



# Measurement of common-mode and differential-mode currents on differential drivers

## Contents:

- 1 Measurement task
- 2 Measuring differential-mode currents using the HFI02  
(current transformer)
- 3 Measuring common-mode currents using the P623 probe

Gunter Langer

Bannewitz, Oktober 2007

LANGER EMV-Technik GmbH

# 1. Measurement task

Symmetrical data transmission systems can produce disturbance emissions on cables and plug-and-socket connectors in two ways:

1. Differential-mode line current and
2. Common-mode line current.

These currents generate disturbance voltages in plug-and-socket connectors and cables through self and mutual induction. The symmetrical portion of the useful signal (Figure 1.1) is responsible for differential-mode currents.

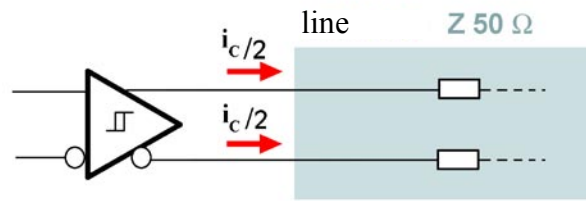
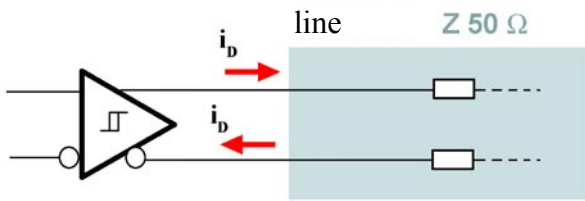


Figure 1.1. Differential-mode current

Figure 1.2. Common-mode current

The asymmetrical portion of the useful signal (Figure 1.2) is responsible for common-mode currents (Figure 1.2):

1. Odd-order common-mode harmonics are generated in the lower frequency range under symmetrical square-wave excitation due to different signal heights on both outputs (Figure 8).
2. Even-order common-mode harmonics are generated in the upper frequency range under symmetrical square-wave excitation due to different edge shapes (Figure 8).

The differential-mode currents are measured with a current transformer. A shunt is used to measure the common-mode currents.

Figure 2. Block diagram

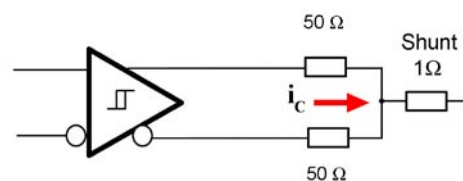
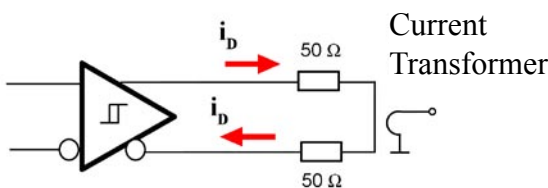


Figure 2.1. Measuring symmetrical currents

Figure 2.2. Measuring common-mode currents

## 2. Measuring differential-mode currents using the HFI02 current transformer

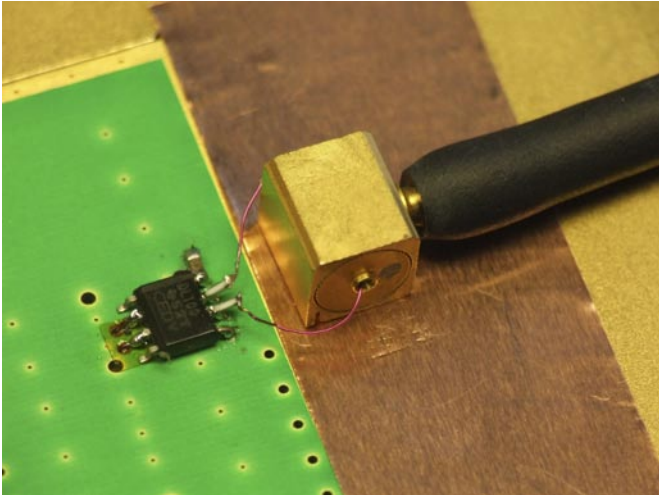


Figure 3. Measurement set-up for measuring symmetrical currents

The output voltage  $U$  of the current transformer (Figure 3) is measured with a spectrum analyser. Conversion to the current on the primary side of the transformer is done by:

$$I_D = U / R$$

in logarithmic notation:

$$I_D \text{ [dBA]} = U \text{ [dB}\mu\text{V]} - R \text{ [dBOhm]}$$

where  $R$  is the transfer ratio of the current transformer.

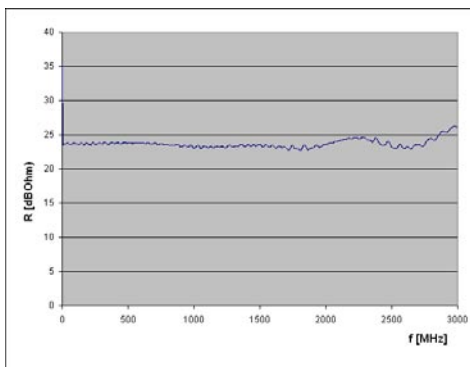


Figure 4. Transfer ratio of the HFI 02 current transformer

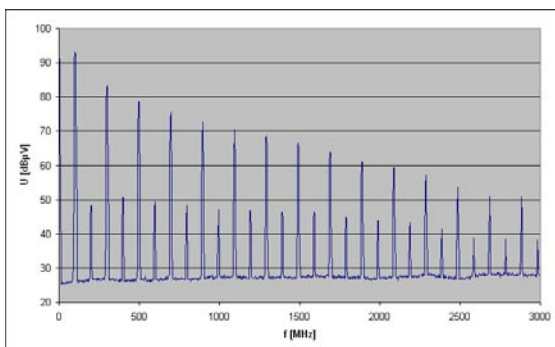


Figure 5. Secondary side voltage  $U$

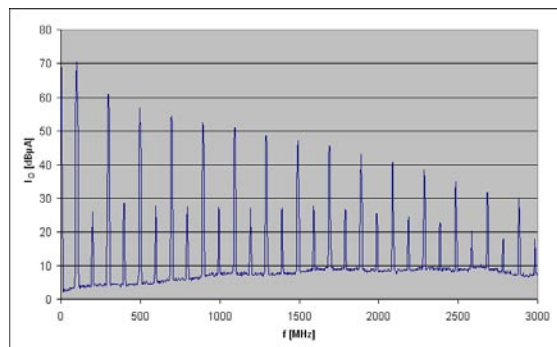


Figure 6. Primary side current  $I_D$  calculated from  $U$  and  $R$

### 3. Measuring common-mode currents using the P623 probe

The measurement is carried out with components of the IC measuring system in accordance with the circuit in Figure 2.2. The probe P623 is used to measure the common-mode currents. It comprises a 1 ohm shunt and a 20 dB amplifier. Figure 6 shows the measurement set-up. The LVDS-IC to be measured is located on an adapter circuit board which is inserted into the GP21 ground plane. Each of the outputs is connected to the input of the P623 probe via a 100 ohm resistor.

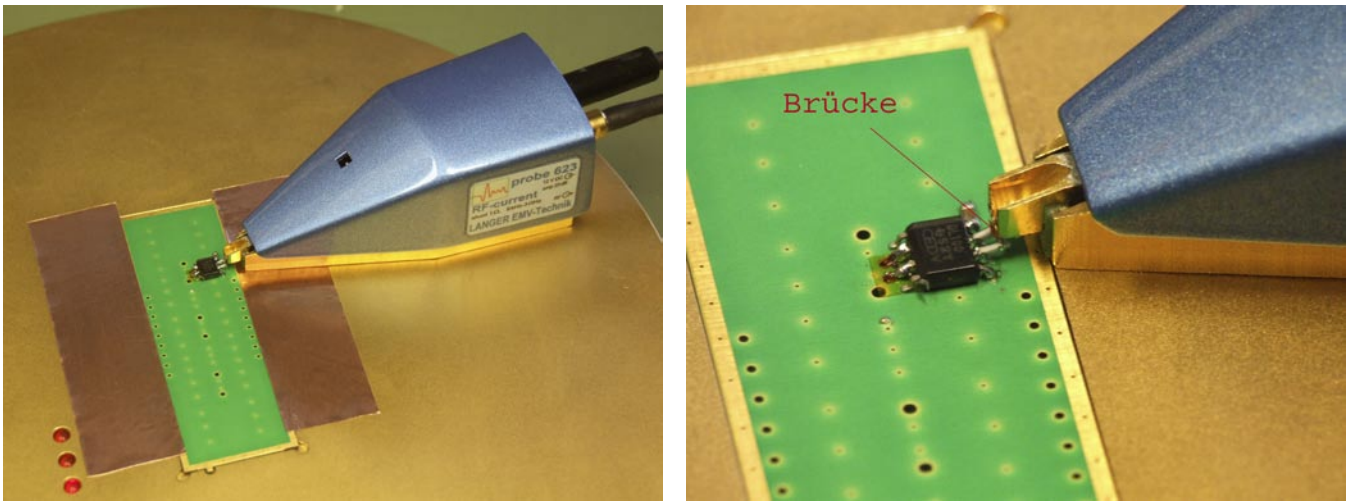


Figure 6. Measurement set-up to determine the LVDS common-mode currents

The P623 probe's output voltage  $U$  (Figure 6) is measured with a spectrum analyser. Conversion to the current on the input of the probe is done by:

$$I_C = U / R$$

in logarithmic notation:

$$I_C \text{ [dBA]} = U \text{ [dB}\mu\text{V]} - R \text{ [dB}\Omega\text{]}$$

where  $R$  is the transfer ratio of the P623 probe (Figure 7).

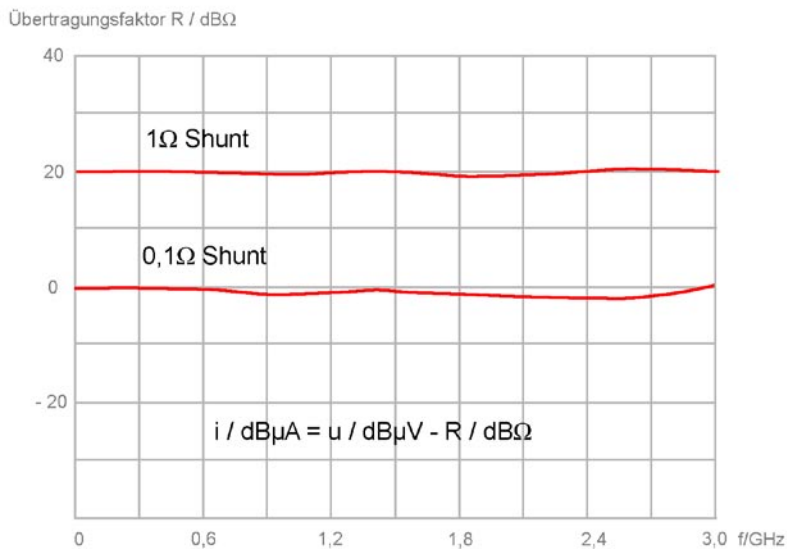


Figure 7. Transfer ratio of the P600 probe

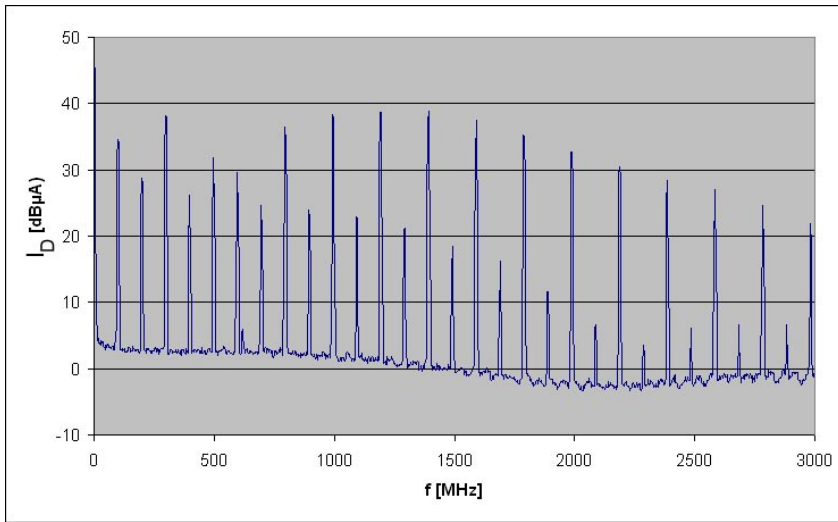


Figure 8. Common-mode current of the LVDS driver

Figure 8 shows the converted common-mode current. As described under 1, the common-mode current is generated by the asymmetrical amplitude under 300 MHz and by the asymmetrical edge at around 1.2 GHz.

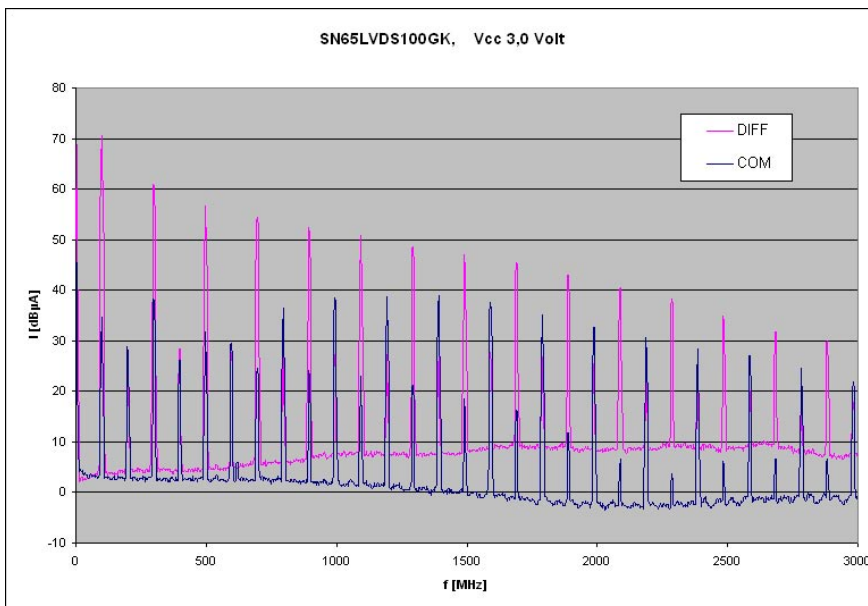


Figure 9. Comparison of common-mode (COM) and differential mode (DIFF) currents

The common-mode current is lower than the differential-mode current. The disturbance emission effect can, however, be equal in practice. The common-mode effect often dominates. This is due to the fact that the respective common-mode transfer ratios can be 10 ... 20 dB larger.