





# G500/G100 Calculator

G500-4001 | G500/100 Calculator v1

## Learning & Development Learning Module







SME Source Markham





## Learning Module Objective

At the completion of this module you will be able to identify and recite all concepts presented.

If you are viewing this as part of a structured training program *PLEASE* complete the associated assessment test. You are required to score above 80%.

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## Learning & Development Learning Module



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## Here's What is Covered in this Module

- Introduction to Calculator 1.
- Mapped Points and Calculator Points 2.
- Application Parameters and Basic Syntax Rules 3.
- Expressions 4.
- Evaluations 5.
- 6. Timers
- Analog Assignments 7.
- Digital Assignments 8.
- Quality Conversions 9.
- 10. Type Conversions
- 11. Averages
- 12. Output to Input Conversion

## Learning & Development Module Objective

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## Introduction to Calculator

Calculator is a built-in mathematical control logic tool to perform basic math functions on MCP data points to automate substation procedure, typically used to carry out the following functions:

- Perform Mathematical, Logical, or Timer based operations on selected system data points
- Automatically operate one or more digital or analog outputs when certain conditions are met

### **To Configure:**

On the **Calculator** tab on the DSAS Editor's Configuration page, you configure the Calculator automation application by:

- Selecting data points referenced in expressions (called mapped points)
- Building expressions

### **To View:**

During runtime, calculated point values are presented to the operator on the Application tab on the Runtime HMI - Point Details page.

<u>à</u>	Point Details										
IED Master Station	n Application Point Group	os									
Home Dir	Application Name		Device ID			Show I/O					
нмі н	IMI	нмі	нмі				iew				
SS00001 S	System Status Manager	SSM	SSM				iew				
RT00000 R	TDB Process					Point De	etails(10.14.24.136)	)			
SC00001 IE	EC61850Client Map F	ile		Applicat	tion Nan	ne	Application A	ddress			
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RM00000 R	Redundancy Manager	34	BB2		BB2 Poi	nt Desc	LD0_CALC/GGIO4	·			
AR00000 A	Atmtd Rcrd Rtrvl Mngr	35	FD1	ł	FD1 Poir	nt Desc	LD0_CALC/GGIO4	·			
CA00000 C	Calculator	36	FD2	ł	FD2 Poir	nt Desc	LD0_CALC/GGIO4	•			
		37	FD3	F	FD3 Poir	nt Desc	LD0_CALC/GGIO4				

ps	Server Map	System Point Manage	Alarm	Calculator	Data Logger	Loa	d Shed	Systemwide	AI
sion	s Calculato	r Points Application F	arameters						
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	Name		Target	Point Type			Target F	Point	Т
	Evaluation		Analog	) Input		•	BB1		0
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	🔍 Mapp Calci Calci Expre	oed Poi ulator Poi essions	k6di)						

Data points must already be configured in the MCP before they can be selected as mapped points in the Calculator.



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## Mapped Points and Calculator Points

### Mapped Points:

Mapped points are those selected system points to be used as variables within Calculator expressions. The following data types are supported for use in expressions.

- Analog Input (AI)
- Digital (binary) Input (DI)
- Analog Output (AO)
- Digital (binary) Output (DO)
- Accumulators
- Text

### **Calculator Points:**

Calculator points can be used to provide input into one or more expressions. Once defined on the Calculator Points page, these analog output and digital output points are shown within the point picker tree on the Expression Builder.

Connections	Client Maps	Server Ma	ap [S	system	Poi
🔒 Save (	Reset				
Mapped Points	Expression	s Calcu	lator Po	oints	A
Analog Input	Analog Outpu	t Digital	Input	Digita	al O
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Devices		PI	lease s	select	the
🗄 🛄 Applicati			ource [	Doint	
		0	ourcer	ont	-
	ing 1   Pay 1   I		000102	2, -102	5
	ine i   Day i   it		000102	2, -102	6
🕒 🖽 🛄 L	ine 2   Bay 1   IE	ED_DN			
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Connections Client Maps Server Map System Point Manager	Alarm Calculator Data Logger	Load Shed Systemwide	ARRM AI Text Enumeration	Oneline Designer
Save 📀 Reset				
Mapped Points Expressions Calculator Points Application Para	meters			
Analog Output Digital Output				
Define Analog Output point(s) you would like to use as a target.				1 <mark>↓</mark> <u>A</u> dd
Source Reference	Alias	Sou	urce Description	
AO 0	0ao	AO	0	
AO 1	1ao	AO	1	

int Mana	ager	Alarm	Calculator	Data Logger	Load Shed	Systemwide	ARRM	AI Text Enumeration	Onel	line Designer	
pplicatio	on Para	ameters									
Dutput	Accur	nulator	Text								
Analog	lnput	points y	ou would like	e to use in the	expressions.					Delete	
Sou			Source Des	cription		Source F	Reference	•	Alias		
			LF_YEAR			LF_YEA	R		6	Sai	
			LE MONTH			LE MON	ITU		7	7oi	

Alias: A short name to reference the point within Calculator and must be unique across all data types. The alias is used as point description in available points list and is only used within the Calculation application. The alias can be 1 to 126 ASCII characters.

Calculator-Owned Points include (1) points defined on Calculator Points page as input into expressions, and (2) points autocreated based on the results of the configured expressions.

## **Application Parameters and Basic Syntax Rules**

The following Calculator Application Parameters can be set to allow you to change the way that time stamps are recorded by the Calculator and whether controls are allowed at Calculator startup

- **Data Change Time Tag** (Use Evaluation Time / Use Trigger Event)
- Allow Controls At Startup (Only Pseudo Points / All Points / Disabled)

### **Basic Syntax Rules:**

To create a valid expression, the following syntax rules of the Calculator must be followed (in addition to the format of the specific operation types)

### **Order of precedence**

• No special precedence is enforced on any Calculator expression, except where parentheses have been used

### White space

• You may insert any number of spaces between operators and operands; the Calculator ignores these spaces

To validate the created expression, click **Validate** button to ensure the expression is valid

Connections	Client Maps
🔒 Save (	Reset
Mapped Points	Expressions
Calculator /	Applicatio

Expression	
<ul> <li>Mapped Poi</li> <li>Calculator Poi</li> <li>Expressions</li> </ul>	Odi  (1di
	7
	4
	1
	0
	Backs

Server Map	System Point Manager	Alarm Calculat	tor Data Logger	Load Shed	Systemwide	AI
Calculato	r Points Application Par eters	ameters				
	Data Change Ti	me Tag	Use trigger e	vent	•	
	Allow Controls A	t Startup	Only Pseudo	Points	-	



The default settings for Data Change Time Tag is Use Trigger Event.

The default value for Allow Controls At Startup is Only Pseudo Points.



## Expressions

**Expressions** are constructed by combining operands and operators to produce a resulting point.

### **Operands**

- Constants
- Any defined reference points
- Quality attributes

### **Operators**

- Mathematical
- Logical
- Bit-wise

The following expressions can be performed to configure:

- Evaluations
- Timers
- Analog assignments
- Digital assignments
- Quality conversions
- Type conversions
- Averages
- Output to Input conversions



### **Resulting Point**

- Point Name
- Data Type

	Map	System Point Manager	Alarm	Calculator	Data Logger	Load She
				7		
C	ulator	Points Application Par	ameters			
	Eva	luation Expressi	on			
	Nam	e	Т	arget Point Ty	/pe	
	Eval	uation	A	nalog Input		-
	Resu	It Point Description				
	AI 0				<b></b>	
					•	
	Expre	ession Notes				
					•	
	гЕхр	ression				

Up to 10000 Calculator Expr can be created.

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633		С

## **Evaluations**

Evaluation expressions perform operations on referenced points and store the result in a Calculator-owned input point.

- Re-evaluated whenever a data change event is issued on a referenced point.
- Quality changes on referenced points only cause re-evaluation if
  - The expression is converting the changed quality flag into a digital input, or
  - The quality change indicates that the referenced point is coming online or has communication restored.

The following operations are supported in evaluation expressions:

- Math operations
- Logical operations
- Bit-wise operations
- Request Type operations
- If-Then-Else construct

Connections Client Mans Se	over Man Syste	m Point Manager	Alarm	Calculator	Data I	logger	Load	Shed	System	nwide	ARRM	ALTex	t Enumer:	ation	Oneline [	)esione	r
		in one manager	7.10111		Data	Loggoi	2000	oned	ey steri			741104	C Enternor	ation		Joorgino	
Mapped Points Expressions	Calculator Points	Application Pa	rameters														
Expressions 😯 👗	Evaluation	Expression															
Evaluations	Client Maps       System Point Manager       Alarm       Calculator       Data Logger       Load Shed       Systemwide       ARRM       Al Text Enumeration       Oneline Designer		Target Point			Target Alias											
Evaluation - 1ai	Evaluation		Analog I	nput			•	BB1			0ai						
Evaluation - 2ai	Result Point Desc	ription															
Evaluation - 4ai	BB1 Point Desc																
Evaluation - 5ai					-												
Analog Assignments	Expression Notes																
Digital Assignments Quality Conversions																	
Type Conversions																	
Averages					•												
	Expression																
	Mapped Po	pints		0di  (1di	i&&6di)												
	🗄 🕀 🗐 Analog	Output															
	Digital I	nput															
	9di	- 0000102, DIGLF_	A														
	100	i - 0000102, DIGLE i - 0000102, DIGLE	.С -В														
	8di	- 0000102, His_cm	 d_support														
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				1	2	3	х^у	%	RT	&&		!	٨	~	CL	TR	NO
				0						(	)	?:					

The Calculator monitors the quality of referenced points for changes in the Questionable and Invalid quality flags. If any referenced point becomes Invalid or Questionable, the resulting point for any expression that includes that referenced point becomes Invalid.

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## Timers

When the result of a binary expression changes, Calculator starts a timer based on the defined hold times. If the value of the binary expression stays constant for the entire timer duration, then the value of the timer expression evaluates to TRUE.

- Timer resolution: 1 second
- Defined by two hold times: rising edge (FALSE to TRUE) and falling edge (TRUE to FALSE).
- Hold times can be positive or zero.

### Example

If you want a Calculator-owned Digital Input 14 to turn ON when digital inputs DI9 and DI10 are the same value for more than 10 seconds, use the following settings:

- Target Point Type: Digital Input
- Target Point: DI 14 (Alias: 14di)
- Expression: 9di==10di
- The Rising Edge Time: 10s
- The Falling Edge Time: 0

Result: The output of Calculator-owned digital input will turn ON after 10 seconds.

Timer Expression											
Name	Target Point Typ	e			Targe	et Point		Targ	et Alias		
Timer	Digital Input			•	DI 14	1		14di			
Result Point Description											
DI 14		<ul> <li>▲</li> <li>▼</li> </ul>									
Expression Notes		•	Rising	g Edge T	ime(s) IO	Falling	Edge Tim 0	ie(s) ≖ ₹			
Mapped Points  Mapped Points  Analog Input  Analog Output  Analog Output  Grave Grav	A _B _C d_support nd_support	10di									
Calculator Points	7	8	9	*	1	In	==	<	>	<<	>>
Expressions	4	5	6	+	-	log	<=	>=	!=	&	
	1	2	3	x^v	%	RT	&&	П	!	٨	~

ipport support	9di==1	Odi									
	7	8	9	*	1	In	==	<	>	<<	>>
	4	5	6	+	-	log	<=	>=	!=	&	
	1	2	3	x^y	%	RT	&&		!	٨	~

Target Point Type for timer expression:

- Digital Input
- Analog Input

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## Analog Assignments

Analog Assignment expressions receive output of operations on referenced analog output and input points and translate them into operations on Mapped Analog Output points.

- Quality changes on the referenced points are monitored.
- Support the same syntax as evaluation expressions

### Example

If you want to send a Setpoint command on say Analog Output AO 0 (mapped in Calculator) if an event occurs on Analog Input point AI 6 (also mapped in Calculator), use the following settings:

- Target Point: Oao (Alias of AO 0)
- Expression: 6ai (Alias of Al 6)

Analog Assignment				
Name				
Analog Assignment				
Target Point				
0 <mark>ao</mark>	С	hoos	]	
Expression Notes			_	
Expression				
Mapped Points Analog Input Analog Input Gai - 0000102, LF_YEAR Tai - 0000102, LF_MONT Orai - 0000102, LF_YEAR Orai - 0000102, LF_MONT Orai - 0000102,	I TH	<u>6ai</u>		
		7	8	
		4	5	
		1	2	
		0		

It is recommended to use brackets around negative numbers in the expressions. e.g., (-1234).)



9	*	1	In	==	<	>		<<	>>	ON	OFF	SEL
6	+	-	log	<=	>=	!=		&	1	PU	PO	A
3	х^у	%	RT	&&	Ш	1		٨	~	CL	TR	NO
				(	)	?:						

## **Digital Assignments**

Digital Assignment expressions receive output of operations on referenced digital output and input points and translate these into operations on Mapped Digital Output points.

- Quality changes on the referenced points are monitored.
- Support the same syntax as evaluation expressions

### **Override Operation**

- None
- Direct Operate
- Direct Operate NoAck
- Select Before Operate

### **Control Routing**

- None
- ON Target Point
- OFF Target Point
- Both Target Points

### **Control Type**

- Inverted Latch
- Latch
- Pulse
- Trip-Close

### **Exampl**e

If you want to send a Trip-Close command on the mapped point DO 10 on receiving an ON event on the mapped point DI 8, use the following settings:

- ON Target Point: 10do
- ON Target Control Type: Trip-Close
- Control Routing: ON Target Point
- Override Operation: None
- Expression: 8di

Digital /

Name

	Override Operation	Control Routing	
gnment	None	<ul> <li>ON Target Point</li> </ul>	•
) ON/Pulse ON Target Po	int		
	Choose		
e	Pulse On Duration	Pulse Off Duration	Num Operations
	▼ 1,000	0	1
)FF/Pulse OFF Target Po	int		
	Choose		
e	Pulse On Duration	Pulse Off Duration	Num Operations
	▼ 0	0	1
lotes		1	
	<b></b>	1	
d Points	8di		
alog Output			
aital Innut			
9di - 0000102, DIGLF_A 10di - 0000102, DIGLF_	B		
9di - 0000102, DIGLF_A 10di - 0000102, DIGLF_ 11di - 0000102, DIGLF_	B C		

When Control Routing is set to "Both Target Points", the resulting actions will be a combination of configuration of ON Target Point Control Type and OFF Target Point Control Type.

## **Quality Conversions**

Quality conversions take a mapped system point and report a binary TRUE or FALSE based on a certain quality flag within that point. The MCP provides the following quality conversion flags:

- ALARM\_INHIBIT
- CHATTER
- COMM\_LOST
- LOCAL\_CONTROL\_ACTIVE
- LOCAL\_FORCE Commonly used to test expressions
- OFFLINE
- OLD\_DATA
- OUTPUT\_INHIBIT

- OVER\_RANGE
- OVERFLOW
- QUESTIONABLE Ceases evaluating the expression while Questionable is asserted
- REF\_CHECK
- REMOTE\_CONTROL\_ACTIVE
- REMOTE\_FORCE
- **RESTART**

### **Exampl**e

if you want to set the created Calculator-owned Digital

Input point DI 15

to TRUE whenever the mapped Analog Point AI 7 is Offline

### And

to FALSE when AI 7 is Online, use the following settings:

- Quality Attribute: OFFLINE
- Source Point: 7ai
- Target Point: DI 15 with Alias: 15di

Quality Conv	ersion/			
Name		Quality Attribute	Source Point	
Quality Conversion			· 7ai	Choose
Farget Point	Target Alias			
DI 15	15di			
Result Point Descri	ption			
DI <b>1</b> 5				
		-		
Expression Notes				
		-		

- SCAN\_INHIBIT Asserts Questionable and Old Data flags
- SECONDARY\_SOURCE
- SECONDARY\_SOURCE\_OFFLINE
- TAGGED
- TEST
- TIME\_SYNC
- ZOMBIE Asserts when the Zombie quality attribute of the mapped point is set

Converted points are a special class of pseudo points that are created based on an actual system point



## Type Conversions

Type conversion points change mapped system points from binary input to analog input, or from analog input to binary input, or from output to input, or from accumulator to binary / analog input, or from text to binary:

- Analog Input to Digital Input
- Digital Input to Analog Input
- Analog Output to Analog Input
- Digital Output to Digital Input

- Accumulator to Analog Input
- Accumulator to Digital Input
- Text to Digital Input

### **Exampl**e

if you want to create an Analog Input to Digital Input type conversion, a new Calculator-owned Digital Input point DI 20 is created where the value of the source mapped Analog Input point AI 10 is converted to a binary TRUE or FALSE, use the following settings:

- Source Point: 10ai
- Target Point Type: Digital Input
- Target Point: DI 20 with Alias: 20di
- Bit Position: 0

### Type Conversion

Type Conversion			
Name	Source Point		
Type Conversion	10ai	Choose	
Target Point Type	Target Point	Target Alias	Bit Position
Digital Input	TI 20	20di	0
Result Point Description			
DI 20			
		•	
Expression Notes			
		▼	

Bit Position: The integer within the value returned from the source point used to determine the state of the Digital Input. (For Analog Input to Digital Input and Accumulator to Digital Input only )



## Averages

Calculator supports both standard and time-weighted averaging on selected mapped Analog Inputs:

- Block: A standard basic arithmetic averaging
- Time-Weighted: An average that considers the amount of time the point remains at each value. Used to reduce the influence of infrequent outliers

### **Exampl**e

if you want to calculate and report Block average to a Calculator-owned Analog Input point AI 33 for the source mapped Analog Input point AI 15 for every hour, use the following settings:

- Source Point: 15ai
- Average Type: Block
- Target Point: AI 33 with Alias: 33ai
- Alignment: 00:00:00
- Sub Block Divisor: 1
- Sliding: Not Selected
- Value Exclusion: Not Selected
- Period: 1 hour

Average					
Name		Average Type		Source Point	
Average		Block	•	15ai	Choose
Target Point	Target Alias	Alignment	Sub Block	Divisor	
AI 33	33ai	00:00:00	<b>▲</b> 1	Sliding	
Value Exclusion: Min	Value Excl	usion: Max			
-0.5	0.5	V	alue Exclusion		
Result Point Description					
AI 33		▲ ▼			
Period: Days Perio	od: Hours P	eriod: Minutes Period	: Seconds		
0	1	0 +	0		
Expression Notes					
		<ul> <li>▲</li> <li>▼</li> </ul>			

### Alignment:

The time of day to align with the period. Periods are positioned such that a new period begins each day at the alignment time

### Sub Block Divisor:

How many segments to divide the period into

### Sliding:

Select if a sliding window should be used. If not selected, Calculator reports the average at every full averaging interval

### Value Exclusion:

An enable/disable flag for excluding or not excluding the range of sample values for the averaging

### Period:

The size of the averaging interval. The size of the period must divide evenly into the alignment interval





## Output to Input Conversions

Output to input conversion expressions enable master stations to communicate with each other by converting two types of

**Calculator-owned** points:

- Digital Output to Digital Input
- Analog Output to Analog Input, Digital Input or Accumulator

### **Exampl**e

if you want to convert the Calculator-owned source Digital Output point DO 12 to the Calculator-owned target Digital Input point DI 13, use the following settings:

- Source Point Type: Digital Output
- Source Point: DO 12 with Alias: 12do
- Target Point Type: Digital Input
- Target Point: DI 13 with Alias: 13di

Name Output To Input Conversion Source Point Type Digital Output
Output To Input Conversion Source Point Type Digital Output
Source Point Type Digital Output
Digital Output
Source Point Description
DO 12
Expression Notes
T <mark>arget Point Type</mark>
Digital Input
Result Point Description
DI 13



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To convert inputs belonging to external applications and devices, use Type Conversion expressions

Bits to Map (AO to DI only): The number of input points to concatenate as the expression's **Digital Input** 





## Thank You for Watching this Module.

If you are watching this as part of a structured learning program, please don't forget to take the test.

Learning & Development Thank You





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