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Short Course

Measurement Error Models Based on Signal and System Thinking

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Measurement errors and uncertainties really handicap Metrology people: Standardised and quantified information has to be provided concerning the amount of uncertainty for all measurement results. An assessment in terms of their credibility would not be possible otherwise. But where do errors and uncertainties come from and how can they be described? Fortunately they follow the *cause and effect principle* too. So we are allowed to use Signal and System Theory together with Stochastics and Statistics.

This Short Course models errors and uncertainties as signals as it is done with any other quantities. Errors appear as temporal and spatial deviations. Uncertainties describe their probabilistic character.

For a beginning we clearly distinguish between three arrangements:
- the *process* in operation, prepared to be observed (alone, without instrumentation)
- the *measurement process* in operation (alone, without process), calibrated and prepared to measure
- the interrelating combination of *process and measurement process* in the temporal and spatial state of the measurement procedure

This allows us to define, what measurement errors really are. And we see that ordinary random variations of process quantities make no contribution to *measurement uncertainties*.

We clearly distinguish between *erroneous measurement processes* and *erroneous measurement results*.

Additionally we have to investigate both, *ideal* and *nonideal* measurement processes and procedures, though ideal ones never exist in practise.

We will realise three, and only three, *main error causes* due to properties of the measurement process:
- nonideal transfer response behaviour (*transfer response error*)
- nonideal sensitivity behaviour to external disturbance quantities (*disturbance quantity error*)
- nonideal loading behaviour upon the process to be observed (*loading quantity error*)

All manifestations of errors turn out to be subcategories of these three main categories. The structure of this universally valid error model tells us, how errors propagate into measurement results on the one hand and how means can be taken to reduce their influence on the other hand.

All the concepts mentioned above are presented in a *top-down approach*, independent of individual physical or technological demands and instrumental realisations.

The Short Course bases on *tutorial modules* and *lecture slides* and is accessible as pdf-documents in the Internet. Additionally, there are links to *examples* and to *exercises* with solutions.

Requirements for this Short Course are small: Basic knowledge in Signal Theory, System Theory, Stochastics and Statistics are sufficient. Know-how in State Space Description would be helpful but is not mandatory.

Modifications

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00	12.05.2011	First Edition