

Scaling formulas

Signal from PV	$I = 4 + 16 \times (PV - LRV) \div (URV - LRV)$
PV from signal	$PV = LRV + (I - 4) \div 16 \times (URV - LRV)$
Percent of span	$\% = (I - 4) \div 16 \times 100$
Signal from percent	$I = 4 + 0.16 \times \%$
Across 250 Ω	4 to 20 mA gives 1 to 5 V

Percent to mA

%	mA	V (250 Ω)
0	4.00	1.00
10	5.60	1.40
25	8.00	2.00
50	12.00	3.00
75	16.00	4.00
90	18.40	4.60
100	20.00	5.00

Square root (DP flow)

Flow from DP	$Q\% = 10 \times \sqrt{(DP\%)}$
Signal	$I = 4 + 16 \times \sqrt{(DP \div DP_{max})}$
DP from flow	$DP\% = (Q\%)^2 \div 100$
Example	25 % DP = 50 % flow = 12 mA

Apply square root once only: in the transmitter or in the DCS, never both. Use a low flow cut off (typically 5 to 10 % flow).

NAMUR NE 43 signal levels

Range	Meaning
3.8 to 20.5 mA	Valid measurement (saturation limits)
≤ 3.6 mA	Failure, downscale
≥ 21.0 mA	Failure, upscale
3.6 to 3.8 or 20.5 to 21.0 mA	Undefined; treat as suspect

Loop power

Supply needed	$V_s \geq V_{tx,min} + I_{max} \times (R_{load} + R_{cable} + R_{barrier})$
Maximum loop resistance	$R_{max} = (V_s - V_{tx,min}) \div I_{max}$
Use I_{max}	about 22 to 23 mA (alarm current, from the data sheet)

HART essentials

- Digital signal: FSK, 1200 Hz = 1, 2200 Hz = 0, about 1 mA peak to peak on top of the analog signal
- Loop needs at least 230 Ω (250 Ω typical) for HART communication
- Multidrop: transmitters fixed at 4 mA, polling addresses 1 to 63
- Up to 4 variables: PV, SV, TV, QV

PLC raw count scaling

General	$PV = LRV + (raw - raw_{min}) \div (raw_{max} - raw_{min}) \times span$
Siemens S7 (4 to 20 mA)	0 to 27648 = 0 to 100 %
16 bit unsigned	0 to 65535

Quick fault finding

Reading	Likely cause
0 mA	Open loop, no supply, blown fuse
3.6 mA or less	Transmitter fault (downscale alarm)
Stuck at 4 mA	Wrong range, isolated or blocked impulse line
Over 20.5 mA	Over range or upscale alarm
Noisy reading	Shield earthed at both ends, AC nearby, poor terminal

2 wire, 3 wire, 4 wire

- 2 wire: loop powered, signal and power share two wires
- 3 wire: common negative for supply and signal
- 4 wire: separate mains or 24 V supply, active output
- Live zero (4 mA) detects broken wires; 0 to 20 mA cannot