PASHA
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APPENDIX E
UDEM ELEMENTS

E.1 Operational elements

The operational elements represent transfer functions containing the integral operation ' s '. They have the following transfer functions:

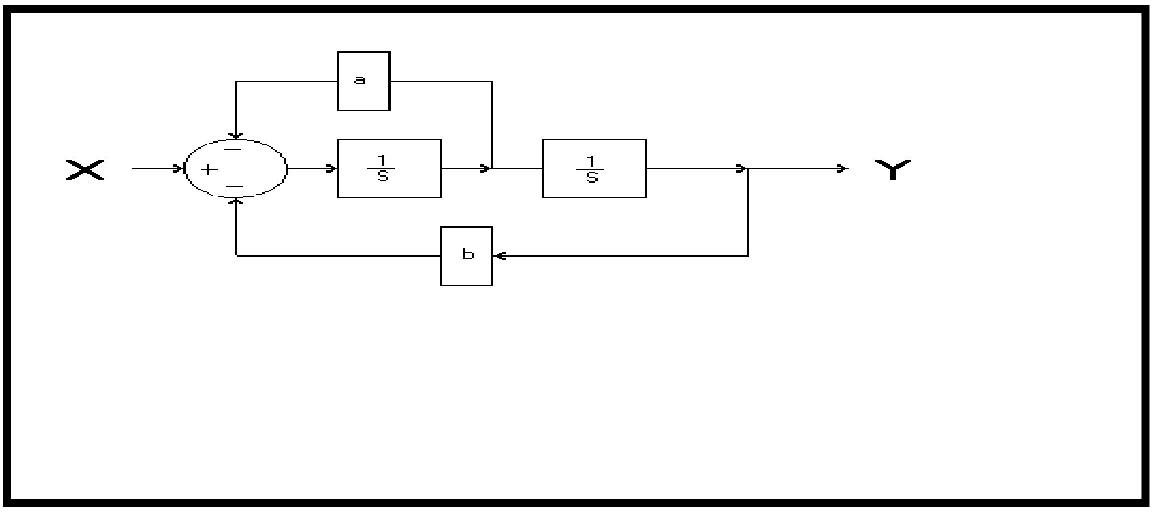
$$\frac{Y}{X} = \frac{Ka}{Kb+Tb\,s}$$

$$\frac{Y}{X} = \frac{Ka\,s}{Kb+Tb\,s}$$

$$\frac{Y}{X} = \frac{Ka+Ta\,s}{Kb+Tb\,s}$$

Where Y is the output and X is the input to the element and Ka, Kb, Ta, Tb are parameters.Using the above transfer function and the block diagram facilities of UDEM, all the higher order transfer functions can also be constructed. The following figure shows how to construct a block representing :

$$\frac{Y}{X} = \frac{1}{(s\,2 + a\,s + b)}$$



E.2 Algebraic function elements

The program accepts blocks representing algebraic functions. Each block can be used to describe a generalized three inputs (X,Y,Z) / single output algebraic equation with addition and multiplication operation. Each input signal , representing a variable, can be associated with one of the specific functions defined in the following table. Each function is also associated with three coefficients which determine the function gain, signal gain and phase shift. The general form of the function is:

Cx.Fx(Px.X+@x) * Cy.Fy(Py.Y+@y) * Cz.Fz(Pz.Z+@z)

where:

X,Y,Z	: Input signals
Cx,Cy,Cz	: Function gain
px,py,pz	: Signal gain
@x,@y,@z	: Phase shifter
Fx,Fy,Fz	: Function name from the following table
*	: Addition or Multiplication or a combination of these

It is possible to represent each term of the function in the form :

$$Cx(X+@x)^{Px} * Cy(Y+@y)^{Py} * Cz(Z+@z)^{Pz}$$

by specifying the 'POW' function name for Fx, or Fy, or Fz.

Function Name	Function Description
EXP	Exponential
SIN	Sinusoidal
COS	Cosinusoidal
LOG	Logarithmic
TAN	Tangent
SIH	Hyperbolic sin
COH	Hyperbolic cos
TAH	Hyperbolic tangent
ASI	Arcsin
ACO	Arccos
ATA	Arctangent
QUA	Quantizer function
POW	When entered, the form of the equation will be changed.
Fab	Where ab is an integer number. between 1 and 99. When entered a tabulated function Which is stored and identified by ab will be used.

Note: Quantizer Function is defined as:
The output = Cx.{IFTX (X/Px) + Qx}
where IFIX is the fixed integer part of (X/Px).

The following are some examples of the algebraic functions which this block can generate :

a) $2 \log(3X + 1)$

b) $5 \sin(4X + 2) + 6 \cos(5Y + 1)$

c) $2.1(X+1)^{3} / (Y+5)^{6}$

d) $2(X+1)^{2}+3\cos(5y+3.4)+4(Z+7)^{5}$

e) $5e^{(6X+2)} * \sin(7Y+1)+\tan(1.2Z+1.3)$

These algebraic functions are useful for a variety of power system modules. However, in the simulation for physical systems, some of the functions cannot be described mathematically or in terms of the standard functions provided in UDEM. Frequently, the only information available is tabulated experimental data which dies not lend itself to analytic expression. Rather than making it necessary to approximate such arbitrary functions by empirical expressions, as is sometimes done e.g. for saturation function. UDEM is capable of including arbitrary functions into the simulation studies.

Data for tabulated functions are entered via the tabulated function data entry page, Section 10.5.1.5, as pairs of numbers. Each tabulated function is associated with a numerical name, 1-99 . It is possible to select any of these functions, inside the algebraic function block, by using can be constructed. This is not supported in some version of PASHA.

E.3 Logical Switch elements

The logical switch elements provide an output form any of three possible inputs depending on the value of a user-defined control variable (CVR). Switches fall into two broad categories: those for which the (CVR) defines the logical completely, and those which need some additional logic operators and parameters. In the first set the (CVR) is defined as:

- MIN : A simple switch is made connecting the lowest input to the output.
- MAX : A simple switch is made connecting the highest input to the output.

In the second set the (CVR) is itself a variable signal,

- TIME : The simulation time determines the switch position.
-Onm : The magnitude of the output of the block number 'nm' in the block diagram determines the switch position.
-Snm : The slip (rate of variation) of the output of the block number 'nm' in the block diagram determines the switch position.

In this group, an internal decision logic is provided by using two possible set values (a,b) and a logical FORTRAN operator (LT,GT). Depending on the magnitude of the (CVR) and the logical operator condition, the output can choose one of the input signals (A, B, C) as follows:

- LT:
    The output is equal to input A
    The output is equal to input B
    The output is equal to input C
- GT:
    The output is equal to input A
    The output is equal to input C
    The output is equal to input B

In addition to the above parameters, a logical switch block implements another user-defined data, the data that defines the initial position of the switch. This is left to be specified by the user, since the initial condition of the switches, in most cases, is very difficult to set automatically. Refer to section 10.5.1.3 for additional information about this element.

E.4 Time Delay elements

A time delay element simulates the dead-time delay of the controller system. This is the time delay between the occurrence and response of an event. The transfer function of a time delay element is represented, in time domain area, by:

$$X(t - t1)$$

Where X(t) is the input function and t1 is the amount of time the output is delayed with respect to the input of element. The function of this block can be represented, in the S domain area, by:

$$e^{-t1\, s}$$

The data included for this block is the dead-time delay of the block, t1. A gain-coefficient is also provided for this block to simulate any possible attenuation or amplification of the input signal. In this way, the transfer function of the block is written as:

$$K\ e^{-t1\, s}$$

where K is the gain coefficient.

Practical time delays are of the order of micro seconds in the case of radar systems or as large as several minutes as in mechanical systems. To cover this wide range, the simulation routine requires a large storage of the input signal as a function of time for reproduction. For this reason the maximum delay must be limited and approximately 3 seconds is allowed in UDEM, depending on sampling time interval. Suitable warnings have been incorporated to flag any situations where the storage was insufficient.

E.5 Limiters

Sometimes it becomes necessary to limit the range of variables to make them conform to practical limits imposed on the physical system being simulated. In general, there are two kinds of limiting named as:

1. static limiting or wide up limits or clipping;
2. dynamic limiting or non-wide up limits.

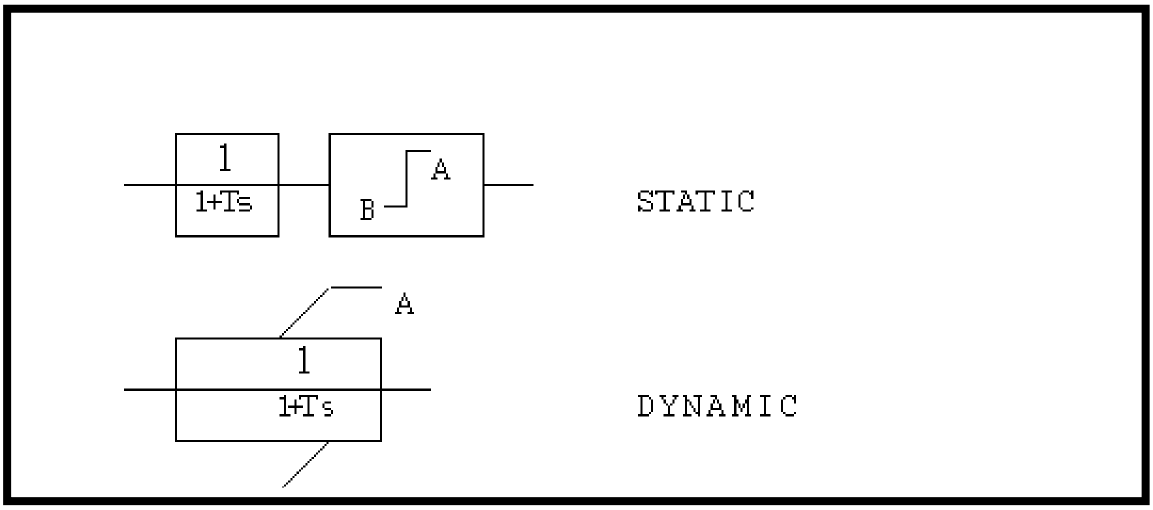
In the first set, the input to the limiter is allowed to have any value while the output is allowed to vary between certain specified limits. when this kind of limiter is located behind an integrator, the output of result will lie between the specified limits but the integrator will behave normally, responding to its input as though the limiter were not present.

There are situations where the output of an integrator itself will be limited by the device construction. This requires a different kind of limiting which is called dynamic limiting.

The following figure contains the standard symbols and the function of the two kinds of limiters. Whether a limiter is static or dynamic depends on how the physical system actually works. For example, a limiter is dynamic if the complex impedance feedback loop of an amplifier is electrically modified or by-passed whenever a limit is reached, or considering a "spring mass" system when the limit on motion is causing the velocity to be zero.

The UDEM limiters contain the value of their output between an upper and lower limit (A, B), subject to a time dependent maximum rate of change (different rates can be used for rise (C) an decrease (D)). This is, however, a static type limiter. The dynamic limiter is not included since its behavior can approximately be simulated by using a logical switch block .

The UDEM limiters can also be used to simulate the "Dead-Band". In a physical system dead-band occurs because of the inability of certain components to react to sufficiently small values of the input signal . The dead-band is included within the limiter function. They are represented with two extra data named as maximum and minimum range of the band (E,F).



E.6 Input / Output elements

The electric network and the UDEM module are solved separately in the PASHA and UDEM programs at each time step. However, variables from one program can be passed to the other program. These interactions between two programs are interchanged by means of input/output sources, which are provided in the block diagram.

Each module is excited by means of signal sources, which are called input signals. The input signals to such a module can be either independent (e.g. a constant value), or dependent i.e. can be functions of a system variable (e.g. the terminal voltage).

The configuration and parameters of the modules will determine the output signals of the block diagram. The output signals can be either passed back to the rest of the system or can simply be used as monitoring points.

Variables, which are passed back and forth between a UDEM module and the rest of the system, are referred to as interface quantities. The interface quantities are variables of system such as busbar voltages, and generator mechanical power. Indeed, the range of possible application of the module (i.e. to be load, motor, governor, remote controller, etc.) depends on complete flexibility in these interface quantities.

The interface quantities provided in the UDEM are organized according to the requirements of the modules to act as a power system element.

A maximum of ten inputs and ten outputs are provided for each module. **Each input can be set to be one of the following, which is referred to as interface quantity**:

(1) Busbar voltage (Real part) "Vr"
(2) Busbar voltage (Imaginary part) "Vi" or "Vm"
(3) Busbar voltage (Magnitude) "Vt"
(4) Busbar voltage (Angle) "Va"
(5) Direct axis voltage "Vd"
(6) Quadrature axis voltage "Vq"
(7) Rotor angle (the angle between real and quadrature axis) "Ra"
(8) Injected active power "Pe"
(9) Injected reactive power "Qe"
(10) shaft or mechanical power of the rotating machine modules "Pm"
(11) Field voltage "Ef" or "Vf"
(12) Field current "If"
(13) Frequency (Busbar frequency for the load module, shaft frequency for the rotating machine modules) "f"
(14) Rotor slip (for rotating machine modules) "S"
(15) Injected current magnitude form the module into the network "It"
(16) Constant value
(17) Constant value
(18) Time "Ti"
(19) Spare "Sp"
(20) Spare "Sp"
(21) Customized "Cu"

(22) Customized "Cu"
(23) Customized "Cu"
(24) Customized "Cu"
(25) Customized "Cu"

Each output can be set to be one of the following :

(1) Injected current (Real part) "Ir"
(2) Injected current (Imaginary part) "Ii" or "Im"
(3) Injected current (Magnitude) "It"
(4) Injected current (Angle) "Ia"
(5) Direct axis current "Id"
(6) Quadrature axis curret "Iq"
(7) Rotor angle (The angle between real and quadrature axes) "Ra"
(8) Injected active power "Pe"
(9) Injected reactive power "Qe"
(10) Shaft or mechanical power of the rotating machine modules "Pm"
(11) Field voltage "Ef" or "Vf"
(12) Field current "If"
(13) Frequency (Busbar frequency for the load module, shaft frequency for the rotating machine modules) "f"
(14) Rotor slip (for rotating machine modules) "S"
(15) Injected current magnitude form the module into the network "It"
(16) Spare "Sp"
(17) Spare "Sp"
(18) Spare "Sp"
(19) Spare "Sp"
(20) Spare "Sp"
(21) Customized "Cu"
(22) Customized "Cu"
(23) Customized "Cu"
(24) Customized "Cu"
(25) Customized "Cu"

Refer to sections 10.5.1.4, 10.12 for more information about inputs and outputs. The customized inputs and outputs will be set by TOM Industrial Consultant according to customer's request.