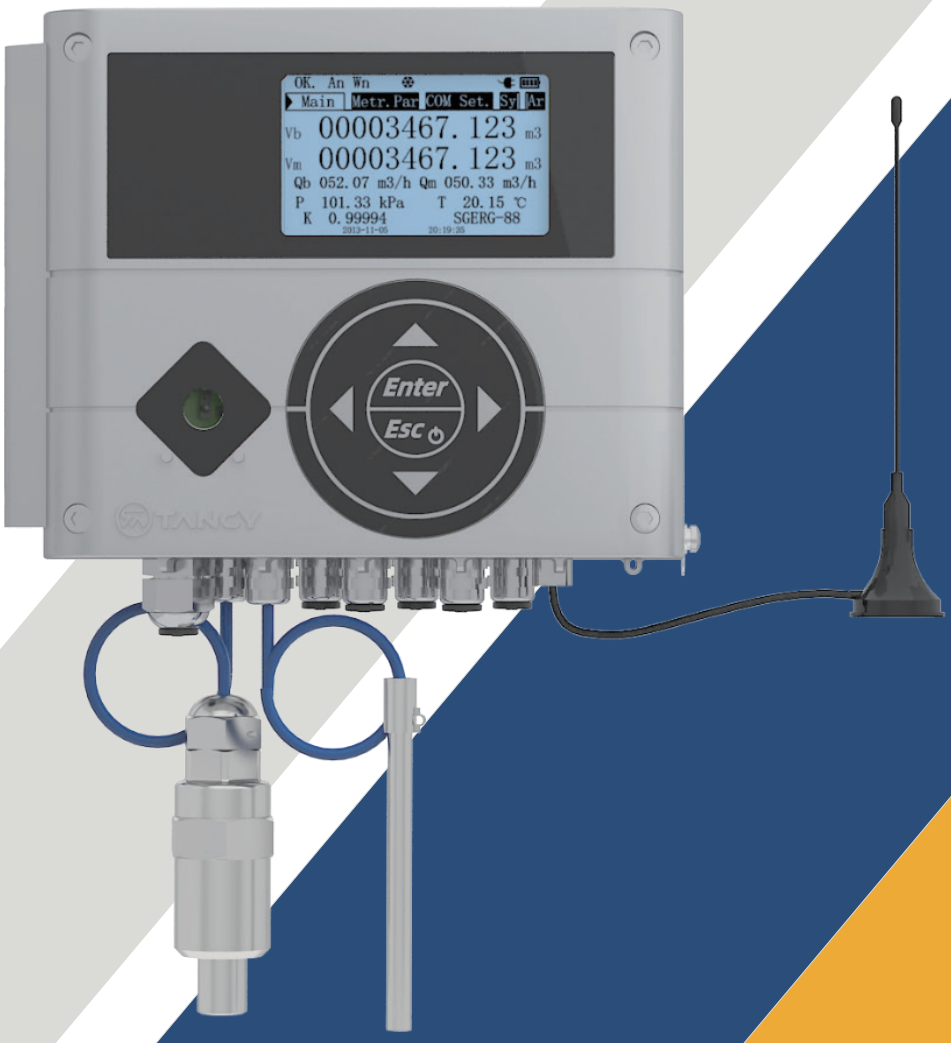
TEC-III

Gas Volume Conversion Device
Operation Manual



V1.1

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Quotation: Definition of Symbols

Symbol	Meaning	Unit
V_m	Volume at measurement(metering) conditions	m^3
V_mD	Disturbed volume at measurement conditions	m^3
V_mT	Total volume at measurement conditions	m^3
V	Corrected volume	m^3
V_b	Volume at reference conditions	m^3
V_bD	Disturbed volume at reference conditions	m^3
V_bT	Total volume at reference conditions	m^3
Q_m	Flow at measurement conditions	m^3/h
Q_b	Flow at base conditions	m^3/h
Q_e	Flow rate of energy	MJ/h
E	Volume of energy	MJ
ET	Total volume of energy	MJ
Q_{max}	Maximum flow at measurement conditions	m^3/h
Q_{min}	Minimum flow at measurement conditions	m^3/h
C	Conversion factor	
K	ratio of compressibility factors: (Z/Z_b)	
Z	Compressibility factor of the gas at measurement conditions	
Z_b	Compressibility factor of the gas at reference conditions	
P	Absolute pressure at measurement conditions	kPa, MPa or bar
P_b	Absolute pressure at reference conditions	kPa, MPa or bar
P_{max}	Maximum gas absolute pressure	kPa, MPa or bar
P_{min}	Minimum gas absolute pressure	kPa, MPa or bar
T	Absolute temperature at measurement conditions (T=t+273.15)	K
T_b	Absolute temperature at reference conditions (T=t+273.15)	K
t	Gas Celsius temperature	°C
t_{max}	Maximum gas temperature	°C
t_{min}	Minimum gas temperature	°C
R_H	Relative humidity (media) at measurement conditions	
R_Hb	Relative humidity at reference conditions	
H_s	Superior calorific value	MJ/m^3

1. INTRODUTION

Gas volume conversion device TEC-III （Hereinafter referred to as EVC）is a device used for measurements of gas volume at base conditions and energy. The correction modes can be set as temperature correction (T), pressure & temperature correction (PT), and pressure & temperature & compressibility correction (PTZ) according to requirement. For PTZ correction, K value can be calculated by AGA8-92DC, SGERG-88, AGA8-G1, AGA8-G2, AGA NX-19 algorithms or set as constant, which is optional. It can be utilized in trade and business measurement cooperate with rotary and turbine gas meters.

TEC-III is designed and produced according to standard EN 12405-1:2021 and EN 12405-2:2012. It complies with CE certification and follows EU directives:

WELMEC 7.2,2022 "Software Guide"(EU Measuring Instruments Directive 2014/32/EU).

WELMEC 11.1,2022 "Common Application for Utility Meters" (EU Measuring Instruments Directive 2014/32/EU).

ATEx DIRECTIVE 2014/34/EU includes intrinsic safety explosion-proof standard EN60079-0, EN60079-11 and EN60079-26.

Housing protection follows IP66 of standard EN60529.

In fully equipped device a Configuration of TEC-III offers:

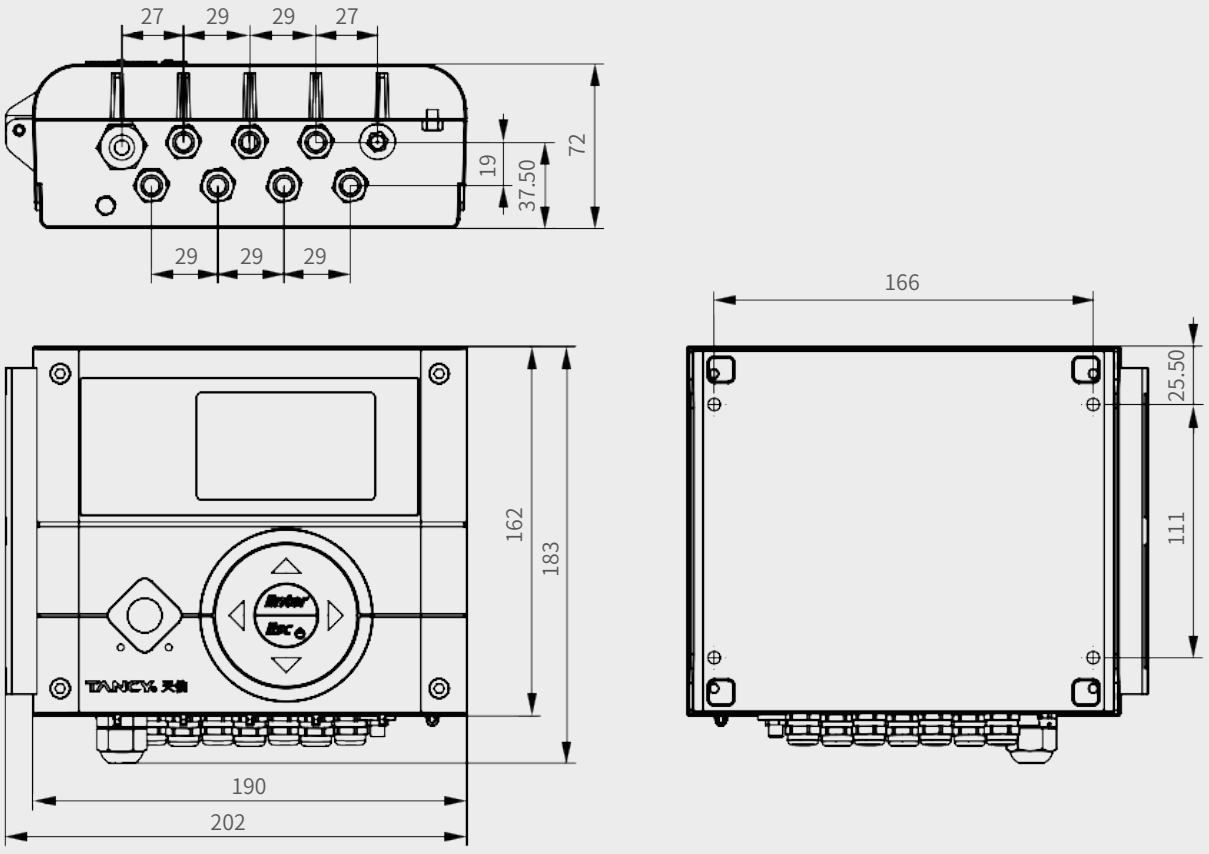
- Digital Pressure Input (Pressure P- metrological channel).
- Digital Temperature Input (Temperature T - metrological channel).
- Up to 7 Configurable Inputs:
  - 2 LF measuring inputs, Reed switch inputs（S1, S2）, frequency up to 2Hz,
  - 2 TS inputs-tamper switch（magnetic interference detection），normally closed（TS1, TS2），
  - 1 HF measuring inputs, with maximum signal frequency up to 5kHz: NAMUR（HF+, HF-），
  - Binary input (DI1, DI2).
- Up to 4 Outputs of “Open Collector” Type:
  - DO1: Output mode can be configured as binary or frequency (1 Hz ～ 5000 Hz),
  - DO2~DO4: Output mode can be configured as binary.
- -Communications:
  - COM1: standard RS-485/ RS-232, active with external power supply,
  - COM2: standard RS-485, active with battery supply（A2, B2 for specific LF communication），
  - COM3: optical interface, standard IEC 62056-21,
  - GSM 2G/3G, 4G, and NB-IoT modem (Optional),
  - Bluetooth 5.0: radio interface (Customizable),
- Input of External Power Supply.
- Additional SCR input for Photoelectric counter encoder (optional, inputs from A2, B2, depend on counter support)
- Additional absolute pressure built-in temperature sensor p2 sensor (optional in non-MID version, inputs from A2, B2, for pressure and temperature reference)
- Additional 4mA ～ 20mA two-wire analogue current output (optional in non-MID version)

The device can be configured using the supplied TEC configured PC software provided by us. This software is also able to read, display and archive both the immediately measured values as well as the contents of internal device archives.

2. Structure and Operating Principle

2.1 Device Structure

2.1.1 Device External Dimension



2.1.2 Device Internal Structure

The device consists of two parts:

- Components in upper cover of the device include processor board, LCD module and touch key panel, all protected by upper cover and metrological lock switch; the processor board consists of processor, memory, interfaces with LCD display, 6 button keyboard, optical communication interface and Bluetooth module. See Figure 2.
- Components in subplate at the bottom of the casing include input/output connector (including temperature sensor input, pressure sensor input, signal input, digital input and output, communication port terminal and external power supply terminal), battery(main battery and IoT battery), 4-20mA current output module and IoT module. The connectors related to metrology are protected by a special cover and fixed by a metrological sealing element. See Figure 3 and 4.

The device is optionally equipped with 2G, 4G or NB-IoT Modem and 4-20mA current output modules. The Modem is installed at subplate, while antenna connector is extended to outside.

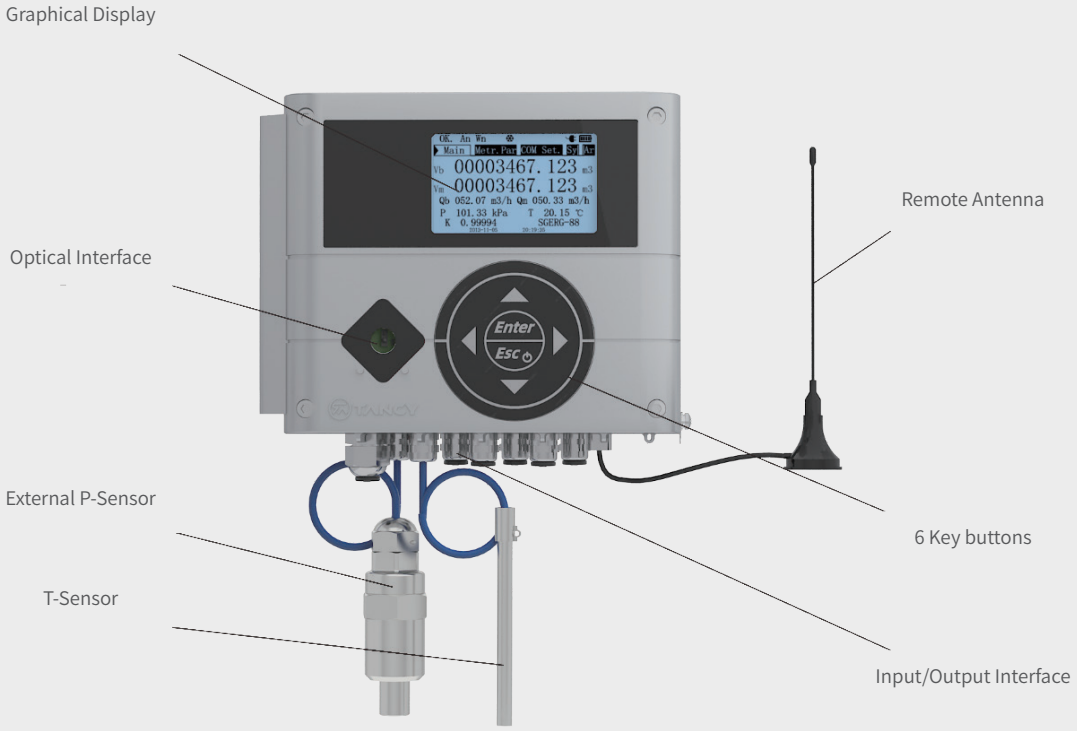


Figure 2 TEC appearance and structure

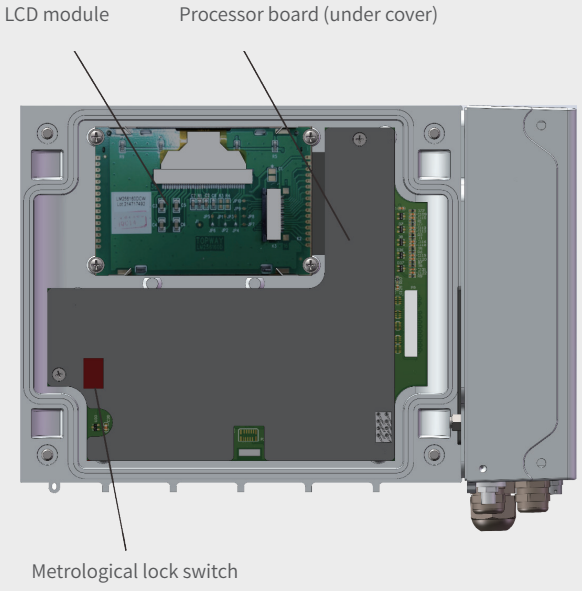


Figure 3 Internal structure of front cover

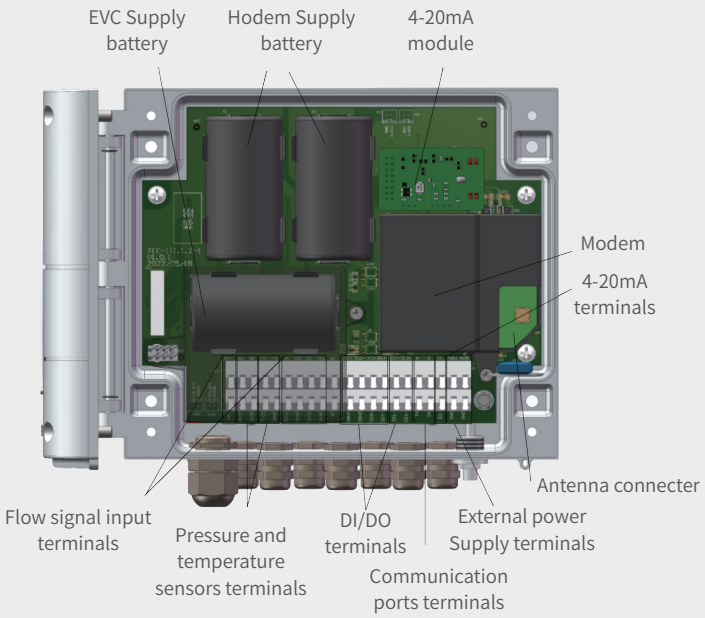


Figure 4 Internal structure of rear cover

2.1.3 Sealing

Seals inside devices includes MID seals, user seal and manufacture seal.

Certificated by third-party metrological verification organization, MID seals are utilized to protect metrological hardware circuits and relevant circuits of interface. If destroyed, MID seals would not ensure the overall performance of the device.

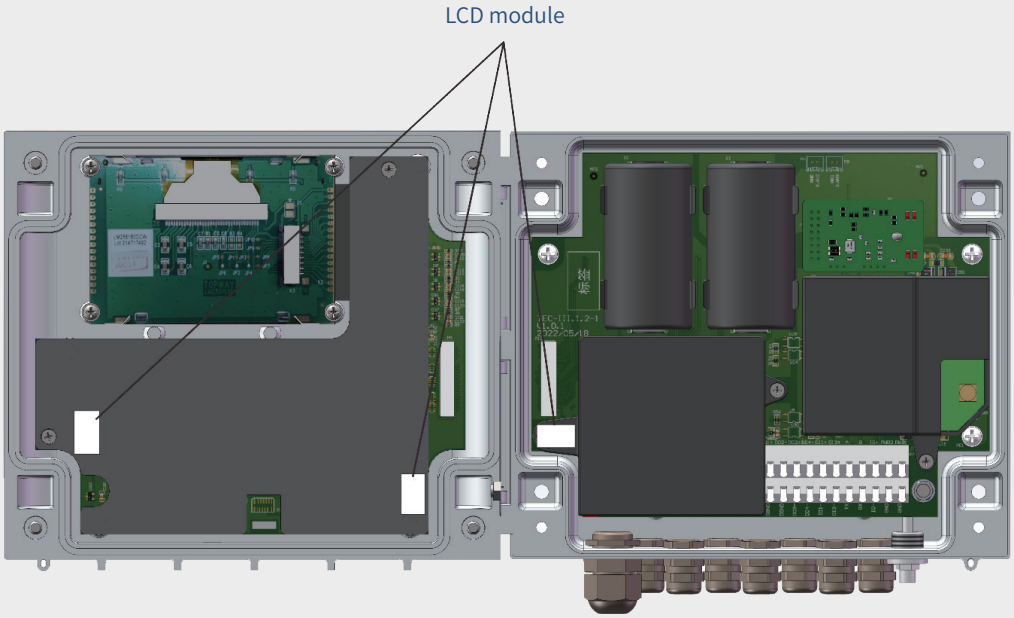


Figure 5 Sealing

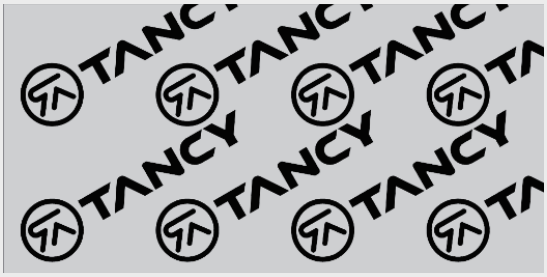


Figure 6. Example of MID and Manufacture sealing mark sticker

2.1.4 Nameplates

1) Basic type (without IoT modem) accords with Ex II 1G Ex ia IIB T4 Ga.

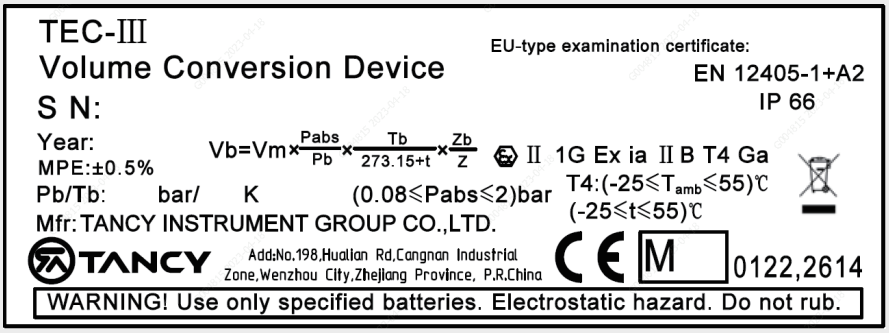


Figure 7. Nameplate reference figure 1

2) Remote type accords with Ex II 2G Ex ib IIB T3 Gb.

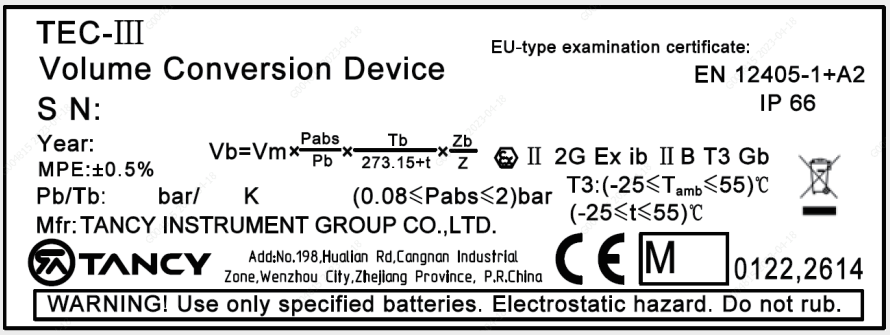


Figure 8. Nameplate reference figure 2

2.2 Operating Principle

The gas meter measures gas volume at measurement conditions (V_m) under specific pressure (P) and temperature (T) conditions. This gas volume (V_m) is converted into a volume (V_b) at base/reference conditions by TEC-III according to EN 12405:

$$V_b = V_m \times \frac{P}{P_b} \times \frac{T_b}{T} \times \frac{Z_b}{Z} = V_m \times \frac{P}{P_b} \times \frac{T_b}{T} \times \frac{1}{K} = V_m \times C$$

By calculating the flow pulse signal received from meter’s output in accordance with set meter coefficient, the device figures out the flow and total volume at measurement condition. Meanwhile, by reading the values indicated in temperature and pressure sensors, the device figures out the pressure and temperature at measurement condition and convert those values into flow, total volume and conversion factor at measurement condition through opted compressibility factor model and volume conversion model. The device will also accomplish operations such as monitoring alarm and data communication on the basis of other set functions.

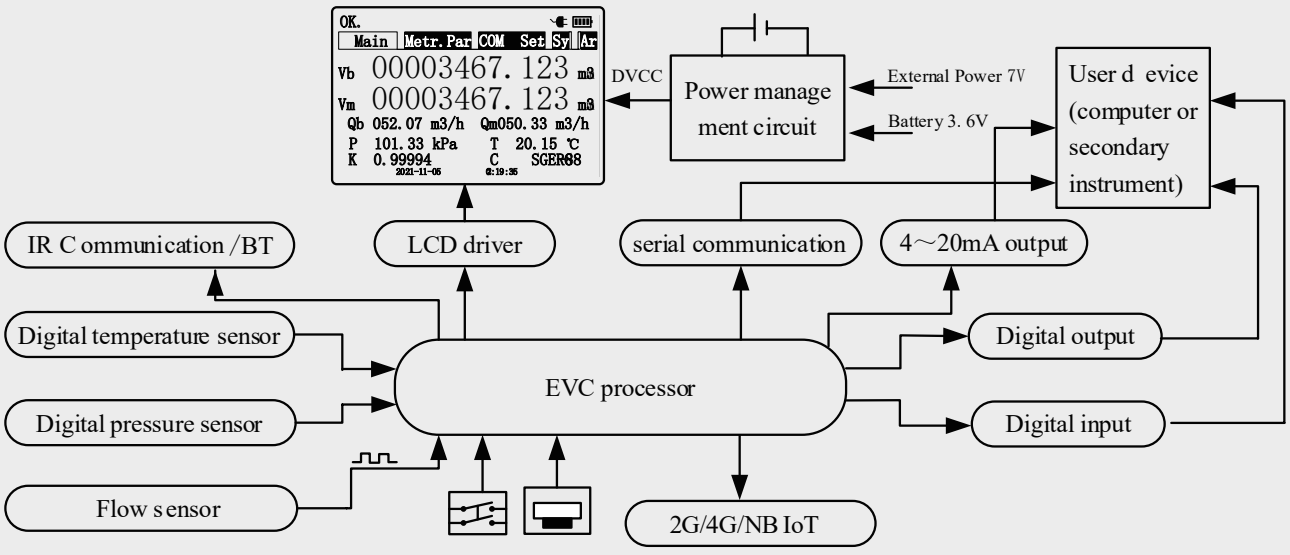


Figure 9 Principle framework

2.2.1 General Characteristics

- Device is equipped with 256×160 monochromatic dot matrix LCD display, which facilitates users to read and operate.
- The measurement is based on the volume counted at measurement condition and the pulse quantity from LF or HF sensors installed on the top of gas meter.
- External sensors the device measure gas pressure and temperature and can easily adjusted to different position during installation.
- The device not only measures and calculates current parameters, but also archives selected parameters and registered alarm status for future read.
- The device archives selected parameters and registered alarm status for analysis.
- Integrated LCD display and keyboard can monitor current measuring data, peak value and active alarm, and can adjust basic operating parameters such as time & date, measuring input limit and transmission parameters. The access permission is required when user adjusts parameters through keyboard and transmission.
- Integrated LCD display is used to view the live parameters reading, active alarm, peak value and keyboard is used to adjust/ configure basic operating parameters such as time & date, and transmission parameters, etc.
- The device is powered by its internal battery which can serve for 6 year or by external power supply. At typical operating condition, a group of IoT modem batteries can serve for 6 years.
- A device is powered by its internal battery which serves for 6 years in certain conditions, and it can also be powered by external power supply. IoT modem’ s batteries can serve for 6 years in certain conditions.

2.2.2 Measurement and Calculation Cycle

TEC-III operates on default at following measurement and calculation cycle:

- Every 30 seconds-when operating in BATT mode (powered by internal battery)
- Every 2 seconds-when operating in EPWR mode (powered by external power supply)
- Every 2 seconds- when LCD display is turned on (in all power modes)
- The frequency of above cycles can be set within 6-60s at BATT mode or 2-60s at EPWR mode respectively.
- During each cycle, at first step device performs read of data about values of all measuring inputs and calculates increments from chosen counting input. Basing on this input data, TEC-III calculates the increment of volume at measurement conditions dV_m, adds it up to counter V_m and calculates flow at measurement conditions Q_m. At the same time, device also checks whether new alarms have occurred or previous alarm situation have been closed.
- During each cycle, a first step device performs to read value of all measuring inputs and calculates increments of chosen counting inputs. Basis on this input data, TEC-III calculates the volume increment (dV_m) at measurement conditions, adding it to counter (V_m) and calculates flow (Q_m) at measurement conditions. At the same time, device also checks whether new alarms have occurred, or previous alarm situations have been closed.
- In next step, basing on the current values of pressure P, temperature T and programmed gas component parameters, unit calculates conversion factor C and then increment of volume at base conditions dVb and flow Q_b. Simultaneously there are calculated values of: V_b, dE, Q_e, E.
- In next step, device calculates conversion factor (C) basis on the current values of pressure (P), temperature (T), and configured gas component parameters and then device performs volume increment (dV_b) at base conditions, adding it to counter (V_b) and calculates flow (Q_b). Simultaneously device calculates dE, Qe and E for Energy.

2.3 Mathematical Model of Volume Conversion

Following standard EN12405-1:2021, Model of volume conversion calculates gas volume at reference condition according to Formula 1.

$$V_b = V_m \times \frac{P}{P_b} \times \frac{T_b}{T} \times \frac{Z_b}{Z} = V_m \times \frac{P}{P_b} \times \frac{T_b}{T} \times \frac{1}{K} = V_m \times C \qquad \text{Formula 1}$$

In Formula 1, $V_m = \frac{N}{k_p}$, N refers to the number of pulses generated by flow sensor. kp refers to constant of meter (meter coefficient, m^{-3}). Vm refers to gas volume at measurement condition.

$K = \frac{Z}{Z_b}$, K is the reciprocal of compressibility factor ratio.

$C = \frac{1}{K} \times \frac{P}{P_b} \times \frac{T_b}{T}$, C is conversion coefficient.

The reciprocal of compressibility factor ratio K expresses the deviation of actual gas from ideal gas, the value which can be set as constant or be calculated by mathematical model AGA8-92DC, SGERG-88, AGA8-G1, AGA8-G2 or AGA NX-19.
Flow at measurement condition can be calculated by Formula 2.

$$Q_m = \triangle V_m / \triangle t \ [m^3/h] \qquad \text{Formula 2}$$

In Formula 2, $\triangle V_m$ refers to volume increment at measurement condition.

$\triangle t$ refers to time span between two LF successive pulses; for HF (NAMUR) input, $\triangle t$ refers to measurement cycle.

Flow of gas volume at reference condition can be calculated by Formula 3.

$$Q_b = C \times \triangle V_m / \triangle t \qquad \text{Formula 3}$$

2.4 Correction of Flow Characteristics Curve of Meter

According to the characteristics curve of meter testing result at Measurement Condition, the corrector can correct the deviation of meter to increase the accuracy of volume measurement. After the function of volume correction being activated, the corrected volume V can be calculated by Formula 4, in which f(Q) is a correction function.

$$V = V_0 \times f(Q) \qquad \text{Formula 4}$$

In formula 4, as a function given by meter testing report, f(Q) refers to error characteristics curve relying on flow rate Q. This device can correct f(Q) by linear interpolation with no more than 8 segments.

Caution:

- The function of calibration can only increase the accuracy of volume measurement. An unqualified meter shall not be used as a qualified one even if its f(Q) is calibrated by corrector.
- The f(Q) shall be valid before using this function, for this function can be activated only by manufacturer or verification organization.

2.5 Disturbed Volume and Total Volume

The device will automatically shift to the calculation of volume at disturbed measurement condition VmD and volume at disturbed reference condition VbD when certain error or disturbance occurs (e.g. magnetic interference is detected, alarm occurs or operating range is exceeded). At the same time, the measurement of volume at reference condition Vb is paused while the volume at measurement condition Vm continues to accumulate.

The total volume at measurement condition VmT and total volume at reference condition VbT can be calculated by Formula 5, according to the volume Vm at measurement condition, volume at disturbed measurement condition VmD , volume at reference condition Vb and volume at disturbed reference condition VbD.

$$V_mT = V_m \quad , \quad V_bT = V_b + V_bD \qquad \text{Formula 5}$$

The operating status at normal or abnormal condition:

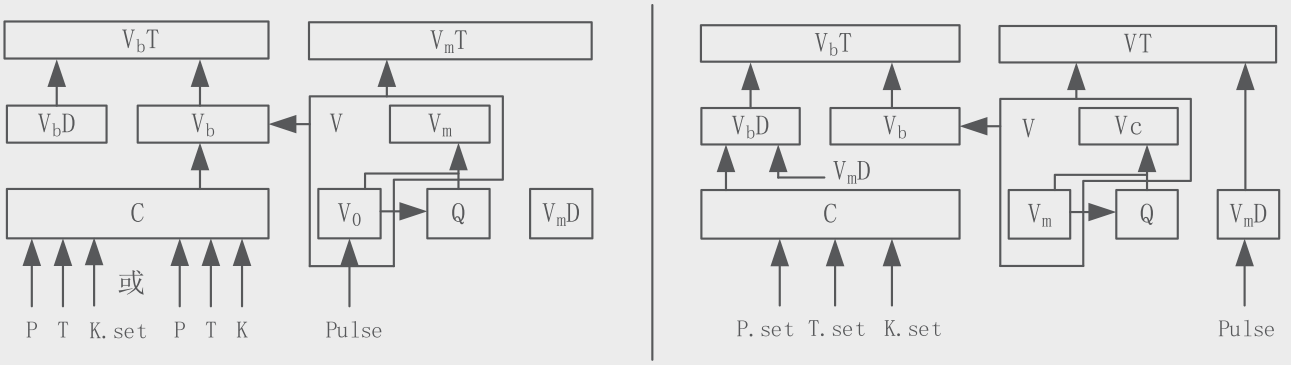


Figure 10 Volume Measurement at Normal Condition

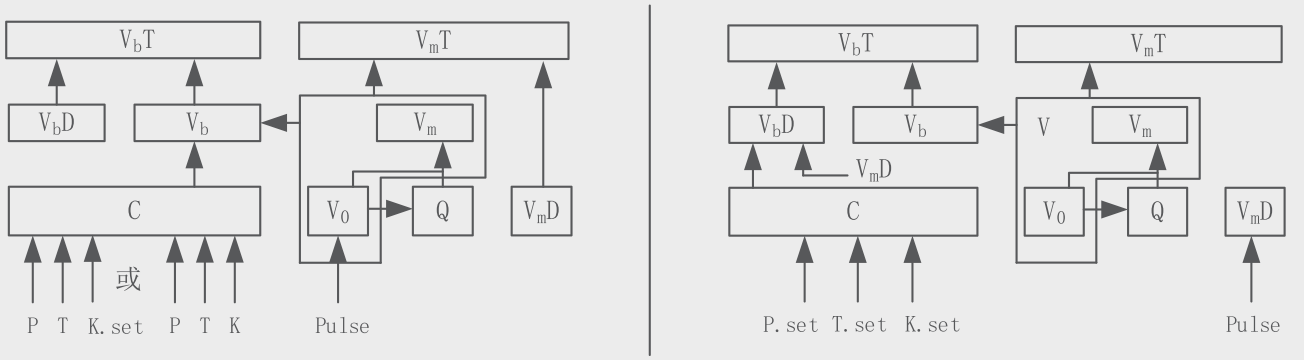


Figure 11 Volume Measurement at Disturbed or Error Occurring Condition

Among them: P.set, T.set, K.set refer to default values of P, T, K.

At normal operating condition, when device runs with PT correction, the ratio of compressibility factor is calculated with default value. At the same time, VmD and VbD are stopped to be measured, while Vm and Vb are directly accumulated to VmT and VbT.

When abnormality occurs, or when disturbances or error measurement occurs, the disturbed measuring value is calculated with default value; and the measuring value or disturbance information will be archived into event log.

2.6 Energy Calculation

$$dV_b \times H_s = dE \qquad \text{Formula 6}$$

dV_b –volume increment at reference condition

H_s –superior calorific value

dE –increment of energy value

The increment dE at normal operating condition will be accumulated to E counter, or to ED counter at disturbed period.

2.7 Corrector mode options

a. PTZ Correction Mode

- With pressure sensor to measures absolute pressure of pipeline gas;
- With temperature sensor to measures temperature of pipeline gas;
- The ratio of compressibility factor is calculated by opted mathematical model (AGA8-92DC, SGERG-88, AGA8-G1/G2 or NX-19 etc.) with input components.

b. PT Correction Mode

- With pressure sensor to measures absolute pressure of pipeline gas;
- With temperature sensor to measures temperature of pipeline gas;
- The ratio of compressibility factor is calculated as a constant.

c. T Correction Mode

- With temperature sensor to measures temperature of pipeline gas;
- The gas pressure is calculated as a constant;
- The ratio of compressibility factor is calculated as a constant.

2.8 Compressibility Calculation

In TEC-III, there is possibility to choose computation algorithm of compressibility factor:

K.mod Value	Name of algorithm
0	SGERG-88 (Hs-d-XCO2-XH2)
1	AGA8-G1 (Hs-d-XCO2)
2	AGA8-G2 (d-XCO2-XN2)
3	AGA8-92DC (full gas composition)
4	AGA NX19-mod (d-XCO2-XN2)
5	K.mod=const.

Sheet 1 Calculation of Compressibility Factor

When using algorithms SGERG-88, AGA8-G1, AGA8-G2, AGA NX-19mod and K1 = const., device requires programming of parameters values such as calorific value Hs and relative density d to be adequate for currently set reference conditions (Tb and pb) for volume calculation and reference conditions for combustion (T1 and P1, here always P1 = Pb). Reference conditions in many European countries: Pb = 1.01325 bar; Tb = 273.15 K; T1 = 298.15 K. when programming full gas composition, no further recalculations are necessary.

Despite the algorithms AGA8-G2 and AGA NX-19mod do not use calorific value Hs for calculation of compressibility factor, it must be programmed, because it is necessary for correct computing energy counter.

According to selected computing algorithm, device requires programming full gas composition or few specific gas parameters.

2.9 Pressure Measurement

TEC-III has one channel external pressure sensor TB148 certified by MID for billing. Optionally add a channel non-MID certified pressure sensor p2 with internal integrated temperature sensor for metering reference. And them inputs the value through I2C/RS485 interface to participate in volume conversion or for other uses. In particular, the diagram of temperature coefficient correction in the pressure sensor is modified by several temperature curves, and the corrected coefficient is stored in EEPROM memory of the pressure sensor, therefore, the pressure sensor can be replaced without restriction.

Measuring ranges:	**Maximum permissible errors for measurements of P and p2**	
	Ambient temperature	
	20 ° C (± 3 ° C)	(-25 ～ +55) ° C (-25 ～ +70) ° C non-MID
(0,8 ～ 2) bar abs1 (1 ～ 5) bar abs1 (2 ～ 10) bar abs1 (4 ～ 20) bar abs1 (10 ～ 50)bar abs2 (20 ～ 100)bar abs2 (0.8 ～ 10) bar abs3 (4 ～ 100) bar abs3	**Measurement of gas pressure P (for billing) or p2 (auxiliary, optional)**	
	± 0,2 % of measured value	± 0,5 % of measured value
Extended ranges without MID certified for pressure P or p2 (auxiliary, optional, non-MID)		
(0,8 ～ 5) bar abs (0.8 ～ 20) bar abs (1 ～ 35) bar abs (1 ～ 50) bar abs (2 ～ 70)bar abs (5 ～ 120)bar abs	± 0,2 %FS when lower 20% Pmax Others ± 0,2 % of measured value	± 0,5%FS when lower 20% Pmax Others ± 0,5% of measured value

Sheet 2 Measurement error of pressure sensor

1 – range of indications from 0.7 bar

2 – range of indications from atmospheric pressure

3 – range extended pressure sensor that can be customized

2.10 Temperature Measurement

TEC-III has one channel external temperature sensor for billing. And it inputs the value through I2C or RS485 interface to participate in volume conversion.

Measurement of gas temperature t	**Maximum permissible errors for measurements of t**	
	Ambient temperature	
	20 ° C (± 3 ° C)	(-25 ～ +55) ° C (-25 ～ +70) ° C non-MID
(-30 ～ +80) ° C	± 0,1 %	± 0,2 %

Sheet 3 Measurement error of temperature sensor

values of errors referred to correct values of temperature, expressed in [K].

3. Specification and Function

3.1 Measurement Characteristics

The device is only equipped with function of one-way volume conversion.

3.1.1 Maximum permissible Error Limit

The comprehensive Maximum permissible error is according standard EN 12405-1:2021.

Ambient temperature	20 ° C (±3 ° C)	(-25 ～ +55) ° C (-25 ～ +70) ° C non-MID
Maximum permissible errors	± 0,5 %	± 1.0%

Sheet 4 Maximum permissible error of EVC

3.1.2 Pressure Transmitter

Main specifications are as follows:

a. Type TB148 for P (I2C interface, external installation, cable length ⩽ 3m);

b. Type SRP-10 for p2 (RS485 interface, external installation, external power is recommended);

c. Overload: ⩽ 1.5P_{max} (Measuring range below 20bar.a);

⩽ 1.25P_{max} (Measuring range above 20bar.a);

-Pmax refers to upper limit of measurement range.

d. Operating Temperature Range: -30°C～ +70°C ;

e. Power supply range: 3V ～ 5V DC;

f. Casing Material: 316 stainless steel;

g. Installed screw thread: 1/4 NPT

3.1.3 Temperature Transmitter

a. Type: TB147 (default, I2C interface, cable length ⩽ 3m) or
SRT-C (optional, PT1000, RS485 interface, external power is recommended);

b. Measurement Range: -30°C～ +80°C ;

c. Power supply range: 3V ～ 5V DC;

d. Casing Material: 316 stainless steel;

e. external diameter: ϕ6;

(The length of temperature body is selected according to the type of meter)

3.2 Operating Condition

a. Environmental Temperature: -25°C～ +55°C or -25°C～ +70°C without MID certified;

b. Relative Humidity: 5% ～ 95%;

c. Atmosphere Pressure: 0.7 bar ～ 1.06 bar (absolute pressure).

3.3 Storage Condition

a. Environmental Temperature: -40 °C～ +80 °C ;
b. less than 90% of relative humidity (without condensation);
c. Atmosphere Pressure: 0.7 bar ～ 1.06 bar (absolute pressure).

3.4 Power Supply and Life Span

Warning: TEC-III is an intrinsically safe instrument and can be operated in potentially explosive atmosphere. The housing of the device should be sealed- replacement of the battery can only be carried out by an authorized person, i.e. a factory or authorized service representative or other persons authorized by the manufacturer. The internal battery shall be replaced with certificated battery of specified model. And it needs to be ensured that no hazardous gas exists at external environment. When battery charge reaches 10% of its remaining capacity, an alarm will be generated (Battery low), the battery should be replaced in time.

a. Internal Battery: one 3.6V lithium battery (EVE ER34615, size D), Life time of device equipped one Battery is over 6 years under following condition:

- Registration period set on every one hour;
- communicating 2 minutes every day;
- LCD display is in sleep mode, Keypad not in use;
- Maximum pulses frequency on LF input <2Hz ;
- measurement cycle: 60 seconds;
- Environmental temperature: 25°C ±3°C ;

b. MODEM Battery pack: two 3.6V lithium battery (EVE ER34615, size D), will running more than 6 years under following condition:

- communicating once every day;

c. External Power Supply;

- External power supply is recommended for optimal performance running, external power supply meet (6.5V DC±10%, 1W) , needs to equipped with safety barrier (Suggested type: INT-S3), it suits for the functions as follow:
  - HF input via NAMUR HF sensor (PWR1);
  - RS485/232 Communication (PWR1);
  - Communicating online through IoT in real time (PWR2).

Warning:
When TEC-III is operated with external power supply in explosive environment, it should be equipped with safety barrier complied with certification parameters.

3.5 Metrological Input Interface

3.5.1 Counting Inputs:

Device is equipped with following counting inputs :

- LF: Pulse(Vpp=3V, 100ms) or Reed switch inputs, Frequency 0Hz ～ 2Hz,Internal battery power supply.
- NAMUR (HF): Frequency 0Hz ～ 5kHz (special configuration); Internal 8V DC power supply generated by external power supply PWR1.

LF, HF input interface

- LF1 (S1) ,LF2 (S2) -- pulse input for connection with LF output of gas meter;

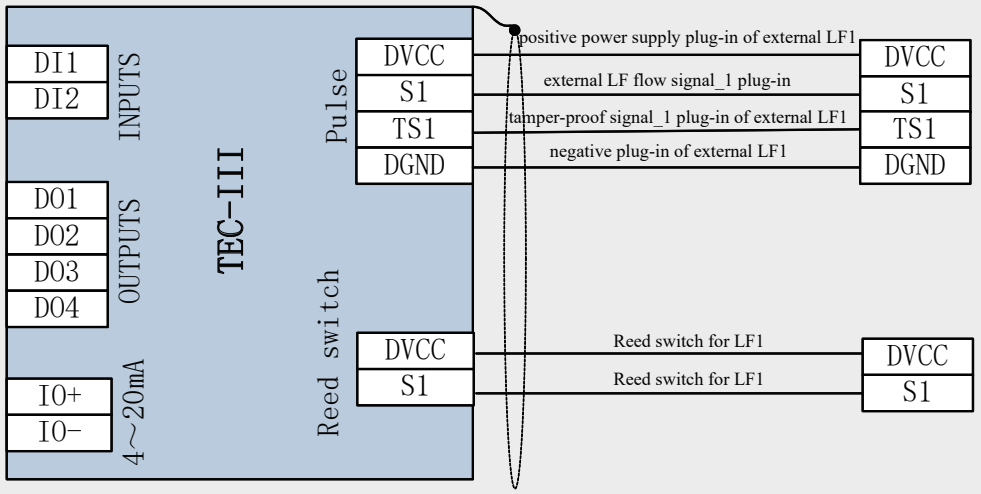


Figure 12 LF connection diagram

- HF1(HF) -- pulse input for connection with HF output of NAMUR standard gas meter, only available when device is powered by external power supply.

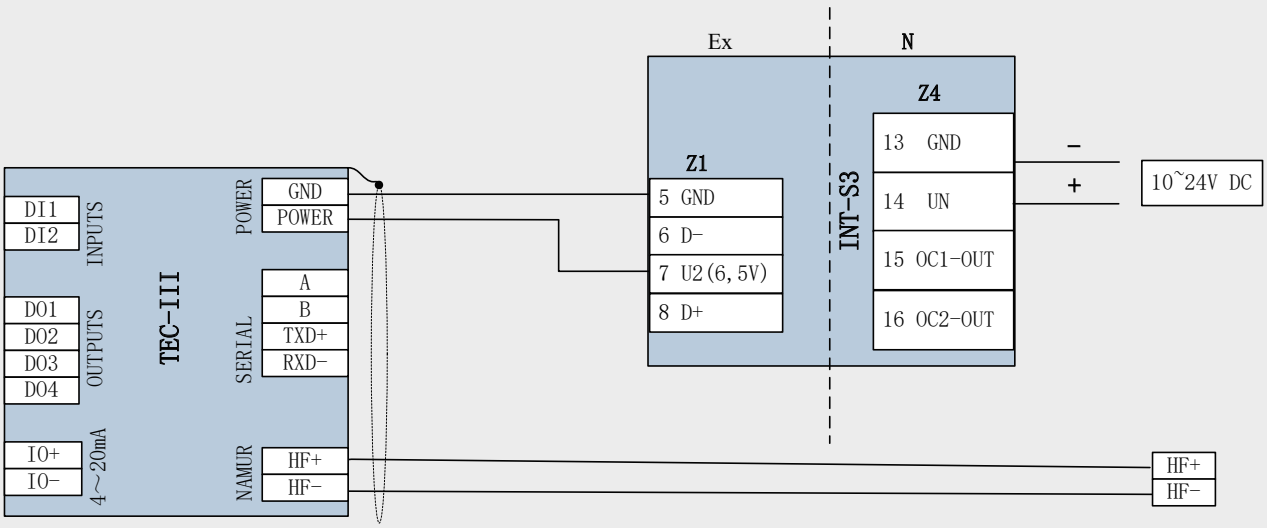


Figure 13 HF connection diagram

3.5.2 Available Configurations:

- LF1 (S1) -- Vm and main counters are driven by LF1 input, without auxiliary input on default.
- LF1(S1) /LF2 (S2) -- Vm and main counters are driven by LF1 input, auxiliary counter Vm2 driven by LF2 input;
- LF1(S1) /HF1 (HF) -- Vm and main counters are driven by LF1 input, auxiliary counter Vm2 driven by HF1 input.
- HF1 (HF) -- Vm and main counters are driven by HF1 input, without auxiliary input.
- HF1 (HF)/LF1(S1) -- Vm and main counters are driven by HF1, auxiliary counter Vm2 driven by LF1 input.

3.6 Non-metrological Input Interface

TEC-III is equipped with four non-metering input interfaces:

- a.Two non-meterological input interface DI1 and DI2，The non-metrological input interfaces are mainly utilized to connect slam shut off which may be inbuilt or separate with pressure regulating valve . These DI’ s can be set as: disabled, constantly opened or closed. If activated, it will generate an alarm signal once it detects an abnormality.
- b. Two non-meterological input interface TS1 and TS2，The non-metrological input interfaces are mainly utilized to monitor whether there is external magnetic field interference to the flowmeter , can be set as: disabled, constantly opened or closed. If activated, it will generate an alarm signal once it detects an abnormality.

Signal Mode: Pulse(Vpp=3V ～ 5V) or reed switch inputs; it is powered by internal battery.

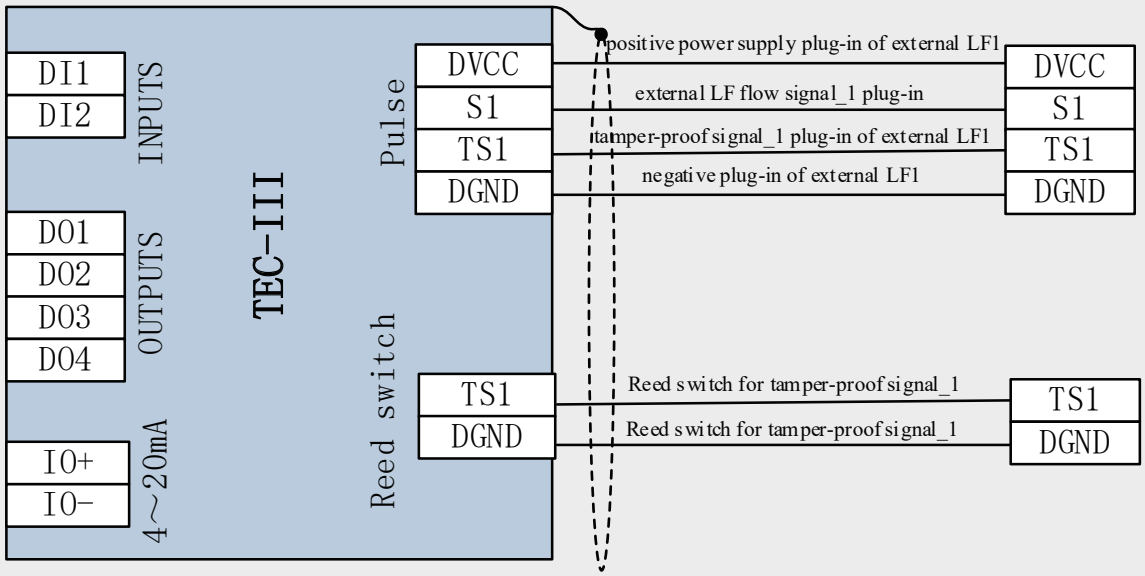


Figure 14 DI connection diagram

3.7 Output interface

TEC-III is equipped with four controlling outputs of “open collector”, which allow cooperation with external systems of automation and signaling. Outputs are made in intrinsically safe version, so it’ s required to use safety barriers when connecting external non-intrinsically safe devices.

DO1 and DO2 are non-optical isolation outputs, while DO3 and DO4 are optical isolation output

available work modes of outputs:

- output switched off （DOx.Mode = Off）
- events and alarm outputs（DOx.Mode = Event）
- volume output （DOx.Mode = Volume）
- （DOx.Mode = Meas.pulse） pulse output at measurement condition (DO1 only) (DOx.Mode = Meas.pulse)
- （DOx.Mode = Corr.pulse） corrected pulse output(DO1 only) (DOx.Mode = Corr.pulse)
- （DOx.Mode = Freq.output） frequency output (DO1 only) (DOx.Mode = Freq.output)

“x” means output number, values 1-4.

Description of available modes is in following paragraphs:

a.Status/Events Output

These modes allow users to control outputs with selected events. There are two types of event controlling modes:
Status output (DOx.Event.mod=Level out): when configured (index of selected event is programmed into parameter DOx.Evt), the output of valid level (DOx.Vaild.level) is controlled as long as selected event is active,
Short pulse output (DOx.Event.mod=Pulse out): when configured (index of selected event is programmed into parameter DOxEvt), the LF output is used to generate alarm signal, which will be kept 4 seconds per minute when alarm exists as long as event is active.

b.Volume Output

The pulse output corresponding with volume. The corresponded volumes are Vb, Vm, VbT and VmT.
the number of pulse output can be calculated by Formula 6:

$$I = V / DO.\text{coeff} \qquad \text{Formula 6}$$

In formula, I refers to pulse number; V refers to corresponded volume increment; DO.coeff refers to volume corresponded with output of an pulse(m^3/Imp.).

c.Pulse Output at Measurement Condition:

After amplified, pulse signal of flow directly input by flow sensor will be output and used for testing of gas meter.

d.Output of Corrected Pulse

Received frequency of flow pulse signal will be output after corrected by flow curve f(Q) and used for testing after meter being corrected.

e.Frequency Output

DO1 can be set to frequency mode (DO1.Mode = Freq.output), where it can output signal with frequency controlled by following parameters:
Selected signal source DO1FIdx (Qm, Qb, QE, QM, p, t)
Range of frequency is 1 Hz-5000 Hz. Configuration of minimum and maximum frequency is performed on parameters DO1.FOMin and DO1.FOMax accordingly. Scaling of selected controlling parameter (to match values of this parameter with min and max frequency) is performed on parameter DO1.FMin and DO1.FMax.

3.8 Communication Interface

In basic configuration, TEC-III is equipped with wireless transmission port COM3 in standard IEC 62056-21 (OPTO), In addition to 2 channels standard RS-485 serial transmission (COM1 and COM2), 1 channel Bluetooth and 1 channel IoT communication (2G,4G and NB-IoT Optional).

Port	baud rate: [bit/s]	address
COM1:	1200 ~ 19200	1 ~ 254
COM2:	1200 ~ 19200	1 ~ 254
COM3:	1200 ~ 19200	1 ~ 254

Sheet 5 Communication parameters configuration range table

3.8.1 Optical Communication

a. Matched Optical Interface: it is installed in the optical window on device panel, fixed by magnet.

b. The interface supports MODBUS RTU protocol and accords with standard IEC62056-21; software of PC can be used to initialize device and read data of historical archive.

c. Relevant parameters such as baud rate and address can be configured by parameters P and P.

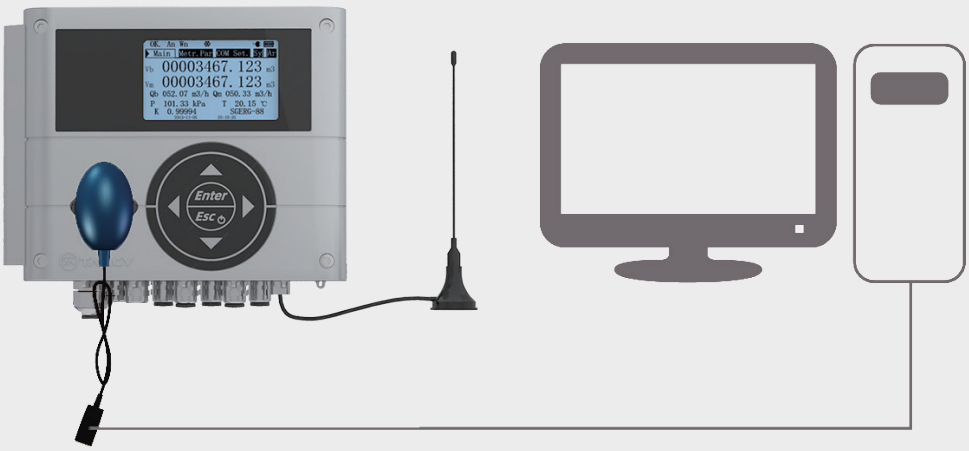


Figure 15 Optical communication

3.8.2 Serial Communication

The device provides serial communication including communication interface of RS485 or RS232. Users can select the communication mode of RS485 or RS232. RS485/RS232 need to be configured by internal hardware connection when it leaves the factory.

a. RS485/RS232:

COM1 serial communication uses optical isolation mode, requiring external power supply shared by communication interfaces of RS485/RS232. RS485 is half-duplex two-wire communication, while RS232 is full-duplex three-wire communication. The internal hardware configuration decides the selection of two types. Figure show the wiring mode.

Relevant parameters such as baud rate and address can be configured .

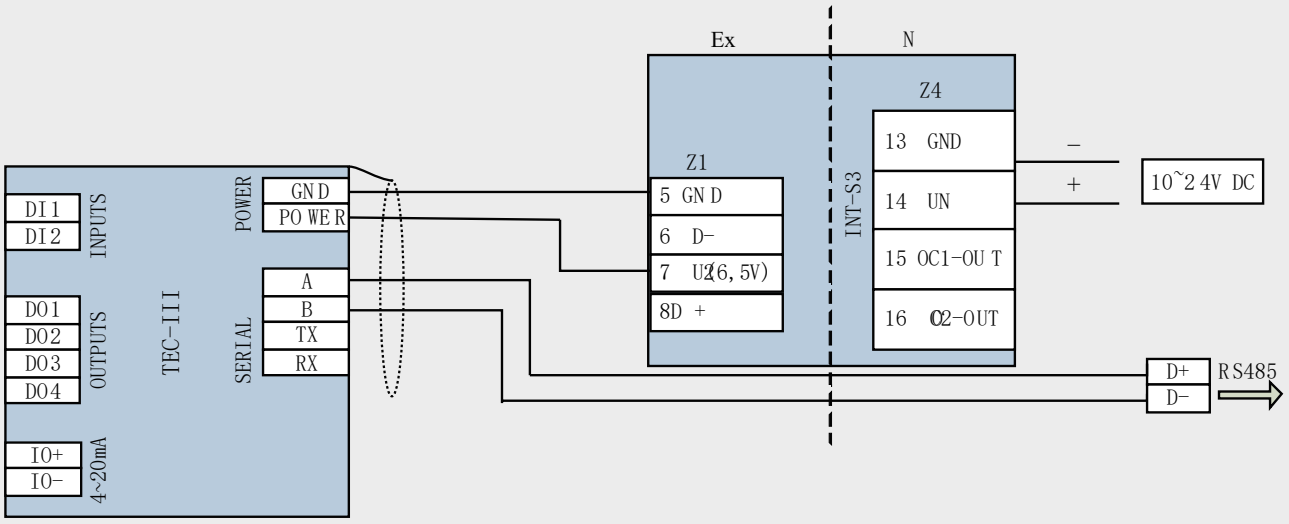


Figure 16 Wiring Mode of Safe Communication of RS485

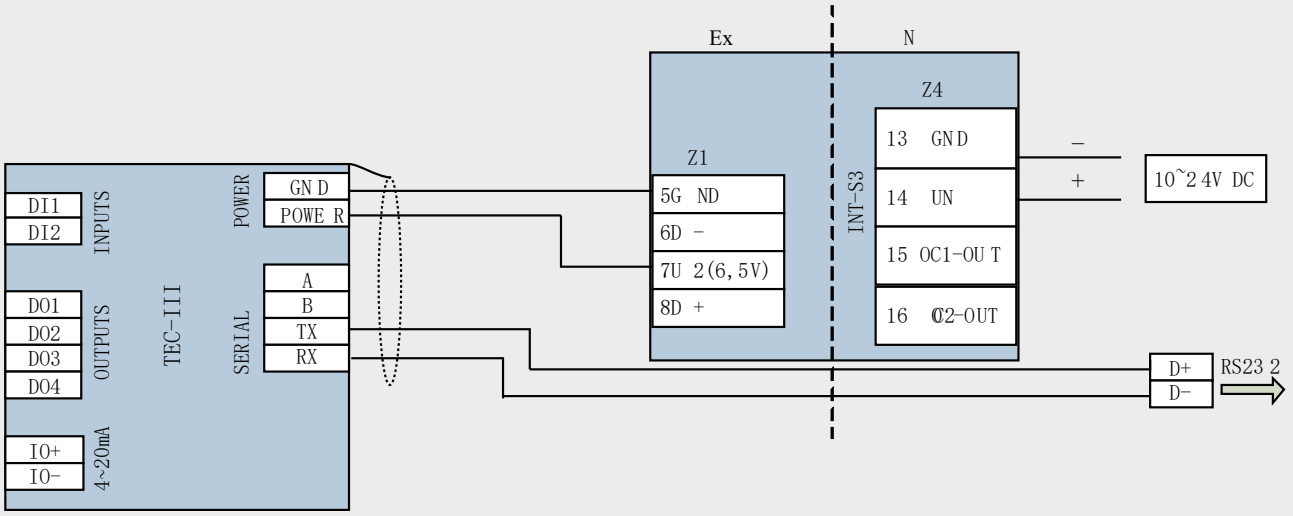


Figure 17 Wiring Mode of Safe Communication of RS232

Communication Protocol: MODBUS RTU

The PC and secondary instrument can be connected and communicated.

b. COM2 RS485 powered by internal battery can directly connect with its ends A2 and B2 without external power supply.

Relevant parameters such as baud rate and address can be configured by parameters .

Warning:

this interface is only served for brief communication connection in the absence of an external power supply, such as temporarily data reading and parameter configuration communication (connecting wire shall be less than 10m).

3.8.3 IoT Communication (optional)

TEC-III has several internal MODEM (2G/4G/NB-IoT) to be selected when ordering. This device supports timed schedule mode and interval mode of data transmission. The timed schedule mode can set the time point up to 12 per day, while interval mode of data transmission can set cycle of interval period ranged from 5 minutes to 30 days by setting parameters. Used as a tool to define configuration files of device, TEC-III configuration software of PC can configure modes of data transmission and transmission time.

The data sent via the IoT Communication may contain data such as:

- current data
- data record of interval period
- hourly data record
- daily data record
- events and alarms
- Configuration parameters

See the remote protocol document for details.

Having successfully connected to Internet, the device will enter Call Window mode for a programmed time period. In this mode it is possible to query the device on demand by superior system, e.g. SCADA.

The device is available online mode when using external power supply. This means that it can be read in real time by external systems on demand, and in the event of an alarm, the service is immediately informed.

3.9 4-20mA Output (optional)

TEC-III optional with one channel 4-20mA standard current output with unidirectional two-wire system, which facilitates the connection with DCS system or secondary instrument. By set parameters current source, the corresponded output quantity can be selected as flow at measurement condition Qm , flow at reference condition Qb . The corresponding value of 4mA is 0, while the corresponding value of 20mA can be set by parameters full scale.

When powered by 24V DC the load of output ends of standard current ranges from 0 Ω ～ 400 Ω, the maximum error number of 4mA to 20mA output is ±0.25%FS.

3.10 Archive

This product equips with the function of data archive and data record, which includes periodic, hourly, daily and monthly records, records of start-stop, IoT communication events, event resetting and power supply event and the archive of event, malfunction of temperature sensor, malfunction of pressure sensor, upper limit alarm, down limit alarm, cover-open alarm, magnetic interference and power-down of power supply.

a.Periodic record: it records values including Vm, Vb, energy E, Qm, Qb, Qe, pressure p and temperature t with an optional record cycle ranging from 0-120 min (0 refers to no generating record) and maximum record: 1440 records.

b.Hourly record: it records device status, time labels and average, minimum and maximum values including Vm, Vb, energy E, Qm, Qb, Qe, pressure p, temperature t, compressibility coefficient K and conversion factor C; maximum record: 11500 records.

c.daily record: it has the same record format as hourly record; The recording time on default is 6:00 am per day (the time of starting day can be set) with maximum record: 1440 records.

d.Monthly record: it has the same record format as hourly record; the recording time on default is 6:00 am of every first day of each month (the time of starting day can be set); maximum record: 450 records.

e.Event Archive: when there is any occurrence and elimination of alarm event or modification of metrological parameters, it records event cause, event information, status, time label and values including Vm, Vb, energy E, Qm, Qb, Qe, pressure p, temperature t, and conversion factor C; maximum record: 600 records.

f.Archives of malfunction of temperature sensor, malfunction of pressure sensor, upper limit alarm, down limit alarm, cover-open alarm, magnetic interference and power-down of power supply: it has the same record format as event archive; 200 maximum records for each archive.

g.Start-stop Record: it records status, time labels and values including Vm, Vb, energy E, Qm, Qb, Qe, pressure p, temperature t, and conversion factor C when flow rate starts or stops; maximum record: 1000 records.

h.Record of IoT Communication Event: it records signal intensity, communication error code, trigger mode, communication time span and time label in the end of IoT communication; maximum record: 100 records.

i.Event Resetting record: when any resetting occurs, it records resetting type, time label, and values before and after resetting including Vm and Vb; maximum record: 600 records.

j.Battery event record: when battery level or voltage status changes, it records battery type, battery level, voltage level and time label; maximum record: 200 records.

3.11 log

Logs include event log, parameter change log, gas component parameter log and calibration log.

a. Event log: it records last 600 status changes (e.g. event and alarm information).

b. Parameter change log: it records last 600 changes of parameter setting and time.

c. Gas component parameter log: it records last 200 setting changes of gas component parameter.

d. Calibration log: it records last 200 changes of parameter related to calibration. Every changes of parameter related to calibration is ruled by law. Only qualified personnel with certain privilege (password) have the right to change relevant parameter data.

3.12 Query to Active Alarm

Users can view active alarm by pressing buttons to access the path: archive -> active alarm

This interface allows to query about alarm code En or An, alarm code description and event archive related to alarm code.

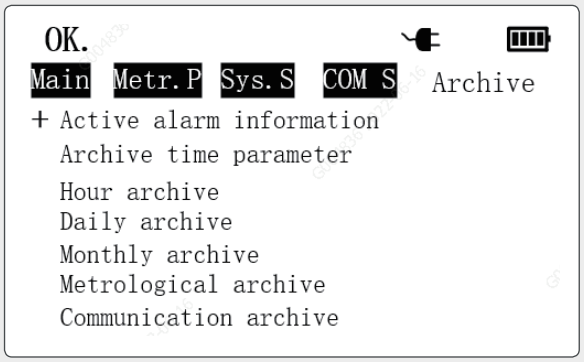


Figure 18 Active Alarm

3.13 Passwords and Privileges

The corrector is designed with Metrological switch and 3 classes of passwords, passwords including metrology password (M), service password (S), and customer password (K). MET switch, together with password protects parameters of device and enhances the reliability of data management, particularly the data related to metrological trade settlement.

Metrology lock (M), service lock (S) and customer lock (K) are respectively matched with 3 passwords. The corresponded privilege is available by inputting correct matched password. (MET switch shall be opened before opening metrology lock)

a. Privilege Class:M > S > K. Higher class covers all privileges of lower class.

M(3): The privilege to configure all parameters of device (including metrological parameter);

S(2): The privilege to configure non-metrological parameter;

K(1): The privilege to configure non-metrological parameter (communication interface);

R(0): Read data only.

b. Access to User's Privilege

Any Following Operation	Available Privilege
● Customer lock, service lock or metrology lock opened. ● customer lock opened by dynamic password	Customer K
● service lock or metrology lock opened. ● service lock opened by dynamic password	Service S
● metrology lock opened ● metrology lock opened by dynamic password	Metrology M

Sheet 6 User Privilege Acquisition

Warning:

1. The metrology lock, service lock and customer lock can be opened directly by dynamic password after such password is enabled.
2. the metrology password is disabled when dynamic password is enabled.
3. The lock opened by parameter interface or local maintenance communication will be locked again if there is no keyboard operation or data communication.

3.14 Explosion-proof Level

As an intrinsically safe device, this product when used at explosive place shall be equipped with corresponded safety barrier. The basic explosion-proof level is Ex II 1G Ex ia IIB T4 Ga, while Ex II 2G Ex ib IIB T3 Gb is the explosion-proof level with IoT Modem.

3.15 Ingress Protection Level

Ingress Protection Level of this product: IP66.

3.16 Intrinsically Safe Electrical Parameters

Circuit	Maximum Input Voltage Ui (V)	Maximum Input Current Ii (mA)	Maximum Input Power Pi (W)	Maximum Internal Equivalent Parameter	
				Ci	Li
PWR1 External Power Supply PWR1 (Terminal P7, Pin PWR1 and GND)	6.51	449	1.34	500uF	300uH
Analog Output 4-20mA (Terminal P7, Pin IO+ and IO-)	28	93	0.66	0	0
MODEM Communication Power Supply (Terminal P7, Pin PWR2 and GND)	6.51	460	1.34	500uFuF	300uH
Digital Output DO1	12	30	0.09	330nF	0
Digital Output DO2, DO3 and DO4	12	30	0.09	220nF	0
RS485 Communication Terminal A and B	6.6	65	0.11	500uF	300uH
RS232 Communication Terminal TX and RX	6.6	65	0.11	500uF	300uH

Circuit	Maximum Input Voltage Uo (V)	Maximum Input Current Io (mA)	Maximum Input Power Po(W)	Maximum Internal Equivalent Parameter	
				Co	Lo
LF flow input	5.4	575	0.78	1uF	100uH
Digital input DI1、DI2	12	30	0.09	0	0

Sheet 7 Intrinsically Safe Electrical Parameter

4. Device Startup

After connected to power supply (internal battery or external power supply), the device will start up automatically. During normal operation, the display will turn off if there is no manual operation. The display will be turned on by holding any key above 2s (except Esc). The display will be turned off by pressing Esc when displaying main interface.

Warning: It is recommended to unplug internal battery if it has been stored for a long time.

5. Operation Instruction

5.1 Display Field Framework and Instruction

5.1.1 Definition of Display Field

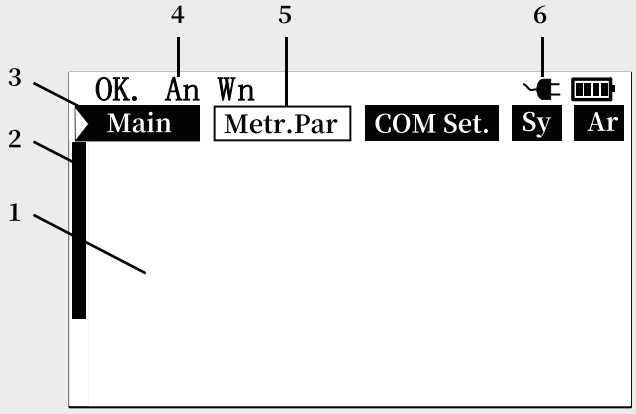


Figure 19 Display Field Framework

1. Data Field；2. Scroll Bar；3. Inactive Menu；4. Status Bar；5. Active Menu；6. Battery Status Bar。

Symbol	Description
	Battery
	External Power Supply
OK	Normal Status, no Alarm
En	Alarm occurs, n refers to alarm code (codes rotate if more than 1 alarm occurs)
G G	IoT Data Communication, IoT Switch on, IoT Signal Intensity, IoT Battery
An	An refers to all kinds of status such as IoT module. “n” refers to status code (codes rotate if more than 1 status exists)
	Privilege Lock Status (interface with no parameter setting) : Privilege Locked M： Metrological Privilege Unlocked S： Service Privilege Unlocked K： Customer Privilege Unlocked
	parameter read-write attribute (parameter setting interface) >： read only ： this parameter is not allowed to be set ： this parameter is allowed to be set

Sheet 8 Description of Symbols on Status Bar

The access permission of parameter read-write can be available by selecting system setting → access permission → inputting correct password.

5.1.2 Definition of Keyboard

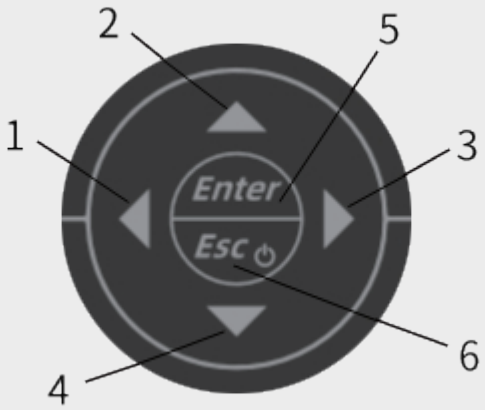


Figure 20 Keyboard

Keys	Function
1——Left	Menu Selection Leftward Moving to the next left index digit of parameter during setting
2——上键 Up	Parameter Selection Upward Increasing currently selected parameter’ s index digit
3——右键 Right	Menu Selection Rightward Moving to the next right index digit of parameter during setting
4——下键 Down	Menu Selection Downward Decreasing currently selected parameter’ s index digit
5——确定键 Enter	entering submenu entering setting of parameter data Confirming option or setting of parameter data
6——返回键 Esc.	the functional key to return to superior menu Canceling option or setting of parameter data, and exiting without saving

Sheet 9 Function of Keys

5.1.3 Menu Operation Setting

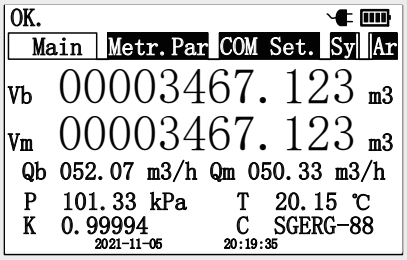
Menus of device include interface, metrological parameters, communication settings, system settings and archive. Menus at this level can be selected by pressing / . Apart from main interface, other four menus have multi-level submenus, which can set relevant parameters and read historical archive records.

Certain parameter marked by “+” in front of it means this parameter contains a submenu, unfolding it by pressing “enter”; if parameter marked by , it means that user has acquired the privilege of write on this parameter and it is available to be set; if parameter marked by , it means that user has not acquired the privilege of write on the parameter and it is unable to be set; if marked by >, the parameter can is read only. The current meter’ s parameters can be viewed by pressing / .

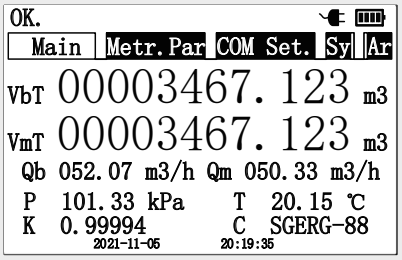
5.2 Main Interface

Main interface is separated into 3 pages, seeing Figure 21. After device powered on or lighting on display,main interface 1 is displayed on default and can be shifted to other pages by pressing ▲ / ▼ .

Main interface 1



Main interface 2



Main interface 3

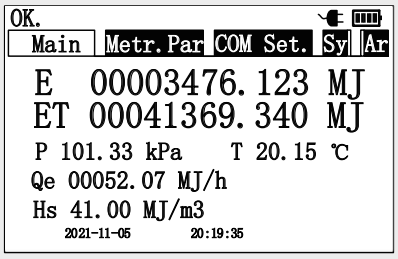
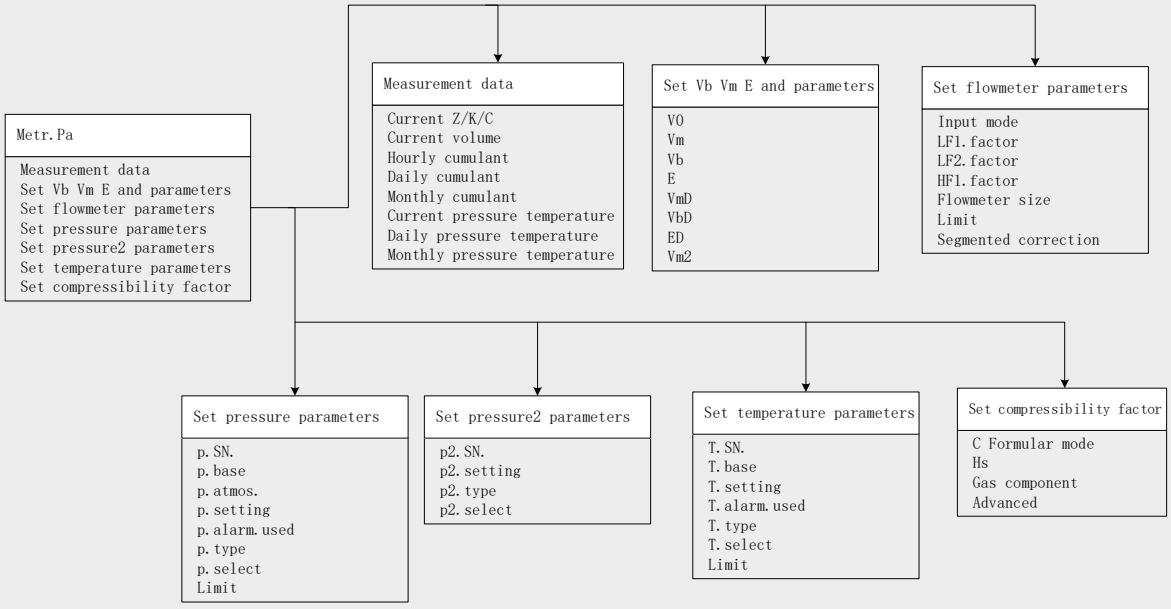


Figure 21 Main Interface

Main Interface 1	volume at reference condition V_b and at measurement condition V_m flow rate at reference condition Q_b and at measurement condition Q_m Pressure P and temperature T at measurement condition The reciprocal of compressibility factor ratio K and C, and Calculation Model Date and time of device
Main Interface 2	volume at reference condition VbT and at measurement condition V_mT flow at reference condition Qb and flow at measurement condition Q_m Pressure P and temperature T at measurement condition The reciprocal of compressibility factor ratio K and C, and Calculation Model Date and time of device
Main Interface 3 (be displayed at first interface if energy measurement is on)	Energy E and total volume of energy ET Pressure P and temperature T at measurement condition flow rate of energy Q_e high calorific value H_s

Sheet 10 Displayed Content of Main Interfaces

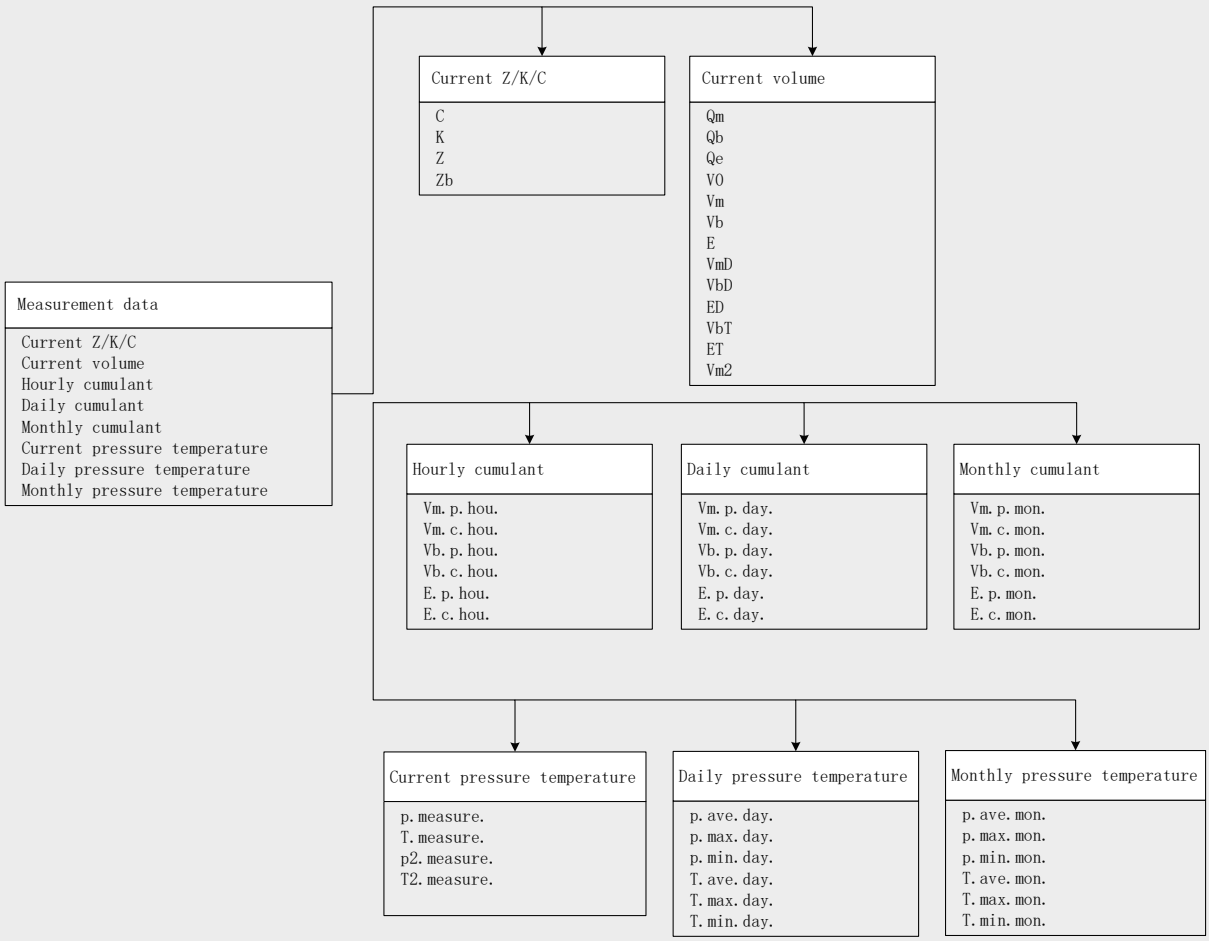
5.3 Metrological Parameter Menus



This menu includes following submenus:

- Measurement data: this menu allows to view current value of Z/K/C, current volume, hourly, daily and monthly cumulant, current pressure & temperature,and daily and monthly pressure & temperature.
- Set Vb, Vm, E and other parameter: this menu allows to configure total volume, total volume of energy and other relevant parameters.
- Set flowmeter parameter: this menu allows to configure input mode of basic frequency, segment correction, measurement control and flow rate limit.
- Set pressure parameter: this menu allows to configure relevant parameters of pressure sensor.
- Set temperature parameter: this menu allows to configure relevant parameters of temperature sensor.
- Set compressibility factor: this menu allows to classify gas component and algorithm parameter and to show calculation attribute of gas.

5.3.1 Measurement Data



This menu allows to view current Z/K/C, current volume, hourly, daily and monthly cumulant, current pressure and temperature, and daily and monthly pressure & temperature.

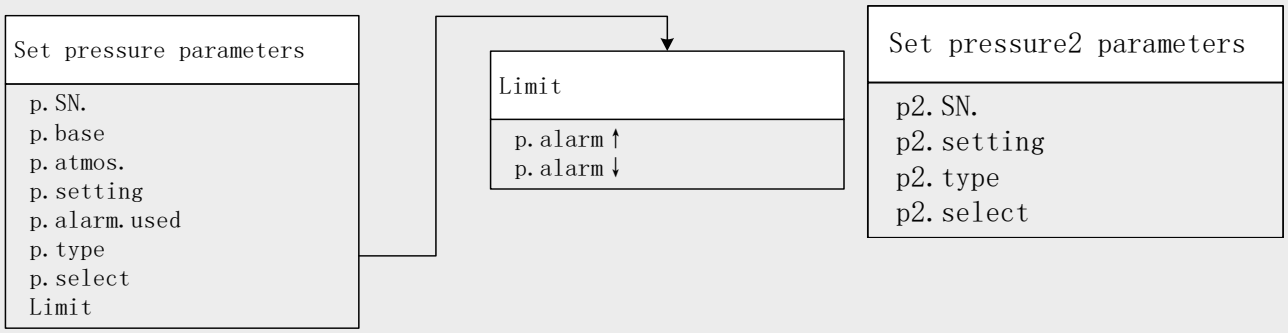
1.Hourly cumulant allows to view values recorded an hour ago and current value;

2.Daily culumant allows to view values recorded a day ago and current value;

3.Monthly culumant allows to view values recorded a month ago and current value;

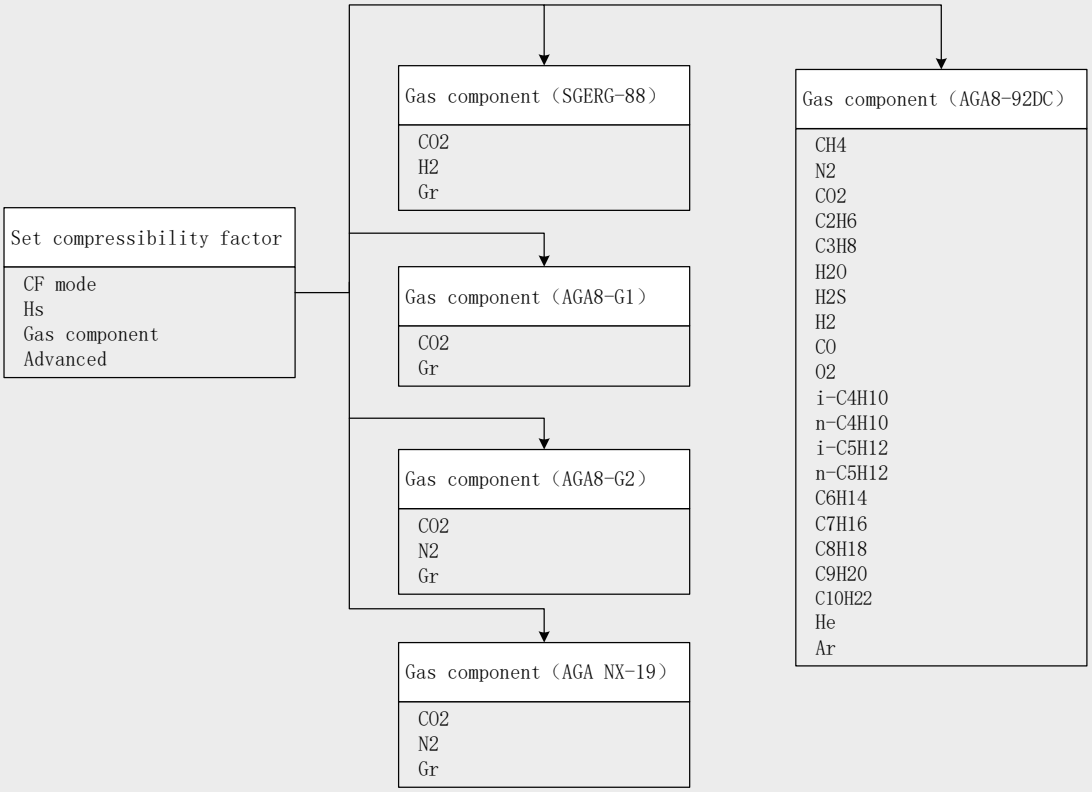
4.daily and monthly pressure & temperature allows to view average, maximum and minimum values of pressure & temperature in a day or a month.

5.3.2 Set Flowmeter Parameter



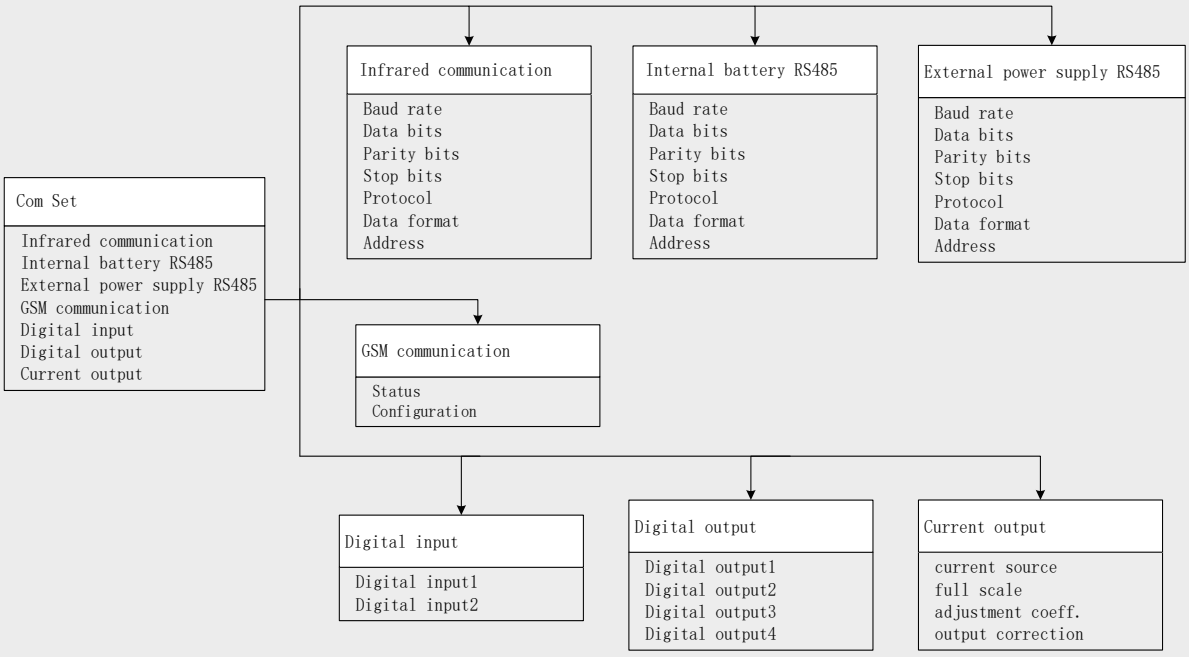
this menu allows to configure relevant parameters of pressure sensor.

5.3.5 Set Compressibility Factor



This menu allows to classify gas component, algorithm parameters, and to show calculation attribute of gas.

5.4 Interface Parameter Menu

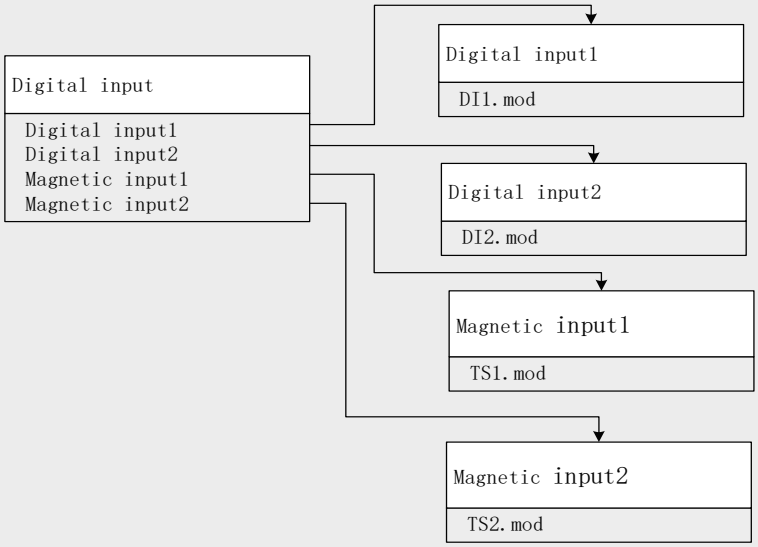


This menu includes:

1.Setting and current status of data transmission interface: serial communication, optical communication and IoT communication.

2.Settings of digital input, digital output and output interface of electrical current.

5.4.1 Digital Input

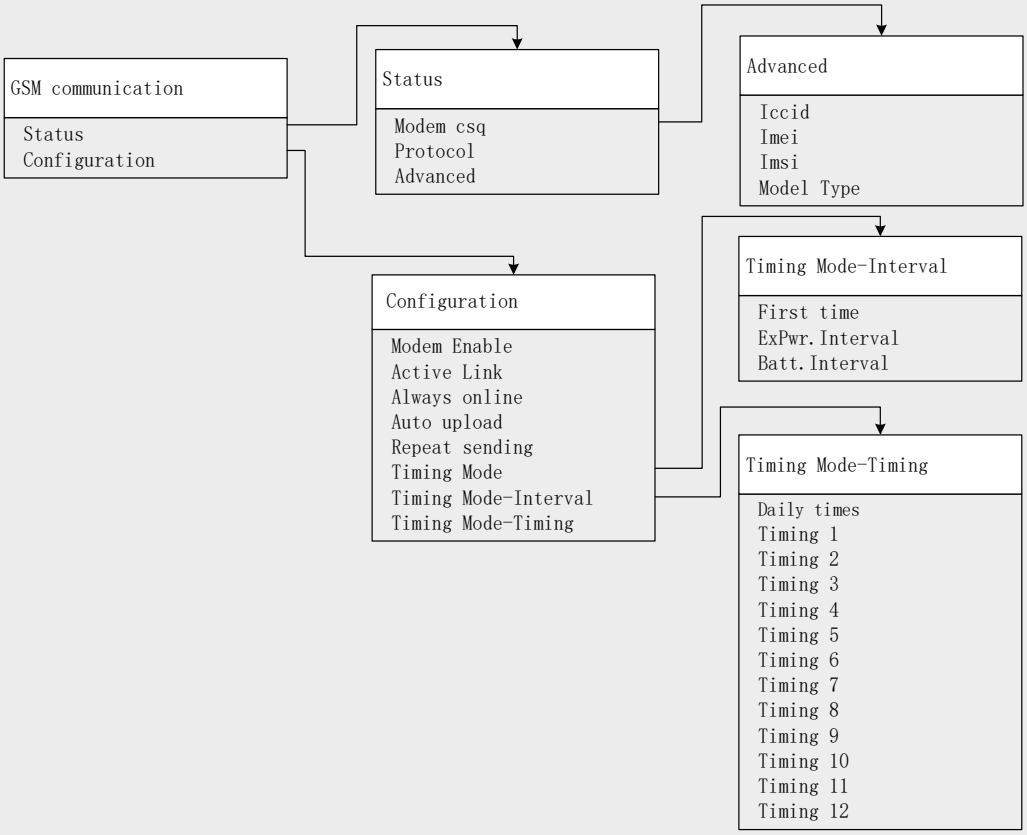


This menu allows to configure status of digital input.

5.4.2 Digital Output

This menu allows to configure digital output with multiple selection of output mode.

5.4.3 IoT Communication

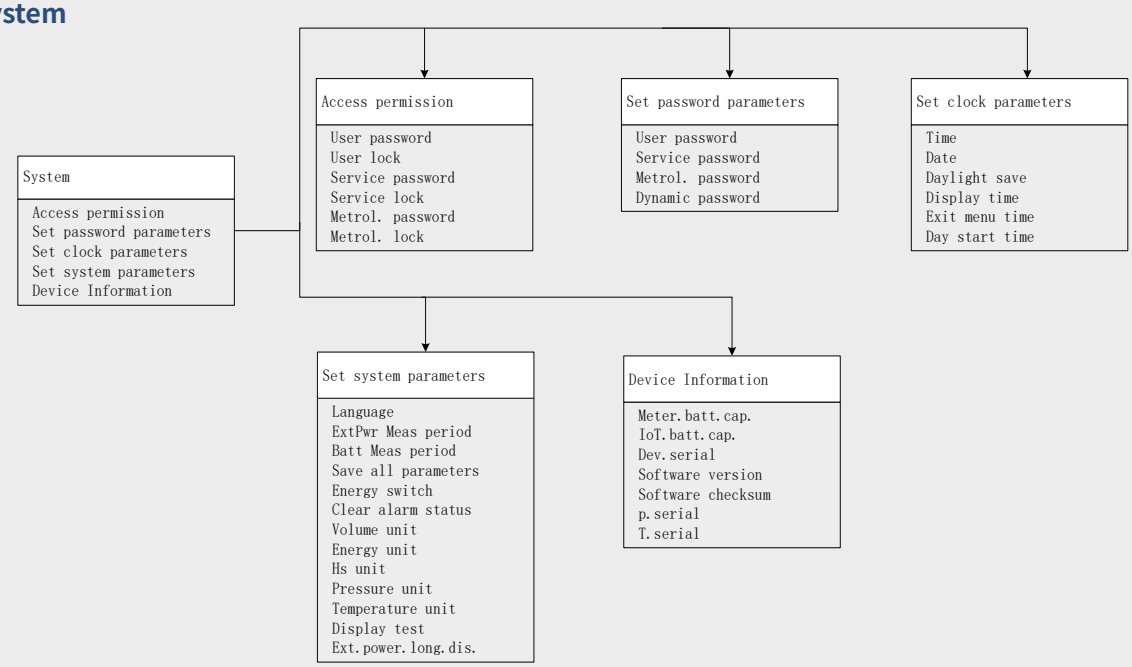


This menu includes status of IoT communication and settable network parameters.

1) Timing mode-interval: it allows to set first starting time, interval of external power supply, and interval of internal battery.

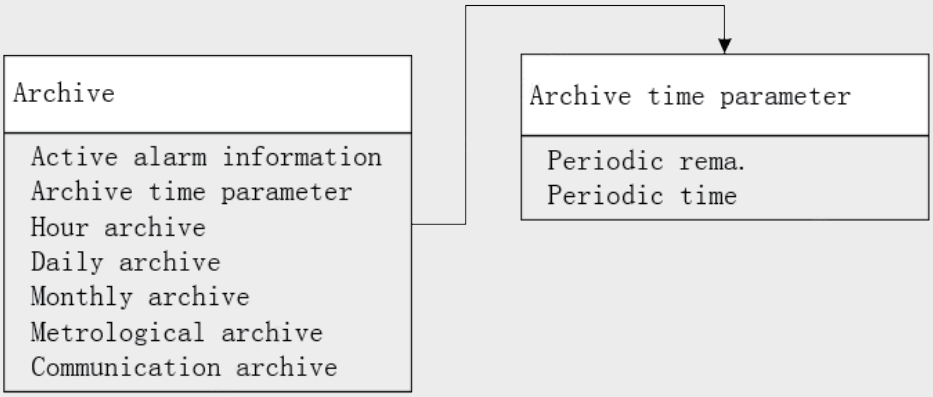
2) Timing mode-timing: it includes daily timing times and daily custom timings up to 12 times

5.5 System



This menu includes access permission, set password parameters, clock parameters and system parameters and device information.

5.6 Archive



This Menu allows to access archive information: active alarm information, archive time parameter, hourly, daily and monthly archives, metrological archive and communication archive.

6. Connection

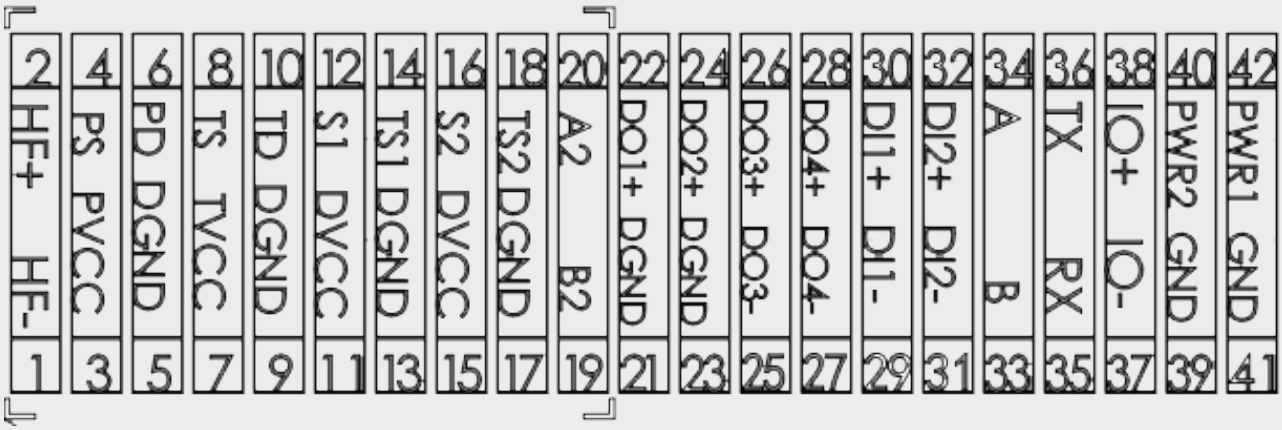


Figure 22 Connection Instruction

Terminal	Name	Terminal	Name
1 HF1-	HF flow signal, negative (HF-)	22 DO1+	digital signal output, positive
2 HF1+	HF flow signal, positive (HF+)	23 DGND	digital signal output, negative
3 PVCC	positive power supply plug-in of external pressure (red)	24 DO2+	digital signal output, positive
4 PS	clock signal plug-in of external pressure (blue)	25 DO3-	digital signal output, negative
5 DGND	negative power supply plug-in of external pressure (black)	26 DO3+	digital signal output, positive
6 PD	digital signal plug-in of external pressure (yellow or white)	27 DO4-	digital signal output, negative

7 TVCC	positive power supply plug-in of external temperature (red)	28 DO4+	digital signal output, positive
8 TS	clock signal plug-in of external temperature (blue)	29 DI1-	digital signal input, negative
9 DGND	negative power supply plug-in of external temperature (black)	30 DI1+	digital signal input, positive
10 TD	digital signal plug-in of external temperature (yellow or white)	31 DI2-	digital signal input, negative
11 DVCC	positive power supply plug-in of external LF1	32 DI2+	digital signal input, positive
12 S1	external LF flow signal_1 plug-in (LF1)	33 B	RS485 communication signal wire D-
13 DGND	negative plug-in of external LF1 (external LF tamper-proof signal_1)	34 A	RS485 communication signal wire D+
14 TS1	tamper-proof signal_1 plug-in of external LF1	35 RX	RS232 communication signal wire
15 DVCC	positive power supply plug-in of external LF2	36 TX	RS232 communication signal wire
16 S2	external LF flow signal_2 plug-in (LF2)	37 IO-	Output of 4-20mA power supply
17 DGND	negative plug-in of external LF2 (external LF tamper-proof signal_2)	38 IO+	Input of 4-20mA power supply
18 TS2	tamper-proof signal_2 plug-in of external LF2	39 GND	negative power supply of IoT MODEM external power
19 B2	RS485 communication signal wire D-	40 PWR2	positive power supply of IoT MODEM external power
20 A2	RS485 communication signal wire D+	41 GND	negative power supply of external power supply
21 DGND	digital signal output, negative	42 PWR1	positive power supply of external power supply

7. Installation

This product is according to EN 60079-11standard of intrinsically safe explosion-proof. The installation of electronics shall refer to EN 60079-14. The standard of pressure pipeline connection shall follow DIN 3861.

The bottom of casing is equipped with 1 channel PG9 waterproof joint, 7 channel PG7 waterproof joints and 1 connector of extended antenna wire, which are all linked by cable shield wire. The cable shall be shielded with adequate external diameter of ϕ5mm for PG9 andϕ6mm for PG7. The length of other wires shall be less than 10m except external power supply and external communication RS 485.

Warning: a grounding terminal on the casing of device is utilized to connecting to the ground. The device must be correctly grounded. In order to ensure the effectiveness of IP 66 protection, after connecting cables to waterproof joints, to the cable shall be pulled back in an appropriate manner to test the reliability of ground.

7.1 Mechanical Installation

TEC-III can be mounted on a wall or be mounted on meters and gas pipeline with a head bracket.

7.1.1 Installed on wall

First, the head bracket shall be fixed on the wall by 4 expansion screws (M5*30). And then the corrector shall be fixed on the head bracket by 4 screws (M5*12) to threaded holes on both sides of the corrector, seeing Figure 23.

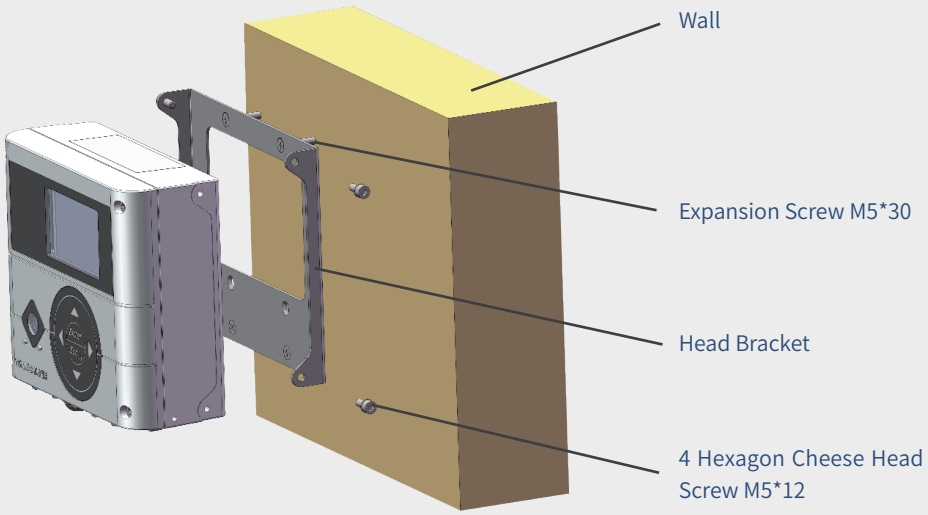
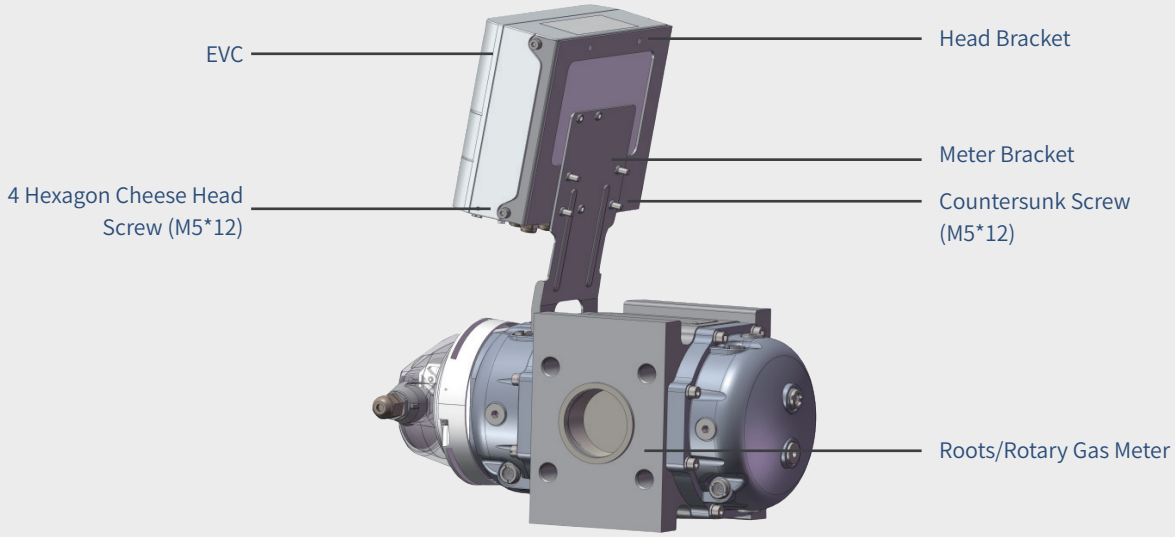


Figure 23 Installed on Wall

7.1.2 Installed on Meter

（1）Installed on Roots/rotary gas meter

First, head bracket shall be tightly fixed with meter bracket by 4 countersunk screws(M5*12) and nuts. And then the corrector shall be fixed on head bracket by 4 hexagon cheese head screw (M5*12) to threaded holes on both sides of the corrector, seeing Figure 24.



（2）Installed on Turbine Gas Meter

First, head bracket shall be tightly fixed with bracket connecting assembly by 4 countersunk screws(M5*14) and nuts. And then the corrector shall be fixed on head bracket by screwing 4 hexagon cheese head screw (M5*12) to threaded holes on both sides of the corrector, seeing Figure 25.

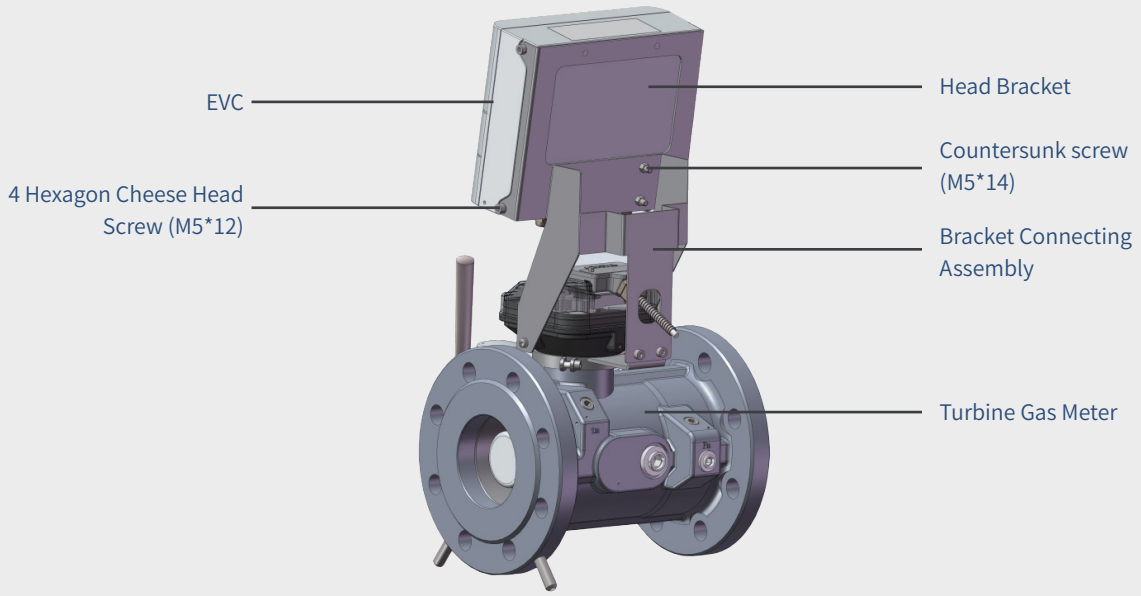


Figure 25 Installed on Turbine Gas Meter

7.1.3 Installed on Pipeline

First, the head bracket shall be fixed on the mounting plate by countersunk screws and nuts (M5) . And then the corrector shall be fixed on the head bracket by 4 hexagon cheese head screw (M5*12) to threaded holes on both sides of the corrector, seeing Figure 26.

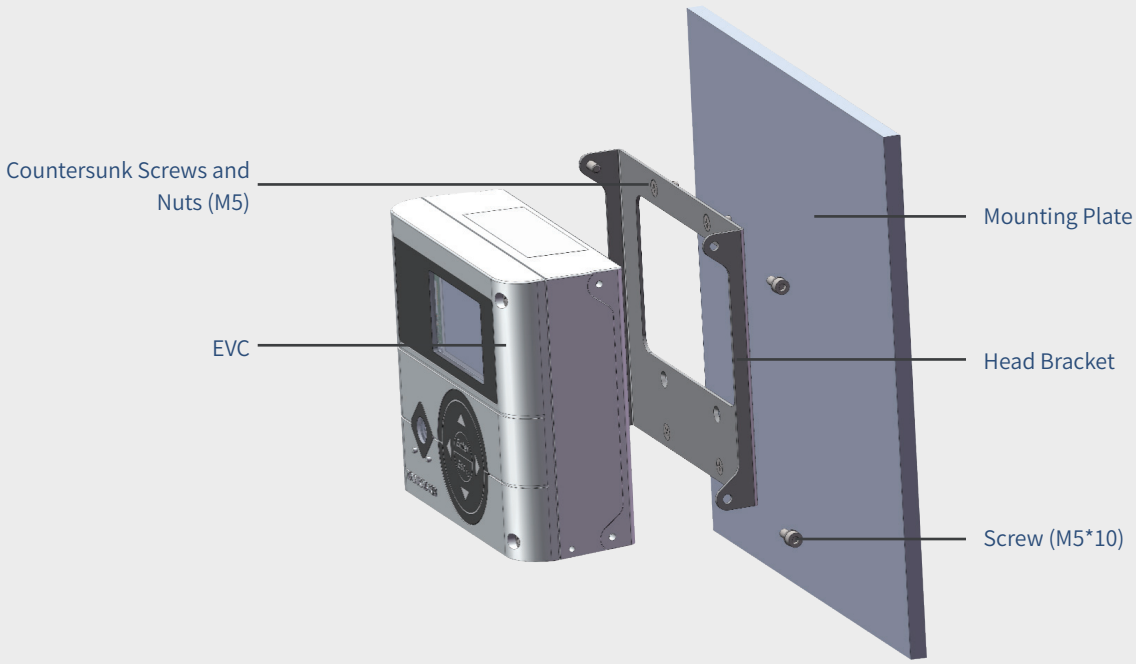


Figure 26 Installed on Pipeline

1.The mounting plate shall be welded to pipeline and fixed by clamp and nuts.

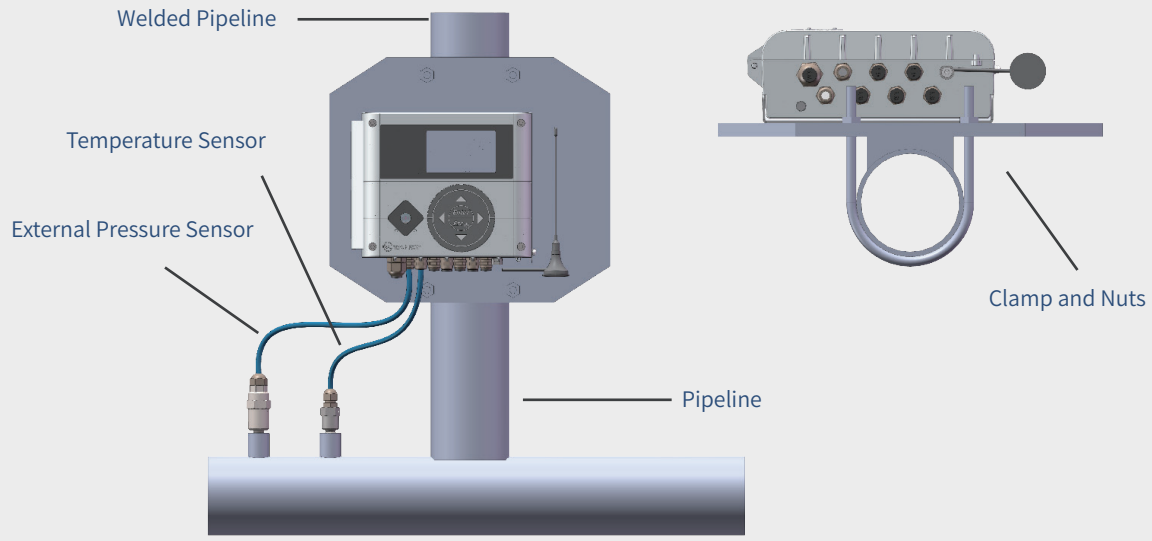


Figure 27 Installed on Pipeline

7.2 Temperature Sensor Installation

As for the installation of temperature sensor, first, temperature casing shall be installed on meter or pipeline. If no corresponded position on pipeline for installing casing, a direct weldolet shall be welded to pipeline to facilitate the installation of temperature casing, seeing Figure 28. The screw thread at the junction of temperature casing is NPT 1/4. Thread sealant shall be applied after screwing the casing. Then the temperature casing shall be plugged in and shall be screwed and fixed by PG7 waterproof joint.

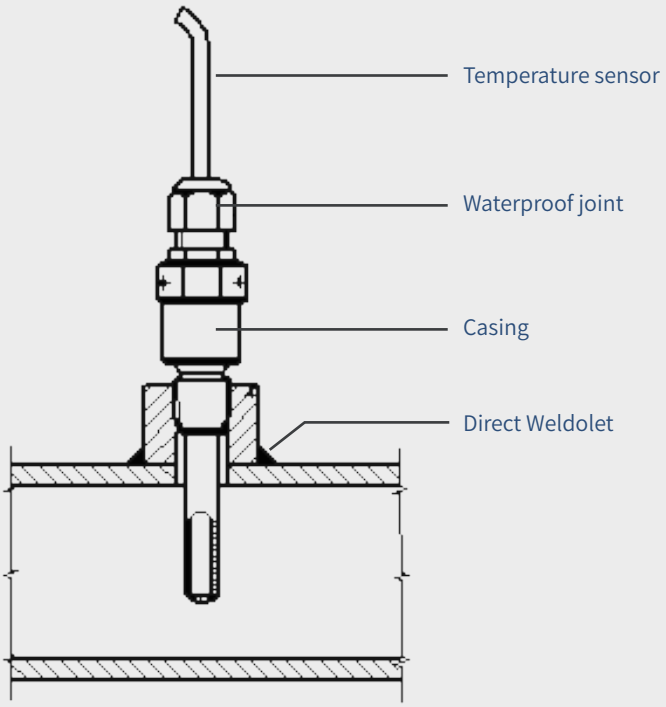


Figure 28 Temperature Sensor Installation

7.3 Shielded Cable Installation

Shielding of the cable must be connected with the contact strip of waterproof joint. All shielding of the device shall be interconnected in case of magnetic interference.

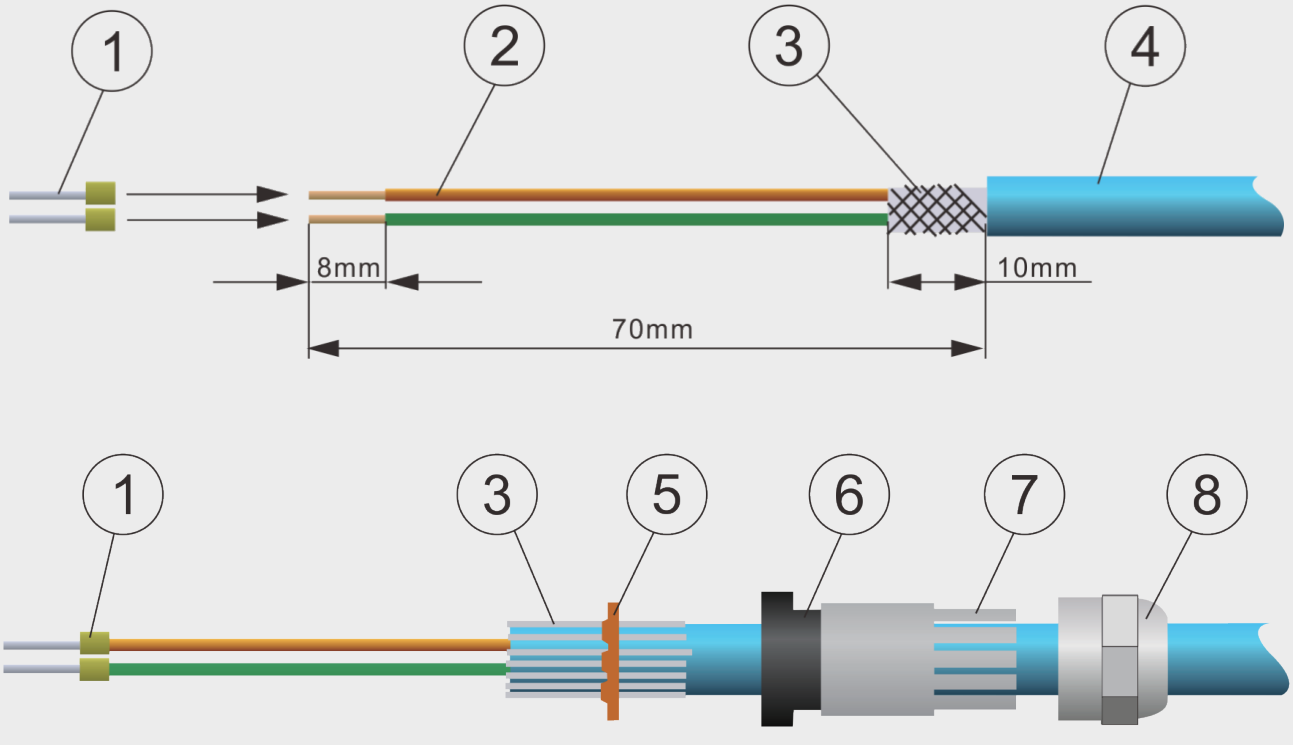


Figure 29 Shielded Cable Installation

Assembly manual and preparation of wires for cable glands: 1- ending sleeves, 2-wires, 3-shielding, 4-cable, 5-contact, 6-seal, 7-claw, 8- sealing nut.

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