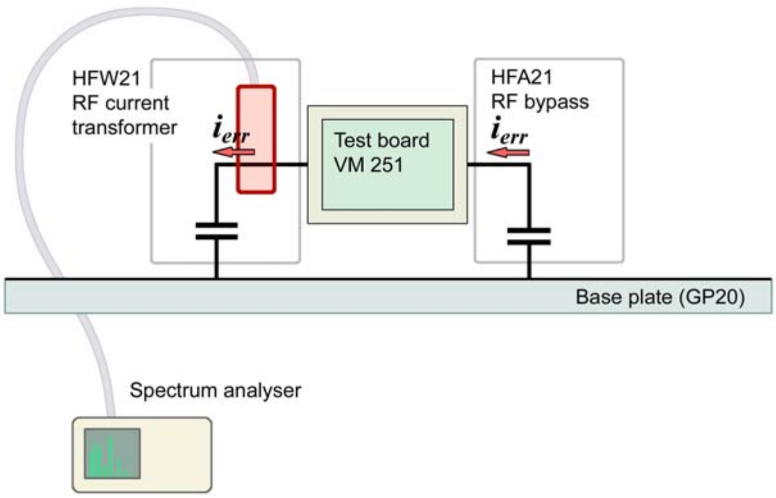
LANGER

EMV-TECHNIK

Experiments

OIVM 251
Disturbance emission model



Experimental set-up for measuring disturbance emissions
from the VM 251 test board with ESA

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1 Preliminary considerations

There are various ways to examine disturbance emissions from the OIVM 251 test board. The majority of the disturbances are caused by the following mechanism:

→ RF current/RF voltage on the test board of the 8051 microcontroller

→ Generation of magnetic and electric alternating fields

→ Excitation of antennas on the test board via the alternating fields

→ Emission of electromagnetic waves

These disturbance emissions can be examined in the far field or near field. The emitted disturbance is measured as an electromagnetic wave in the far field with an antenna while in the near field it is detected with near field probes or the disturbance emission development system (ESA). Detection in the near field is via electric and magnetic fields or voltage and current.

2 Measuring disturbance emissions with an antenna

2.1 Measuring set-up

The electromagnetic wave that is radiated by the test board is measured with an antenna to examine disturbance emissions from a test board. These disturbances are emitted via the test board's rod antennas. The resonant frequencies of the radiated electromagnetic wave are determined through the length of the rod antennas. These resonant frequencies are calculated for the rod antennas (as a dipole) by:

$$f = \frac{c}{\lambda} = n \cdot \frac{c}{2 \cdot l}$$

$f \ldots frequeny$

$\lambda \ldots wave\,length\ on\ rod\ antenna$

$n = 1, 2, 3, \ldots (1 \Rightarrow 1.st\ point\ resonance,\ half\ wavelength;\ 2 \Rightarrow full\ wavelength; usw.)$

$c \ldots speed\ of\ ligth\ \left(\approx 300.000 \frac{km}{s}\right)$

$l \ldots length\ of\ antenna$

Furthermore, the following applies to the current and voltage distribution on a dipole:

A current minimum is always present at the ends of a dipole. The charge on the dipole is in phase quadrature to the current.

The rod antennas are excited through a magnetic or electric field. The magnetic field generates a displacement current in the antenna. The electric field induces a voltage over the antenna. It hence results from the current and voltage distribution on a dipole:

Half the wavelength is excited through the magnetic field in the middle of the dipole. Half the wavelength is excited through the electric field at the end of the dipole.

Hence, it follows for the test board that:
the disturbance emission (at half the wavelength) is induced by the magnetic field (current) if both rod antennas of the test board are used. The disturbance emission is induced through the electric field (voltage) if one rod antenna is used.

The disturbance emission can be measured with an antenna according to Figure 2.1.

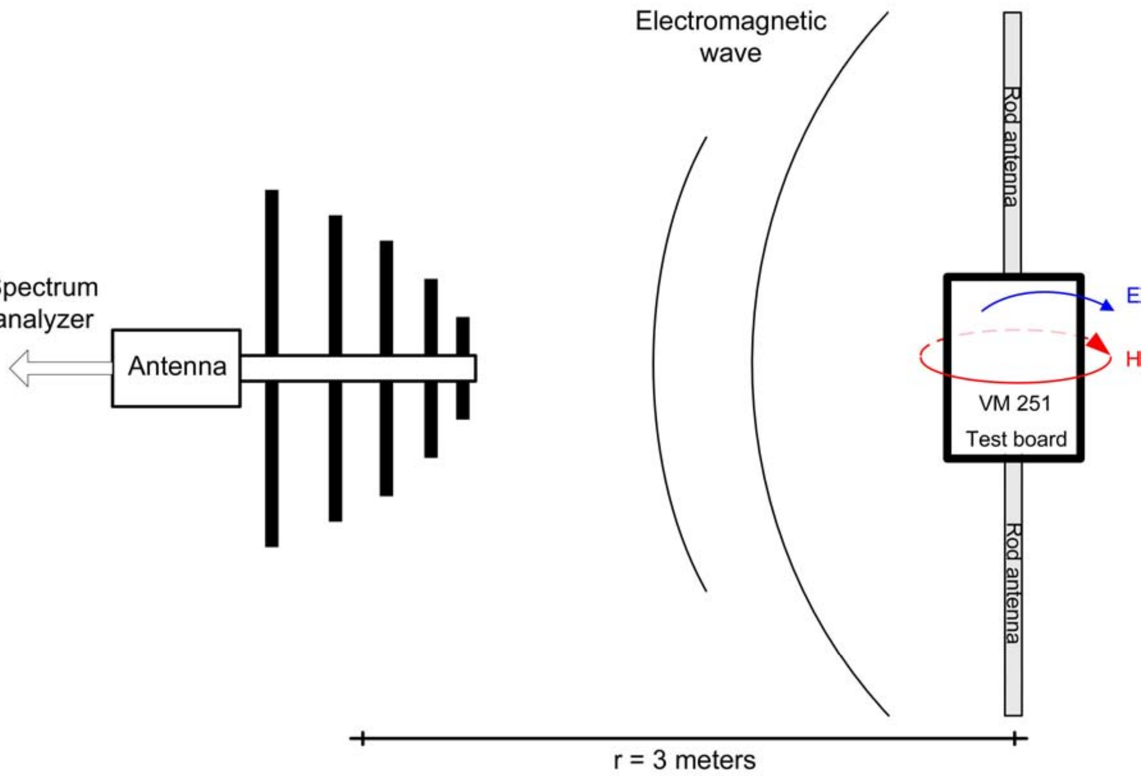

Figure 2.1: Measuring set-up to examine disturbance emissions with an antenna

3 Measuring disturbance emissions with ESA

3.1 Measuring set-up

The experiments with ESA are meant to illustrate disturbance emissions from the test board. The strength of the near fields also determines disturbance emissions from the test board in the far field. Examinations with an antenna and ESA thus lead to similar results.
The measuring set-up including ESA is shown in Figure 3.1. Disturbance emissions from the test board are measured with the RF current transformer. It measures the antenna exciting current. The RF bypass affects the current flow on the test board. A voltage is generated between the test board ground and the ground plate in the case of an open circuit termination. More current flows across the test board ground in the case of a short-circuit.

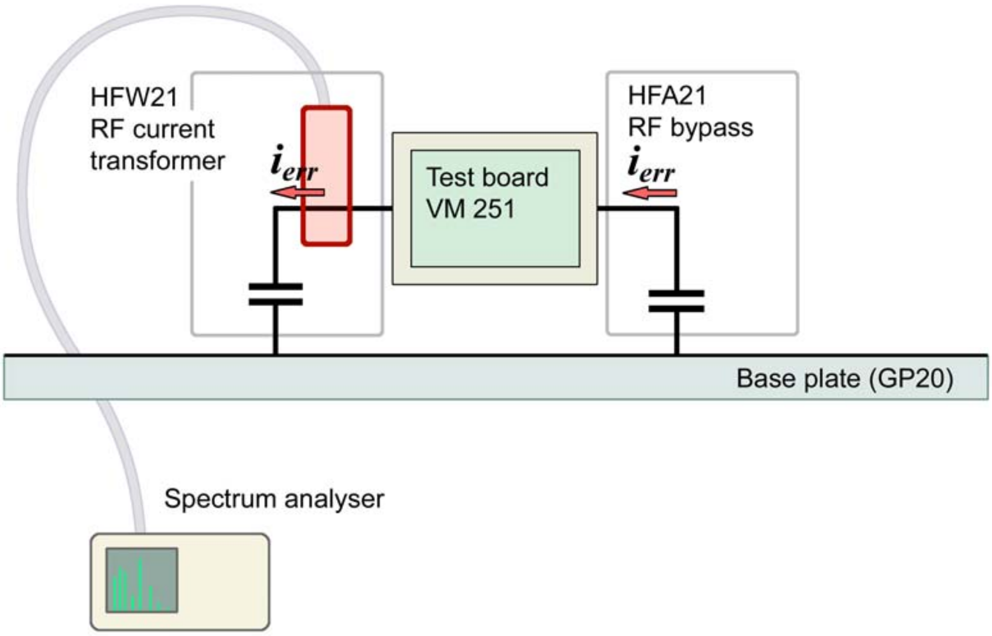

Figure 3.1: Measuring set-up to examine disturbance emissions with ESA

3.2 Measurements

The following measurements show the difference between disturbances emitted through current and voltage or magnetic and electric fields respectively. The disturbance emission is induced through voltage in an open circuit (HFA 21 disconnected or at low capacity). An electric field is generated.
The induction is through current under short-circuit conditions. A magnetic field is generated.

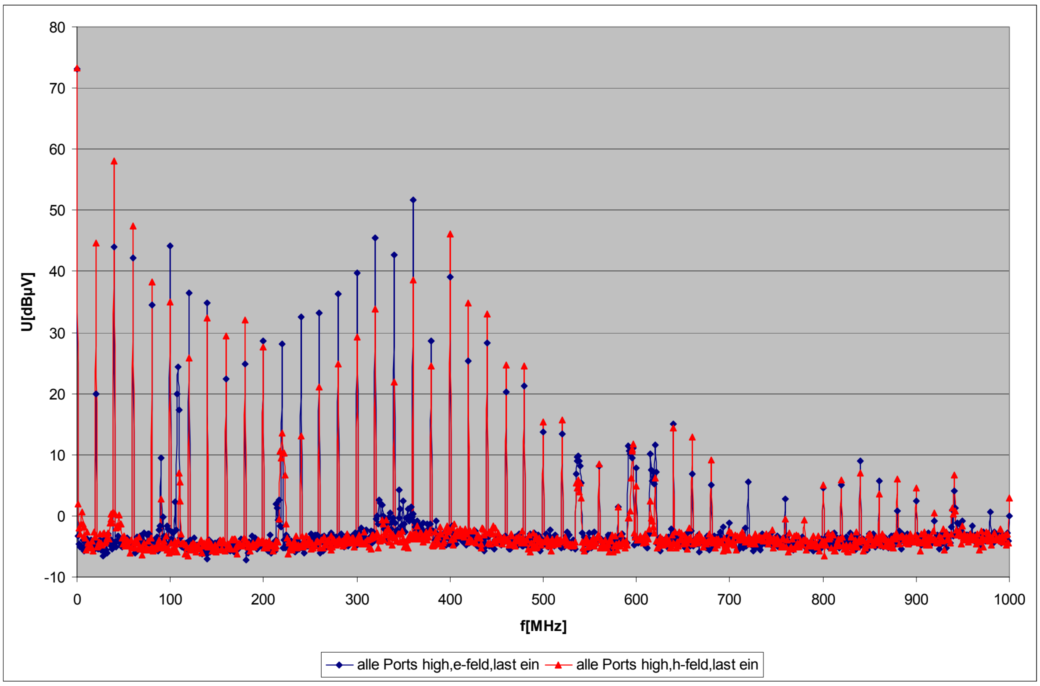

Figure 3.2: Effect of the RF bypass on the emission of disturbances

The blue curve in Figure 3.2 shows the emission of disturbances which is measured by the spectrum analyzer in an open circuit (without HFA 21). The red curve shows the emission of disturbances in a short-circuit.
The blue curve has a resonant frequency at 360 MHz which is influenced by the inductivity of the line from the antenna socket to the current transformer and the capacity between the test board ground and the GP 20 ground plate. This point of resonance moves from 360 MHz to 400 MHz in the case of a short-circuit termination on test board since the inductivity of the electric circuit decreases due to the short-circuit. The disturbance emission increases between 20 MHz and 80 MHz since more current flows through the test board via the short-circuit.

Figure 3.3 shows the effect of the load on the emission of disturbances. The orange curve shows the emission of disturbances without any load. The red curve shows the emission of disturbances with a load capacitor.

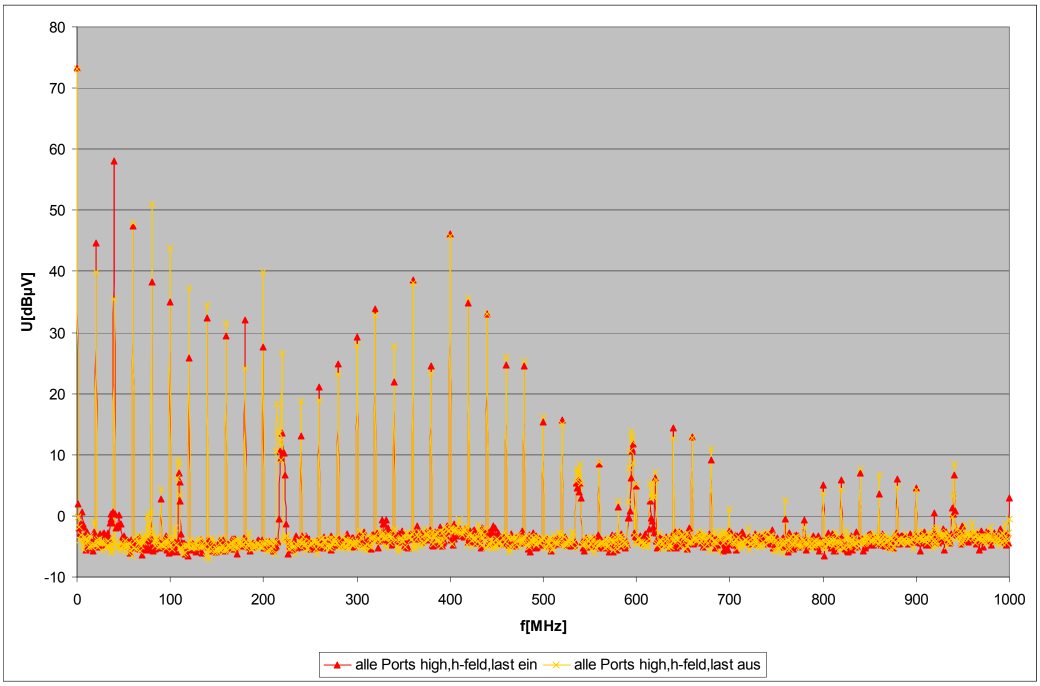

Figure 3.3: Effect of the load on the emission of disturbances

The effect of the load is low at high frequencies since the inductive resistance of the line decouples the load capacitor at the end of the line. By comparison, more current passes through the load capacitor at lower frequencies (20 and 40 MHz).

This document presents the basic ways in which disturbances are emitted through current and voltage or magnetic and electric fields respectively. The set-up to measure emitted disturbances can be expanded as required through the use of filters in the power supply or of the Vcc bridge, for example.