TECHNICAL NOTE

Analog Outputs

BB0122 Rev. A2

Introduction

SATEC meters may be equipped with optional analog outputs that are programmable to provide a current proportional to selected measured electrical parameters.

The devices can be ordered with one of the following analog output options:

- 0-20 mA
- 4-20 mA
- 0-1 mA/0-2 mA - 0-1 mA option with 100% overload (regular 0-1 mA order)
- ±1 mA/±2 mA - ±1 mA option with 100% overload (regular ±1 mA order)
- 0-1 mA/0-3 mA - 0-1 mA option with 200% overload (special 0-1 mA order)
- ±1 mA /±3 mA - ±1 mA option with 200% overload (special ±1 mA order)
- 0-1 mA/0-5 mA - 0-1 mA option with 400% overload (special 0-1 mA order)
- ±1 mA /±5 mA - ±1 mA option with 400% overload (special ±1 mA order)

You can find complete setup instructions in the corresponding Installation and Operation Manual for your meter. The purpose of this document is to provide guidelines for calculation of analog output currents and corresponding measured (real) parameters.

See the following tables for analog output scales and formulas for calculating analog output currents. The default output scales can be changed via the analog output setup from the meter front panel or through the supplemental PAS software.

Note that the output scales for 0-1 mA and ±1 mA analog outputs are always programmed for 0 mA and +1 mA regardless of the ordered current overload option (100%, 200% or 400%). If you wish to use the entire output range of 2 mA, 3 mA or 5 mA, depending on your order, set the analog output scales in your device as follows:

0-2 mA: set the 1 mA scale to 1/2 of the required full scale output for uni-directional parameters, and set the 0 mA scale to the negative full scale and the 1 mA scale to zero for bi-directional parameters.

±2 mA: set the 1 mA scale to 1/2 of the required full-scale output for both uni-directional and bi-directional parameters.

0-3 mA: set the 1 mA scale to 1/3 of the required full scale output for uni-directional parameters, and set the 0 mA scale to the negative full scale and the 1 mA scale to 1/3 of the negative full scale for bi-directional parameters.

±3 mA: set the 1 mA scale to 1/3 of the required full-scale output for both uni-directional and bi-directional parameters.

0-5 mA: set the 1 mA scale to 1/5 of the required full scale output for uni-directional parameters, and set the 0 mA scale to the negative full scale and the 1 mA scale to 1/5 of the negative full scale for bi-directional parameters.

±5 mA: set the 1 mA scale to 1/5 of the required full-scale output for both uni-directional and bi-directional parameters.

Analog Output 4-20 mA

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage V No PT	0 V (Low scale, V_{low}) 1.2 × 690 = 828V (High scale, V_{high})	4 mA 20 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 16}{V_{HIGH} - V_{LOW}} + 4$	$V_{REAL} = \frac{(I_{AO} - 4) \times (V_{HIGH} - V_{LOW})}{16} + V_{LOW}$	
Voltage via PT	0 V (Low scale, V_{low}) 144 × K, V (High scale, V_{high})	4 mA 20mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) 2 × I_p, A (High scale, I_{high})	4 mA 20 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 16}{I_{HIGH} - I_{LOW}} + 4$	$I_{REAL} = \frac{(I_{AO} - 4) \times (I_{HIGH} - I_{LOW})}{16} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 (Low scale) -0.50 -0.99 1.00 0.50 0.0 (High scale)	4 mA 8 mA 11.88 mA 12 mA 16 mA 20 mA	For negative PF: $I_{AO} = 4 - PF_{REAL}$ x8 For positive PF: $I_{AO} = 20 - PF_{REAL}$ x8	If PF < 12mA: $PF_{REAL}=(4-I_{AO})/8$ If PF ≥ 12mA: $PF_{REAL} = (20 - I_{AO})/8$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 1.00 (High scale, PF_{high})	4 mA 20 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 16}{PF_{HIGH} - PF_{LOW}} + 4$	$PF_{REAL} = \frac{(I_{AO} - 4) \times (PF_{HIGH} - PF_{LOW})}{16} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 100 Hz (High scale, f_{high})	4 mA 20 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 16}{f_{HIGH} - f_{LOW}} + 4$	$f_{REAL} = \frac{(f_{AO} - 4) \times (f_{HIGH} - f_{LOW})}{16} + f_{LOW}$	
Active power kW, P	-(V_{high} × I_{high} × n), kW (Low scale, P_{low}) 0 kW V_{high} × I_{high} × n, kW (High scale, P_{high})	4 mA 12 mA 20 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 16}{P_{HIGH} - P_{LOW}} + 4$	$P_{REAL} = \frac{(I_{AO} - 4) \times (P_{HIGH} - P_{LOW})}{16} + P_{LOW}$	I_{high}= 2 × I_p n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n=2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 16}{Q_{HIGH} - Q_{LOW}} + 4$	$Q_{REAL} = \frac{(I_{AO} - 4) \times (Q_{HIGH} - Q_{LOW})}{16} + Q_{LOW}$	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) (V_{high} × I_{high} × n)/2, kVA V_{high} × I_{high} × n, kVA (High scale, S_{high})	4 mA 12 mA 20 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 16}{S_{HIGH} - S_{LOW}} + 4$	$S_{REAL} = \frac{(I_{AO} - 4) \times (S_{HIGH} - S_{LOW})}{16} + S_{LOW}$	
Power demand	As for apparent power				

Analog Output 0-20 mA

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) 1.2×690 = 828V (High scale, V_{high})	0 mA 20mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 20}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{20} + V_{LOW}$	
Voltage via PT	0 V (Low scale, V_{low}) $144 \times K$, V (High scale, V_{high})	0 mA 20mA			K = PT ratio
Current, I	0 A (Low scale, I_{low}) $2 \times I_p$, A (High scale, I_{high})	0 mA 20mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 20}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{20} + I_{LOW}$	I_p =CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 (Low scale) -0.50 -0.99 1.00 0.50 0.0 (High scale)	0 mA 5 mA 9.9 mA 10 mA 15 mA 20mA	For negative PF: $I_{AO} = - PF_{REAL} \times 10$ For positive PF: $I_{AO} = 20 - PF_{REAL} \times 10$	If PF < 10 mA: $PF_{REAL} = -I_{AO}/10$ If PF ≥ 10 mA: $PF_{REAL} = (20 - I_{AO})/10$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 1.00 (High scale, PF_{high})	0 mA 20mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 20}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{20} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 100 Hz (High scale, f_{high})	0 mA 20mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 20}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{20} + f_{LOW}$	
Active power, kW, P	$-(V_{high} \times I_{high} \times n)$, kW (Low scale, P_{low}) 0 kW $V_{high} \times I_{high} \times n$, kW (High scale, P_{high})	0 mA 10 mA 20 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 20}{P_{HIGH} - P_{LOW}}$	$P_{REAL} = \frac{I_{AO} \times (P_{HIGH} - P_{LOW})}{20} + P_{LOW}$	$I_{high} = 2 \times I_p$ n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 20}{Q_{HIGH} - Q_{LOW}}$	$Q_{REAL} = \frac{I_{AO} \times (Q_{HIGH} - Q_{LOW})}{20} + Q_{LOW}$	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/2$, kVA $V_{high} \times I_{high} \times n$, kVA (High scale, S_{high})	0 mA 10 mA 20 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 20}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{20} + S_{LOW}$	
Power demand	As for apparent power				

Analog Output 0-1 mA

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) 1.2×690 = 828V (High scale, V_{high})	0 mA 1 mA	$I_{AO} = \frac{V_{REAL} - V_{LOW}}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = I_{AO} \times (V_{HIGH} - V_{LOW}) + V_{LOW}$	
Voltage, V via PT	0 V (Low scale, V_{low}) $144 \times K$, V (High scale, V_{high})	0 mA 1 mA			K = PT ratio
Current, I	0 A (Low scale, I_{low}) $2 \times I_p$, A (High scale, I_{high})	0 mA 1 mA	$I_{AO} = \frac{I_{REAL} - I_{LOW}}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = I_{AO} \times (I_{HIGH} - I_{LOW}) + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 (Low scale) -0.50 -0.99 1.00 0.50 0.0 (High scale)	0 mA 0.25 mA 0.495 mA 0.5 mA 0.75 mA 1 mA	For negative PF: $I_{AO} = -PF_{REAL} \times 0.5$ For positive PF: $I_{AO} = 1 - PF_{REAL} \times 0.5$	If PF < 0.5 mA: $PF_{REAL} = -I_{AO} \times 2$ If PF ≥ 0.5 mA: $PF_{REAL} = (1 - I_{AO}) \times 2$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 1.00 (High scale, PF_{high})	0 mA 1 mA	$I_{AO} = \frac{PF_{REAL} - PF_{LOW}}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = I_{AO} \times (PF_{HIGH} - PF_{LOW}) + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 100 Hz (High scale, f_{high})	0 mA 1 mA	$I_{AO} = \frac{f_{REAL} - f_{LOW}}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = I_{AO} \times (f_{HIGH} - f_{LOW}) + f_{LOW}$	
Active power, kW, P	$-(V_{high} \times I_{high} \times n)$, kW (Low scale, P_{low}) 0 kW $V_{high} \times I_{high} \times n$, kW (High scale, P_{high})	0 mA 0.5 mA 1 mA	$I_{AO} = \frac{P_{REAL} - P_{LOW}}{P_{HIGH} - P_{LOW}}$	$P_{REAL} = I_{AO} \times (P_{HIGH} - P_{LOW}) + P_{LOW}$	$I_{high} = 2 \times I_p$ n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{Q_{REAL} - Q_{LOW}}{Q_{HIGH} - Q_{LOW}}$	$Q_{REAL} = I_{AO} \times (Q_{HIGH} - Q_{LOW}) + Q_{LOW}$	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/2$, kVA $V_{high} \times I_{high} \times n$, kVA (High scale, S_{high})	0 mA 0.5 mA 1 mA	$I_{AO} = \frac{S_{REAL} - S_{LOW}}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = I_{AO} \times (S_{HIGH} - S_{LOW}) + S_{LOW}$	
Power demand	As for apparent power				

Analog Output ±1 mA

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) $1.2 \times 690 = 828$V (High scale, V_{high})	0 mA 1 mA	$I_{AO} = \frac{V_{REAL} - V_{LOW}}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = I_{AO} \times (V_{HIGH} - V_{LOW}) + V_{LOW}$	
Voltage, V via PT	0 V (Low scale, V_{low}) $144 \times$ K, V (High scale, V_{high})	0 mA 1 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) $2 \times I_p$, A (High scale, I_{high})	0 mA 1 mA	$I_{AO} = \frac{I_{REAL} - I_{LOW}}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = I_{AO} \times (I_{HIGH} - I_{LOW}) + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 -0.50 -0.99 1.00 (Low scale) 0.50 0.0 (High scale)	-1 mA -0.5 mA -0.01 mA 0 mA 0.5 mA 1 mA	For negative PF: $I_{AO} = -1 - PF_{REAL}$ For positive PF: $I_{AO} = 1 - PF_{REAL}$	If PF < 0 mA: $PF_{REAL} = -1 - I_{AO}$ If PF ≥ 0 mA: $PF_{REAL} = 1 - I_{AO}$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 1.00 (High scale, PF_{high})	0 mA 1 mA	$I_{AO} = \frac{PF_{REAL} - PF_{LOW}}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = I_{AO} \times (PF_{HIGH} - PF_{LOW}) + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 100 Hz (High scale, f_{high})	0 mA 1 mA	$I_{AO} = \frac{f_{REAL} - f_{LOW}}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = I_{AO} \times (f_{HIGH} - f_{LOW}) + f_{LOW}$	
Active power, kW P	$-(V_{high} \times I_{high} \times n)$, kW ($P_{low}$) 0 kW (Low scale) $V_{high} \times I_{high} \times n$, kW (High scale, P_{high})	-1 mA 0 mA 1 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 2}{P_{HIGH} - P_{LOW}} - 1$	$P_{REAL} = (I_{AO} + 1) \times (P_{HIGH} - P_{LOW})/2 + P_{LOW}$	$I_{high} = 2 \times I_p$ n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 2}{Q_{HIGH} - Q_{LOW}} - 1$	$Q_{REAL} = (I_{AO} + 1) \times (Q_{HIGH} - Q_{LOW})/2 + Q_{LOW}$	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/2$, kVA $V_{high} \times I_{high} \times n$, kVA (High scale, S_{high})	0 mA 0.5 mA 1 mA	$I_{AO} = \frac{S_{REAL} - S_{LOW}}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = I_{AO} \times (S_{HIGH} - S_{LOW}) + S_{LOW}$	
Accumulated power demands	As for apparent power				

Analog Output 0-2 mA range (0-1 mA option with 100 % overload)

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) $(1.2 \times 690)/2$ = 414V (High scale) 1.2×690 = 828V (V_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 2}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{2} + V_{LOW}$	
Voltage, V via PT	0 V (Low scale, V_{low}) $(144 \times K)/2$, V (High scale) $144 \times K$, V (V_{high})	0 mA 1 mA 2 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) $(2 \times I_p)/2$, A (High scale) $2 \times I_p$, A (I_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 2}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{2} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 (Low scale) -0.50 1.00 (High scale) 0.50 0.0	0 mA 0.5 mA 1 mA 1.5 mA 2 mA	For negative PF: $I_{AO} = -PF_{REAL}$ For positive PF: $I_{AO} = 2 - PF_{REAL}$	If PF< 1.0 mA: $PF_{REAL} = -I_{AO}$ If PF≥ 1.0 mA: $PF_{REAL} = 2 - I_{AO}$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 0.50 (High scale) 1.00 (PF_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 2}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{2} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 50 Hz (High scale) 100 Hz (f_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 2}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{2} + f_{LOW}$	
Active power kW, P	$-(V_{high} \times I_{high} \times n)$, kW (Low scale, P_{low}) 0 kW (High scale) $V_{high} \times I_{high} \times n$, kW ($P_{high}$)	0 mA 1 mA 2 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 2}{P_{HIGH} - P_{LOW}}$	$P_{REAL} = \frac{I_{AO} \times (P_{HIGH} - P_{LOW})}{2} + P_{LOW}$	$I_{high} = 2 \times I_p$
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 2}{Q_{HIGH} - Q_{LOW}}$	$Q_{REAL} = \frac{I_{AO} \times (Q_{HIGH} - Q_{LOW})}{2} + Q_{LOW}$	n=3 for 3LN3, 4LN3 and 3BLN3 configurations,
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/2$, kVA, (High scale) $V_{high} \times I_{high} \times n$, kVA ($S_{high}$)	0 mA 1 mA 2 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 2}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{2} + S_{LOW}$	n = 2 for other configurations
Power demand	As for apparent power				

For using the entire output range of 2 mA, set the 1 mA scale in your device to 1/2 of the required full scale output for uni-directional parameters, and set the 0 mA scale to the negative full scale and the 1 mA scale to zero for bi-directional parameters.

Analog Output ±2 mA range (±1 mA option with 100% overload)

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) (1.2 × 690)/2 = 414V (High scale) 1.2 × 690 = 828V (V_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 2}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{2} + V_{LOW}$	
Voltage via PT	0 V (Low scale, V_{low}) (144 × K)/2, V (High scale) 144 × K, V (V_{high})	0 mA 1 mA 2 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) (2 × I_p)/2, A (High scale) 2 × I_p, A (I_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 2}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{2} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 -0.50 1.00 (Low scale) 0.50 (High scale) 0.0	-2 mA -1 mA 0 mA 1 mA 2 mA	For negative PF: I_{AO} = -2 x (1 + PF_{REAL}) For positive PF: I_{AO} = 2 x (1 - PF_{REAL})	If PF < 0 mA: PF_{REAL} = -1 - I_{AO}/2 If PF ≥ 0 mA: PF_{REAL} = 1 - I_{AO}/2	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 0.50 (High scale) 1.00 (PF_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 2}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{2} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 50 Hz (High scale) 100 Hz (f_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 2}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{2} + f_{LOW}$	
Active power, kW, P	-(V_{high} × I_{high} × n), kW (P_{low}) 0 kW, (Low scale) (V_{high} × I_{high} × n)/2, kW (High scale) V_{high} × I_{high} × n, kW (P_{high})	-2 mA 0 mA 1 mA 2 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 4}{P_{HIGH} - P_{LOW}} - 2$	P_{REAL}= (I_{AO} + 2) × (P_{HIGH} - P_{LOW})/4 + P_{LOW}	I_{high}= 2 × I_p n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 4}{Q_{HIGH} - Q_{LOW}} - 2$	Q_{REAL}= (I_{AO} + 2) × (Q_{HIGH} - Q_{LOW})/4 + Q_{LOW}	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) (V_{high} × I_{high} × n)/2, kVA, (High scale) V_{high} × I_{high} × n, kVA (S_{high})	0 mA 1 mA 2 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 2}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{2} + S_{LOW}$	
Power demand	As for apparent power				

For using the entire output range of ±2 mA, set the 1 mA scale in your device to 1/2 of the required full scale output for both uni-directional and bi-directional parameters.

Analog Output 0-3 mA range (0-1 mA option with 200 % overload)

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) $(1.2 \times 690)/3$ = 414V (High scale) 1.2×690 = 828V (V_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 3}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{3} + V_{LOW}$	
Voltage, V via PT	0 V (Low scale, V_{low}) $(144 \times K)/3$, V (High scale) $144 \times K$, V (V_{high})	0 mA 1 mA 3 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) $(2 \times I_p)/3$, A (High scale) $2 \times I_p$, A (I_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 3}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{3} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 (Low scale) -0.50 -0.667 (High scale) 1.00 0.50 0.0	0 mA 0.75 mA 1 mA 1.5 mA 2.25 mA 3 mA	For negative PF: $I_{AO} = -PF_{REAL} \times 3/2$ For positive PF: $I_{AO} = 3 - PF_{REAL} \times 3/2$	If PF< 1.5 mA: $PF_{REAL} = -I_{AO} \times 2/3$ If PF≥ 1.5 mA: $PF_{REAL} = (3 - I_{AO}) \times 2/3$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 0.333 (High scale) 1.00 (PF_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 3}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{3} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 33 Hz (High scale) 99 Hz (f_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 3}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{3} + f_{LOW}$	
Active power kW, P	$-(V_{high} \times I_{high} \times n)$, kW (Low scale, P_{low}) $-(V_{high} \times I_{high} \times n)/3$, kW (High scale) 0 kW $V_{high} \times I_{high} \times n$, kW ($P_{high}$)	0 mA 1 mA 1.5 mA 3 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 3}{P_{HIGH} - P_{LOW}}$	$P_{REAL} = \frac{I_{AO} \times (P_{HIGH} - P_{LOW})}{3} + P_{LOW}$	$I_{high} = 2 \times I_p$
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 3}{Q_{HIGH} - Q_{LOW}}$	$Q_{REAL} = \frac{I_{AO} \times (Q_{HIGH} - Q_{LOW})}{3} + Q_{LOW}$	n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/3$, kVA, (High scale) $V_{high} \times I_{high} \times n$, kVA ($S_{high}$)	0 mA 1 mA 3 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 3}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{3} + S_{LOW}$	
Power demand	As for apparent power				

For using the entire output range of 3 mA, set the 1 mA scale in your device to 1/3 of the required full scale output for uni-directional parameters, and set the 0 mA scale to the negative full scale and the 1 mA scale to 1/3 of the negative full scale for bi-directional parameters.

Analog Output ±3 mA range (±1 mA option with 200% overload)

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) $(1.2 \times 690)/3$ = 414V (High scale) 1.2×690 = 828V (V_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 3}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{3} + V_{LOW}$	
Voltage via PT	0V (Low scale, V_{low}) $(144 \times K)/3$, V (High scale) $144 \times K$, V (V_{high})	0 mA 1 mA 3 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) $(2 \times I_p)/3$, A (High scale) $2 \times I_p$, A (I_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 3}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{3} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 -0.667 1.00 (Low scale) 0.667 (High scale) 0.0	-3 mA -1 mA 0 mA 1 mA 3 mA	For negative PF: $I_{AO} = -3 \times (1 + PF_{REAL})$ For positive PF: $I_{AO} = 3 \times (1 - PF_{REAL})$	If PF < 0 mA: $PF_{REAL} = -1 - I_{AO}/3$ If PF ≥ 0 mA: $PF_{REAL} = 1 - I_{AO}/3$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 0.333 (High scale) 1.00 (PF_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 3}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{3} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 33 Hz (High scale) 99 Hz (f_{high})	0 mA 1 mA 3 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 3}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{3} + f_{LOW}$	
Active power, kW, P	$-(V_{high} \times I_{high} \times n)$, kW ($P_{low}$) 0 kW, (Low scale) $(V_{high} \times I_{high} \times n)/3$, kW (High scale) $V_{high} \times I_{high} \times n$, kW ($P_{high}$)	-3 mA 0 mA 1 mA 3 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 6}{P_{HIGH} - P_{LOW}} - 3$	$P_{REAL} = (I_{AO} + 3) \times (P_{HIGH} - P_{LOW})/6 + P_{LOW}$	$I_{high} = 2 \times I_p$ n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 6}{Q_{HIGH} - Q_{LOW}} - 3$	$Q_{REAL} = (I_{AO} + 3) \times (Q_{HIGH} - Q_{LOW})/6 + Q_{LOW}$	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/3$, kVA, (High scale) $V_{high} \times I_{high} \times n$, kVA ($S_{high}$)	0 mA 1 mA 3 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 3}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{3} + S_{LOW}$	
Power demand	As for apparent power				

For using the entire output range of ±3 mA, set the 1 mA scale in your device to 1/3 of the required full scale output for both uni-directional and bi-directional parameters.

Analog Output 0-5 mA range (0-1 mA option with 400 % overload)

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) $(1.2 \times 690)/5$ = 165.6V (High scale) 1.2×690 = 828V (V_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 5}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{5} + V_{LOW}$	
Voltage, V via PT	0 V (Low scale, V_{low}) $(144 \times K)/5$, V (High scale) $144 \times K$, V (V_{high})	0 mA 1 mA 5 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) $(2 \times I_p)/5$, A (High scale) $2 \times I_p$, A (I_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 5}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{5} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 (Low scale) -0.4 (High scale) -0.50 1.00 0.50 0.0	0 mA 1 mA 1.25 mA 2.5 mA 3.75 mA 5 mA	For negative PF: $I_{AO} = -PF_{REAL} \times 5/2$ For positive PF: $I_{AO} = 5 - PF_{REAL} \times 5/2$	If PF< 2.5 mA: $PF_{REAL} = -I_{AO} \times 2/5$ If PF≥ 2.5 mA: $PF_{REAL} = (5 - I_{AO}) \times 2/5$	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 0.200 (High scale) 1.00 (PF_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 5}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{5} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 20 Hz (High scale) 100 Hz (f_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 5}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{5} + f_{LOW}$	
Active power kW, P	$-(V_{high} \times I_{high} \times n)$, kW (Low scale, P_{low}) $-(V_{high} \times I_{high} \times n)/5$, kW (High scale) 0 kW $V_{high} \times I_{high} \times n$, kW ($P_{high}$)	0 mA 1 mA 2.5 mA 5 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 5}{P_{HIGH} - P_{LOW}}$	$P_{REAL} = \frac{I_{AO} \times (P_{HIGH} - P_{LOW})}{5} + P_{LOW}$	$I_{high} = 2 \times I_p$ n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 5}{Q_{HIGH} - Q_{LOW}}$	$Q_{REAL} = \frac{I_{AO} \times (Q_{HIGH} - Q_{LOW})}{5} + Q_{LOW}$	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) $(V_{high} \times I_{high} \times n)/5$, kVA, (High scale) $V_{high} \times I_{high} \times n$, kVA ($S_{high}$)	0 mA 1 mA 5 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 5}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{5} + S_{LOW}$	
Power demand	As for apparent power				

For using the entire output range of 5 mA, set the 1 mA scale in your device to 1/5 of the required full scale output for uni-directional parameters, and set the 0 mA scale to the negative full scale and the 1 mA scale to 1/5 of the negative full scale for bi-directional parameters.

Analog Output ±5 mA range (±1 mA option with 400% overload)

Parameter	Programmable scales (Low scale and High scale), output limits (low and high) and typical points, natural units	Analog output, mA	Output current calculation, I_{AO}, mA	Real (measured) parameter calculation	Notes
Voltage, V No PT	0 V (Low scale, V_{low}) (1.2 × 690)/5 = 165.6V (High scale) 1.2 × 690 = 828V (V_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 5}{V_{HIGH} - V_{LOW}}$	$V_{REAL} = \frac{I_{AO} \times (V_{HIGH} - V_{LOW})}{5} + V_{LOW}$	
Voltage via PT	0V (Low scale, V_{low}) (144 × K)/5, V (High scale) 144 × K, V (V_{high})	0 mA 1 mA 5 mA			K = PT ratio
Current I	0 A (Low scale, I_{low}) (2 × I_p)/5, A (High scale) 2 × I_p, A (I_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 5}{I_{HIGH} - I_{LOW}}$	$I_{REAL} = \frac{I_{AO} \times (I_{HIGH} - I_{LOW})}{5} + I_{LOW}$	I_p = CT primary current, Multiplier 2 for 100% overload
Signed power factor, PF	-0.0 -0.667 1.00 (Low scale) 0.667 (High scale) 0.0	-5 mA -1 mA 0 mA 1 mA 5 mA	For negative PF: I_{AO} = -5 x (1 + PF_{REAL}) For positive PF: I_{AO} = 5 x (1 - PF_{REAL})	If PF < 0 mA: PF_{REAL} = -1 - I_{AO}/5 If PF ≥ 0 mA: PF_{REAL} = 1 - I_{AO}/5	
Lag and lead power factor, PF	0.00 (Low scale, PF_{low}) 0.333 (High scale) 1.00 (PF_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(PF_{REAL} - PF_{LOW}) \times 5}{PF_{HIGH} - PF_{LOW}}$	$PF_{REAL} = \frac{I_{AO} \times (PF_{HIGH} - PF_{LOW})}{5} + PF_{LOW}$	
Frequency, f	0 Hz (Low scale, f_{low}) 20 Hz (High scale) 100 Hz (f_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(f_{REAL} - f_{LOW}) \times 5}{f_{HIGH} - f_{LOW}}$	$f_{REAL} = \frac{f_{AO} \times (f_{HIGH} - f_{LOW})}{5} + f_{LOW}$	
Active power, kW, P	-(V_{high} × I_{high} × n), kW (P_{low}) 0 kW, (Low scale) (V_{high} × I_{high} × n)/5, kW (High scale) V_{high} × I_{high} × n, kW (P_{high})	-5 mA 0 mA 1 mA 5 mA	$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 10}{P_{HIGH} - P_{LOW}} - 5$	P_{REAL}= (I_{AO} + 5) × (P_{HIGH} - P_{LOW})/10 + P_{LOW}	I_{high}= 2 × I_p n=3 for 3LN3, 4LN3 and 3BLN3 configurations, n = 2 for other configurations
Reactive power kvar, Q	As for active power		$I_{AO} = \frac{(Q_{REAL} - Q_{LOW}) \times 10}{Q_{HIGH} - Q_{LOW}} - 5$	Q_{REAL}= (I_{AO} + 5) × (Q_{HIGH} - Q_{LOW})/10 + Q_{LOW}	
Apparent power kVA, S	0 kVA (Low scale, S_{low}) (V_{high} × I_{high} × n)/5, kVA, (High scale) V_{high} × I_{high} × n, kVA (S_{high})	0 mA 1 mA 5 mA	$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 5}{S_{HIGH} - S_{LOW}}$	$S_{REAL} = \frac{I_{AO} \times (S_{HIGH} - S_{LOW})}{5} + S_{LOW}$	
Power demand	As for apparent power				

For using the entire output range of ±5 mA, set the 1 mA scale in your device to 1/5 of the required full scale output for both uni-directional and bi-directional parameters.

Calculation Examples

Example 1

The meter is installed on a 24 kV power line with 400:5A current transformers and 24,000:120V potential transformers:

I_p = CT primary current = 400A and 3-phase

K = PT ratio = 24000/120 = 200.

Wiring configuration is 4Ln3, n = 3.

The full-scale analog output ranges are as follows:

Voltage:

Low voltage V_{low} = 0 V.

High voltage $V_{high} = 144 \times K = 144 \times 200 = 28800$ V.

Current:

Low current I_{low} (0 or 4 mA) = 0 A,

High current $I_{high} = 2 \times I_p = 2 \times 400 = 800$ A

Active and reactive power:

Low power $P_{low} = - n \times V_{high} \times I_{high} /1000 = -3 \times 28800 \times 800/1000 = -69,120$ kW (kvar)

High power $P_{high} = n \times V_{high} \times I_{high} /1000 = 3 \times 28800 \times 800/1000 = 69,120$ kW (kvar)

The programmable analog output scales should be as follows:

Voltage:

Low scale, 0 mA/4 mA (all ranges): 0 V.

High scale, 1 mA/20 mA (4-20 mA, 0-20 mA, 0-1mA, ±1 mA ranges): V_{high}= 28800 V.

High scale, 1 mA (0-2 mA, ±2 mA ranges): V_{high}/2 = 28800/2 = 14400 V.

High scale, 1 mA (0-3 mA, ±3 mA ranges): V_{high}/3 = 28800/2 = 9600 V.

Current:

Low scale, 0 mA/4 mA (all ranges): 0 A.

High scale, 1 mA/20 mA (4-20 mA, 0-20 mA, 0-1mA, ±1 mA ranges): I_{high}= 800 A.

High scale, 1 mA (0-2 mA, ±2 mA ranges): I_{high}/2 = 800/2 = 400 A.

High scale, 1 mA (0-3 mA, ±3 mA ranges): I_{high}/3 = 800/3 = 267 A.

Active and reactive power:

Low scale, 0 mA/4 mA (4-20 mA, 0-20 mA, 0-1 mA, 0-2 mA, 0-3 mA ranges): P_{low} = -69,120 kW (kvar).

Low scale, 0 mA (±1 mA, ±2 mA, ±3 mA range): P_{low} = 0 kW (kvar).

High scale, 1 mA/20 mA (4-20 mA, 0-20 mA, 0-1mA, ±1 mA ranges): P_{high} = 69,120 kW (kvar).

High scale, 1 mA (0-2 mA range): 0 kW (kvar).

High scale, 1 mA (±2 mA range): P_{high}/2 = 69,120/2 = 34560 kW (kvar).

High scale, 1 mA (0-3 mA range): P_{low} /3 = -69,120/3 = -11520 kW (kvar).

High scale, 1 mA (±3 mA range): P_{high}/3 = 69,120/3 = 11520 kW (kvar).

Example 2

The meter with regular ±1 mA analog outputs (100% overload) is installed on the power line of Example 1. The analog outputs are programmed in the meter for the ±1 mA output range.

What should the analog output currents be if the instrument shows the following measured (real) quantities?

Voltage = 24,800 V

Current = 460A

Active power P_{TOTAL} = 17170 kW

Apparent power S_{TOTAL} = 19736 kVA

The output currents would be as follows:

Voltage output: $$I_{AO} = \frac{V_{REAL} - V_{LOW}}{V_{HIGH} - V_{LOW}} = \frac{24800 - 0}{28800 - 0} = 0.861\text{mA}$$

Current output: $$I_{AO} = \frac{I_{REAL} - I_{LOW}}{I_{HIGH} - I_{LOW}} = \frac{460 - 0}{800 - 0} = 0.575\text{ mA}$$

Active power output: $$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 2}{P_{HIGH} - P_{LOW}} - 1 = \frac{((17170 - (-69120)) \times 2}{69120 - (-69120)} - 1 = 0.248\text{ mA}$$

Apparent power output: $$I_{AO} = \frac{S_{REAL} - S_{LOW}}{S_{HIGH} - S_{LOW}} = \frac{19736 - 0}{69120 - 0} = 0.286\text{mA}$$

Example 3

The meter with regular ±1 mA analog outputs (100% overload) is installed on the power line of Example 1. The analog outputs are programmed in the meter for the ±2 mA output range.

What should the analog output currents be if the instrument shows the measured (real) quantities like in Example 2?

The output currents would be as follows:

Voltage output: $$I_{AO} = \frac{(V_{REAL} - V_{LOW}) \times 2}{V_{HIGH} - V_{LOW}} = \frac{(24800 - 0) \times 2}{28800 - 0} = 1.722\text{mA}$$

Current output: $$I_{AO} = \frac{(I_{REAL} - I_{LOW}) \times 2}{I_{HIGH} - I_{LOW}} = \frac{(460 - 0) \times 2}{800 - 0} = 1.15\text{mA}$$

Active power output: $$I_{AO} = \frac{(P_{REAL} - P_{LOW}) \times 4}{P_{HIGH} - P_{LOW}} - 2 = \frac{((17170 - (-69120)) \times 4}{69120 - (-69120)} - 2 = 0.497\text{mA}$$

Apparent power output: $$I_{AO} = \frac{(S_{REAL} - S_{LOW}) \times 2}{S_{HIGH} - S_{LOW}} = \frac{(19736 - 0) \times 2}{69120 - 0} = 0.571\text{mA}$$

Example 4

The meter with regular ±1 mA analog outputs (100% overload) is installed on the power line of Example 1. The analog outputs are programmed in the meter for the ±2 mA output range.

Which real electrical quantities does the meter measure if the analog output currents are as follows?

Voltage analog output I_{AO1} = 0.861 mA

Current analog output I_{AO2} = 1.15 mA

Active power analog output I_{AO3} = 0.497 mA

Apparent power analog output I_{AO4} = 0.571 mA

The meter readings would be as follows:

Measured voltage: $V_{REAL} = I_{AO} \times (V_{HIGH} - V_{LOW})/2 + V_{LOW}$ = 0.861 x (28800 - 0)/2 + 0= 12398 V

Measured current: $I_{REAL} = I_{AO} \times (I_{HIGH} - I_{LOW})/2 + I_{LOW}$ = 1.15 x (800 - 0)/2 + 0 = 460 A

Measured active power: $P_{REAL} = (I_{AO} + 2) \times (P_{HIGH} - P_{LOW})/4 + P_{LOW}$ = (0.497 + 2) x (69120 – (-69120))/4 + (-69120) =17176 kW

Measured apparent power: $S_{REAL} = I_{AO} \times (S_{HIGH} - S_{LOW})/2 + S_{LOW}$ = 0.571 x (69120 – 0)/2 + 0 = 19734 kVA