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Antisystem-Approach (ASA) for Engineering of Wide Range of Dynamic Systems

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Abstract: Following the famous third physical Newton's laws, "for every action there is an equal and opposite re-action", a new approach for analysis and design of dynamic systems was introduced by [Zacher, 1997] and called «Antisystem-Approach» (ASA). According to this approach, a single isolated dynamic system does not exist alone. For every dynamic system, which transfers its inputs into outputs with an operator A in one direction, there is an equal system with the same operator A, which transfers other inputs into outputs in opposite direction. The antisystem does not have to be a physical system; it can also be a mathematical model of the original system. The most important feature of ASA is the exact balance between a system and its antisystem, which is called "energy" or "intensity". In the group theory the system and antisystem are denote as antisymmetric. They build duality, which is common in many branches of sciences as mathematics, physics, biology etc. In the twenty years since first publication of the ASA there were developed different methods and applications, which enable to simplify the engineering, analysing the antisystem instead of original system. In the proposed paper is given the definition of ASA und are shown its features. It is described, how the ASA was used in electrical and chemical engineering, automation, informatics. Only several applications will be discussed, although ASA-solutions are common and could be used for wide range of dynamic systems.

Keywords: Antisystem-approach, Antisymmetry, Antineuron, Balance control, Compression of variables

Introduction

The wide range of dynamic system is usually described with ordinary or partial differential equations. The analytical solutions of linear ordinary differential equations with constant coefficients are well known. But solutions of nonlinear ordinary differential equations or linear partial differential equations with variable coefficients are possible only by low order of differential equations or only with numerical methods. Of course, it is widely known that the differential equations could be transferred from time-domain into Laplace-domain and will be described like algebraic equations or as transfer functions. It could simplify the solution by SISO-systems (Single Input Single Output), but not by MIMO-systems (Multi Input Multi Output). In the last case the Laplace-transformed partial differential equations will be represented as multistage multivariable systems of Figure 1, which are according to remark of Richard Bellman "a curse of dimensionality" [Bellman, 1957].

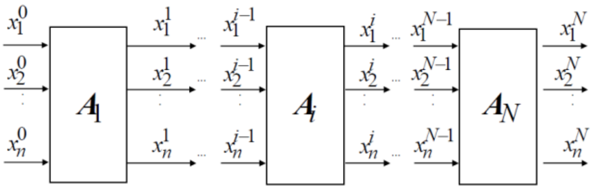

Figure 1. Multistage MIMO-System with *n* Variables and *N* Stages

For each stage in Figure 1 is valid the following transfer relation with the matrix **A***i*

$$\mathbf{X}_i = \mathbf{A}_i \mathbf{X}_{i-1}$$

between input and output vectors with *n* components:

$$\mathbf{X}_{i-1} = \begin{pmatrix} x_1^{i-1} \\ \dots \\ x_n^{i-1} \end{pmatrix} \qquad \mathbf{X}_i = \begin{pmatrix} x_1^{i} \\ \dots \\ x_n^{i} \end{pmatrix}$$

A new approach for analysis and design of dynamic SISO- and MIMO-systems was introduced in [Zacher, 1997] and called «Antisystem-Approach» (ASA). Since this first publication there were developed different methods and applications of ASA for control theory, feedback control, multivariable control, pattern recognition, decomposition of large systems, variables compression up to a new kind of ASA-Controller and a model of artificial neural network.

In the following is given the definition of ASA und are shown its features. After short historical review about previous examples of different kinds of interacting systems it is described, how the ASA can be used in electrical and chemical engineering, automation, informatics. It will be shown only several applications, although the ASA-solutions are common and could be used for wide range of dynamic systems like following:

- balance control instead of feedback control
- design of linear multivariable control systems.
- optimisation of linear multi-variable multi-stage dynamic systems.
- calculation of MIMO-transfer functions
- calculations of nonlinear electrical and magnetic fields.
- data compression and recognition.
- artificial antineutrons networks.

The overview of publications about ASA and briefly description are given in [Auer, 2010].

ASA-Definition

If one system (called original system) transfers its inputs **X** into outputs **Y** with an operator **A** in one direction, then a second system (called antisystem) always exists, which transfers the inputs $\mathbf{W}_y$ into outputs $\mathbf{W}_x$ with the same or transposed operator $\mathbf{A}^T$ in the opposite direction on the original system (Figure 2). The antisystem does not have to be a physical system; it can also be a mathematical model of the original system. According to abstract algebra and group theory the system **A** and antisystem $\mathbf{A}^T$ are antisymmetric. Two things are called antisymmetric, if they are symmetric, but are acting in opposite directions [Zamorzaev, 1929].

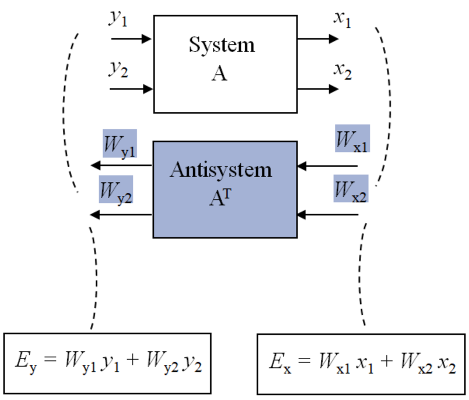

Figure 2. MIMO-System with n =2 Variables and Antisystem, which are Antisymmetric and Build a Duality

The most important feature of ASA is the balance between the system **A** and its antisystem $\mathbf{A}^T$ by any values of input vectors **X** and $\mathbf{W}_y$, namely a balance of scalar values E_x and E_y , which are called “energy” or “intensity”:

$$E_x = E_y$$

In the equation above the values of E_x and E_y are scalar products of properly input and output vectors of system and antisystem:

$$E_x = \mathbf{X} \cdot \mathbf{W}_x^T$$

$$E_Y = \mathbf{Y} \cdot \mathbf{W}_y^T$$

The balance of “energy” or “intensity” is valid by systems of high dimensionality, like shown in Figure 3.

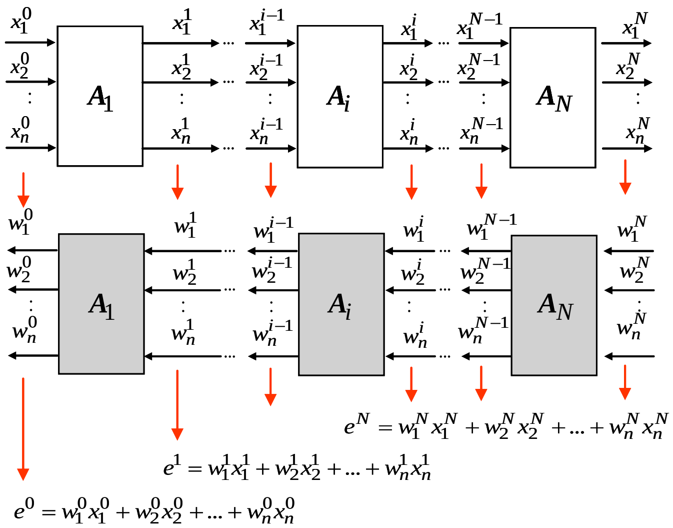

Figure 3. Multistage MIMO-System and its Antisystem with n Variables and N Stages

The values of system input vector **X** are usually given be the engineering task definition and could not be changes. Instead of it the antisystem input vector $\mathbf{W}_y$ can be chosen arbitrary from designer. And exactly this feature is the main advantage of ASA, namely: the possibility to choose the antisystem input vector $\mathbf{W}_y$ in such a way, that the engineering task of dynamic system **A** will be solved upon antisystem $\mathbf{A}^T$ more easy and optimal, as the solution of the original system **A**. By n = 1 has ASA no advantages against conventional analysis with original vectors. The bigger is n, the more reduction is expected from calculations with ASA.
In other words, the ASA enables to analyse an antisystem $\mathbf{A}^T$ with vectors $\mathbf{W}_x$, $\mathbf{W}_y$ instead of original system **A** with vectors **X, Y**.

Historical Review

The interaction of two systems is known since Newton's third law of motion: „For every action there is an equal and opposite re-action. "

The principle of antisymmetry, based upon operations of symmetry, but with the opposite direction of variables, has been known since 1929. Simple but illustrative examples are given in the fundamental work [Sivardiere, 1995] about symmetry/antisymmetry in mathematics, physics, chemistry and shown in Figure 4.
In crystallography, a distinction is made between the following types like antireflection, antiidentity, antiinversion.

Antireflection: $L^+ \to R^+$ und $L^- \to R^-$
Antiidentity: $L^+ \to L^-$ und $R^+ \to R^-$
Antiinversion: $L^+ \to R^-$ und $L^- \to R^+$

Even more complicated operations lead to color antisymmetry:

Red (1, +) → Blue (2, +) → Green (p, +) → ...
Red (1, –) → Green (2, –) → Blue (p, –) → ...

and to Cross-Symmetry:

$S_1 + S_2 + \ldots \to T_1 + T_2 + \ldots$
$T_1 + T_2 + \ldots \to S_1 + S_2 + \ldots$
$S \cdot T \to T^{-1} \cdot S^{-1}$
$S_1 + T_2 + \ldots \to T_1 + S_2 + \ldots$

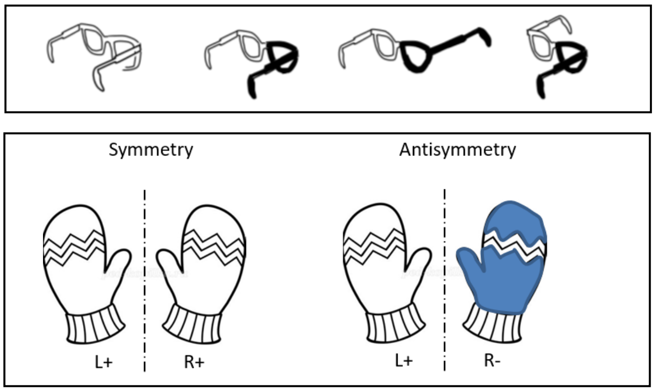

Figure 4. Antisymmetry Examples, According to [Sivardiere, 1995]:
Glasses (source of Figure [Sivardiere, 1995], page 325) and Mittens (source of Figure [Zacher, 2020], page 145])

Atomic physics, according to which every particle has its antiparticle, delivers convincing successes of antisymmetry. The mathematical description of a system and its antisystem was proposed by Paul Dirac as brackets for system $\mathbf{X^i} >$ and for antisystem $<\mathbf{W^i}$. Applying this description for Figure 3, the „energy" balance will be written as below:

$$< \mathbf{W^i} \; \mathbf{X^i} > = < \mathbf{W^i} \; \mathbf{X^i} >$$

The review of antisymmetry and duality applications in mathematics, electrotechnics, system- and control-theory was done in [Zacher, 2003] and [Zacher, 2020]. However, there was no antisymmetric representation in technical areas until 1933.

The periodical "VDE-Nachrichten" reported on the 23.03.2001 about project "Active-Noise-Control" of the Research Centre the German Air- and Space-Drive (DLR) co-operated with the MTU Aero-Engine and European Aeronautic Defense and Space Company Germany for the noise-damping with the method of Paul Lueg (patented 1933).

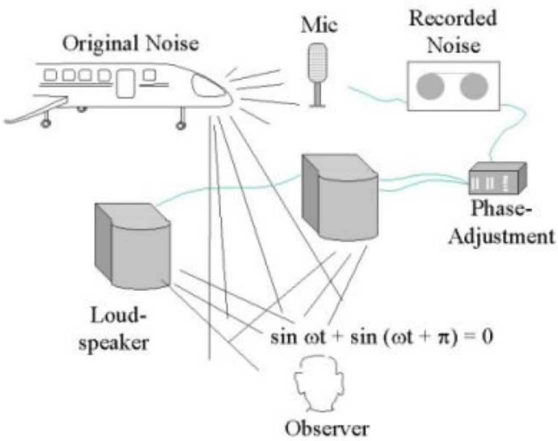

Figure 5. "Active-Noise-Control" as an Interaction of two Noise Generators

According to this method the noise can be damped, when two identical generators will be compared (Figure 5): the first one is the noise generator and the second one is the record of the first generator, i.e. with the same magnitude, the same frequency but different phase. By an observer appears the sum of both, oscillations, in which the noise will be damped.

The MATLAB®/Simulink simulation for a simplified example of sin-noise oscillations is shown in Figure 6. This example is not real application but only a demonstration of the noise-damping.

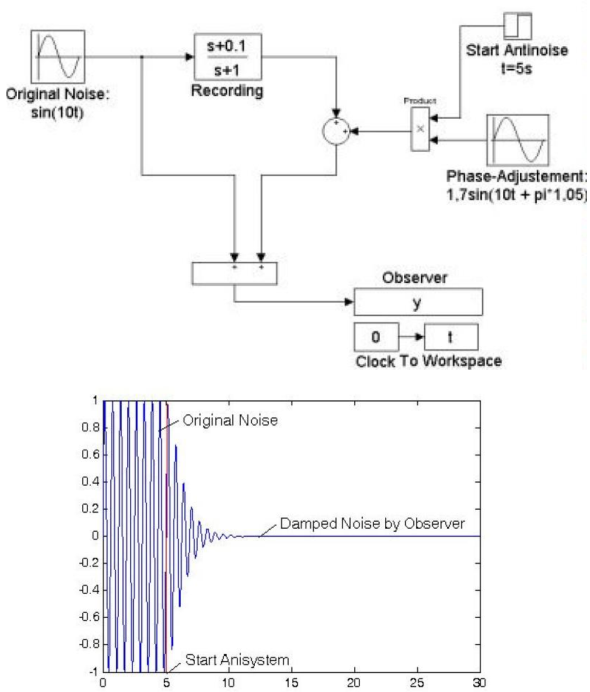

Figure 6. Simulation model of noise damping

First research results about antisystems by control theory [Sacharjan, 1968] indicate a balance between input and output variables of a multi-stage MIMO-system. The state vectors were compressed into scalar values, which significantly reduced the computing time and memory requirements (Figure 7). This method was called by [Sacharjan, 1983] "variables compression".

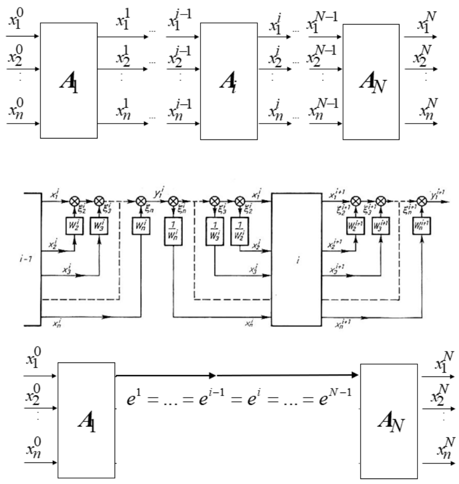

Figure 7. Variables Compression for Calculation of Transfer Functions of a Multi-stage MIMO-system

In the book [Zacher, 2003] was proposed an interaction of two systems, like shown in Figure 3, instead of weighted sums e^i in Figure 6. It was the beginning of the antisystem-approach, which applications will be discussed below.

ASA-Applications

To simplify the description of ASA and to show how it can be used by different kinds of dynamic systems let us begin by very simple examples like linear algebraic equations.

Single Input Single Output (SISO) Multistage System

The multistage system, shown in Figure 8, has one input x_1 and one output x_4.

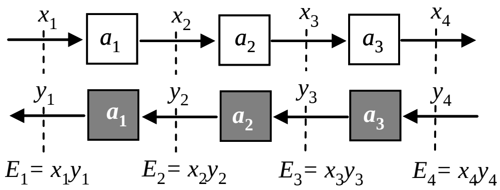

Figure 8. "Energy" balance $E_1 = E_2 = E_3 = E_4$

The same by the antisystem: one input y_4 and one output y_1. The system behaviour is linear:

$$x_2 = a_1 x_1 \qquad y_3 = a_3 y_4$$
$$x_3 = a_2 x_2 \qquad y_2 = a_2 y_2$$
$$x_4 = a_3 x_3 \qquad y_1 = a_1 y_2$$

The product E is called "energy" by [Zacher, 2012]. It is very easy to proof, that there is the "energy" balance for each stage:

$$x_1 y_1 = x_2 y_2 = x_3 y_3 = x_4 y_4$$

<u>Example of application</u>:

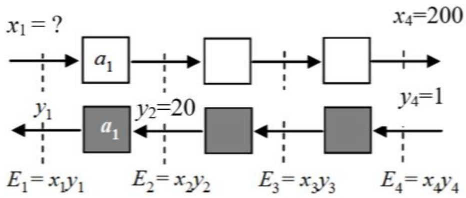

Figure 9. Disturbed system

Supposing the system is disturbed, and an observer has only the following information (Figure 9):

$$a_2 = 2 \qquad y_2 = 20$$
$$x_4 = 200 \qquad y_4 = 1$$

To define is the value of x_1.

<u>Solution</u>:

$$E_4 = x_4 y_4 = 200 \cdot 1 = 200$$
$$E_2 = E_4 = 200 = x_2 y_2 = 20 x_2$$
$$x_2 = \frac{200}{20} = 10$$
$$x_1 = \frac{1}{a_1} x_2 = \frac{1}{2} \cdot 10 = 5$$

Multi Input Single Output (MISO) System

The Figure 10 shows an example of the MISO system and SIMO (Single Input Multi Output) antisystem, given by [Zacher, 2008b].

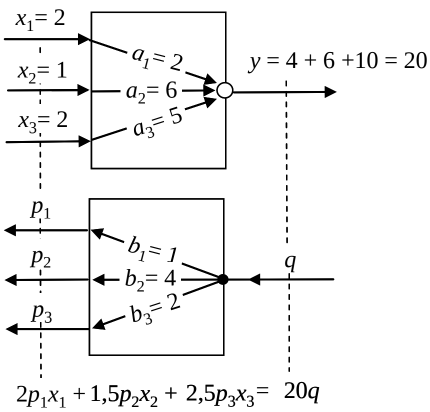

Figure 10. The System MISO and its Antisystem SIMO

The common expressions for the system inputs x_1, x_2 , x_3 and the output y and also for the antisystem single input q and outputs p_1, p_2, p_3 are:

$$y = a_1x_1 + a_2x_2 + a_3x_3$$
$$p_1 = b_1q$$
$$p_2 = b_2q$$
$$p_3 = b_3q$$

If there is

$$b_1 = a_1$$
$$b_2 = a_2$$
$$b_3 = a_3$$

the balance takes place:

$$q \cdot y = p_1x_1 + p_2x_2 + p_3x_3$$

Multi Input Multi Output (MIMO) System

An example of the multistage MIMO-system with n variables as given in Figure 1. The simple example with $n = 2$ variables is shown in Figure 11.

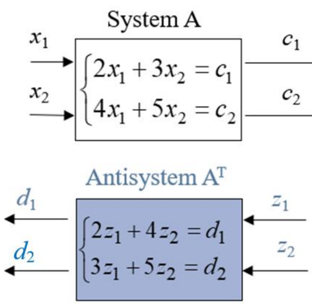

Figure 11. The MIMO-System A and its MIMO-Antisystem A^T

Example of application:
Given is the system of two linear algebraic equations, which should be solved:

$$\begin{cases} 2x_1 + 3x_2 = 28 \\ 4x_1 + 5x_2 = 48 \end{cases}$$

Solution:
Although the solution is very well known, a new approach is proposed by [Zacher, 2008a].
First of all, let us build the antisystem:

$$\begin{cases} 2z_1 + 4z_2 = d_1 \\ 3z_1 + 5z_2 = d_2 \end{cases}$$

Then we will apply the following values to the antisystem

$$z_1 = 1$$

$$d_2 = 0$$

and calculate d_1 and z_2:

$$3z_1 + 5z_2 = 0 \quad \rightarrow \quad z_2 = -0{,}6$$

$$d_1 = 2z_1 + 4z_2 \quad \rightarrow \quad d_1 = -0{,}4$$

According to the “energy” balance

$$d_1 x_1 + d_2 x_2 = c_1 z_1 + c_2 z_2$$

We can calculate the solution:

$$(-0,4)\cdot x_1 + 0\cdot x_2 = 28\cdot 1 + 48\cdot(-0,6)$$

$$x_1 = 2$$

$$x_2 = 8$$

The whole algorithm is shown in Figure 2.

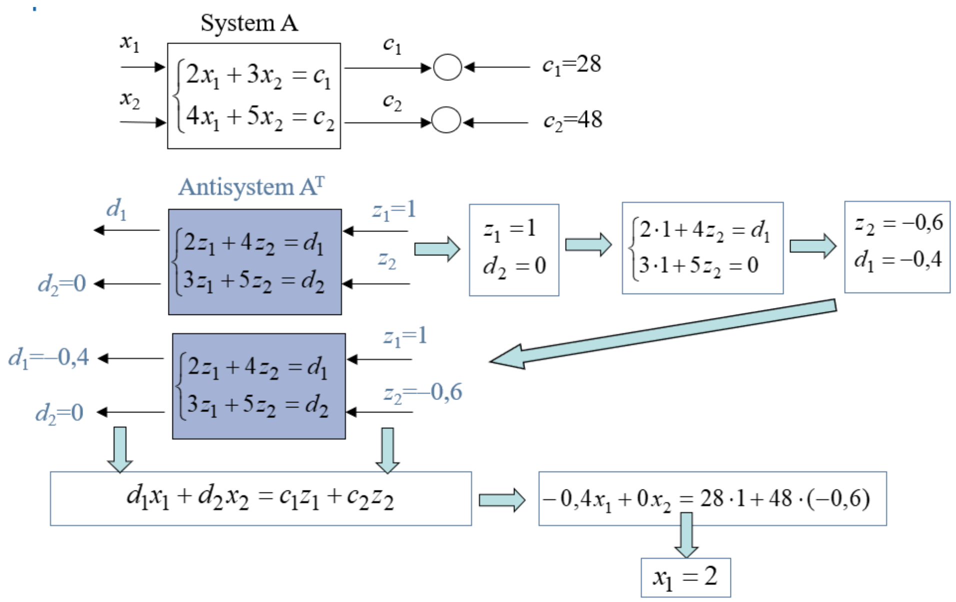

Figure 12. The algorithm of solution with ASA

Examples of ASA-Implementation

Balance Control

According to [Zacher, 2017b] the classical closed loop, in which the error e as difference between set point w and process value x will be controlled

$$e(t) = w - x(t),$$

in not only one possible option of control. Instead of it the error between “energy” of a plan as a system and its antisystem could be controlled, as shown in Figure 13. The plant to be controlled is $G_S(s)$ and is called a "system". The antisystem is the transfer function $G_M(s)$. If both are equal

$$G_S(s) = G_M(s),$$

then there is a balance between “energy” $e_y(s)$ and $e_x(s)$ by every arbitrary function $w_y(s)$:

$$y(s)w_y(s) = x(s)w_x(s)$$

$$e_y(s) = e_x(s)$$

If the plant $G_S(s)$ will be disturbed, then the balance above also will be disturbed. The controller (not shown in Figure x) should recognise the difference

$$e(t) = e_y(t) - e_x(t)$$

and act through actuating value $y(t)$, bringing the "energies" $e_y(s)$ and $e_x(s)$ again to balance. The advantage of the balance control is especially large by multivariable MIMO-systems, because "energies" $e_y(s)$ and $e_x(s)$ are scalar values, while set point w and process value x are vectors.

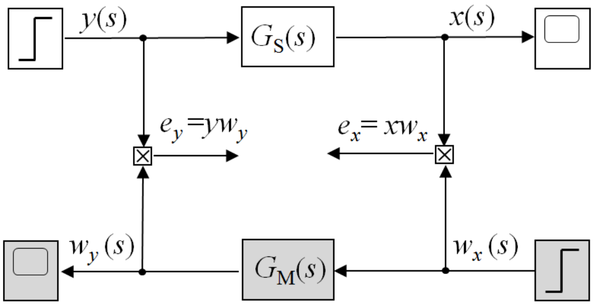

Figure 13. The Principle of Balance Control

[Schmitt, 2016] implemented the balance control for one motor as a plant $G_S(s)$. As an antisystem $G_M(s)$ was the second motor applied, which was exactly like the plant motor (Figure 14). A microcontroller-board STM32F Discovery was programming as a controller (Figure 15) to measure the balance between "energies" $e_y(s)$ and $e_x(s)$ and to change the actuating value $y(s)$, if the balance was disturbed. The step response of the balance control is shown in Figure 16. It is seen that the quality of the balance control is the same as of the classical feedback control, if not better.

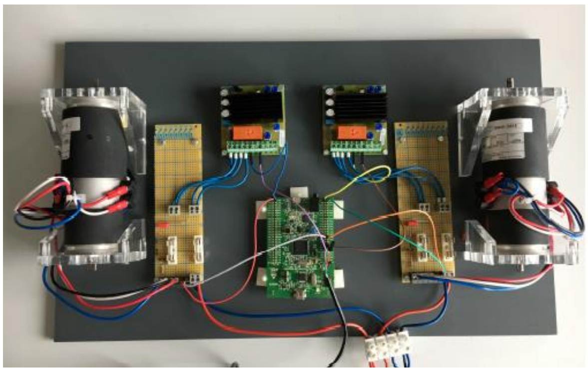

Figure 14. Balance Control with Two Similar Motors as System and Antisystem

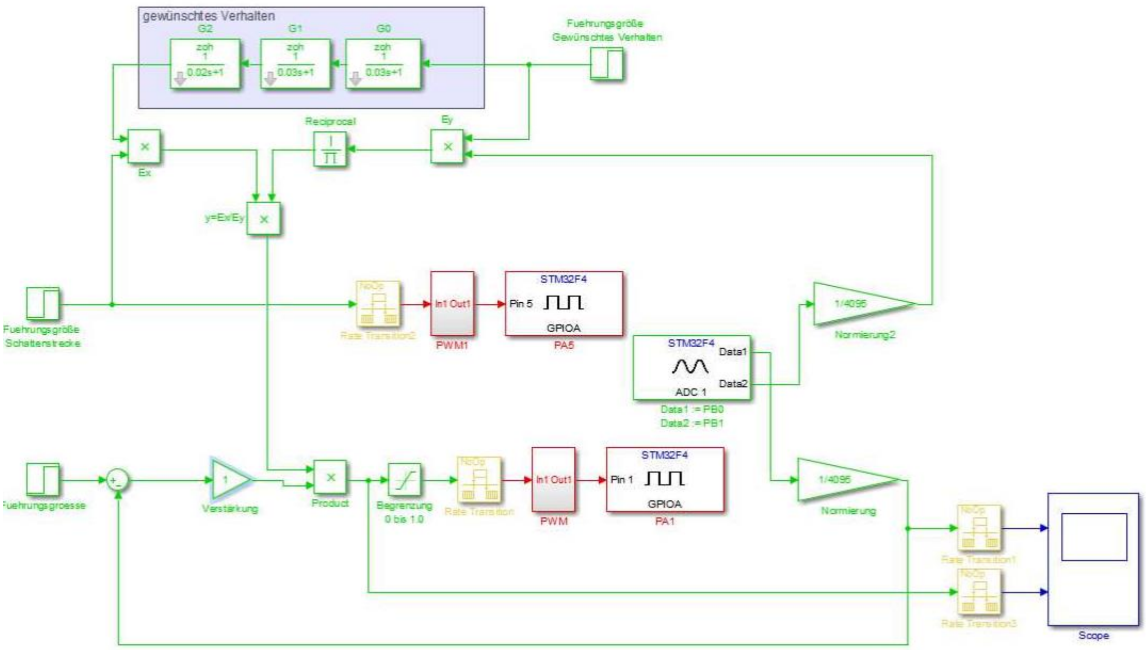

Figure 15. Microcontroller-board STM32F Discovery as a Balance Controller

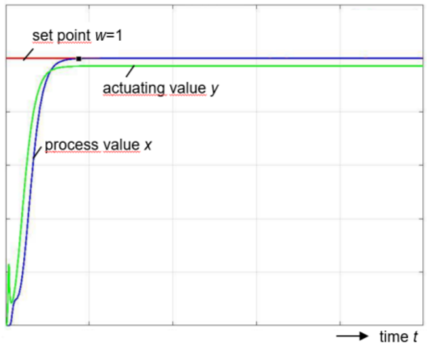

Figure 16. Step Response of Balance Control

MIMO-Control

The MIMO control of industrial processes is very well studied; the design methods are developed and described, but the practical use is complicated because of the high dimension of the system. The commonly used methods for MIMO closed-loop control are state space feedback and observer design. The decoupling of MIMO subsystems brings the best results, but the realisation is complicated because of derivative parts by decoupling.
In the following is shown, how the ASA will be applied by MIMO-system, using the same principle, as in Figure 13. The main advantage of ASA for MIMO is the use of "energy"-variables, which are scalars, instead of original control variables, which are vectors of the dimension n. The balance control for one real MIMO-plant upon [Zacher, Saeed, 2017] is given in Figure 17, the step responses are seen in Figure 18. The control quality by ASA is better as by classical control.

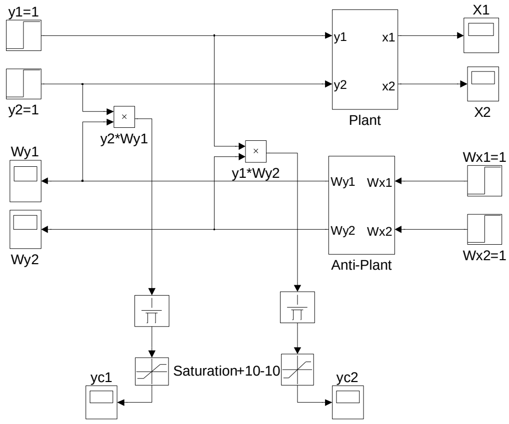

Figure 17. The Principle of Balance Control for a MIMO-Plant

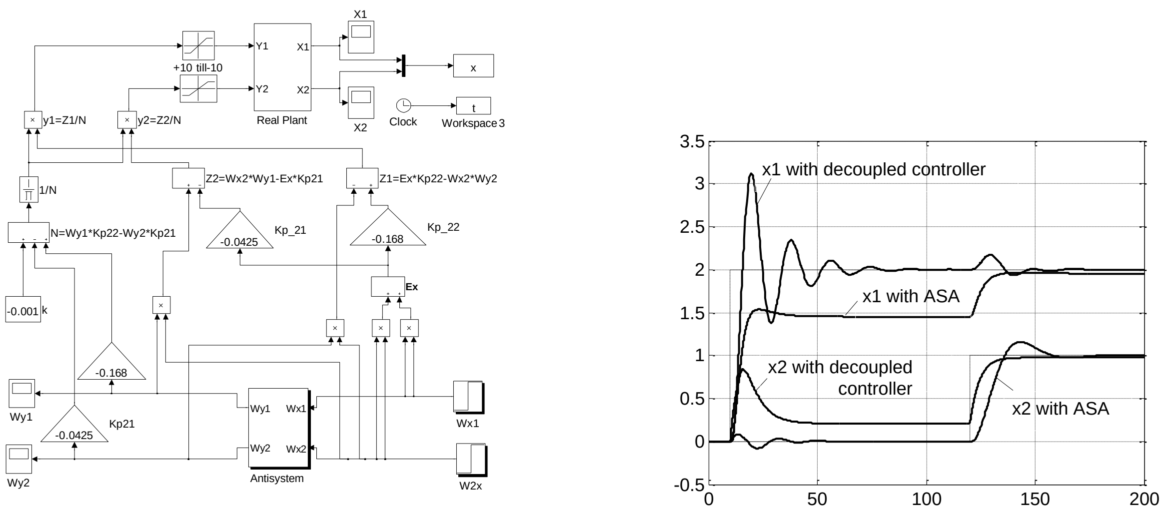

Figure 18. Balance Control of a Real MIMO-Plant with n = 2 and Step Response

ASA-Controller

ASA-Controller is a model-based controller $G_R(s)$, which is built as a classical compensated controller, but with an antisystem, so called “shadow plant” [Zacher, Reuter, 2017). Instead of compensation of the plant $G_S(s)$ with its reciprocal

$$G_R(s) = \frac{1}{G_S(s)}$$

two blocks will be built:

$$G_R(s) + 1 \quad \text{and} \quad \frac{1}{1 + G_R(s)}$$

The blocks above also compensate each other (Figure w), but without reciprocal of the plant transfer function $G_S(s)$, which brings many advantages, as shown by [Zacher, 2016a].
The three options of ASA-controller are possible:

a) with software model of the plant (Figure 19), developed by [Zacher, 2017a] and realised by [Wessel, 2014].
b) with hardware-model of the plant (Figure 20, left), developed and realised by [Zacher, 2017a]
c) with the shadow plant, like the plant itself (Figure 20, right), developed by [Zacher, 2016b] and realised by [Groß, 2015].
d) with bypass, developed by [Zacher, 2016 c] and realised by [Mille, 2017].

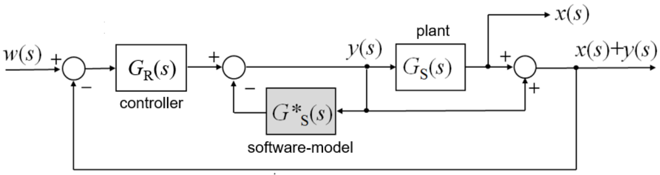

Figure 19. ASA-Controller with Software-Model of the Plant.

$G_R(s)$ is the model-based controller to achieve the desired dynamic behaviour, given by developer.

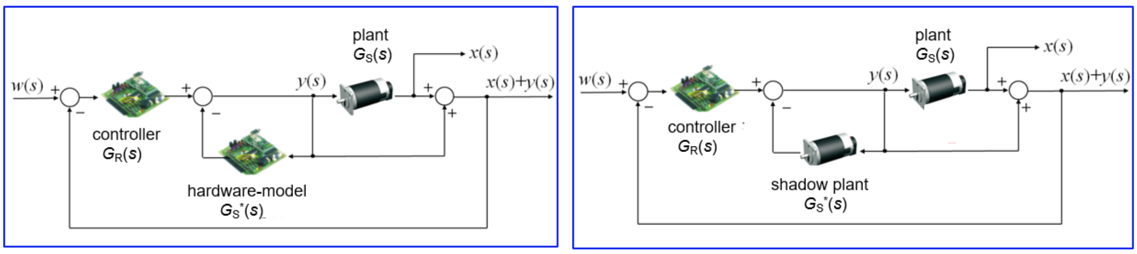

Figure 20. ASA-Controller with hardware-model of the plant (on the left) and with the shadow plant.

The test results confirm that the control quality by all options of ASA-controller, shown above, was better as by classical model-based controller.

Nonlinear Electric and Magnetic Fields

A nonlinear electric field will be discretized and shown as a grid of ohmic resistances (Figure 21, above). The initial and final values of electrical voltages are given, to define is the current on only one resistance, e.g. the current i_{41}. The system (electrical grid in Figure 44 above) is described with vectors

$$\mathbf{I}^1 = \mathbf{B}^{-1}\ (\mathbf{U}^3 - \mathbf{A}\,\mathbf{U}^0)$$
$$\mathbf{U}^3 = [\ 10 \quad 10 \quad 10 \quad 10\ ]$$
$$\mathbf{U}^0 = [100 \quad 100 \quad 100 \quad 100\ ]$$

and matrice:

$$\mathbf{A} = \mathbf{R}^3\,\mathbf{R}^2\,\mathbf{g}^2\,\mathbf{g}^1 + (\mathbf{R}^2 + \mathbf{R}^3)\,\mathbf{g}^1 + \mathbf{R}^3\,\mathbf{g}^2 + \mathbf{E}$$
$$\mathbf{B} = \mathbf{R}^3 + \mathbf{R}^2 + \mathbf{R}^1 + \mathbf{R}^1\,\mathbf{R}^2\,(\mathbf{g}^1 + \mathbf{g}^2) + \mathbf{R}^3\,\mathbf{R}^2\,\mathbf{g}^2 + \mathbf{R}^3\mathbf{R}^2\mathbf{R}^1\mathbf{g}^2\mathbf{g}^1$$

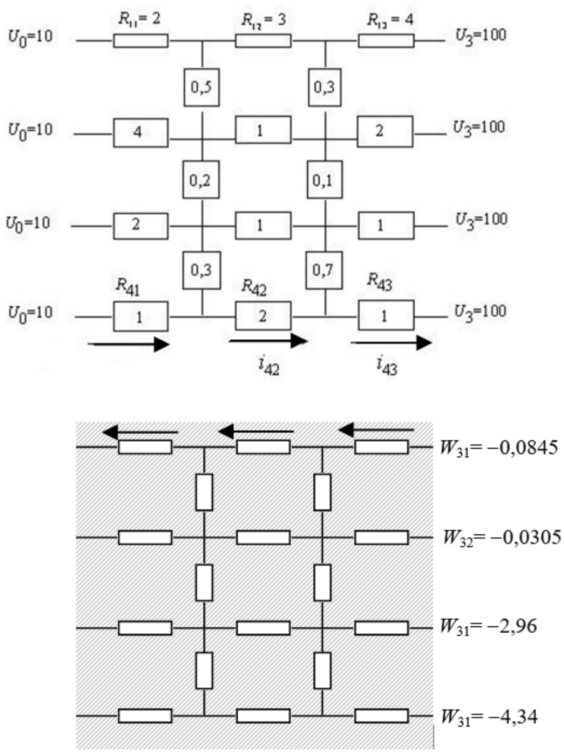

Figure 21. Nonlinear Electrical Field as Grid of Electrical Resistances (above) and its Antisystem.

Let us build the antisystem (see Figure 21):

$$\mathbf{W}^5 = \mathbf{E}$$
$$\mathbf{W}^4 = \mathbf{W}^5\, \mathbf{R}^3$$
$$\mathbf{W}^3 = \mathbf{W}^4\, \mathbf{g}^2\, \mathbf{e}^2 = \mathbf{W}^3 + \mathbf{W}^5$$
$$\mathbf{W}^2 = \mathbf{e}^2\, \mathrm{R}^2\, \mathbf{e}^3 = \mathbf{W}^2 + \mathbf{W}^4$$
$$\mathbf{W}^1 = \mathbf{e}^1\, \mathbf{g}^1\, \mathbf{e}^1 = \mathbf{W}^1 + \mathbf{e}^2 = \mathbf{A}$$
$$\mathbf{W}^0 = \mathbf{e}^1\, \mathbf{R}^1\, \mathbf{e}^0 = \mathbf{W}^0 + \mathbf{e}^1 = \mathbf{B}$$

The "energy" balance

$$\mathbf{e}^0\, \mathbf{I}^1 = \mathbf{W}^5\, \mathbf{U}^3 - \mathbf{e}^1\, \mathbf{U}^0 ,$$

follows from the antisystem equation:

$$\mathbf{I}^1 = (\mathbf{e}^0)^{-1}(\mathbf{W}^5\, \mathbf{U}^3 - \mathbf{e}^1\, \mathbf{U}^0)$$

Now we choose and apply to the input of antisystem such vector $\mathbf{W}^3$, which all components should be orthogonal to the components of the given vector $\mathbf{U}^3$ except of only one component, namely of component i = 4:

$$\mathbf{W}^3 = [\ -0{,}0845 \quad -0{,}0305 \quad -2{,}96 \quad -4{,}34\ ]$$

In this case all components of the "energy" vector $\mathbf{e}^0$ are equal 0 except of the component i = 4:

$$\mathbf{e}^1 = [\ 0{,}353 \quad 0{,}278 \quad 2{,}875 \quad -11{,}1\ ]$$
$$\mathbf{e}^0 = [\ 0 \qquad 0 \qquad 0 \quad 27{,}66\ ]$$

The desired current i_{41} will be easy calculated:

$$\mathbf{I}^1 = (\mathbf{e})^{-1}(\mathbf{W}^5\, \mathbf{U}^3 - \mathbf{e}^1\, \mathbf{U}) = i_{41} = 24{,}9$$

The advantage of the antisystem is, that we you calculate only the desired value i_{41} and not the whole vector $\mathbf{I}^1$.

Data Compression and Recognition

One of the frequently tasks by supervising of technological processes is to recognize, which value of many displayed indicator has changed. The indicators, shown in Figure 22, are "data". They build matrix $\mathbf{A}^2$ (system), which should be compared with the pattern matrix $\mathbf{A}^1$ (antisystem) and the changed indicator should be located.

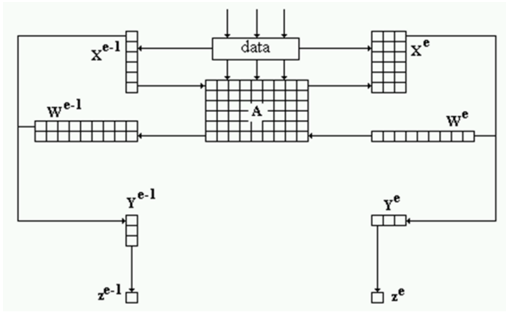

Figure 22. Task and Solution of Data Compression with ASA

According to ASA the change will be defined as written in [Zacher, 1997].
Let us apply the test vector $\mathbf{X}^0$ and the test matrix $\mathbf{W}^1$ to inputs of system and antisystem. The "energy" matrices $\mathbf{Y}^0$ and $\mathbf{Y}^1$ will be calculated and the sum of their components z_x and z_w will be compared:

$$\mathbf{Y}_0 = \mathbf{W}_0\mathbf{X}_0$$
$$\mathbf{Y}_1 = \mathbf{W}_1\mathbf{X}_1$$
$$z_0 = y_1^0 + y_2^0$$
$$z_1 = y_1^1 + y_2^1 + y_3^1$$

As far there is

$$z_0 = z_1$$

The "data" is equal "pattern" and no changes do happen (Figure 23).

Matrix $\mathbf{A}^1$:

A=

2,4	4,4	5,2	4,8	4,8	2,0	3,6	3,6	2,4
5,6	4,8	4,0	5,6	3,2	5,6	5,6	4,0	4,0
4,4	4,8	4,8	4,4	3,6	3,2	2,4	4,8	4,0
3,6	2,0	4,8	4,0	4,0	4,8	4,4	2,8	3,6
2,4	3,6	2,0	3,2	4,0	5,6	2,8	4,4	5,6
3,2	5,2	4,8	5,6	3,2	3,6	3,6	4,8	2,8

$\mathbf{W}^1$=

6	5	4	3	2	1

$\mathbf{X}^0$=

1
2
3
4
5
6
7
8
9

$\mathbf{X}^1$=

26,8	55,2	75,6
27,2	72,0	107,2
28,4	54,8	91,2
22,0	64,8	85,6
15,6	66,4	105,2
28,0	60,0	88,8

$\mathbf{W}^0$=

60,0	69,6	70,4	74,4	59,2	52,8	59,2	60,8	50,4
18,8	18,4	23,2	24,0	23,2	29,2	22,4	22,0	24,8

$\mathbf{Y}^0$=

2675,2
1068,4

$\mathbf{Y}^1$=

535,6	1297,6	1910,4

z= 3743,6

Figure 23. No Changes Between System and Antisystem (source [Zacher, 1997])

Supposing the component a_{45} of the data (matrix $\mathbf{A}^2$) has changed:

a_{45new} = 4,3.

Then the compressed values are shown in Figure 24.

$\mathbf{X}^1$=

26,8	55,2	75,6
27,2	72,0	107,2
28,4	54,8	91,2
22,0	**66,3**	85,6
15,6	66,4	105,2
28,0	60,0	88,8

$\mathbf{W}^0$=

60,0	69,6	70,4	74,4	59,2	52,8	59,2	60,8	50,4
18,8	18,4	23,2	24,0	**24,1**	29,2	22,4	22,0	24,8

$\mathbf{Y}^0$=

2675,2
1072,9

$\mathbf{Y}^1$=

535,6	**1302,1**	1910,4

$\mathbf{z}_{new}$ = **3748,1**

Figure 24. One Indicator Changes his Value, no balance between system and antisystem (source [Zacher, 1997])

The condition $z \neq z_{new}$ means, that a variable is changed. Compering the values of $\mathbf{Y}^1$, $\mathbf{X}^0$, $\mathbf{X}^1$, $\mathbf{W}^0$, $\mathbf{W}^1$ we define the number of the block with component a_{45} and the error:

The changed component a_{45} of the matrix $\mathbf{A}^2$ could be calculated:

Antineutrons Networks

The system and antisystem are presented by [Zacher, 1997] and [Zacher, 2000] as networks (Figure 25).

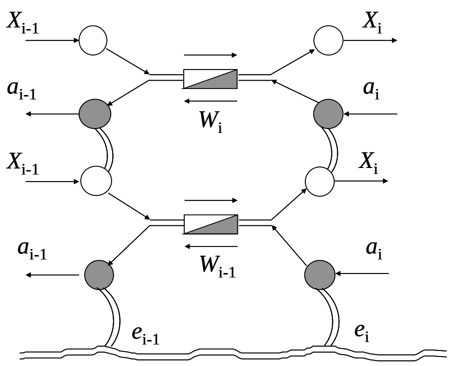

Figure 25. Network of Antineurons

Each pair neuron-antineuron has the following features:

- there is balance of "energy" $e_{i-1} = e_i$ for each pair.
- the weights W_i will be taken on from patterns a_i by training
- the "energy" of the network

$$E = \sum_i e_i$$

is minimal if the actual input **X** is equal to the training input **A**. On this way a pattern could be recognized.

Conclusion

According to the antisystem approach (ASA) no additional tool or controller is needed for engineering and control of a dynamic system, only a dynamic system itself. As far as the ASA based upon symmetry and antisymmetry, an antisystem could be easily build from original system and the "energy" balance between both, system and antisystem, will be achieved. On this way the engineering task could be solved on three levels:

- the original level with vectors of original system, which are given and could not be changed.
- the antisystem level with vectors, which could be changed as requested by developer
- the "energy" level with scalars, which meet a balance

The benefits of the ASA are:

- simplicity
- reduction of dimensionality
- the possibility to create an appropriate antisystem
- the possibility to exchange the task of system engineering into the task of antisystem engineering

ASA-Applications, given in this paper, confirm the advantages of the ASA.

Concluding the description and brief overview of ASA-applications it should be mentioned the necessity of the further developments in this field. As all new approaches the ASA needs detailed analysis and research for development of new generation of control systems.

References

Auer, S. (2010) *Die gelöschte Webseite*. Verlag Dr. Zacher, ISBN 978-3-937638-19-5, Wiesbaden

Bellman, R. (1957) *Dynamic Programming*. Princeton University Press, New Jersey

Groß, D. (2015) Entwurf und Untersuchung einer modellbasierten prädiktiven Regelung mit ASA-Konzept. *Master-Thesis, Hochschule Darmstadt, FB EIT, Fernstudium*

Kattanek, S. & Sacharjan, S. (1968) Berechnung von Übertragungsfunktionen des Festbettreaktors durch Reduzierung des Signalflußbildes. In: *Chemische Technik*, XX, No. 12, pp. 725-728

Mille, R. (2017) Rapid Control Prototyping eines ASA-Controllers mit MATLAB PLC Coder. Verlag Dr. Zacher, ISBN 978-3-937638-28-7, Stuttgart

Sacharjan, S. (1983) Basics of variables compression. -in: *Two methods of increased effciency of complex technological processes. Haiastan Publications, Yerevan*

Schmitt, O. (2016) Bilanzregelung nach dem ASA-Konzept mit Schattenstrecke. *Studienarbeit, Fachbereich Technik, DHBW Mannheim, Mannheim*

Sivardiere, J. (1995) *La symmetrie en mathematiques, physiques et chimie*. Presse Universitaires de Grenoble

Wessel, S. (2014) Entwicklung eines ASA-basierenden Reglers für Volumenstromregelung. *Master-Thesis, Hochschule Darmstadt, FB EIT, Fernstudium*

Zacher, S. (1997) Antisysteme versus Neuronale Netze: Das Prinzip und die Anwendungsbeispiele. – in: *Anwendersymposium zu Fuzzy Technologien und Neuronalen Netzen, 19. bis 20. November 1997, Dortmund*

Zacher, S. (2000) *SPS-Programmierung mit Funktionsbausteine*, Berlin/Offenbach: VDE-Verlag

Zacher, S. (2003) *Duale Regelungstechnik*. Berlin/Offenbach: VDE-Verlag

Zacher, S. (2008a) *Mobile Mathematik. Ein neues Konzept zur Lösung von linearen Gleichungssystemen*,

Verlag Dr. Zacher, ISBN 978-3-937638-13-3, Wiesbaden

Zacher, S. (2008b) *Existentielle Mathematik.* Verlag Dr. Zacher, ISBN 978-3-937638-16-4, Wiesbaden

Zacher, S., Saeed, W: Design of multivariable control systems using Antisystem-Approach. -*in: 7. Fachkolloquium AALE, Wien*

Zacher, S. (2012) *Verbotene Mathematik.* Verlag Dr. Zacher, ISBN 978-3-937638-22-5, Wiesbaden

Zacher, S. (2016a) Unwirksame Strecke. – *in „Automation-Letters", No. 6, Verlag Dr. Zacher, Stuttgart, https://www.zacher-international.com/Automation_Letters/06_Unwirksame_Strecke.pdf*

Zacher, S. (2016b) ASA-Implementierung. – *in „Automation-Letters", No. 8, Verlag Dr. Zacher, Stuttgart*

https://www.zacher-international.com/Automation_Letters/08_ASA-Implementierung.pdf

Zacher, S. (2016c) ASA-Regler mit Bypass. – *in "Automation-Letters", No. 29, Verlag Dr. Zacher, Stuttgart,*

https://www.zacher-international.com/Automation_Letters/29_ASA_Regler_mit_Bypass.pdf

Zacher, S. (2017a) *ASA-Regler. Test und Nachbesserung. – in "Automation-Letters", Nr. 32, Verlag Dr. Zacher, Stuttgart, https://zacher-international.com/Automation_Letters/32_ASA_Regler_Test.pdf*

Zacher, S. (2017b) *ASA: Bilanzregelung. – in "Automation-Letters", Nr. 33, Verlag Dr. Zacher, Stuttgart, https://zacher-international.com/Automation_Letters/33_ASA_Bilanzregelung.pdf*

Zacher, S., Reuter, M. (2017) *Regelungstechnik für Ingenieure* (15. Aufl.). Wiesbaden: Verlag Springer Vieweg

Zacher, S. (2020) Drei Bode-Plots-Verfahren für Regelungstechnik. Wiesbaden: Verlag Springer Vieweg