

Instruction Manual
HAS55E03IM11S
11/2003

Software Version 3.7.x

Supplement to Software Manual 3.4.x

NGA 2000 Software Manual for
TFID Analyzer and Analyzer Module (combined with
NGA 2000 Platform, MLT, CAT 200 or TFID Analyzer)



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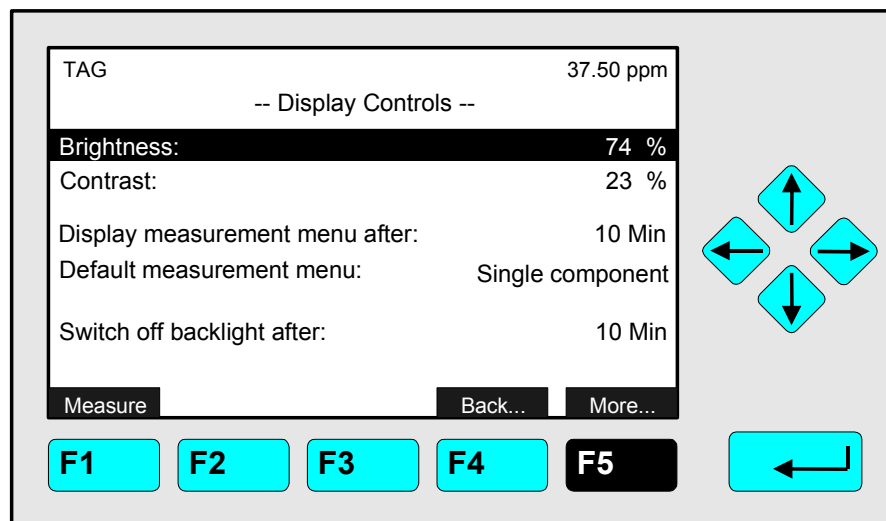
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This chapter describes some important features / changes implemented in software revision 3.6.x, shipped with the newest versions of Fisher-Rosemount NGA gas analyzers and has to be used in combination with the software 3.4.x manual.

1. Display Controls Menu

The Display Controls menu (see chapter 7) now has additional menu lines:



Setting parameters:

- ◆ Select any line of variables using the ↓ -key or the ↑ -key.
- ◆ Select the variable using the ↵ -key or the → -key.
- ◆ Change the whole value using the ↑ -key or the ↓ -key or select single digits using the ← -key or the → -key and enter a new value using the ↑ -key or the ↓ -key.
- ◆ Confirm the new value using the ↵ -key or cancel and return to the previous value using the F2 -key.

Line of variables "Display measurement menu after:"

The value entered in this line defines the time to expire without operator input before the display automatically returns to the measurement display.

Options: 10 s, 30 s, 1 min, 5 min, 10 min, 30 min, Never.

Line of variables "Default measurement menu:"

Use this line to select the display the analyzer returns to when the time entered in line "display measurement menu after:" has expired.

Options: Single Component (Display) or Multi Component (Display)

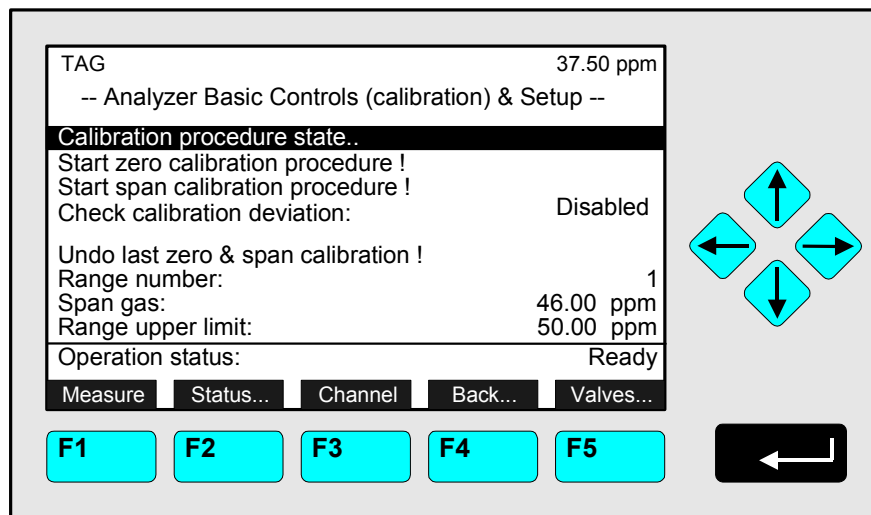
Line of variables "Switch off backlight after:"

The value entered in this line defines the time to expire without operator input before the backlight is switched off automatically. Using this function saves energy and expands the backlight's lifetime.

Options: 10 s, 30 s, 1 min, 5 min, 10 min, 30 min, Never.

2. Analyzer Basic Controls (calibration) & Setup Menu

One line was added to this menu (see chapter 4.4, p. 4-19):



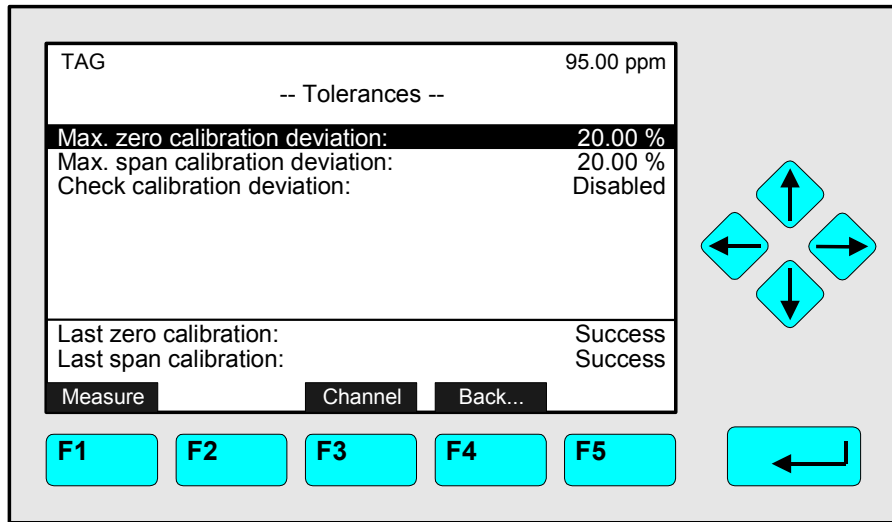
Function Line "Undo last zero & span calibration !"

Use this function to reset an analyzer's calibration values to default factory settings if the last calibration procedure has been completed with a poor result due to wrong settings and the calibration is in an undefined status.

Depend on the "Measurement Display Configuration" settings a screen may appear asking for confirmation prior to executing the function (see chapter 3.7, p. 3-6 and chapter 5.1.8, p. 5-49).

3. Tolerances Menu

The stability tolerance range 1 ... 4 lines of the menu Tolerances (see chapter 5.1, p. 5-8) have been moved into a new menu within the service level:



The stability tolerance function is still enabled but not longer operator definable. Factory setting for all 4 values (ranges 1 ... 4) is 10 %.

Calculator on Control Module Level (Platform, TFID, MLT or CAT 200 Analyzer)

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1 System Calculator (on Control Module Level)

1.1 Principle of program set-up

As it would be a too high effort to realize a comfortable mathematical formula system we created a syntax which is easy to input and easy to realize.

As we assume that customers or service people have to set-up the program only one times for an installed system it should be acceptable to realize a form which is only done by inputting numbers.

Therefore we have mainly to differ between positive and negative numbers.

The program **operations** are assigned with **negative numbers**.

The **operands** which are used by these input operations are **positive numbers**. These positive numbers symbolize signals which are part of a signal pool.

Also we have to know that there are used **different classes of operands**. That means we have different classes of signal pools.

Those are:

- Live values (real measuring values)
- Constant values
- Memory values.

In each of these classes exists an own numbering and we determine by the operator itself which class of these operands is meant.

Remark:

Opposite to former versions allowing calculator function within ONE TFID/MLT/CAT 200 analyzer module (AM) or for ONE TFID/MLT analyzer (or CAT 200 analyzer resp.) ONLY now the system calculator is based on the Control Module level (CM).

This allows to include ALL analyzer modules resp. MLT channels of a NGA 2000 analyzer system into the calculation.

The results of the system calculator can be put onto the 2-8 analog outputs of the programmable Input/Output Module SIO.

The SIO as a Control Module I/O is then located in a platform or in a TFID, MLT or CAT 200 Analyzer.

In the following table we find all the currently available operators (negative numbers) and their meaning. Hereby is used the acronym "IR" for the actually calculated intermediate result of the program.

Table 1-1: The Operators of the System Calculator

| Operator number | Acronym | Description |
|-----------------|--------------|---|
| -1 | ADD I | add following live value operand to the IR ($IR = IR + I$) |
| -2 | SUB I | subtract following live value operand from IR ($IR = IR - I$) |
| -3 | DIV I | divide IR by following live value operand ($IR = IR / I$) |
| -4 | MUL I | multiply IR with following live value operand ($IR = IR * I$) |
| -5 | ADDC c | add following constant value operand to the IR ($IR = IR + c$) |
| -6 | SUBC c | subtract following constant value operand from IR ($IR = IR - c$) |
| -7 | DIVC c | divide IR by following constant value operand ($IR = IR / c$) |
| -8 | MULC c | multiply IR with following constant value operand ($IR = IR * c$) |
| -9 | ADDM m | add following memory value operand to the IR ($IR = IR + m$) |
| -10 | SUBM m | subtract following memory value operand from IR ($IR = IR - m$) |
| -11 | DIVM m | divide IR by following memory value operand ($IR = IR / m$) |
| -12 | MULM m | multiply IR with following memory value operand ($IR = IR * m$) |
| -13 | STOM m | store IR at following memory value and set $IR = 0.0$ ($m = IR; IR = 0$) |
| -14 | STOR r | store IR to following result and set $IR = 0.0$ ($r = IR; IR = 0$) |
| -15 | NOP | no operation (placeholder) |
| -16 | ABS | convert IR into absolute value ($IR = IR $) |
| -17 | EOP | end of program |
| -18 | SQRT | build square root of IR ($IR = \sqrt{IR}$) |
| -19 | NEG | negate IR ($IR = -IR$) |
| -20 | INC | increment IR ($IR = IR + 1$) |
| -21 | DEC | decrement IR ($IR = IR - 1$) |
| -22 | INV | invert IR ($IR = 1 / IR$) |
| -23 | EXP | exponential function ($IR = e^{IR}$) |
| -24 | POWM | IR raised to the power of the following memory value operand ($IR = IR^m$) |
| -25 | IF> m1 m2 m3 | if $IR > 1^{st}$ following memory value then $IR = 2^{nd}$ following memory value else $IR = 3^{rd}$ following memory value |
| -26 | IF< m1 m2 m3 | if $IR < 1^{st}$ following memory value then $IR = 2^{nd}$ following memory value else $IR = 3^{rd}$ following memory value |
| -27 | IF= m1 m2 m3 | if $IR = 1^{st}$ following memory value then $IR = 2^{nd}$ following memory value else $IR = 3^{rd}$ following memory value |
| -28 | LN | natural logarithm ($IR = \ln(IR)$) |
| -29 | LOG | base 10 logarithm ($IR = \log(IR)$) |

1.2 Live values (real measuring values)

In the platform calculator we have a **signal pool** of momentary up to 25 possible live signals. The first 10 signals in this pool are fix assigned the rest of the signals are free assignable.

Table 1-2: Live Values Pool

| Number | Assignment | assignment type |
|-----------|-------------------------|-----------------|
| Signal 1 | Result 1 | fixed |
| Signal 2 | Result 2 | fixed |
| Signal 3 | Result 3 | fixed |
| Signal 4 | Result 4 | fixed |
| Signal 5 | reserved | fixed |
| Signal 6 | reserved | fixed |
| Signal 7 | reserved | fixed |
| Signal 8 | reserved | fixed |
| Signal 9 | reserved | fixed |
| Signal 10 | reserved | fixed |
| Signal 11 | MLT 1/CH1 Concentration | programmable |
| Signal 12 | TFID Concentration | programmable |
| Signal 13 | MLT 2/CH3 Temperature | programmable |
| Signal 14 | TFID Temperature | programmable |
| Signal 15 | not assigned | programmable |
| | | programmable |
| Signal 25 | not assigned | programmable |

By using these numbers of the signal pool we determine the live value operands in the calculator's program.

Example of a calculator program with upper signal assignment:

$$\text{Result 1} = (\text{MLT 1/CH1 Concentration}) + (\text{TFID Concentration})$$

| | | |
|------------|-----|---|
| Step (o+1) | -1 | ADD (at beginning the intermediate result IR = 0) |
| Step (o+2) | 11 | Signal 11 (here: MLT1/CH1 Concentration) |
| Step (o+3) | -1 | ADD |
| Step (o+4) | 12 | Signal 12 (here: TFID Concentration) |
| Step (o+5) | -14 | Store IR to result |
| Step (o+6) | 1 | Result 1 |
| Step (o+7) | -17 | End of program |
| | | |
| | | |

1.3 Constant values

The same principle is used for the constant values. We have a **pool** of free assignable constant values.

Example of a constant signal pool:

| Number | Assignment |
|-------------|------------|
| Constant-1 | 1.000000 |
| Constant-2 | 10.00000 |
| Constant-3 | 100.0000 |
| Constant-4 | 1000.000 |
| Constant-5 | 10000.00 |
| | |
| Constant-21 | 500.0000 |

By using the numbers of the signal pool we determine again the constant operands in the calculator's program.

Example of a calculator program with upper live signal and constant assignment:

$$\text{Result1} = (\text{MLT } 1/\text{CH1-Concentration}) + 100$$

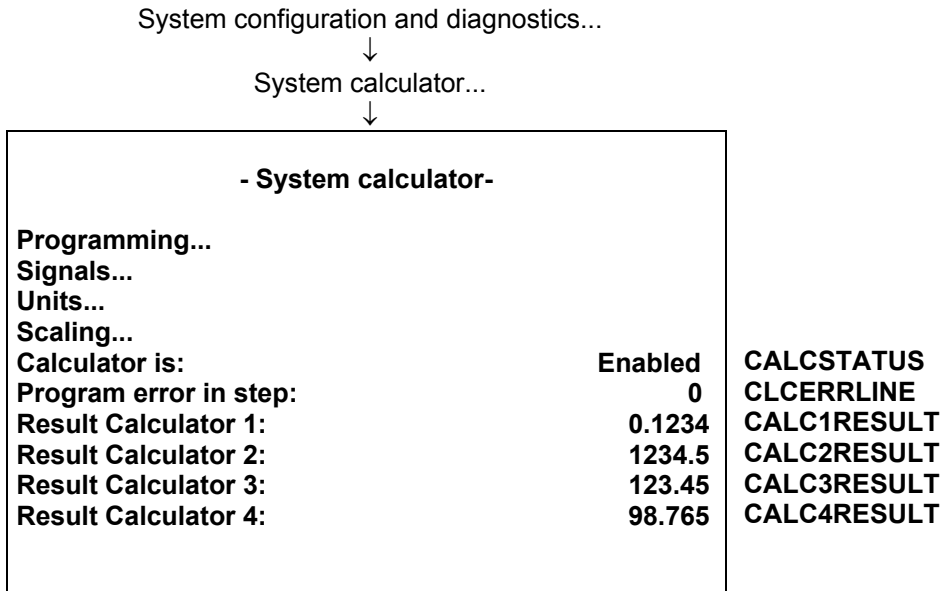
| | | |
|------------|-----|---|
| Step (o+1) | -1 | ADD (addition by using the live operand's class) |
| Step (o+2) | 11 | Live value number 11 (here: MLT1/CH1-Concentration) |
| Step (o+3) | -5 | ADDC (addition by using the constant operand's class) |
| Step (o+4) | 3 | Constant number 3 (here: 100.0) |
| Step (o+5) | -14 | Store IR to result |
| Step (o+6) | 1 | Result 1 |
| Step (o+7) | -17 | End of program |
| | | |
| | | |

1.4 Memory values

The same principle as in constant values is used again for the memory values. We have a **pool** of usable memory places where intermediate calculation results can be stored to.

1.5 Menu tree for the system calculator

The following pictures show the menu tree and the LON variables which are assigned to the single menu lines.



Picture 1-1: System Calculator Menu

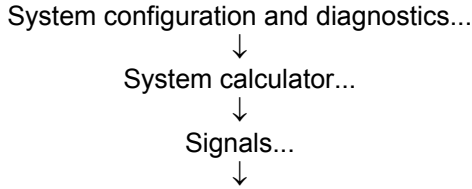
With the 'Calculator is' parameter we show whether the system calculator functionality is

- **Disabled**
- **Enabled**
- has a **Program Error** (after trying to enable)

In the case of a program error by the 'Program error in step:' parameter is displayed in what step of the program this error happened. If there is no error this parameter equals '0'.

1.5.1 Submenu 'Signals'

The live values' signal assignment is done in the submenu 'Signals...'.



| - Signals - | |
|---------------------------------------|----------------------|
| Signal number: | 11 |
| Choose signal source module... | |
| Choose signal... | |
| Signal name: | Concentration |
| Signal comes from: | MLT/CH1 |
| Current signal value: | 123.45 ppm |
| View... | |

CALCSIGNUMC

CALCSRSEL_

CALCSIGSEL_

CALCSIGC

CALCSRCC

CALCVALC

fct3: **CASIGLST_**

Picture 1-2 : Signal Assignment of System Calculator

The single signals of the pool (selected by 'Signal number') are assigned by first selecting the source analyzer module (AM) resp. analyzer channel of the requested signal and then the signal name itself. Please, note that is only possible to modify the programmable type of signal numbers.

To realize the signal name's selection there is used an already implemented feature of the AMs. It has being used for the small bar graphs display and for the analog outputs of the SIO module. It is the **SVCONT/SVNAME** variable mechanism. This mechanism provides the possibility to have a link to the LON variables of an AM which are listed in the SVCONT enum. In the SVNAME variable are listed the related human readable strings.

If we want to assign the signals not via the menu but via LON variable access we have to do the following steps:

1. Enter signal number by setting CALCSIGNUMC.
2. Enter the source of the signal by setting CALCSRCC to the TAG-variable's string of the requested channel.
3. Set CALC_ENTRYSIG (instead of using CALCSIGC) to the enum value that the signal has in the SVCONT-variable.

It is possible to show a listing of the whole signal pool with the entered programmable as well as the fixed assignments.

| -- Signal List -- | | |
|--------------------------|-------------------------------|-------------------|
| List offset: | | 10 |
| Signal (o+1): | Concentration: MLT/CH1 | MENU1LINE |
| Signal (o+2): | Concentration: MLT/CH2 | MENU2LINE |
| Signal (o+3): | Concentration: MLT/CH3 | MENU3LINE |
| Signal (o+4): | Concentration: TFID | MENU4LINE |
| Signal (o+5): | Temperature: MLT/CH1 | MENU5LINE |
| Signal (o+6): | Temperature: MLT/CH2 | MENU6LINE |
| Signal (o+7): | Pressure: MLT/CH1 | MENU7LINE |
| Signal (o+8): | Flow: MLT/CH3 | MENU8LINE |
| Signal (o+9): | ????: ???? | MENU9LINE |
| Signal (o+10): | ????: ???? | MENU10LINE |

<< Back... >>

fct3: **BACKVARS**
fct4: **ESCAPE**
fct5: **LOADVARS**

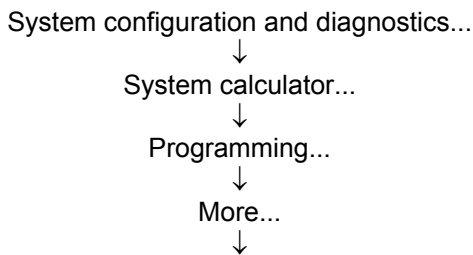
Picture 1-3: Listing of Signal Assignment

1.5.2 Submenu 'Programming'

The constant values are configured in the submenu 'Programming...'.
 System configuration and diagnostics...
 ↓
 System calculator...
 ↓
 Programming...
 ↓

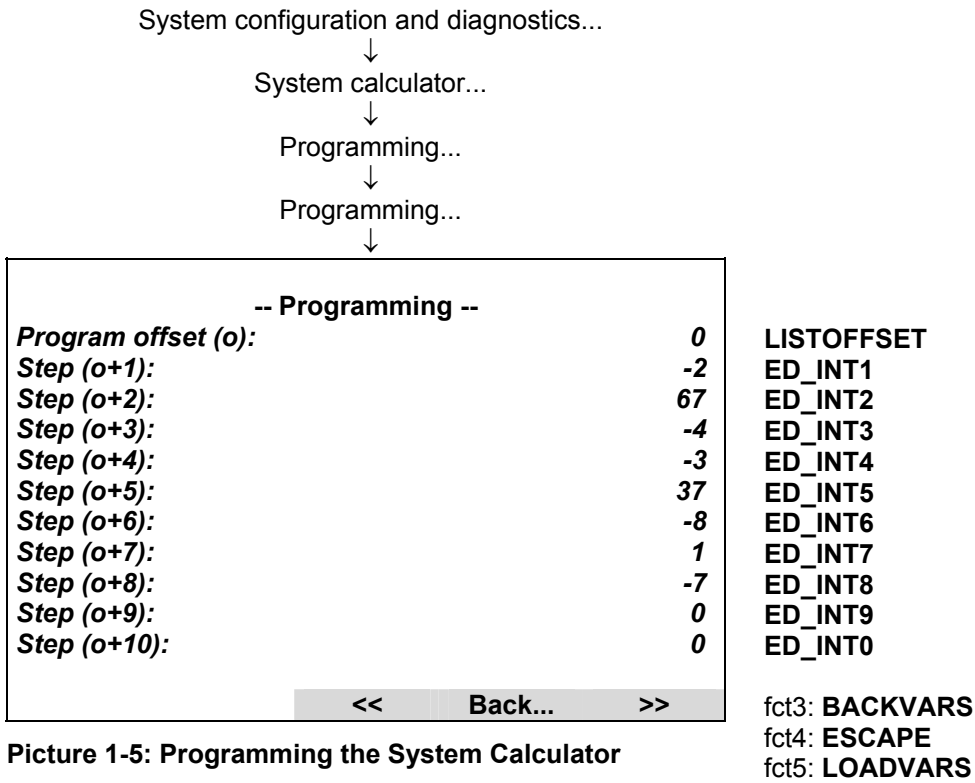
| - Constants (1/3) - | | |
|----------------------------|-----------------|------------------------|
| Constant -1: | 1.000000 | CALCAC1 |
| Constant -2: | 10.00000 | CALCAC2 |
| Constant -3: | 100.0000 | CALCAC3 |
| Constant -4: | 1000.000 | CALCAC4 |
| Constant -5: | 10000.00 | CALCAC5 |
| Constant -6: | 100000.0 | CALCAC6 |
| Constant -6: | 1000000 | CALCAC7 |
| Programming... | | CALCPRG_ |
| | More... | fct5: CALCCONS2 |

Picture 1-4: Constant Values Assignment



| - Constants (2/3) - | | |
|----------------------------|-----------------|------------------------|
| Constant -8: | 0.100000 | CALCBC1 |
| Constant -9: | 0.010000 | CALCBC2 |
| Constant -10: | 0.001000 | CALCBC3 |
| Constant -11: | 0.000100 | CALCBC4 |
| Constant -12: | 0.000010 | CALCBC5 |
| Constant -13: | 0.000001 | CALCBC6 |
| Constant -14: | 0.200000 | CALCBC7 |
| | More... | fct5: CALCCONS3 |

After having done the set-up of the signals we can do the programming of Calculator algorithm itself. It is done in the submenu 'Programming...'.



Picture 1-5: Programming the System Calculator

If we want to assign the signals not via the menu but via LON variable access we have to be aware of following:

1. The PLC-programming as well as the programming for the system calculator happens indirectly via the edit variable-array ED_INTx.
To differ what the programming is for there exists the LON variable PROGTYT.
Setting PROGTYT = 0 means we want to program the system calculator.
Setting PROGTYT = 1 means we want to program the system PLC.
2. By using the variable LISTOFFSET we determine what part of the whole programming list we want to program.
For example, setting LISTOFFSET = 60, means by usage of ED_INT1...ED_INT10 we are able to modify the program steps 61...70.

2 Display Calculator Results on Mini-bargraph

In order to show the calculator results on the mini-bargraphs of the single component display we overworked the architecture of the bargraph displays.

All the signals which are shown on this display in the versions up to now belonged always to the selected component, that means they belonged all to the same AM-channel or to an I/O module which is bound to it.

To show a calculator result which belongs to the CM we have to **assign signals of a different node/subnode** to the single component display's bargraphs. Therefore we have chosen a way which enables us to do a complete free signal assignment.

Also we are able to set-up the calculator result's **unit** and its **range limits**.

And finally we are able to assign an own **signal name** to the bar graphs. Up to now there have been shown the name that is noticed in the SVNAME variable. For most of signals this is sufficient. But especially for signals which have no unique function (like calculator results) we want to show configurable and therefore more intuitive signal names.

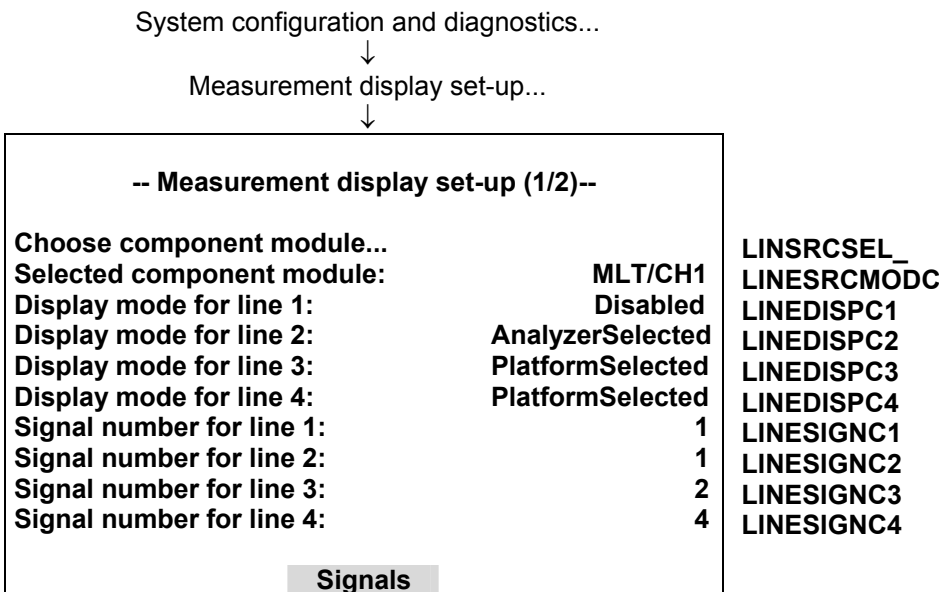
By inventing this new bargraphs display structure we also looked to have a behavior which can fulfill the current functionalities.

Therefore we created the possibility to assign signals of I/O modules and their implemented SVCONT/SVNAME signals as well as the ANALOGOUTPUT/ANOPUNITS variable of older I/O module versions.

2.1 Display mode

For each selectable component we can compose bar graph displays. This composition can show signals of a prepared pool from any attached network node.

To have the possibility of being compatible to current software versions we create also a mode which displays the signals as they are selected by the analyzers itself.



Picture 2-1: Measurement Display Set-up

In upper menu we first select the component we want to do the assignment for ("Choose component module...").

By use of the four "Display mode for line x"-parameters we select the handling of the 4 bar graphs.

Disabled: The bar graph is switched off.

AnalyzerSelected: The bar graph receives the signal from the SVNAMEx-variable of the selected component module (AM). This is the already implemented and mainly used mode.

PlatformSelected: The bar graph receives its signal from a signal pool that is installed in the Control Module itself.

2.2 Assign signals and convenient names

If we use the 'PlatformSelected' signal mode we have to determine what signal number of the pool has to be displayed. The selection of this number is performed in the appropriate menu line "Signal number for line x".

Now we have to determine only what kind of signal is behind each signal number of the pool. This is done in the following menu display.

System configuration and diagnostics...



Measurement display set-up...



Signals...



| - Assign mini-bargraph signals - | | |
|--|-------------------|----------------|
| Signal number: | 4 | SGNSNUMC |
| Choose signal source module... | | AUXSRCSEL_ |
| Choose signal... | | AUXSIGSEL_ |
| Signal description: | NOx-Calculation | SGNDESCRC |
| Signal comes from: | Control Module | SGNSRCMODC |
| Signal name: | Sys.-calculator 1 | SGNSRCSIGC |
| <input type="button" value="View..."/> | | fct3: AUXLIST_ |

Picture 2-2: Platform selected Signal Assignment

We are able to assign signals which come from all installed nodes/subnodes and have the SVCONT/SVNAME variable. Further more we present I/O modules which have the ANALOGOUTPUT / ANOPUNITS variable.

The procedure is the following:

First we select the signal number we want to assign the signal for.

Then we choose the source (node/subnode) the signal shall come from.

After this we choose the signal itself of the selected source.

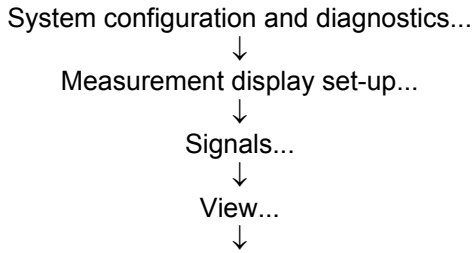
With the "Signal description" parameter, which is an editable string variable, we create the ability to give a convenient signal name to each of the assigned signals.

If we want to assign this not via the menu but via LON variable access we have to do the following steps:

1. Enter signal number by setting SGNSNUMC.
2. Enter the source of the signal by setting SGNSRCMODC to the TAG variable's string of the requested channel.
3. Set SGN_ENTRYSIG (instead of using SGNSRCSIGC) to the enum value that the signal has in the SVCONT variable.
4. Enter the signal description by setting SGNDESCRC.

Calculator on Control Module Level

A complete overview of the signals in the pool can be obtained then in the following menu.



| - Signal List - | | |
|--|-----------------------------------|------------|
| Signal offset (o): | 0 | LISTOFFSET |
| Signal 1+o: | Sys.-calculator 1: Control Module | MENU1LINE |
| Description: | Sum of CO and CO2 | MENU2LINE |
| Signal 2+o: | Sys.-calculator 2: Control Module | MENU3LINE |
| Description: | SysCalc2 | MENU4LINE |
| Signal 3+o: | Sys.-calculator 3: Control Module | MENU5LINE |
| Description: | SysCalc3 | MENU6LINE |
| Signal 4+o: | Sys.-calculator 4: Control Module | MENU7LINE |
| Description: | SysCalc4 | MENU8LINE |
| Signal 5+o: | ????: ???? | MENU9LINE |
| Description: | ???? | MENU10LINE |
| << Back... >> | | |

fct3: **BACKVARS**
fct4: **ESCAPE**
fct5: **LOADVARS**

Picture 2-3: Listing of assigned Signals

3 Assignment to SIO Analog Outputs

The assignment of the system calculator results to an analog output of the SIO board is realized by extending the selectable module types. Now it is also possible to select the platform itself with its own signals (calculator results).

That means we have added the SVCONT/SVNAME variable for node/subnode 0 (platform). Here we assigned then the new CALCxRESULT variables of the system calculator.

Programmable Logic Control (PLC) on Control Module Level (Platform, TFID, MLT or CAT 200 Analyzer)

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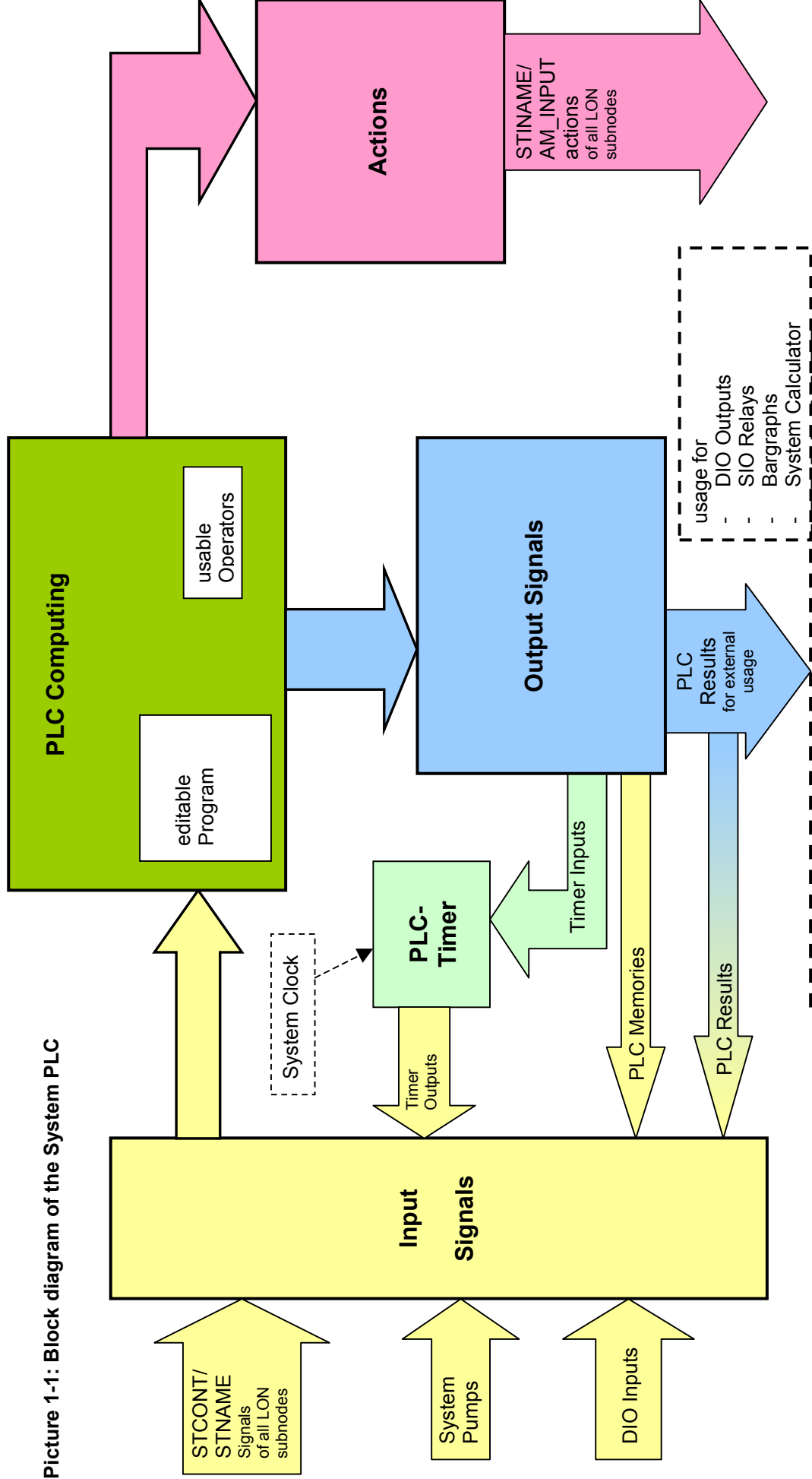
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1 Function Survey

Picture 1-1: Block diagram of the System PLC



2 Principle of Program Setup

As it would be a too high effort to realize a comfortable mathematical formula system we created a syntax which is easy to input and easy to realize.

As we assume that customers or service people have to setup the program only one times for an installed system it should be acceptable to realize a form which is only done by inputting numbers.

Therefore we have mainly to differ between positive and negative numbers.

The program **operations** are assigned with **negative numbers**.

The **operands** which are used by these input operations are **positive numbers**. These positive numbers symbolize signals which are part of a signal pool.

Also we have to know that there are used **different classes of operands**. That means we have different classes of signal pools.

Those are:

- Input signals
- Output signals
- Actions.

In each of these classes exists an own numbering and we determine by the operator itself which class of these operands is meant.

Remark:

Opposite to former versions allowing PLC function within ONE TFID/MLT/CAT 200 analyzer module (AM) or for ONE TFID/MLT analyzer (or CAT 200analyzer resp.) ONLY now the system PLC is based on the Control Module level (CM).

This allows to include ALL analyzer modules resp. MLT channels of a NGA 2000 analyzer system into the PLC system.

The results of the system PLC can be put onto the programmable Input/Output Modules SIO or DIO.

The SIO or DIO's can work as Control Module I/O's being then located in a platform or in a MLT, CAT 200 or TFID Analyzer but also as local I/O's in (remote) TFID, MLT or CAT 200 analyzer module.

3 Operators

In the following table we find all the currently available operators (negative numbers) and their meaning. Hereby is used the acronym "IR" for the actually calculated intermediate result of the PLC program.

Table 3-1: The Operators of the System PLC

| Operator number | Acronym | Description |
|-----------------|----------|---|
| -1 | NOP | no operation (placeholder) |
| -2 | OR | OR combine the input signals with following ID; store to IR |
| -3 | AND | AND combine the input signals with following ID; store to IR |
| -4 | INVERT | invert the IR |
| -5 | STORE | set/clear the output signal with the following ID according IR |
| -6 | CLEAR | clear the IR |
| -7 | END | end of program |
| -8 | SET | set the IR |
| -9 | LOAD | load IR according input signal with following ID; |
| -10 | IF i1 i2 | if IR = True then IR = input signal with 1 st following ID else IR = input signal with 2 nd following ID |
| -11 | CALL | actions call according IR by using following ID of actions pool |

4 Input Signals

In the platform PLC we have a **signal pool** for the input signals. The first part in this pool are fix assigned the rest of the signals are free assignable.

Table 4-1: Example of an Input Signals Pool

| Signal ID | Assignment | assignment type |
|-----------|----------------------------|-----------------|
| 1 | PLC Result 1 | fixed |
| 2 | PLC Result 2 | fixed |
| 3 | PLC Result 3 | fixed |
| .. | .. | fixed |
| 15 | PLC Result 15 | fixed |
| 16 | PLC Memory 1 | fixed |
| 17 | PLC Memory 2 | fixed |
| .. | .. | fixed |
| 30 | PLC Memory 15 | fixed |
| 31 | PLC Timer1 Out | fixed |
| 32 | PLC Timer2 Out | fixed |
| 33 | PLC Timer3 Out | fixed |
| 34 | PLC Timer4 Out | fixed |
| 35 | PLC Timer5 Out | fixed |
| 36 | PLC Timer6 Out | fixed |
| 37 | PLC Timer7 Out | fixed |
| 38 | PLC Timer8 Out | fixed |
| 39 | reserved | fixed |
| 40 | reserved | fixed |
| 41 | System-DIO-Board 1 Input 1 | fixed |
| 42 | System-DIO-Board 1 Input 2 | fixed |
| .. | .. | fixed |
| 47 | System-DIO-Board 1 Input 7 | fixed |
| 48 | System-DIO-Board 1 Input 8 | fixed |
| 49 | System-DIO-Board 2 Input 1 | fixed |
| 50 | System-DIO-Board 2 Input 2 | fixed |
| .. | .. | fixed |
| 55 | System-DIO-Board 2 Input 7 | fixed |
| 56 | System-DIO-Board 2 Input 8 | fixed |
| 57 | System-Pump 1 | fixed |
| 58 | System-Pump 2 | fixed |
| .. | .. | fixed |
| 62 | reserved | fixed |
| 63 | On-Signal | fixed |
| 64 | Off-Signal | fixed |
| 65 | MLT1/CH1-Failure | programmable |
| 66 | MLT1/CH1-Conc.Low-Low | programmable |
| 67 | MLT1/CH3-Flow Low | programmable |
| 68 | TFID-Cal. in progress | programmable |
| 69 | CLD-Maintenance request | programmable |
| 70 | Control Module-SYS:Valve1 | programmable |
| 71 | Control Module-SYS:Valve2 | programmable |
| 72 | Control Module-SYS:Valve3 | programmable |
| .. | .. | programmable |
| 127 | not assigned | programmable |
| 128 | not assigned | programmable |

5 Output Signals

The same principle as for input signals is used for the output signals. We have a **pool** of usable buffer places where intermediate calculation results can be stored to.

The content of these buffers may be used for further processing.

Table 5-1: Output Signals Pool

| Signal ID | Assignment | Tip |
|-----------|----------------|--|
| 1 | Result 1 | full usable LON variable (PLCRESULT1) |
| 2 | Result 2 | full usable LON variable (PLCRESULT2) |
| 3 | Result 3 | full usable LON variable (PLCRESULT3) |
| .. | .. | full usable LON variable |
| .. | .. | full usable LON variable |
| 14 | Result 14 | full usable LON variable (PLCRESULT14) |
| 15 | Result 15 | full usable LON variable (PLCRESULT15) |
| 16 | Memory 1 | intermediate storage |
| 17 | Memory 2 | intermediate storage |
| .. | .. | intermediate storage |
| .. | .. | intermediate storage |
| 29 | Memory 14 | intermediate storage |
| 30 | Memory 15 | intermediate storage |
| 31 | Timer 1 Input1 | usage depends on timer mode |
| 32 | Timer 2 Input1 | usage depends on timer mode |
| 33 | Timer 3 Input1 | usage depends on timer mode |
| 34 | Timer 4 Input1 | usage depends on timer mode |
| 35 | Timer 5 Input1 | usage depends on timer mode |
| 36 | Timer 6 Input1 | usage depends on timer mode |
| 37 | Timer 7 Input1 | usage depends on timer mode |
| 38 | Timer 8 Input1 | usage depends on timer mode |
| 39 | reserved | |
| 40 | reserved | |
| 41 | Timer 1 Input2 | usage depends on timer mode |
| 42 | Timer 2 Input2 | usage depends on timer mode |
| 43 | Timer 3 Input2 | usage depends on timer mode |
| 44 | Timer 4 Input2 | usage depends on timer mode |
| 45 | Timer 5 Input2 | usage depends on timer mode |
| 46 | Timer 6 Input2 | usage depends on timer mode |
| 47 | Timer 7 Input2 | usage depends on timer mode |
| 48 | Timer 8 Input2 | usage depends on timer mode |
| 49 | reserved | |
| 50 | reserved | |
| .. | .. | |
| 56 | reserved | |
| 57 | System-Pump 1 | full usable LON variable (SYSPUMP1) |
| 58 | System-Pump 2 | full usable LON variable (SYSPUMP2) |
| 59 | reserved | |
| .. | .. | |
| 69 | reserved | |
| 70 | reserved | |

Programmable Logic Control (PLC) on Control Module Level

In the output signal pool the Results1..15 are assigned as full usable LON variable-array.

They are also implemented in the STCONT/STNAME-feature. So the PLC Results can be linked to digital outputs of DIO or to the relays of SIO.

They are also implemented in the SVCCONT/SVNAME-feature. So we are able to link them to analog outputs of SIO, the bargraphs display and to the system calculator signals.

By using the signal IDs of the signal pools we determine the input resp. the output signal operands in the PLC's program.

Following are examples that use the signal assignment of "Table 4-1: Example of an Input Signals Pool".

Result1 = (MLT1/CH1-Failure) OR (MLT/CH1-Conc.Low-Low) OR (DIO1-Input5)

Table 5-2: Example of a PLC program using input and output signals

| | | |
|------------|----|--|
| Step (o+1) | -2 | OR (at beginning the intermediate result IR = 0) |
| Step (o+2) | 65 | Input-Signal 65 (here: MLT1/CH1-Failure) |
| Step (o+3) | 66 | Input-Signal 66 (here: MLT/CH1-Conc.Low-Low) |
| Step (o+4) | 45 | Input-Signal 45 (System-DIO-Board 1 Input 5) |
| Step (o+5) | -5 | Store IR to output buffer |
| Step (o+6) | 1 | Output-Signal 1 (PLC Result 1) |
| Step (o+7) | -7 | End of program |
| | | |

SR-Flip-Flop

| Set (DIO1-Input5) | Reset (DIO1-Input6) | Out (Result5) |
|-------------------|---------------------|---------------|
| 0 | 0 | last Out |
| 0 | 1 | 0 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

Table 5-3: Example of a SR-Flip-Flop as PLC program

| | | |
|-------------|-----|---|
| Step (o+1) | -9 | LOAD |
| Step (o+2) | 46 | IR = 'Reset' ->Input-Signal 46 (System-DIO-Board 1 Input 6) |
| Step (o+3) | -10 | IF (Reset = 1) |
| Step (o+4) | 64 | then IR = 0 |
| Step (o+5) | 5 | else IR = last Out (PLC Result 5) |
| Step (o+6) | -5 | STORE |
| Step (o+7) | 30 | to Memory15 |
| Step (o+8) | -9 | LOAD |
| Step (o+9) | 45 | IR = 'Set' ->Input-Signal 45 (System-DIO-Board 1 Input 5) |
| Step (o+10) | -10 | IF (Set = 1) |
| Step (o+11) | 63 | then IR = 1 |
| Step (o+12) | 30 | else Memory15 |
| Step (o+13) | -5 | STORE |
| Step (o+14) | 5 | to Out (PLC Result 5) |
| Step (o+15) | -7 | End of program |
| | | |

6 Actions

The same principle as for input and output signals is used again for the **actions**. We have a **pool** where available actions of the different modules can be assigned to. By using the action IDs of this pool the single actions can be called according to the intermediate result which is calculated in the PLC program.

Table 6-1: Example of an Actions Pool

| Action ID | Assignment | assignment type |
|-----------|-------------------------------|-----------------|
| 1 | MLT1/CH1-AM:Zero-Cal | programmable |
| 2 | MLT1/CH1-HoldAnalogOutput | programmable |
| 3 | MLT1/CH3-ExtStatus1 | programmable |
| 4 | MLT1/CH2-External failure | programmable |
| 5 | Control Module-SYS:Zero-Cal | programmable |
| 6 | Control Module-SYS:Cancel-Cal | programmable |
| 7 | not assigned | programmable |
| 8 | not assigned | programmable |
| | .. | programmable |
| | .. | programmable |
| 19 | not assigned | programmable |
| 20 | not assigned | programmable |

Following is an example that uses the signal assignment of "Table 4-1: Example of an Input Signals Pool" and of "Table 6-1: Example of an Actions Pool"

MLT1/CH1-AM:Zero-Cal = /(MLT1/CH3-Flow Low) AND (DIO1-Input5)

This means: Start zero calibration of MLT1/CH1 if flow of MLT1/CH3 is not too low and digital input 5 of DIO-Board 1 goes high.

Table 6-2: Example of a PLC program using actions

| | | |
|------------|----|--|
| Step (o+1) | -2 | OR (at beginning the intermediate result IR = 0) |
| Step (o+2) | 67 | Input-Signal 67 (here: MLT1/CH3-Flow Low) |
| Step (o+3) | -4 | invert the IR (build "!(MLT1/CH3-Flow Low)") |
| Step (o+4) | -3 | AND (current IR with following input signals) |
| Step (o+5) | 37 | Input-Signal 37 (System-DIO-Board 1 Input 5) |
| Step (o+5) | -8 | perform action |
| Step (o+6) | 1 | Action-ID 1 (here: MLT1/CH1-AM:Zero-Cal) |
| Step (o+7) | -7 | End of program |
| | | |

7 Time controlled Logic

In order to do time dependent logic controls it is necessary to use **timers**.

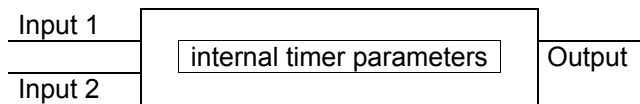
These timers enable us to have:

- switch-off delays
- switch-on delays
- configurable pulse width square waves
- date and time controlled start of timer functions

To achieve all these variety of features the timers are implemented in different running modes. To control the timers by other PLC signals the timers are provided with 2 digital inputs. The function of the digital inputs depends on the elected timer mode.

The output of the timer function block is used by the PLC again for further processing.

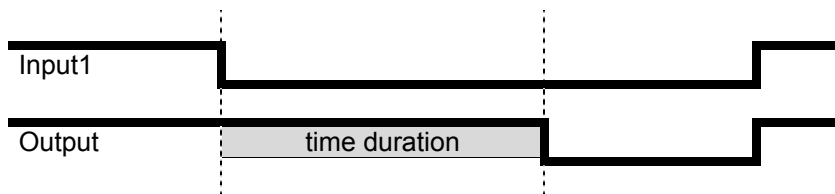
Picture 7-1: The Timer Function Block



7.1 Off-Delay Mode

The following picture shows the timed response of the 'Off-delay' timer mode.

Picture 7-2: Off-delay Timer Mode Diagram



When 'Input1' of the timer is True, 'Output' is set True and the elapsed time counter is set to zero. When 'Input1' is False for longer than the 'time duration', 'Output' is set False.

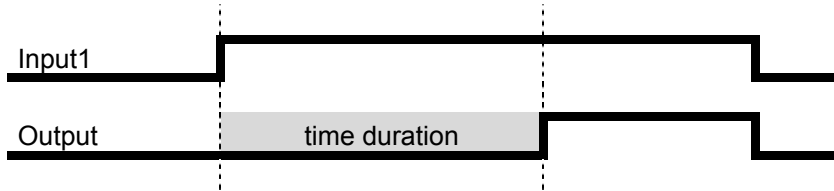
That means it is specified the time duration that must elapse before the False output value is applied.

'Input2' of the timer is not used in this mode.

7.2 On-Delay Mode

The following picture shows the timed response of the 'On-delay' timer mode.

Picture 7-3: On-delay Timer Mode Diagram



When 'Input1' of the timer is False, 'Output' is set False and the elapsed time counter is set to zero. When 'Input1' is True for longer than the 'time duration', 'Output' is set True.

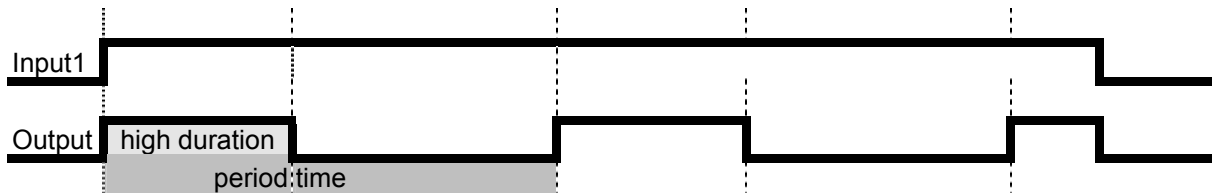
That means it is specified the time duration that must elapse before the True output value is applied.

'Input2' of the timer is not used in this mode.

7.3 Repeated Pulse Mode

The following picture shows the timed behavior of the 'Repeated-Pulse' timer mode.

Picture 7-4: Repeated-Pulse Timer Mode Diagram



When 'Input1' of the timer is False, 'Output' is set False.

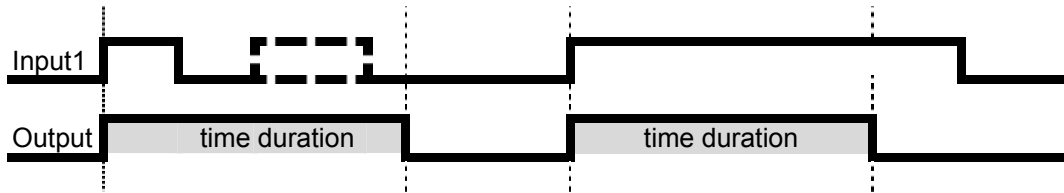
When 'Input1' is True, the 'Output' is set according a square wave. On the rising edge of 'Input1' it begins with setting the 'Output' True until the high duration time is elapsed. Then 'Output' is set False and remains False for the rest of the period time. Then 'Output' is set True again for the high duration time, and so forth. This procedure goes on endless until Input1 is set False.

'Input2' of the timer is not used in this mode.

7.4 Single Pulse Mode

The following picture shows the timed behavior of the 'Single Pulse' timer mode.

Picture 7-5: Single Pulse Timer Mode Diagram



When 'Input1' of the timer changes from False to True (rising edge trigger) during 'Output' is False, 'Output' is set True until time duration is elapsed. Then 'Output' is set False.

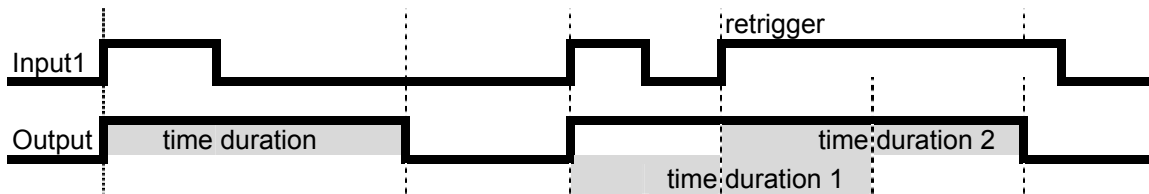
'Input2' of the timer is not used in this mode.

Tips: The pulse width on Input1 is not relevant, the duration of the pulse on 'Output' is always the same. The level changes on Input1 are scanned on a configurable rate. Therefore the time between edges (rising and falling) has to be at minimum of this set update rate.

7.5 Retriggering Single Pulse Mode

The following picture shows the timed behavior of the 'Retriggering Single Pulse' timer mode.

Picture 7-6: Retriggering Single Pulse Timer Mode Diagram



When 'Input1' of the timer changes from False to True (rising edge trigger), 'Output' is set True until time duration is elapsed. Then 'Output' is set False.

When 'Input1' changes from False to True again during Output is still set True the elapsing of the duration starts new.

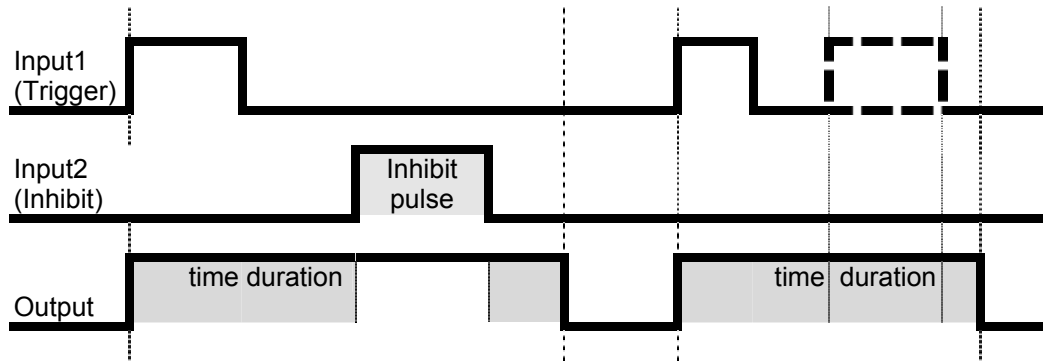
'Input2' of the timer is not used in this mode.

Tips: The pulse width on Input1 is not relevant, the duration of the pulse on 'Output' is only stretched if there is a rising edge on Input1 again. The level changes on Input1 are scanned on a configurable rate. Therefore the time between edges (rising and falling) has to be at minimum of this set update rate.

7.6 Inhibited Single Pulse Mode

The following picture shows the timed behavior of the 'Inhibited Single Pulse' timer mode.

Picture 7-7: Inhibited Single Pulse Timer Mode Diagram



When 'Input1' (logical trigger) of the timer transitions from False to True (rising edge trigger), 'Output' is set True until time duration is elapsed. Then 'Output' is set False.

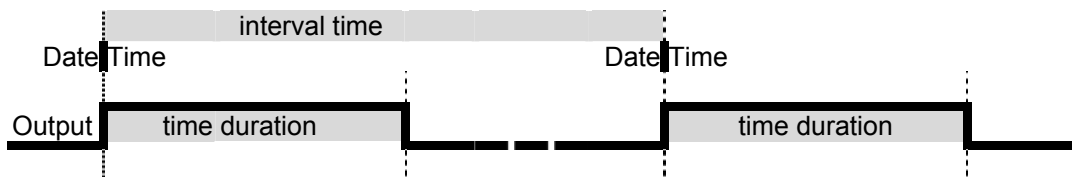
'When 'Input2' (logical inhibit) of the timer is set during 'Output' is True (elapsing duration) the time stops and retains its value until Input2 transitions to False again. I.e., the duration time is increased by the inhibit pulses duration.

Tips: The duration of the pulse on 'Output' does not depend on the pulse width of Input1. The level changes on Input1 are scanned on a configurable rate. Therefore the time between edges (rising and falling) has to be at minimum of this set update rate.

7.7 Clock Triggered Pulse Mode

In the clock triggered pulse mode the behavior of the output is similar as in 'single pulse mode'. But the pulse is not triggered by Input1 but at a certain date/time.

Picture 7-8: Clock Triggered Pulse Timer Mode Diagram



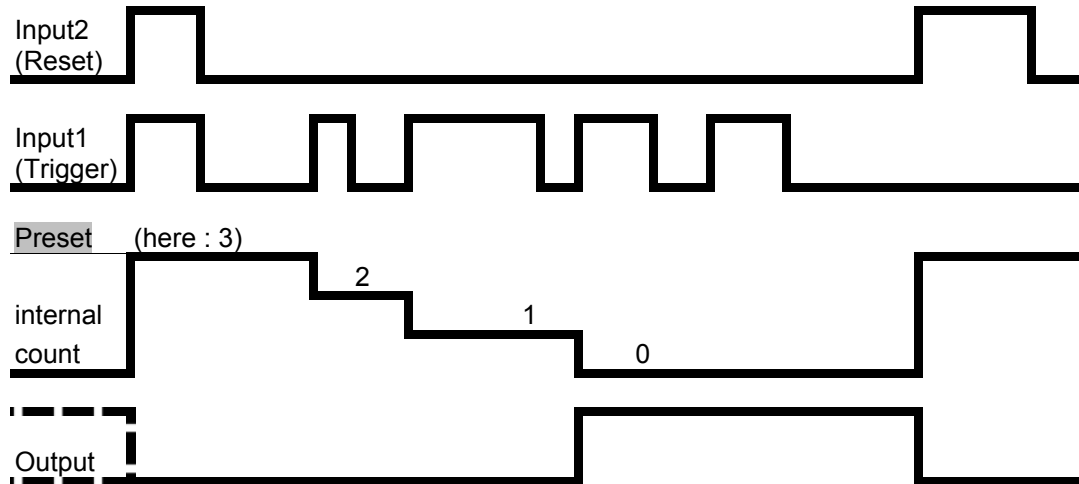
When the real time clock of the device reaches a set date/time (time trigger), 'Output' is set True until time duration is elapsed. Then 'Output' is set False. This procedure recurs after a set interval time.

'Input1' and 'Input2' of the timer are not used in this mode.

7.8 Counter Mode

The following picture shows the timed behavior of the 'Counter' mode.

Picture 7-9: Counter Mode Diagram



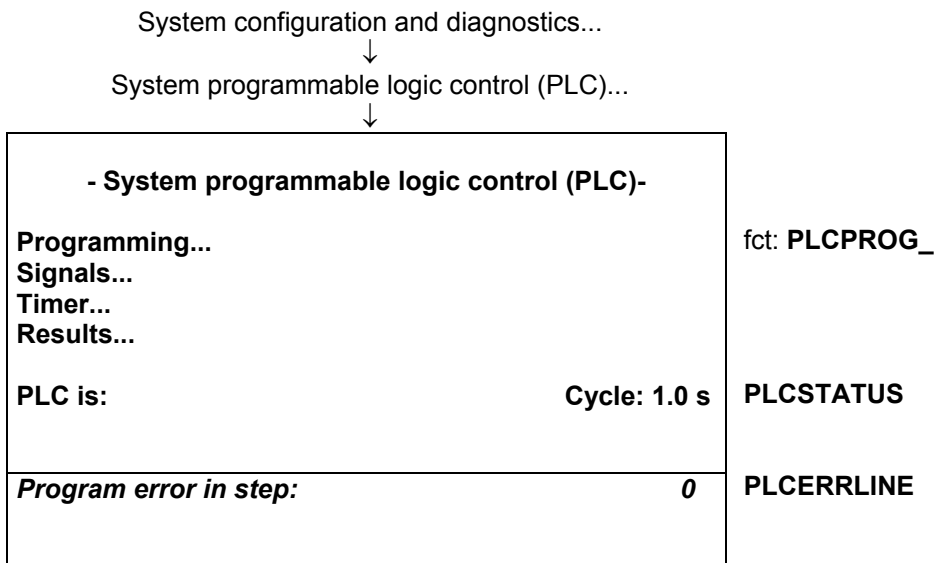
When 'Input2' (logical 'Reset') of the timer is set to True, 'Output' is set False and the internal decrement counter is set to its preset value.

After Input2 is set False the rising edges on Input1 (logical 'Trigger') decrement the counter. When the counter is less than or equal to zero, 'Output' is set True and the counter holds its value.

Tips: The level changes on Input1 are scanned on a configurable rate. Therefore the time between edges (rising and falling) has to be at minimum of this set update rate.

8 Menu Tree for the System PLC

The following pictures show the menu tree and the LON variables which are assigned to the single menu lines.



Picture 8-1: System PLC Menu

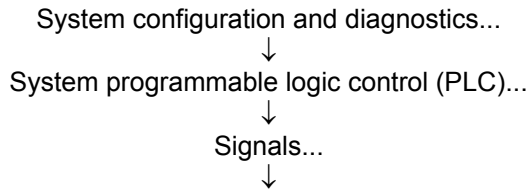
With the 'PLC is' parameter we disable or enable PLC function. Also, with enabling the PLC there is the choice with which cyclic rate the programmed algorithm is called.

- **Disabled**
- has a **Program Error** (after trying to enable)
- **Cycle 0.1 s**
- **Cycle 0.2 s**
- **Cycle 0.5 s**
- **Cycle 1.0 s**

In the case of a program error by the 'Program error in step:' parameter is displayed in what step of the program this error happened. If there is no error this parameter equals '0'.

8.1 Submenu 'Signals'

All programmable signal assignments are done in the submenu 'Signals...'.



| - Signals - | |
|--|--|
| Actions... | |
| - Input signals - | |
| Signal number: | 65 |
| Choose signal source module... | |
| Choose signal... | |
| Signal name: | Failure |
| Signal comes from: | MLT/CH1 |
| Current signal level: | Off |
| <input type="button" value="View..."/> | <input type="button" value="Outputs"/> |

PLCSIGNUMC [65 .. 128]
 PLCSRSEL_
 PLCSIGSEL_
 PLCSIGC
 PLCSRCC
 PLCLEVELC
 fct3: PLCSIGLST_
 fct5: PLCOUTLST_

Picture 8-2 : Input Signal Assignment of System PLC

The single signals of the pool (selected by 'Signal number') are assigned by first selecting the source analyzer module (AM) resp. analyzer channel of the requested signal and then the signal name itself. Please, note that it is only possible to modify the programmable type of signal numbers.

For the signal name's selection there is used an already implemented feature of the AMs. It has being used for the digital outputs of the DIO resp. the SIO module. It is the **STCONT/STNAME** variable mechanism. This mechanism provides the possibility to have a link to the LON variables of an AM which are listed in the STCONT enum. In the STNAME variable are listed the related human readable strings.

If we want to assign the signals not via the menu but via LON variable access we have to do the following steps:

1. Enter signal number by setting PLCSIGNUMC.
2. Enter the source of the signal by setting PLCSRCC to the TAG-variable's string of the requested channel.
3. Set PLC_ENTRYSIG (instead of using PLCSIGC) to the enum value that the signal has in the STCONT-variable.

8.1.1 Input Signals Listing

Via the **View** function key it is possible to show a listing of the whole input signal pool with the entered programmable as well as the fixed assignments.

The name of the fix signal assignments can be listed easily by using the enum variable PLC1INAME/ PLC2INAME which contains all the fix assigned signal's name (currently 64 names).

Here is shown a display according "Table 4-1: Example of an Input Signals Pool".

| -- Signal List -- | | |
|--|--------------------------------------|--------------------------|
| List offset: | | 60 |
| Signal (o+1): | ????: fix: Off | MENU1LINE (live) |
| Signal (o+2): | ????: fix: Off | MENU2LINE (live) |
| Signal (o+3): | ????: fix: Off | MENU3LINE (live) |
| Signal (o+4): | ????: fix: Off | MENU4LINE (live) |
| Signal (o+5): | Failure: MLT/CH1: Off | MENU5LINE (live) |
| Signal (o+6): | Conc.Low-Low: MLT/CH1: Off | MENU6LINE (live) |
| Signal (o+7): | Flow Low: MLT/CH3: On | MENU7LINE (live) |
| Signal (o+8): | Cal. in progress: FID: Off | MENU8LINE (live) |
| Signal (o+9): | Maintenance request: CLD: Off | MENU9LINE (live) |
| Signal (o+10): | ????: ????: Off | MENU10LINE (live) |
| << Back... >> | | |

Picture 8-3: Listing of Input Signal Assignment

fct3: **BACKVARS**
 fct4: **ESCAPE**
 fct5: **LOADVARS**

8.1.2 Output Signals Listing

Via the **Outputs** function key it is possible to show a listing of the whole output signal pool.

The name of the this fix output signal assignments can be listed easily by using the enum variable PLC1ONAME/PLC2ONAME which contains all the fix assigned signal's name.

Here is shown a display with Output Signals

| -- Signal List -- | | |
|--|-----------------------------|--------------------------|
| List offset: | | 30 |
| Signal (o+1): | PLC Timer-1 In1: Off | MENU1LINE (live) |
| Signal (o+2): | PLC Timer-2 In1: Off | MENU2LINE (live) |
| Signal (o+3): | PLC Timer-3 In1: Off | MENU3LINE (live) |
| Signal (o+4): | PLC Timer-4 In1: Off | MENU4LINE (live) |
| Signal (o+5): | PLC Timer-5 In1: Off | MENU5LINE (live) |
| Signal (o+6): | PLC Timer-6 In1: Off | MENU6LINE (live) |
| Signal (o+7): | PLC Timer-7 In1: Off | MENU7LINE (live) |
| Signal (o+8): | PLC Timer-8 In1: Off | MENU8LINE (live) |
| Signal (o+9): | Reserved: Off | MENU9LINE (live) |
| Signal (o+10): | Reserved: Off | MENU10LINE (live) |
| << Back... >> | | |

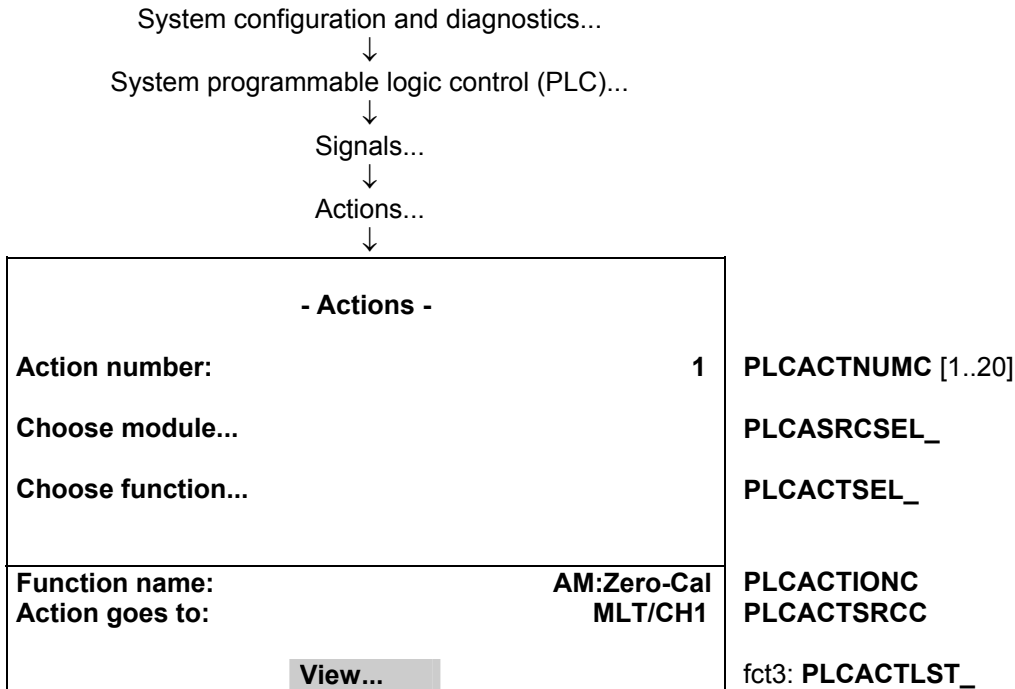
LISTOFFSET
MENU1LINE (live)
MENU2LINE (live)
MENU3LINE (live)
MENU4LINE (live)
MENU5LINE (live)
MENU6LINE (live)
MENU7LINE (live)
MENU8LINE (live)
MENU9LINE (live)
MENU10LINE (live)

fct3: BACKVARS
fct4: ESCAPE
fct5: LOADVARS

Picture 8-4: Listing of Output Signal Assignment

8.2 Submenu 'Actions'

All programmable action assignments are done in the submenu 'Actions...'.



Picture 8-5 : Actions Assignment of System PLC

The single actions of the pool (selected by 'Action number') are assigned by first selecting the source analyzer module (AM) resp. analyzer channel of the requested action and then the function name itself.

For the function name's selection there is used an already implemented feature. It has being used for the digital inputs of the DIO module. It is the **STINAME** and **AM_INPUT/DI_MSGE** variable mechanism. This mechanism provides the possibility to have a link to functions of an AM which are listed in the STINAME-enum of the platform or at the AM_INPUT-enum of the single modules.

If we want to assign the actions not via the menu but via LON variable access we have to do the following steps:

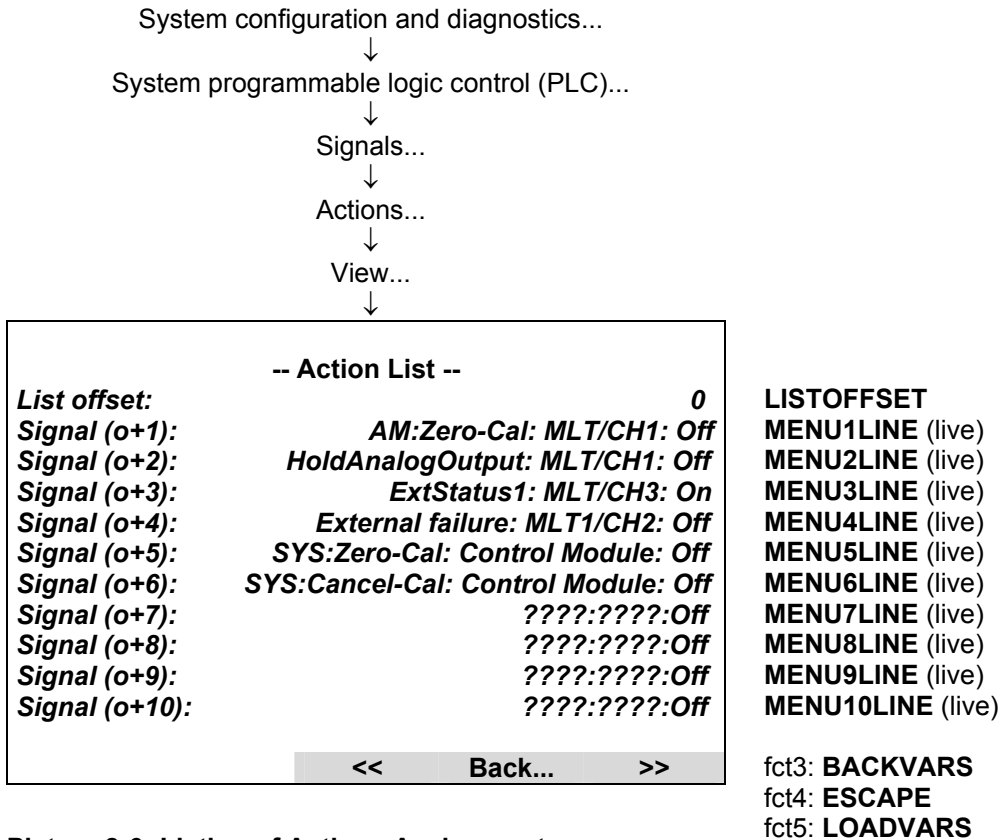
1. Enter action number by setting PLCACTNUMC.
2. Enter the source of the signal by setting PLCACTSRCC to the TAG-variable's string of the requested channel.
3. Set PLC_ENTRYACT (instead of using PLCACTIONC) to the corresponding enum value. This value is calculated by usage of STINAME of the platform and AM_INPUT of the selected module.

If you select an action which is listed in STINAME, the enum value is just the value of STINAME.

If you select an action which is listed in AM_INPUT you have to add the enum value of AM_INPUT to the number of available enum values of STINAME.

8.2.1 Actions Listing

It is possible to show a listing of the whole actions pool with the entered assignments as well as the corresponding signal levels.



Picture 8-6: Listing of Actions Assignment

8.3 Submenu 'Timers'

The setup of the timers is configured in the submenu 'Timers...'.
 System configuration and diagnostics...
 ↓
 System programmable logic control (PLC)...
 ↓
 Timers...
 ↓

- Timers -

| | | |
|-------------------------|------------------|---|
| Timer number: | 1 | PLCTMRNUMC [1..8] |
| Timer mode: | Off-delay | PLCTMRMODC [see Table 8-1] |
| Duration: | 30 sec | PLCDURATC [1..3600] |
| Period / Counts: | 180 sec | PLCTIMC [1..3600] / PLCUC (variable unit) |
| Hours (0..23): | 15 | PLCHOURC |
| Minutes: | 10 | PLCMINUTC |
| Month: | 3 | PLCMONTHC |
| Day: | 21 | PLCDAYC |

View...
States...

fct3: **PLCTMRLST_**
 fct4: **PLCTMRSTAT_**

Picture 8-7: Timers Setup of System PLC

The single timers are configured by first selecting the timer number itself (currently 1...8).

Further configuration parameters depend on the mode the timer has to run in. Therefore the mode has to be elected as next.

In following table see the selectable timer modes and the related meaning of the rest of the parameters.

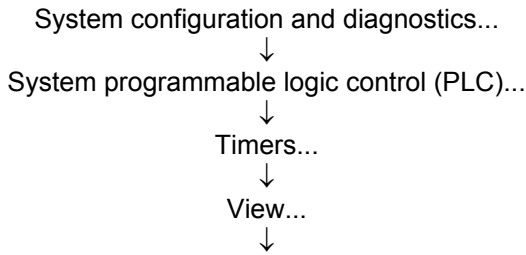
Table 8-1: Different Timer Modes and the Related Meaning of the other Parameters

| Timer mode | Off-delay | On-delay | Repeated-Pulse | Single-Pulse | Retrig-Single-Pulse | Inhib-Single-Pulse | Clock-Trig-Pulse | Counter |
|----------------------------------|------------|------------|-----------------------|------------------|-----------------------|-----------------------|--|--------------------|
| Duration | delay time | delay time | True pulse width | True pulse width | min. True pulse width | min. True pulse width | True pulse width | - |
| Period/Counts | - | - | period time [seconds] | - | - | - | Interval time [minutes] | Preset count value |
| Hours Minutes Month Day | - | - | - | - | - | - | date/time of next triggering the pulse | - |

For more information on the different timer modes see also chapter "7 Time controlled Logic".

Programmable Logic Control (PLC) on Control Module Level

It is possible to show a listing of the timers' configuration.

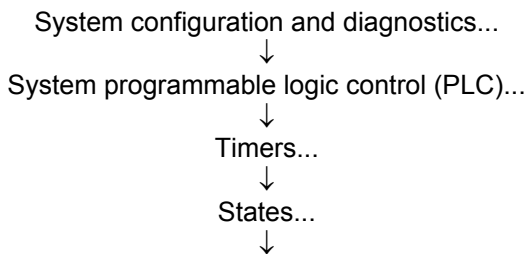


| - Timer Setup - | | |
|---|---------------------------|------------|
| Offset (o): | 0 | LISTOFFSET |
| Mode / Duration of timer 1+o: | On-delay / 20 s | MENU1LINE |
| Period / Counts: | ---- | MENU2LINE |
| Next Start time: | ---- | MENU3LINE |
| Mode / Duration of timer 2+o: | Clock-Trig-Pulse / 20 s | MENU4LINE |
| Period / Counts: | 1440 min | MENU5LINE |
| Next start Time & Date: | 10:30:00 January 31, 2002 | MENU6LINE |
| Mode / Duration of timer 3+o: | Repeated-Pulse / 2 s | MENU7LINE |
| Period / Counts: | 6 s | MENU8LINE |
| Next Start time: | ---- | MENU9LINE |
| << Back... >> | | |

fct3: BACKVARS
fct4: ESCAPE
fct5: LOADVARS

Picture 8-8: Listing of Timers' Configuration

It is possible to show the actual states of timers' inputs and outputs as well as the current counting to perform the different timing functions.



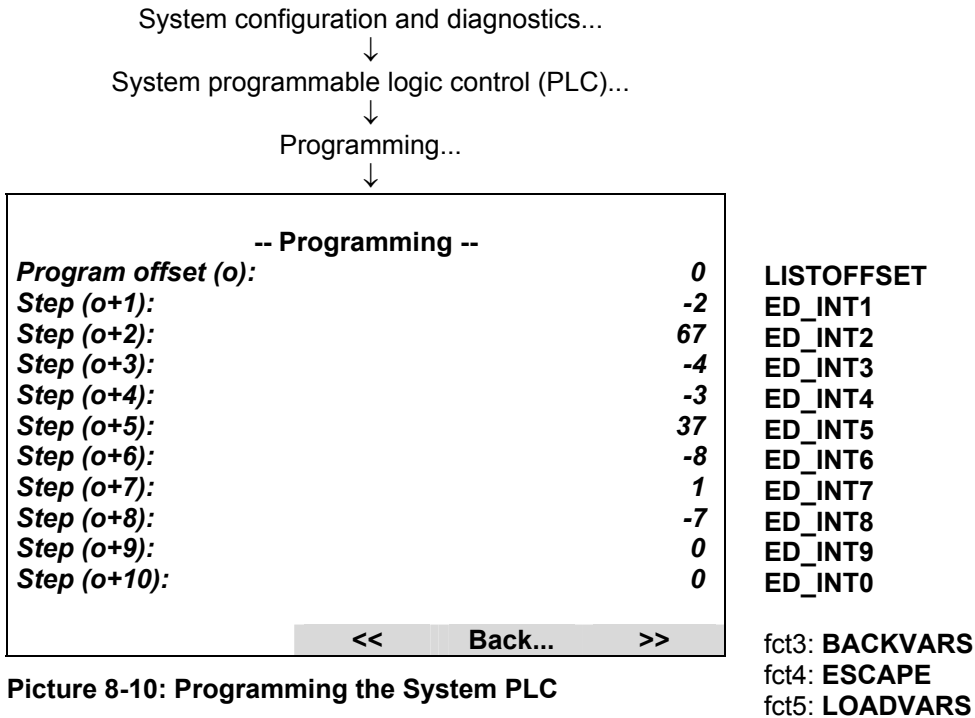
| - Timer States - | | |
|---|--------------|------------|
| Offset (o): | 0 | LISTOFFSET |
| Timer 1+o (In1/In2/Out): | On/Off/Off | MENU1LINE |
| Count: | 3 | MENU2LINE |
| Timer 2+o (In1/In2/Out): | Off/On/On | MENU3LINE |
| Count: | 7 | MENU4LINE |
| Timer 3+o (In1/In2/Out): | Off/Off/ Off | MENU5LINE |
| Count: | 3 | MENU6LINE |
| Timer 4+o (In1/In2/Out): | On/On/On | MENU7LINE |
| Count: | 0 | MENU8LINE |
| Timer 5+o (In1/In2/Out): | Off/Off/Off | MENU9LINE |
| Count: | 0 | MENU10LINE |
| << Back... >> | | |

fct3: BACKVARS
fct4: ESCAPE
fct5: LOADVARS

Picture 8-9: Display of Timers' States

8.4 Submenu 'Programming'

After having done the setup of the signals and eventually necessary timers we can do the programming of PLC algorithm itself. It is done in the submenu 'Programming...".



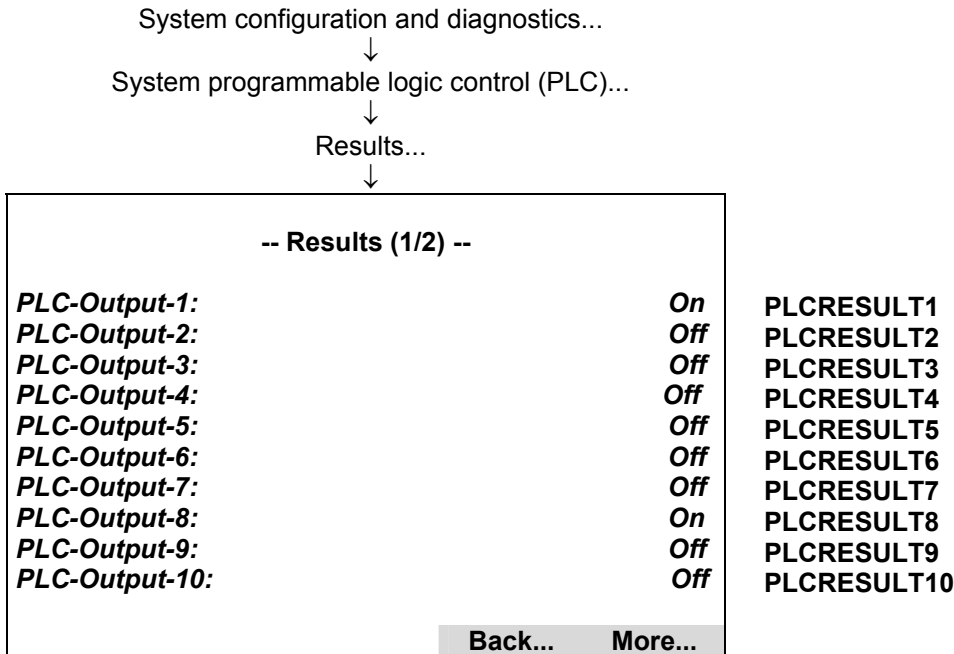
Picture 8-10: Programming the System PLC

If we want to assign the signals not by means of the menu but via LON variable access we have to be aware of following:

1. The PLC-programming as well as the programming for the system calculator happens indirectly via the edit variable-array ED_INTx.
To differ what the programming is for there exists the LON variable PROGTYP.
Setting PROGTYP = 0 means we want to program the system calculator.
Setting PROGTYP = 1 means we want to program the system PLC.
2. By using the variable LISTOFFSET we determine what part of the whole programming list we want to program.
For example, setting LISTOFFSET = 60, means by usage of ED_INT1...ED_INT10 we are able to modify the program steps 61...70.

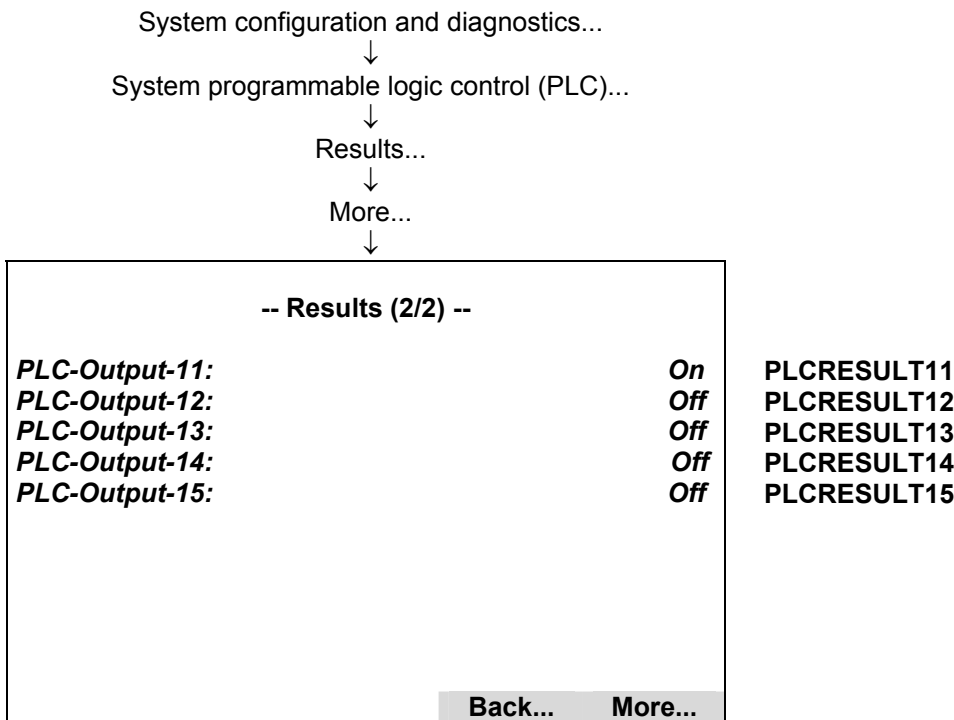
8.5 Submenu 'Results'

The results of the PLC calculations can be observed in the submenu 'Results...'.



fct4: ESCAPE
fct5: PLCRESULTS2

Picture 8-11: Display of the System PLC Results



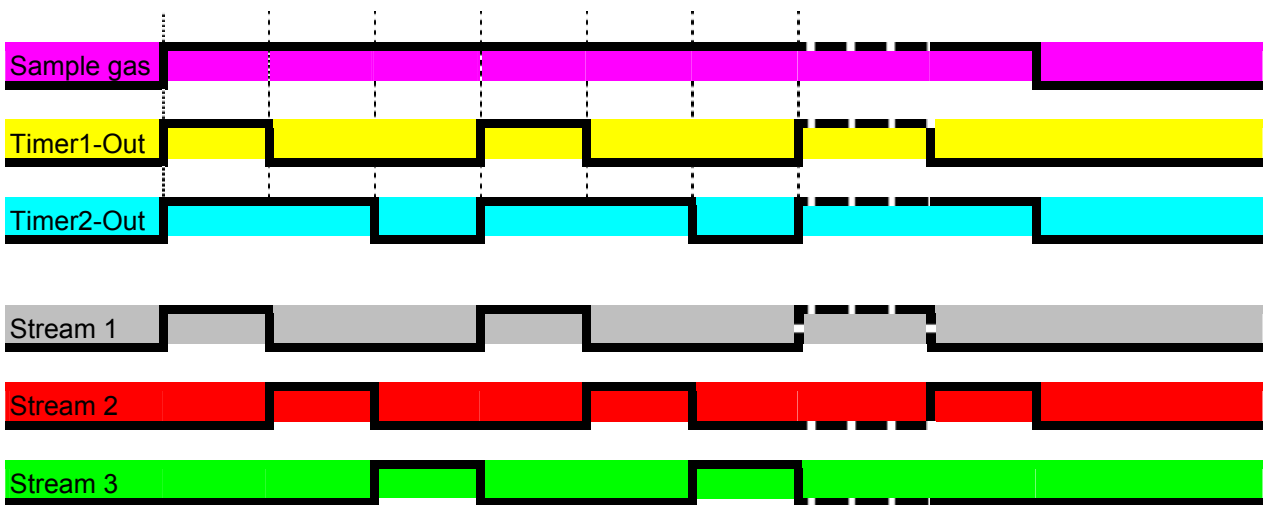
9 Applications

9.1 Stream Control with an active System Calibration

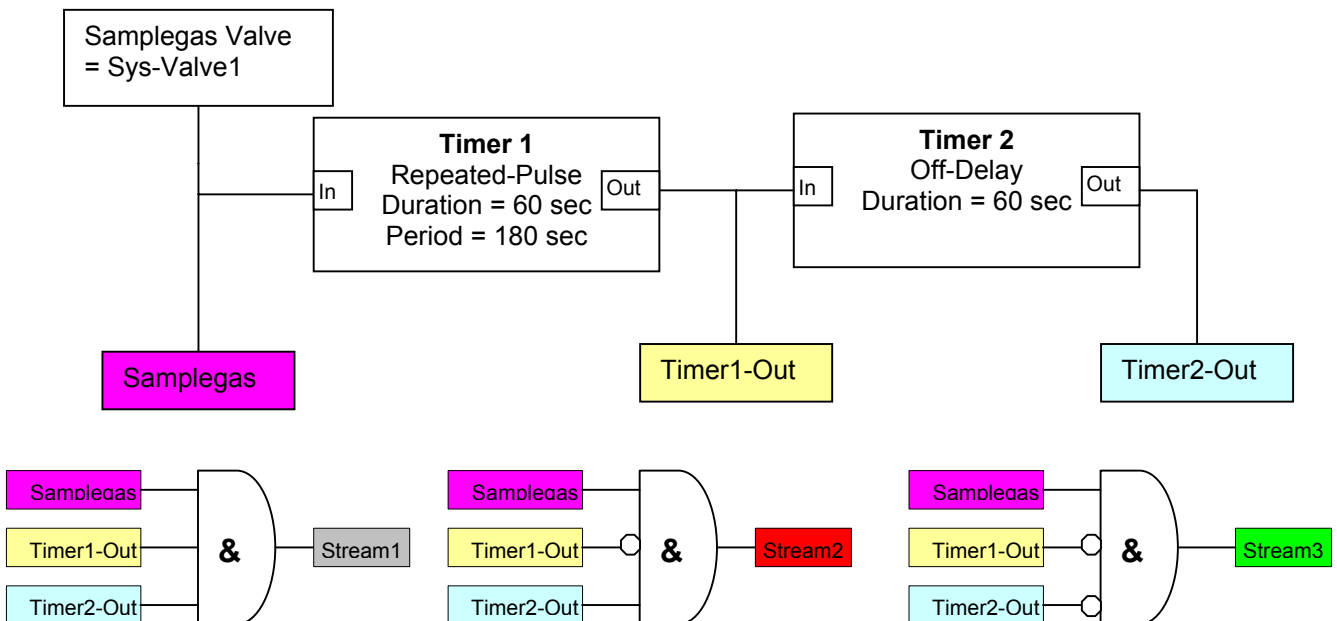
If the system calibration is in the 'sample gas state' we do not want to have only one sample gas stream flowing but alternating 3 gas streams.

To realize this, we could use 2 timers which give us 3 different signal combinations. These 3 signal combinations are evaluated in that way that for each combination one of the streams is switched on.

| Timer1-Out | Timer2-Out | Stream 1 | Stream 2 | Stream 3 |
|------------|------------|----------|----------|----------|
| On | On | On | Off | Off |
| Off | On | Off | On | Off |
| Off | Off | Off | Off | On |



To vary the switching durations we only have to configure the both timers.



For the program we presuppose following assignments:

Programmable Logic Control (PLC) on Control Module Level

Input-ID 65 = Control Module: Sys.-Valve1

PLC-Result 1 = Stream 1

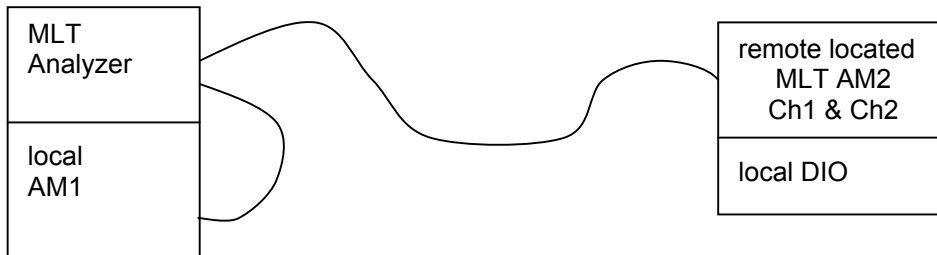
PLC-Result 2 = Stream 2

PLC-Result 3 = Stream 3

| | | | |
|-----------|----|---|-------------|
| Step (1) | -9 | LOAD | |
| Step (2) | 65 | Control-Module SYS:Valve-1 (= Input-Signal 65) | |
| Step (3) | -5 | STORE to | |
| Step (4) | 31 | Timer1-Input1 (= Output-Signal 31) | |
| Step (5) | -9 | LOAD | |
| Step (6) | 31 | Timer1-Output (= Input-Signal 31) | |
| Step (7) | -5 | STORE to | |
| Step (8) | 32 | Timer2-Input1 (= Output-Signal 32) | |
| Step (9) | -1 | | |
| Step (10) | -1 | | |
| Step (11) | -9 | LOAD | |
| Step (12) | 65 | Control-Module SYS:Valve-1 (= Input-Signal 65) | |
| Step (13) | -3 | AND | |
| Step (14) | 31 | Timer1-Output | |
| Step (15) | 32 | Timer2-Output | |
| Step (16) | -5 | STORE to | |
| Step (17) | 1 | PLC-Result1 (= Output-Signal 1) | => Stream 1 |
| Step (18) | -1 | | |
| Step (19) | -1 | | |
| Step (20) | -9 | LOAD | |
| Step (21) | 31 | Timer1-Output | |
| Step (22) | -4 | INVERT | |
| Step (23) | -3 | AND | |
| Step (24) | 65 | Control-Module SYS:Valve-1 | |
| Step (25) | 32 | Timer2-Output | |
| Step (26) | -5 | STORE to | |
| Step (27) | 2 | PLC-Result2 (= Output-Signal 2) | => Stream 2 |
| Step (28) | -1 | | |
| Step (29) | -1 | | |
| Step (30) | -9 | LOAD | |
| Step (31) | 31 | Timer1-Output | |
| Step (32) | -2 | OR | |
| Step (33) | 32 | Timer2-Output | |
| Step (34) | -4 | INVERT (build: not Timer1-Output and not Timer2-Output) | |
| Step (35) | -3 | AND | |
| Step (36) | 65 | Control-Module SYS:Valve-1 | |
| Step (37) | -5 | STORE to | |
| Step (38) | 3 | PLC-Result3 (= Output-Signal 3) | => Stream 3 |
| Step (39) | -7 | End of program | |

9.2 Remote Valve Switching with an active System Calibration

We have a MLT AM involved in a system calibration. But the MLT AM is not located nearby the platform device but in a certain distance.



Here we have the possibility to give the MLT AM2 valve switching commands via the LON network correspondingly to the activated system valves of the system calibration utility. These commanded valve states can be put onto the digital outputs of a local DIO board resp. onto the relays of a local SIO board.

We presuppose the following situation:

| System calibration Module setup | AM1-Ch1 | MLT-AM2/CH1 | MLT-AM2/CH2 |
|---------------------------------|---------|-------------|-------------|
| Samplegas-Valve | Valve-1 | Valve-1 | Valve-1 |
| Zerogas-Valve | Valve-2 | Valve-2 | Valve-2 |
| Spangas1-Valve | Valve-3 | Valve-3 | Valve-4 |
| Spangas2-Valve | Valve-3 | Valve-3 | Valve-4 |
| Spangas3-Valve | Valve-3 | Valve-3 | Valve-4 |
| Spangas4-Valve | Valve-3 | Valve-3 | Valve-4 |

For the local DIO board of MLT-AM2 we do the following setup:

| setup of local DIO on AM2 | Signal code | Signal-Description |
|---------------------------|-------------|---------------------------|
| Output #1 | 155 | External Signal #1 of Ch1 |
| Output #2 | 156 | External Signal #2 of Ch1 |
| Output #3 | 157 | External Signal #3 of Ch1 |
| Output #4 | 158 | External Signal #4 of Ch1 |

For the inputs signal pool of the System PLC we do following assignment:

| Signal ID | Assignment |
|-----------|-----------------------------|
| 71 | Control Module: SYS:Valve-1 |
| 72 | Control Module: SYS:Valve-2 |
| 73 | Control Module: SYS:Valve-3 |
| 74 | Control Module: SYS:Valve-4 |

For the action pool of the System PLC we do following assignment:

| Signal ID | Assignment |
|-----------|-------------------------|
| 1 | MLT-AM2/CH1: ExtStatus1 |
| 2 | MLT-AM2/CH1: ExtStatus2 |
| 3 | MLT-AM2/CH1: ExtStatus3 |
| 4 | MLT-AM2/CH1: ExtStatus4 |

The System PLC program could look like as follows:

Programmable Logic Control (PLC) on Control Module Level

| | | |
|-----------|-----|--|
| Step (1) | -9 | LOAD |
| Step (2) | 71 | Control-Module SYS:Valve-1 (= Input-Signal 71) |
| Step (3) | -11 | CALL action |
| Step (4) | 1 | ExtStatus1 of MLT-AM2/CH1 (= Action #1) |
| Step (5) | -9 | LOAD |
| Step (6) | 72 | Control-Module SYS:Valve-2 (= Input-Signal 72) |
| Step (7) | -11 | CALL action |
| Step (8) | 2 | ExtStatus2 of MLT-AM2/CH1 (= Action #2) |
| Step (9) | -9 | LOAD |
| Step (10) | 73 | Control-Module SYS:Valve-3 (= Input-Signal 73) |
| Step (11) | -11 | CALL action |
| Step (12) | 3 | ExtStatus3 of MLT-AM2/CH1 (= Action #3) |
| Step (13) | -9 | LOAD |
| Step (14) | 74 | Control-Module SYS:Valve-4 (= Input-Signal 74) |
| Step (15) | -11 | CALL action |
| Step (16) | 4 | ExtStatus4 of MLT-AM2/CH1 (= Action #4) |
| Step (39) | -7 | End of program |
| | | |

NGA 2000

Software Manual

Supplement: System Calibration

NGA Software Version 3.7.X

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1 Introduction

Beside the possibility to zero and span each TFID (CLD/FID) analyzer or analyzer module (MLT/CAT 200 channel) individually and independently from the others, **System Calibration (SYSCAL)** allows to combine the calibration procedures of **ALL Analyzer Modules (AM's)** of an **NGA 2000 analyzer system** into a **common process**.

This is been achieved with a new assignment of the valves. The idea is not longer to require for each gas of each analyzer an own valve.

Instead of we have a pool of valves. The valves of this pool can be assigned to the different gases of the analyzers. That also means different analyzers can share the same valve for their gases. So we have the possibility to reduce the number of valves and also the consumption of calibration gases.

The program, which will allow this, runs on the **Control Module (CM)** level and needs **programmable Input/Output Modules (I/O's: DIO and SIO)** on control module level too (CM [system] I/O's located in a platform or MLT, CAT 200 or TFID analyzer):

SIO: Standard I/O module with 2 to 8 analog outputs, RS 232/485 and 3 relay contacts

DIO: Digital I/O board with 8 digital inputs and 24 digital outputs

System calibration allows to use those outputs - relay contacts or digital outputs - to run calibration valves after assigning the valves to certain outputs (of course: physical connections between I/O's and valves are required as well!).

The assignment has to be done in a proper way which is described in the next chapters.

The displayed menus are also inscribed with the appropriate LON Variables.

2 Valves for system calibration

Before using the system calibration we have to put together the required valve pool. There are three types of I/O modules supporting this:

- DIO - 24 digital outputs / 8 digital inputs (max. 4 modules per CM)
- SIO - 3 digital outputs [relay contacts] (max. 1 module per CM)
- [CVU - 4 digital outputs (max. 4 modules per CM) – in progress; not available, c.f.]

Software supports up to 32 system valves.

2.1 Assigning an output port to a system valve

Assigning of an output can be accomplished by using the menus for selected output module (DIO, SIO or CVU [c.f.]).

There we have to select the NGA Control Module as the Source Module. Control module then provides the signals for system valve V1...V32.

For example the DIO:

Analyzer and I/O module expert configuration...



I/O module controls...



DIO module(s)...



| - DIO-MODULE OUTPUTS- | | |
|---------------------------|---------------------------|--------------------|
| Inputs... | | |
| Outputnumber: | 1 | DIOOUTNUMC |
| Choose module... | | |
| Choose signal... | | |
| Invert output: | DISABLED | DIOOUTINVC |
| Module status: | NORMAL | DIOMODSTAC |
| Slot ID: | 1 | DIOSLOTIDC |
| Signal name: | SYS:VALVE-1 | DIOOUTSIGC |
| Signal level: | OFF | DIOOUTSTATC |
| Signal comes from: | NGA Control Module | DIOOUTSRCC |

There we have to

- select "Outputnumber"
- then choose "NGA Control Module" as module
- then choose the wanted valve "SYS: VALVE-x" as signal

It is also possible to configure the DIO outputs via LON Variables (i.e. SLTA adapter or protocol).

Therefore is the LON variable "DIOOUT_ENTRYSIG" which corresponds to "DIOOUTSIGC" and evaluates enum values of "ST1NAME" (enum values 0..19), "ST2NAME" (enum values 20..39) or "ST3NAME" (enum values 40..59).

For digital output we have to set-up variables in following order.

1. DIOSLOTIDC
2. DIOOUTNUMC
3. DIOOUTSRCC
4. DIOOUT_ENTRYSIG SYS: VALVE-1 = 20 (enum value in ST2NAME)
 SYS: VALVE-2 = 21
 .
 .
 .
 SYS:VALVE-32 = 51 (enum value in ST3NAME)

For each needed system valve we have to repeat these appropriate selections.

It is also possible to distribute the system valves onto different output modules.

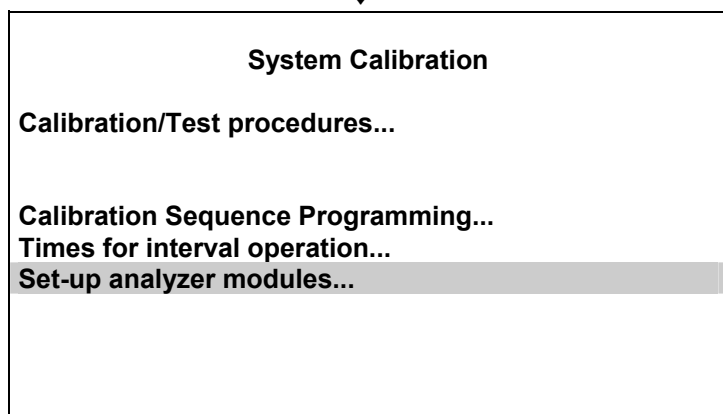
3 Operating System Calibration

Because there are many possibilities how to use SYSCAL it must be customized through the Expert Operator. There we can find the menu "System Calibration" from where we can do the required set-ups and start routines.

System configuration and diagnostics...



System calibration...



Meaning of displayed menu points:

- Calibration/Test procedures...: starting and stopping of system calibration and test procedures
- Calibr. Sequ. Programming...: programming of user defined calibration sequences
- Times for interval operation...: setting up of automatically started system calibrations
- Set-up analyzer modules...: include and set-up different analyzer modules into system calibration.

3.1 Set-up analyzer modules

Before we can run any system calibration features we have to include the different analyzer modules (**AM's**) into system calibration by set-up needed parameters. Only after correct setting up, an AM is included into system calibration and only then it makes sense to go into the other menus.

System configuration and diagnostics...



System calibration...



Set-up analyzer modules...



| Analyzer Set up | | |
|---|-----------|-----------|
| Choose analyzer module.... | | |
| Gas type: | SPANGAS-1 | SCAMGAS |
| Assigned to system valve: | V5 | SCVALVE |
| Purge time: | 20 s | SCPURGE |
| Note: Ranges are always calibrated separately ! | | |
| <hr/> | | |
| Analyzer module: | MLT/CH2 | SCMODULE |
| Module enabled for system-cal: | NO | SCCONTROL |
| View... | | |

Setting up an AM for system calibration means **assigning valves from system valve pool**. The Control Module provides support of up to **32 system-valves** V1....V32. We have to decide which valves deliver which gases for an analyzer module. Also we have to know the purge time from a valve to the AM.

For each of the following types in the parameter „Gas type“ we have to assign a valve and the appropriate purge time :

- SAMPLE-GAS
- ZERO-GAS
- SPANGAS-1 (span gas for range 1)
- SPANGAS-2 (span gas for range 2)
- SPANGAS-3 (span gas for range 3)
- SPANGAS-4 (span gas for range 4)

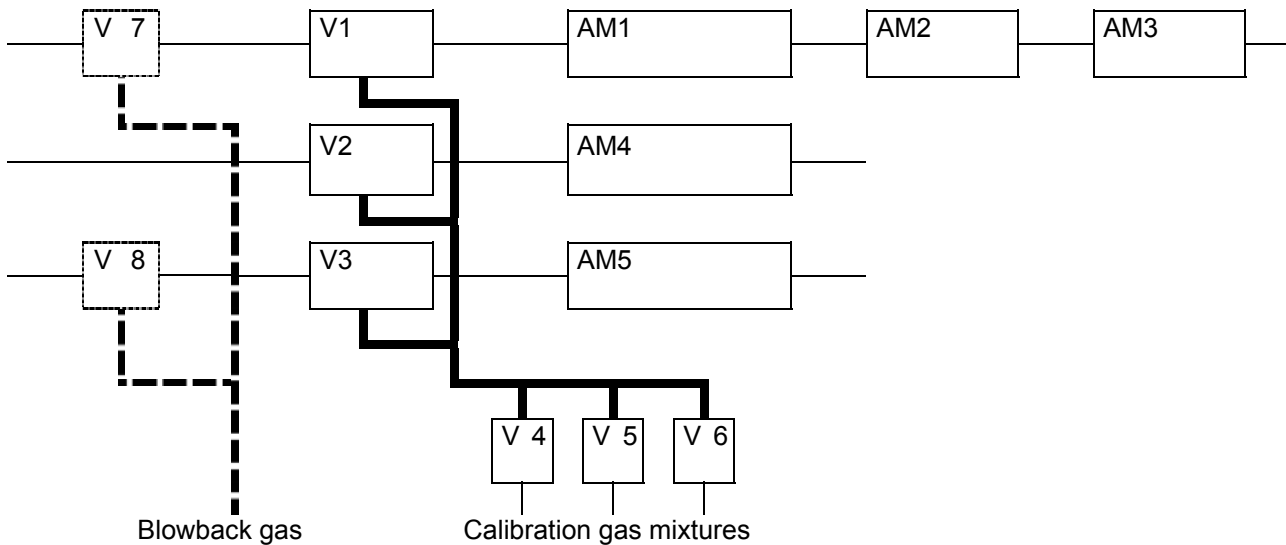
Optionally we can assign a blowback valve but this is not mandatory.

Conditions for the assignment:

- **Once a valve has been assigned to be a sample gas valve for any AM it must not be used for zero or span gases !**
- **The zero valve of an AM can not be a span valve of the same AM.**
- **All upper gas types have to be assigned to a system-valve.**
- **If we assign a blowback valve it must not be used for any other gases.**

NGA 2000 System Calibration

Example for an analyzer system:



Appropriate assignment:

| | AM1 | AM2 | AM3 | AM4 | AM5 |
|------------|-----|-----|-----|-----|-----|
| SAMPLE-GAS | V1 | V1 | V1 | V2 | V3 |
| ZERO-GAS | V4 | V4 | V5 | V5 | V6 |
| SPANGAS-1 | V5 | V5 | V4 | V6 | V5 |
| SPANGAS-2 | V5 | V5 | V4 | V6 | V5 |
| SPANGAS-3 | V6 | V5 | V4 | V4 | V4 |
| SPANGAS-4 | V6 | V5 | V4 | V4 | V4 |
| BLOWBACK | V7 | V7 | V7 | - | V8 |

As we can see, additionally we can assign **blowback valves** in the "Gas Type" set-up. In the upper example these are valves V7 and V8.

The blowback valve is switched on then during a blowback procedure, all other valves are switched off.

The blowback procedure looks for the purge times which are configured for this blowback valves. For the procedure is taken then the **maximal purge time** of the assigned blowback valves.

This entire assigning procedure is to perform for all analyzer modules which should be included in system calibration.

To display the assigned valves and purge times for each AM we can push the soft key „View...“.

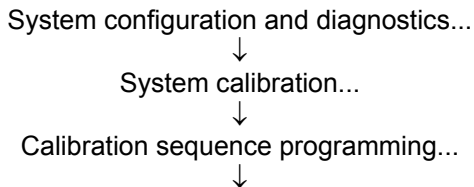
If we want to exclude an AM from SYSCAL we can do this by entering an invalid valve. We can watch in the display whether an AM is enabled for system calibration.

Attention: Remember to assign a system valve to an output port!

3.2 Programming Calibration Sequences

Beside the standard programs “zero calibration“ and “zero/span calibration“ it is possible to run the system calibration in an user definable order of up to 40 steps.

The menu to set-up this feature looks as follows.



| -- Calibration Sequence Programming -- | | |
|--|-----------------|-------------------|
| Step #: | 1 | SCSTEP |
| Calibration procedure type: | ZERO-CAL | SCCALTYPE1 |
| Choose specific analyzer module... | | |
| Select all analyzer modules! | | |
| Program steps 1-10... | | |
| Program steps 11-20... | | |
| Program steps 21-30... | | |
| Program steps 31-40... | | |
| Analyzer-module: | MLT/CH3 | SCSTEPMOD |

For programming the sequence you must

1. select “Step #“
2. select “Calibration procedure type“
3. select module

Repeat this order for all program steps.

The programmable “Calibration procedure types“ are:

- | | |
|------------------|---|
| 1. NoOp | no operation (for deleting a step in an existing program) |
| 2. Zero-Cal | do a zero calibration |
| 3. Span-Cal | do a span-calibration for all available ranges |
| 4. Zero/Span-Cal | do a zero-cal then a span-cal for all available ranges |
| 5. Span1-Cal | do a span calibration only for range #1 |
| 6. Span2-Cal | do a span calibration only for range #2 |
| 7. Span3-Cal | do a span calibration only for range #3 |
| 8. Span4-Cal | do a span calibration only for range #4 |
| 9. END-OF-PGRM | end of sequence |
| 10. Blowback | do a blowback |

NGA 2000 System Calibration

For each step we have the choice to select a specific AM or to activate the step for all enabled AM's.

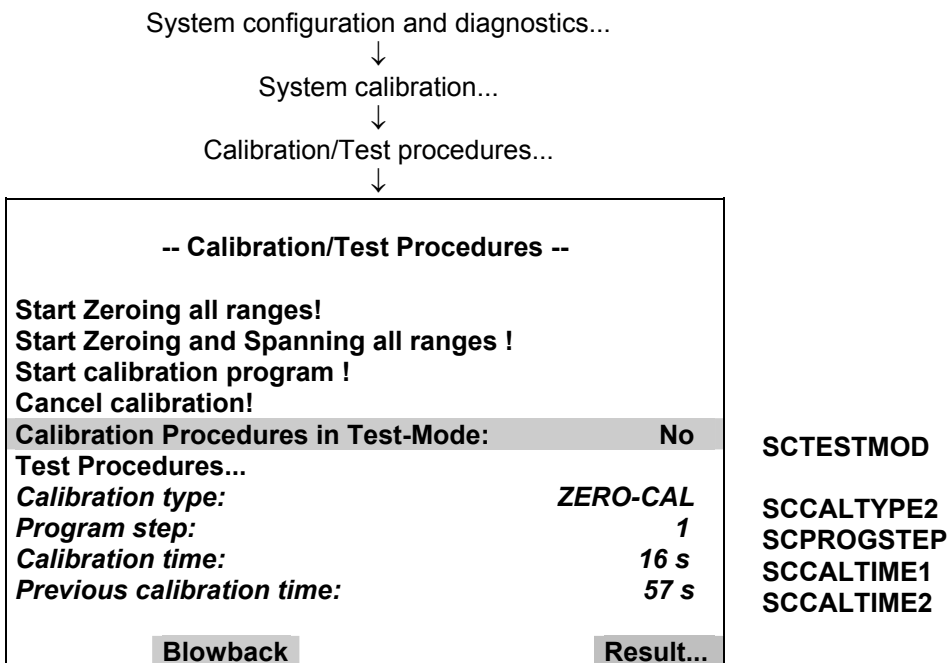
After the program is input, the appropriate menu can give an overview of the current program:

-- Calibration Sequence Program --

| | |
|------------------|--------------------------|
| Step #1: | Zero-Cal:ALL |
| Step #2: | Span-Cal: FID |
| Step #3: | Span-Cal: CLD |
| Step #4: | Span1-Cal:MLT/CH1 |
| Step #5: | Span2-Cal:MLT/CH1 |
| Step #6: | Span3-Cal:MLT/CH1 |
| Step #7: | Span4-Cal:MLT/CH1 |
| Step #8: | Span3-Cal:MLT/CH2 |
| Step #9: | END-OF-PROGRAM |
| Step #10: | END-OF-PROGRAM |

3.3 Set-up general parameters

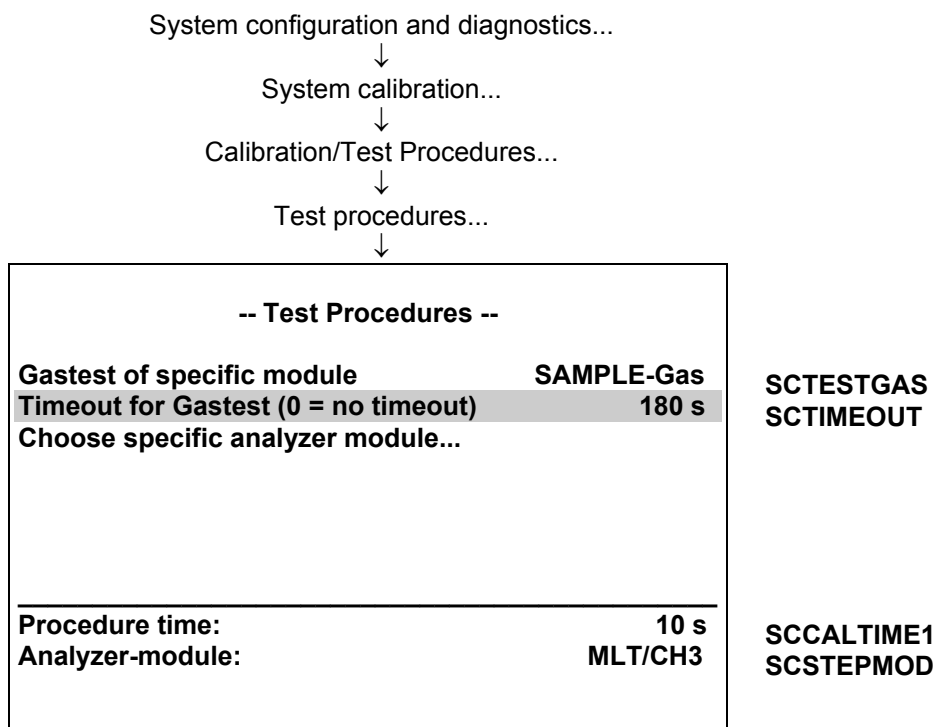
One general parameter is "Calibration Procedures in Test-Mode". It is located in the menu "Calibration/Test procedures".



With this parameter we can run all the calibration procedures either in the defined mode or in a test mode. The test mode means that the valve switching and waiting for purge times is done in the same manner like in the normal calibration procedure.

The only difference is that the single **calibrations** of the modules and the appropriate times the modules would need for the calibration **are not done**.

A further general parameter is "Timeout for Gastest". It is located in the menu "Test procedures".



This parameter is related to the possibility to activate a gas valve of a specific module for test purposes. Here we can determine a time after which an activated gas test automatically switches back onto SAMPLE-Gas.

Is this parameter set to "0" no automatic back switching is done.

3.4 Controlling System Calibration

After setting-up there is the possibility to start 3 different modes:

- system zero-calibration:* In this mode a zero-cal of all modules, which are enabled for SYSCAL, will be performed. The order of modules depends on purge time for zero-valves because the whole calibration is time optimized.
- system zero/span-calibration:* In this mode will be performed a zero-cal and a span-cal for every enabled AM. The order of calibration is optimized to have a minimum of calibration time. The only condition is to have for each AM first the zero-cal and after this the span-cal. With zero-cal an AM is zeroed with all ranges together, the span-cal is done separately for all available ranges. A range is available if its span-gas value is > 0.0.
- user defined sequence program:* In this mode the user is responsible for the optimization. See set-up of this mode.
- blowback procedure:* In this mode are switched off the assigned sample gas and calibration gas valves. An assigned blowback valve is switched on.
- gas test: It is also possible to switch for test purposes onto a specific gas of a specific module. A calibration is not done.

Any mode can be started by the following instances:

- Manually by operator interaction
- Triggered by programmable input (DIO)
- protocol command
- Programmed time-automatic (no gas test possible!)
- LON Variable "CMFUNC »

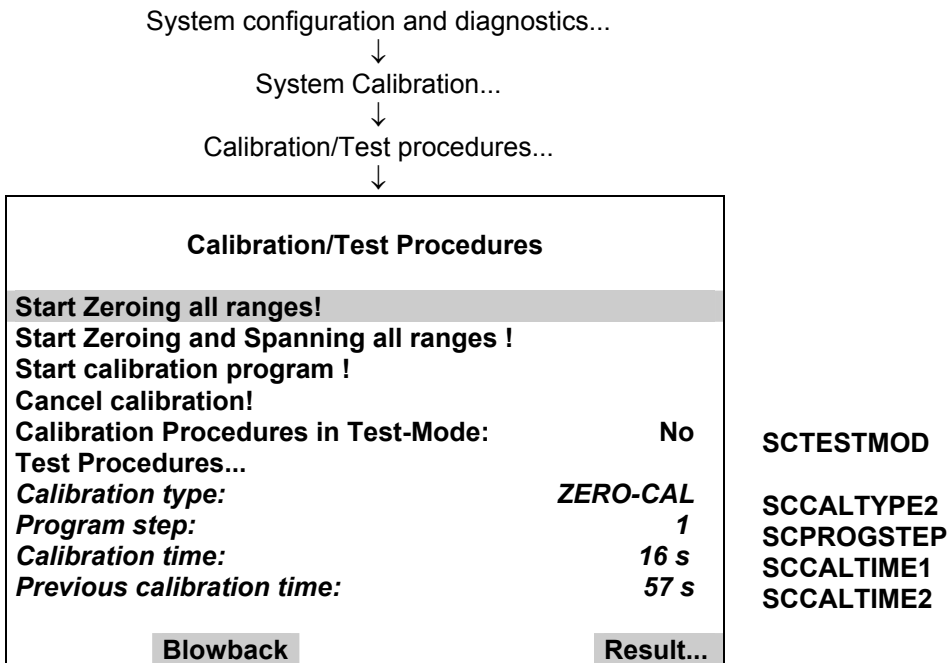
It is also possible to cancel a running system calibration. This can be done by the following instances:

- Manually by operator interaction
- Triggered by programmable input (DIO)
- protocol command
- LON Variable "CMFUNC"

There is no priority by which way SYSCAL can be started. If SYSCAL was started it can not be restarted by a further instance. Only after canceling it can be restarted.

3.4.1 Control via menu system

The possibility to control via menu is located in the menu page „Calibration/Test procedures“. There can be started and stopped any kind of system calibration respectively test procedure.



During a running SYSCAL there can be watched current information:

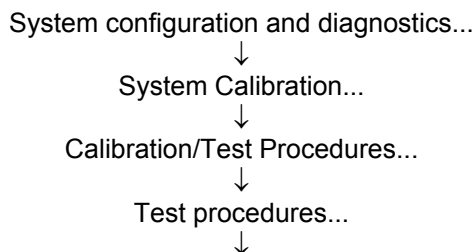
- running calibration type
- running program step of user defined program (other modes than user program show a „0“!)
- consumed calibration time
- calibration time of last valid SYSCAL

The result of calibration for included AM's is displayed in an own menu page. This can be achieved by soft key "Result..." from different menu pages of SYSCAL.

| - Calibration Results - | | |
|---------------------------------------|-------|------------|
| Choose analyzer module... | | |
| Analyzer-module: | CLD | SCMODULE |
| Enabled for system-cal: | No | SCCONTROL |
| <hr/> | | |
| Result of last run: | OK | SCLRESULT |
| Successfully calibrated ranges: | 1+2+4 | SCVALIDITY |
| Zero-Cal fail of any analyzer module: | NO | SCRESULT1 |
| Span-Cal fail of any analyzer module: | YES | SCRESULT2 |

Remember to run the calibration procedures as a test without actually to calibrate assert parameter "Calibration Procedures in Test-Mode" to <Yes>.

It is also possible to switch for test purposes onto a specific gas of a specific module. This possibility is located in menu "Test procedures".



| -- Test Procedures -- | | |
|---|-------------------|------------------|
| Gastest of specific module | SAMPLE-Gas | SCTESTGAS |
| Timeout for Gastest (0 = no timeout) | 180 s | SCTIMEOUT |
| Choose specific analyzer module... | | |
| <hr/> | | |
| Procedure time: | 10 s | SCCALTIME1 |
| Analyzer-module: | MLT/CH3 | SCSTEPMOD |

NGA 2000 System Calibration

Here we first choose the specific analyzer module and then we select at the parameter "Gastest of specific module" the required gas.

Each of the following types is possible:

- All closed
- Zero-Gas
- SAMPLE-Gas (test mode deactivated)
- SpanGas-1 (span gas for range 1)
- SpanGas-2 (span gas for range 2)
- SpanGas-3 (span gas for range 3)
- SpanGas-4 (span gas for range 4)
- Blowback

With parameter "Timeout for Gastest" we can determine a time after which the activated gas test switches automatically back onto SAMPLE-Gas.

Is this parameter set to "0" the automatic back switching is not done automatically and user must break this mode with a "Cancel Calibration" Command.

3.4.2 Control System Calibration by LON Variables

SYSCAL can also be controlled by LON Variable CMFUNC. Setting this variable will cause the appropriate function (see following table).

| CMFUNC | function which is started |
|--------|-------------------------------------|
| 1 | system zero-calibration |
| 2 | system zero/span-calibration |
| 3 | user defined sequence program |
| 4 | cancel a running system calibration |
| 5 | blowback procedure |
| | |

We can also realize some other functionality with setting of LON Variables. Therefore see the appropriate menu pages, where the concerned variables are documented.

For example: "Test procedures".

| --Test Procedures -- | | |
|---|-------------------|-------------------|
| Gastest of specific module | SAMPLE-Gas | SCTESTGAS |
| Timeout for Gastest (0 = no timeout) | 180 s | SCTIMEOUT |
| Choose specific analyzer module... | | |
| <hr/> | | |
| Procedure time: | 10 s | SCCALTIME1 |
| Analyzer-module: | MLT/CH3 | SCSTEPMOD |

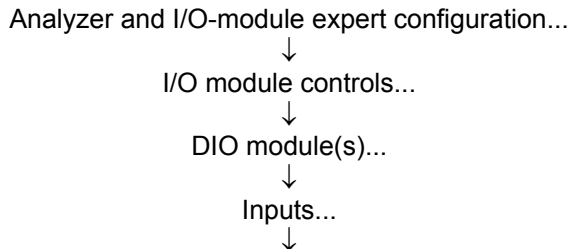
Here we have first to set variable SCSTEPMOD similar to the TAG of the requested analyzer module. Setting SCTIMEOUT will set the timeout. And setting variable SCTESTGAS to the appropriate enum value will start the procedure.

Table of enum values and procedures:

| SCTESTGAS-function | ??? | Zero-Gas | SAMPLE-Gas | Span Gas-1 | Span Gas-2 | Span Gas-3 | Span Gas-4 | Blowback |
|--------------------|-----|----------|------------|------------|------------|------------|------------|----------|
| enum value | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |

3.4.3 Control System Calibration by Programmable Input

We can use the possibility to control SYSCAL by triggering with a programmable input. This feature is supported by inputs of the DIO Module. Assigning of an programmable input can be accomplished by using the menus for DIO module.



| -- DIO- Module Inputs -- | |
|---------------------------|-----------------------|
| Inputnumber: | 5 |
| Choose module... | |
| Choose function... | |
| <hr/> | |
| Slot ID: | 1 |
| Signal name: | SYS:Cancel-Cal |
| Signal level: | OFF |
| Signal comes from: | Control Module |

DIOINPNUMC

DIOSLOTIDC

DIOINPSIGC

DIOINPSTATC

DIOINPSRCC

There we have to select

1. wanted input number
2. the appropriate module as Source Module (see following table)
3. the wanted function for system calibration

The provided functions for system calibration are:

| function | source module | function (positive edge) | function (negative edge) | enum value in STINAME |
|-------------------|---------------|---|--------------------------|-----------------------|
| SYS:Zero-Cal | CM | start system zero-calibration | - | 6 |
| SYS:Zero/Span-Cal | CM | start system zero/span-calibration | - | 7 |
| SYS:Program-Cal | CM | start user defined sequence program calibration | - | 8 |
| SYS:Cancel-Cal | CM | stop a running procedure and disable any start commands | enable starting commands | 9 |
| SYS:CAL-Test-Mode | CM | switches into test mode | switches off test mode | 10 |
| SYS:AM-Zero-Gas | AM | switches zero gas-valve | stop a running procedure | 11 |
| SYS:AM-Span-Gas1 | AM | switches span gas-valve for range 1 | stop a running procedure | 12 |
| SYS:AM-Span-Gas2 | AM | switches span gas-valve for range 2 | stop a running procedure | 13 |
| SYS:AM-Span-Gas3 | AM | switches span gas-valve for range 3 | stop a running procedure | 14 |
| SYS:AM-Span-Gas4 | AM | switches span gas-valve for range 4 | stop a running procedure | 15 |
| SYS:BlowbackI | CM | start system blowback procedure | - | 22 |

Please take notice that all actions are edge-triggered. Therefore take care of functionality of positive as well as negative edge.

It is also possible to configure the DIO inputs only per LON Variables (i.e. SLTA-adapter or protocol). Therefore is the LON variable "DIOINP_ENTRYSIG" which corresponds to "DIOINPSIGC" and evaluates enum values of "STINAME".

For each digital input we have to set-up variables in following order.

1. DIOSLOTIDC
2. DIOINPNUMC
3. DIOINPSRCC
4. DIOINP_ENTRYSIG (see enum value in STINAME)

3.4.4 Control System Calibration by protocol command

We can start and stop SYSCAL over serial interface by protocol commands. Therefore the commands **SCAL**, **STBY** and **ASTZ** has to be used.

Start-Command: SCAL Kx m (n)

| m (type of SYSCAL) | Kx (channel number) | n (optional parameter) |
|-----------------------|------------------------|---|
| 0 = ZERO-CAL | K0 | n = 1: switch into test mode else: switch into normal mode |
| 1 = ZERO/SPAN-CAL | K0 | |
| 2 = PROGRAM | K0 | |
| 3 = TEST ZERO-GAS | K1...999 | timeout in sec |
| 4 = TEST SPAN-GAS1 | K1...999 | timeout in sec |
| 5 = TEST SPAN-GAS2 | K1...999 | timeout in sec |
| 6 = TEST SPAN-GAS3 | K1...999 | timeout in sec |
| 7 = TEST SPAN-GAS4 | K1...999 | timeout in sec |
| 8 = TEST CLOSE GASES | K1...999 | timeout in sec |
| 9 = BLOWBACK | K0 | not used |

If optional parameter n is not in command string the appropriate variable is not changed.

Starting condition: All attached AM's are in the Standby-Mode (AK STBY) and the variable CALSTAT is 0, otherwise the response is BUSY (BS).

Stop-Command: STBY K0

Only using K0 will stop running SYSCAL-procedure (besides all the procedures of the other AM's).

Check-Command: ASTZ K0

The ASTZ K0 command gives the information if a SYSCAL-procedure is running or not.

If running it returns a "SCAL" if not this string is missed.

3.4.5 Time controlled System Calibration

To activate a time controlled system calibration we have to set-up this in own menu pages. For each of the time controlled procedures exists an own menu page.

System configuration and diagnostics...



System Calibration...



Times for interval operation...



| | |
|--|-----------------------------------|
| -- Times for Zero Interval Operation -- | |
| Zero-Cal is: | ENABLED |
| Start time | |
| Month: | 2 |
| Day: | 20 |
| Hours: | 10 |
| Minutes: | 15 |
| Interval time: | 24 h |
| Next calibration events... | |
| Time & Date: | 15:26:10 February 19, 2001 |
| ZeroSpan Program | Blowback |

SCSTZERO

SCBGNZERO1
 SCBGNZERO2
 SCBGNZERO3
 SCBGNZERO4
 SCIVZERO

S_TIME

System configuration and diagnostics...



System Calibration...



Times for interval operation...



fct2: ZeroSpan



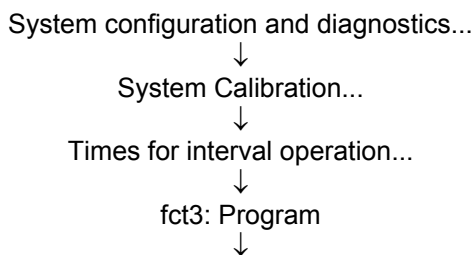
| | |
|---|-----------------------------------|
| -- Times for Zero&Span Interval Operation -- | |
| Zero&Span Cal is: | DISABLED |
| Start time | |
| Month: | 2 |
| Day: | 20 |
| Hours: | 10 |
| Minutes: | 15 |
| Interval time: | 24 h |
| Next calibration events... | |
| Time & Date: | 15:26:10 February 19, 2001 |

SCSTZEROSPAN

SCBGNZSPAN1
 SCBGNZSPAN2
 SCBGNZSPAN3
 SCBGNZSPAN4
 SCIVZEROSPAN

S_TIME

NGA 2000 System Calibration

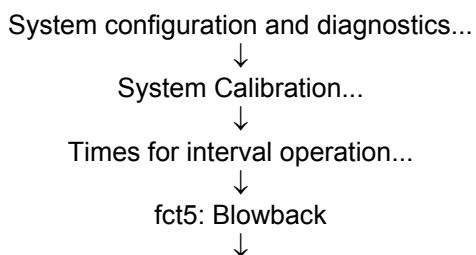


| -- Times for Program Cal Interval Operation -- | |
|---|----------------------------|
| Program Cal is: | DISABLED |
| Start time | |
| Month: | 2 |
| Day: | 20 |
| Hours: | 10 |
| Minutes: | 15 |
| Interval time: | 24 h |
| Next calibration events... | |
| Time & Date: | 15:26:10 February 19, 2001 |

SCSTPRGM

**SCBGNPRGM1
SCBGNPRGM2
SCBGNPRGM3
SCBGNPRGM4
SCIVPRGM**

S_TIME



| -- Times for Blowback Interval Operation -- | |
|--|----------------------------|
| Blowback is: | DISABLED |
| Start time | |
| Month: | 2 |
| Day: | 20 |
| Hours: | 10 |
| Minutes: | 15 |
| Interval time: | 24 h |
| Next calibration events... | |
| Time & Date: | 15:26:10 February 19, 2001 |

SCSTBLOWB

**SCBGNBLOWB1
SCBGNBLOWB2
SCBGNBLOWB3
SCBGNBLOWB4
SCIVBLOWB**

S_TIME

For the different SYSCAL-modes there is the possibility to

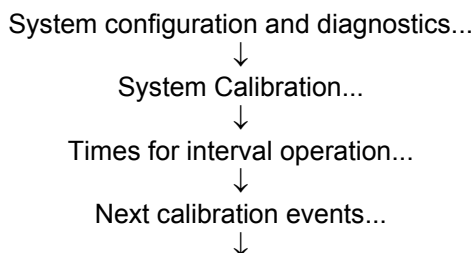
- enable/disable the time controlled activation
- determine start time of activities (date/time of current year)
- determine in which time intervals after start time the activation is done

Attention:

Other than in some AM-functionalities the interval time is to be input as interval hours. For example, for a weekly calibration you have to calculate $24 \text{ h} * 7 = 168 \text{ h}$.

Is the input date/time before present point of date/time then there are added further interval times until it is later.

We can display the calculated times in menu page „next calibration events“...
But these times will only appear when the appropriate time controlled procedure type is enabled.



| Next Calibration Events | | |
|---------------------------|-----------------------------------|------------------|
| Zero-Cal: | 10:15:00 February 22, 2003 | Menu1Line |
| Zero&Span-Cal: | 10:15:00 February 22, 2003 | Menu2Line |
| Program-Cal: | 10:15:00 February 22, 2003 | Menu3Line |
| Blowback: | 10:15:00 February 22, 2003 | Menu4Line |
| Time & Date: | 15:26:10 February 19, 2003 | S_TIME |

3.5 Calibrate single Analyzers

Each specific analyzer has still the possibility to start a calibration over other instances than SYSCAL. For this functionality we now have some additional considerations.

- Do not start a calibration of a single AM during a running SYSCAL. This will confuse the valve switching and the calibration commands of SYSCAL. Therefore look also for all automatic start instances of an analyzer.
- A single calibration cannot use the purge times of system valve settings. Instead of we have to set-up the AM's own parameters in the manner to wait for the required purge time after a valve switching.
- It is refused to start single calibration of a second AM if the needed calibration gas valve is also any calibration gas valve of the first started AM.

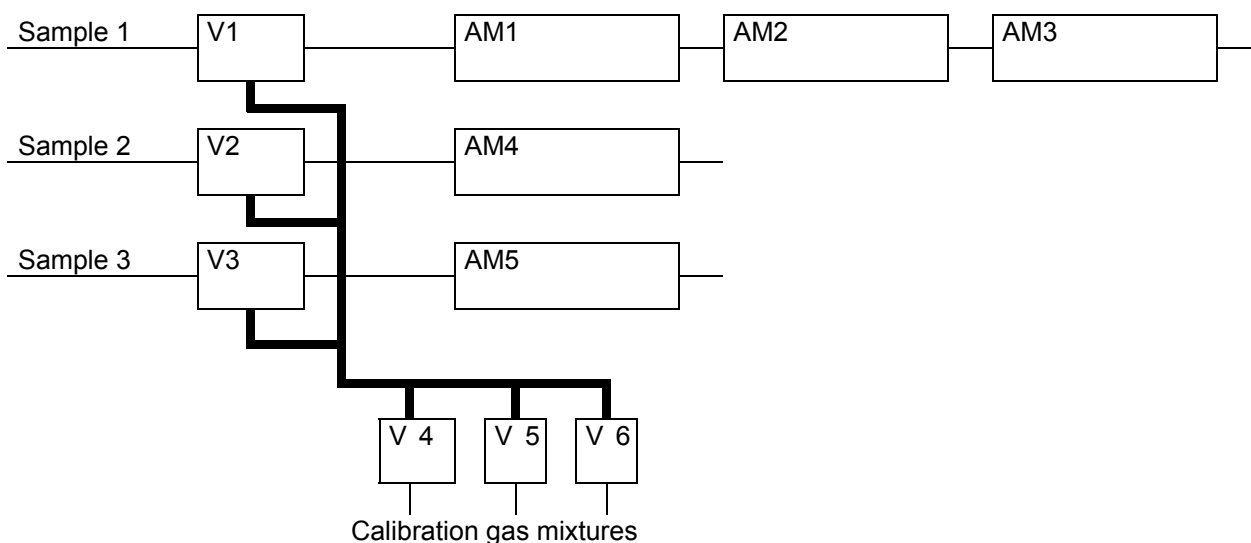
These considerations are valid for all AM's which are included into SYSCAL.

4 Functionality

4.1 Gas flow

The gas flow through the analyzers can be configured in any way:

1. only serial
2. only parallel
3. serial and parallel mixed



Connections for program logic and flow configurations:

- To each AM (MLT/ CAT 200 channel) must be assigned a sample gas valve.
- During a calibration of an AM the assigned sample gas valve will be closed and returns to the OPEN-state after the calibration of the AM is done.
- The calibration gases can only flow into an AM if sample gas valve is closed.
- With a opened sample gas valve it is expected to actually flow sample gas.

The state of assigned sample gas valve also decides about some AM specific states!

4.2 *Running system calibration*

The system calibration is running in an own task. This task is only allowed to run once. Any try to restart this task is refused.

The main steps SYSCAL task has to do are realized in the following way.

1. Fill all actions to do into a **sequence buffer**.
2. Make some preparations before starting the actions
3. Work through the sequence buffer
4. Restore states and make some other finishing work

The contents of the sequence buffer depends on the type of SYSCAL (ZERO_ALL, ZEROSPAN_ALL or USER_PROG). With the start command this type is delivered.

It is allowed to cancel the SYSCAL task. This is realized by setting a parameter to a defined value. This parameter is watched during step 3("working through the sequence buffer"). If a cancel is caused the task cancels its current action in step 3, works through step 4 and ends.

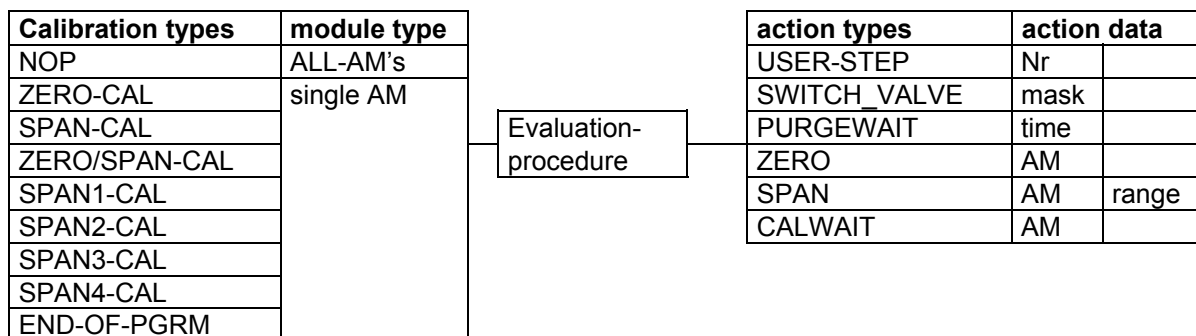
Canceling the SYSCAL task per digital input will also disable any further starting action as long as the digital input will stay at "cancel state".

4.2.1 Filling sequence buffer

The contents of the sequence buffer depends on

- calibration types and belonging module type
- coherence of modules and system valves

An evaluation procedure has the choice of listed action types.



One calibration type has following sequence frame:

1. SWITCH_VALVE
2. do different PURGEWAIT, ZERO, or SPAN which are possible with this valve adjustment (order is determined by shortest purge time)
3. do different CALWAIT (wait for finishing a started calibration)

The evaluation procedure optimizes the order of actions by time.

The only condition is in case of ZERO/SPAN-CAL, where an AM has to do first its "ZERO" before any of its "SPAN's" can be done.

The PURGEWAIT-delay-measurement is started with the last SWITCH_VALVE-action.

We can see, that the SYSCAL-types "ZERO_ALL" and "ZEROSPAN_ALL" are special cases of a user program.

- ZERO_ALL: ZERO CAL of ALL AM's
- ZEROSPAN_ALL: ZERO/SPAN CAL of ALL AM's

Example of a filled sequence buffer

Assignment of modules, system valves and purge times:

| | AM1 | AM2 | AM3 |
|------------|-------------|-------------|-------------|
| SAMPLE-GAS | V1 / 5 sec | V1 / 5 sec | V2 / 4sec |
| ZERO-GAS | V4 / 10 sec | V4 / 10 sec | V5 / 12 sec |
| SPANGAS-1 | V5 / 10 sec | V5 / 10 sec | V6 / 12 sec |
| SPANGAS-2 | V5 / 10 sec | V5 / 10 sec | V6 / 12 sec |
| SPANGAS-3 | V6 / 10 sec | V5 / 10 sec | V4 / 14 sec |
| SPANGAS-4 | V6 / 10 sec | V5 / 10 sec | V4 / 14 sec |

To do is following user program:

1. ZERO-CAL ALL modules
2. SPAN4-CAL AM2
3. END-OF-PGRM

Belonging sequence buffer:

| action type | action data[0] | action data[1] |
|--------------|-------------------|----------------|
| USER_STEP | 1 | |
| SWITCH_VALVE | 0006 hex (V4, V2) | |
| PURGEWAIT | 10 | |
| ZERO | AM1 | |
| PURGEWAIT | 10 | |
| ZERO | AM2 | |
| CALWAIT | AM1 | |
| CALWAIT | AM2 | |
| SWITCH_VALVE | 0011 hex (V5,V1) | |
| PURGEWAIT | 12 | |
| ZERO | AM3 | |
| CALWAIT | AM3 | |
| USER_STEP | 2 | |
| SWITCH_VALVE | 0012 hex (V5, V2) | |
| PURGEWAIT | 10 | |
| SPAN | AM2 | 4 |
| CALWAIT | AM2 | |
| END-OF-PGRM | | |

The size of sequence buffer is currently 320.

4.2.2 Before starting actions

Before any action of sequence buffer is done there are some preparations to do:

- store previous calibration time for the case of canceling
- previous calibration time is now the actual one
- actual calibration time is reset
- cancel any running calibration of an AM

4.2.3 Control of actions

4.2.3.1 *Switch valves*

The SWITCH_VALVE action just takes the action data[0] (valve mask) for the new setting of system valves.

We have just to modify LON variable STCONT3, STCONT4 and partially STCONT5 , which are linked to system valves.

This action also resets time (takes system tick) for delay measurement of purge times.

4.2.3.2 *Wait for Purging*

The PURGEWAIT action looks for the present time went over since last SWITCH_VALVE action.

For the still required difference up to the needed purge time is now waited. It gives time to other tasks. If there is no additional time to wait it is continued directly with next action.

4.2.3.3 Zero Calibration

Before starting of zero calibration there are some parameters (LON variables) to modify. After ending system calibration these modified variables are restored to their previous value.

- CONTROL: This variable determines which instance is controlling range of an AM. The parameter is set to "controlled by control module"
- ZERORNGS: This variable determines if all ranges are zeroed together or separately. The parameter is set to "zero all ranges together".
- AMSERPHYSTAT: This variable exists only in a multi-channel AM (MLT!) and determines if the AM has a serial/parallel gas flow. The parameter is set to "parallel gas flow" because only this state allows SYSCAL to calibrate the different channels simultaneously.

After modifying these parameters zero calibration is started by LON variable:

- AMFN: This variable can start functions on a AM. It is set to the value for function "Zero".

4.2.3.4 Span Calibration

The span calibration can be done only in single ranges. Any action for a span calibration in a range can only be done if "span gas value \neq 0.0".

Before starting then span calibration there are some parameters (LON variables) to modify. After ending system calibration these modified variables are restored to their previous value.

- CONTROL: This variable determines which instance is controlling range of an AM. The parameter is set to "controlled by control module"
- CALRANGES: This variable determines if all ranges are spanned together or separately. The parameter is set to "span all ranges separately".
- AMSERPHYSTAT: This variable exists only in a multi-channel AM (MLT!) and determines if the AM has a serial/parallel gas flow. The parameter is set to "parallel gas flow" because only this state allows SYSCAL to calibrate the different channels simultaneously.
- CRANGE: This variable controls the current range of an AM. It is set to the respectively required range.

After modifying these parameters span calibration is started by LON variable:

- AMFN: This variable can start functions on a AM. It is set to the value for function "Span".

4.2.3.5 Wait for Finishing Calibration

Any AM has the LON variables

- CALSTAT

Whether the selected AM is still calibrating or not, is checked by reading the variable CALSTAT.

This CALSTAT-check is done in time intervals. During the intervals time is given to other tasks.

4.2.4 Finishing System Calibration

After system calibration was working through the sequence buffer or it was canceled there is to do some finishing work.

- Actualize some displayed LON variables
- Look for some still running calibrations in case of canceling and cancel them, too.
- Restore modified LON variables of AM's.
- Switch system valves to sample gas state for all AM's
- Cause to set any AM's LON variable PROCESS = "valid sample gas" after purging time of sample gas valve.

4.3 Running Single Analyzer Calibration

A single analyzer calibration also needs to switch appropriate system valves.

The difference to the system calibration is that calibration procedure of AM is already running and we have to respond upon this state.

The reaction is possible by watching any change of the LON variable CALSTAT.

- CALSTAT_ZERO (zero calibration in progress): switch off belonging sample valve and switch on zero valve.
- CALSTAT_SPAN (span calibration in progress): switch off belonging sample valve and switch on span valve appropriate current state of CRANGE-
to
variable.
- CALSTAT_DONE (calibration finished): switch on sample valve and switch off calibration gas valves.

After a calibration command the AM itself is responsible to wait the required purge times until calibration actually is done.

The reaction onto a CALSTAT-change is only active if no system calibration is running.

4.4 Holding analog outputs of the SIO and avoid limit violation alarms

Any AM has LON variable:

- PROCESS

This variable is an input-variable. Its meaning is to tell the AM that another instance is not allowing the measurement sample to flow valid.

In the AM are some states depending from PROCESS.

- "valid measurement" only if PROCESS = "valid sample gas".
- holding analog outputs if PROCESS = "no valid sample gas"
- watching limit violations is switched off if PROCESS = "no valid sample gas"

It's now the task of the system calibration to handle the variable PROCESS for any involved AM. This is done in the following way:

Any switching of a system valve looks if in the switched valves is a sample valve of any AM. If yes, then it sets PROCESS like follows.

| sample gas valve | time delay | PROCESS-variable |
|------------------|----------------------------|------------------|
| switched off | - | sample not valid |
| switched on | purge time of sample valve | sample valid |

It's very important to notice following:

SYSCAL only watches state of appropriate sample gas valve for setting of PROCESS-variable.

Any additional valve, serial to sample valve, which can switch off flow of sample gas cannot be registered for logic of PROCESS variable.

NGA 2000 System Calibration

NGA 2000

Additional AK Protocol Commands

NGA Software Version 3.7.x

| | |
|----------------|---------------------------------|
| SHDA Kn | deactivate "Hold" Status |
|----------------|---------------------------------|

Description: We have the possibility to activate the "Hold" feature not only per calibration. We can do this also by AK Command "SHDE". With command "SHDA" we have the possibility to deactivate an activated "Hold" again.

see also: SHDE

| | |
|----------------|-------------------------------|
| SHDE Kn | activate "Hold" Status |
|----------------|-------------------------------|

Description: We have the possibility to activate the "Hold" feature not only per calibration. We can do this also by AK Command "SHDE". With command "SHDA" we have the possibility to deactivate an activated "Hold" again.

see also: SHDA

| | |
|----------------------|--|
| SCAL Kx m (n) | start "System Calibration" procedures |
|----------------------|--|

Description: To control the system calibration procedures the commands "SCAL", "STBY" and "ASTZ" have to be used. With "SCAL" the procedures are started. For more exact description of procedures see also "documentation of system calibration".

Starting condition:

All attached AMs are in the Standby Mode (AK STBY) and the variable "CALSTAT" is 0, otherwise the response is BUSY (BS).

Syntax:

| m (type of SYSCAL) | Kx (channel number) | n (optional parameter) |
|-----------------------|------------------------|---|
| 0 = ZERO-CAL | K0 | n = 1: switch into test mode else: switch into normal mode |
| 1 = ZERO/SPAN-CAL | K0 | |
| 2 = PROGRAM | K0 | |
| 3 = TEST ZERO-GAS | K1...999 | timeout in sec |
| 4 = TEST SPAN-GAS1 | K1...999 | timeout in sec |
| 5 = TEST SPAN-GAS2 | K1...999 | timeout in sec |
| 6 = TEST SPAN-GAS3 | K1...999 | timeout in sec |
| 7 = TEST SPAN-GAS4 | K1...999 | timeout in sec |
| 8 = TEST CLOSE GASES | K1...999 | timeout in sec |
| 9 = BLOWBACK | K0 | not used (NEW) |

If optional parameter n is not in command string the appropriate variable is not changed.

Stop Command: STBY K0

Only using K0 will stop running "SYSCAL" procedure (besides all the procedures of the other AM's).

Check Command: ASTZ K0

The "ASTZ K0" command gives the information if a "SYSCAL" procedure is running or not.

If running it returns a "SCAL" if not this string is missed.

ALIK Kn a b c

Output of Linearization curve

Description: With this command we can get x/y values of linearization curve. We can determine the wanted segment of the linearization curve and the intervals between the curve pairs. This command is only possible with a MLT/TFID Analyzer.

Syntax: Kn: it is only a single channel call possible (no K0!).
a: starting concentration of segment (in ppm)
b: ending concentration of segment (in ppm)
c: interval between the curve pairs (in ppm)

Conditions: $a < b ; c > 0.0$

Answer: ALIK s y1 x1 y2 x2 y3 x3 ...

s: error status
y: nominal value
x: actual value

TFID Software 3.7.x - Addendum to 3.4.x

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