USER MANUAL

ONE-STOP SOLUTION

ONE-STOP SERVICE

HUNAN MACSENSOR COMPANY LIMITED

User Manual for MRCM600 Radar Flowmeter

Important Notices and Restrictions on Use

Note: Follow the instructions provided with this product and fully comply with the following precautions to avoid harm to the instrument and human body.

Notice

The user of this manual must be aware of the potential hazards associated with this instrument and its accessories.

All operators should be familiar with the safety precautions and warnings outlined in this section before operating the instrument. Failure to follow the operating instructions may reduce the instrument's performance or pose a risk to human health.

Graphic symbol:

⚠ Note: Attention/Warning

This section describes the precautions to be taken during transportation, use, and maintenance. Points to note are as follows:

✧ Operating environment and power precautions

⚠ Warning: Do not use this device in places where flammable and explosive gases are present or may be present.

⚠ Note: Do not touch or place the instrument in water.

⚠ Note: Do not place the instrument in extreme temperatures and avoid static electricity.

✧ Instrument operation

⚠ Note: No matter in the use, storage or transportation of the instrument, should be carefully taken and placed, do not fall.

⚠ Note: The installation and setting of this radar flowmeter can only be installed and operated by professional technicians.

⚠ Note: Please do not disassemble the radar flowmeter or make any changes to it, otherwise it will not be guaranteed.

⚠ Note: If the instrument fails, please be sure to give our after-sales maintenance, do not disassemble!

✧ RS232 ports, RS485 ports

⚠ Warning: System equipment or computer equipment connected to RS232 interface or RS485 must comply with BS EN60950/IEC950 standard.

✧ Instrument components

⚠ Warning: The instrument is not equipped with internal spare parts, do not disassemble the instrument parts without authorization.

✧ Control of hazardous substances

Discard MRCM600 Please comply with the Hazardous Substances management regulations and dispose of it as waste electronic/electrical products.

⚠ Warning: Do not throw the old equipment into the separate waste or municipal garbage.

✧ Use restriction regulations

The MRCM600 is designed to meet the requirements of routine and safety.

✧ Declaration

The MRCM600 is designed to meet and comply with the requirements of low voltage indicators.

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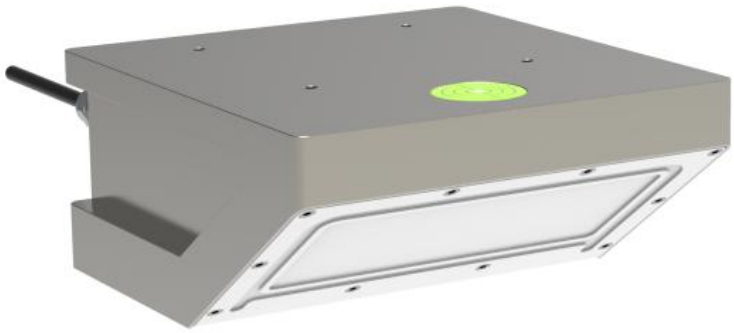
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1 Product Introduction

1.1 Introduction

MRCM600 radar flowmeter is a non-contact integrated flow monitoring equipment, which can realize non-contact real-time measurement of water level, velocity and flow in rivers, open channels, reservoirs, sewage pipe networks, flood prevention and early warning occasions. According to the built-in software algorithm, calculate and output instantaneous section flow and cumulative flow, while output velocity, water level, easy to connect to the database platform, and view the measurement information on the cloud platform. It supports digital (RS485, RS232) or analog (4-20mA) transmission of measurement results, and uses the standard Modbus-RTU protocol, RTU adopts the hydrologic protocol SL651 protocol, in order to meet the individual needs of customers, the company can also provide custom protocols.

MRCM600 radar flowmeter has the characteristics of low power consumption, small size, high reliability, simple operation and easy maintenance. The measurement process is not affected by environmental factors such as temperature, air pressure, sediment, dust, river pollutants, floating objects on the water surface, and air.



1.2 Feature & Specification

1.2.1 Features of equipment

- Small size, high reliability, simple operation, easy maintenance;
- Not affected by temperature, sediment, dust, river pollutants, floating on the water surface, air pressure and other environmental factors;
- used for non-contact flow measurement in open channels, river channels, irrigation channels, underground drainage networks, flood control and other occasions;
- Non-contact measurement, easy to measure, no pollution to the environment;
- With rainy mode to prevent interference caused by rain;

- Waterproof grade IP68, effectively avoid internal components moisture;
- Low power consumption, can use solar power, easy to install maintenance-free;

1.2.2 Electrical characteristics

- 7-32V power supply, wide power supply voltage to facilitate the choice of power supply mode;
- Low working current and standby current, can use solar power supply, easy installation, maintenance-free;
- Lightning protection circuit, can be lightning 6KV. Thunderstorms can effectively protect equipment against lightning strikes;
- High test accuracy, stable data. Effectively ensure the accuracy of the test;
- Support RS485,RS232,4-20MA and other wired communication mode;
- Support Lora and other wireless communication methods;

1.3 Measure principle

MRCM600 radar flowmeter uses planar microwave technology, uses Doppler radar principle to measure the surface velocity of water flow, and uses built-in microstrip radar technology to measure the water level. According to the flow-area method, the section area is first converted from the measured water level, and then the average velocity is converted from the surface velocity combined with the section parameters. The flow rate is obtained by establishing the empirical formula of the cross section velocity distribution in circular, rectangular and trapezoidal channels and combining with the hydraulic model algorithm. It is a non-contact flow measuring instrument that can accurately measure flow without changing the boundary conditions of channels, rivers, pipelines, etc.

1.3.1 Velocity measurement principle

The radar velocity sensor in the MRCM600 radar flowmeter adopts the principle of Doppler radar velocity measurement. When measuring the speed of the water surface, the radar velocity sensor emits microwave to the water surface, and the microwave will be absorbed and reflected when it meets the water surface. Part of the reflected wave is received by the radar velocity sensor probe, and then converted into an electrical signal, processed by the measurement circuit and measured the Doppler frequency shift, and then according to the above principle through the signal processing algorithm such as FFT can calculate the water velocity.

The principle of Doppler velocity measurement is as follows: when the radar wave transmitting source and the target are relatively stationary, the receiving frequency and the transmitting frequency are equal:

$$f_{reception} = f_0 = \frac{c_0}{\lambda} \qquad 1.1$$

When the position of the transmitting wave source is fixed and the moving target is moving in the direction of the wave source with the speed v relative to the transmitting wave source, the speed of the radar wave for the moving target increases to $c_0 + v$, and the number of wavelengths of the radar waves arriving at the moving target per unit time, namely the receiving frequency is:

$$f'_{reception} = \frac{c_0 + v}{\lambda} \qquad 1.2$$

Doppler shift:

$$f_D = f'_{reception} - f_0 \qquad 1.3$$

The speed of a moving target:

$$V = f_D \cdot \lambda = \frac{f_D}{f_0} \cdot c_0 \qquad 1.4$$

When the value is positive, the velocity is in the same direction as the transmitting wave, and the negative sign is in the opposite direction. If the speed of the moving target is proportional to the frequency shift, there is:

$$v = \left(\frac{f'_{\text{reception}}}{f_0} - 1 \right) \cdot c \qquad 1.5$$

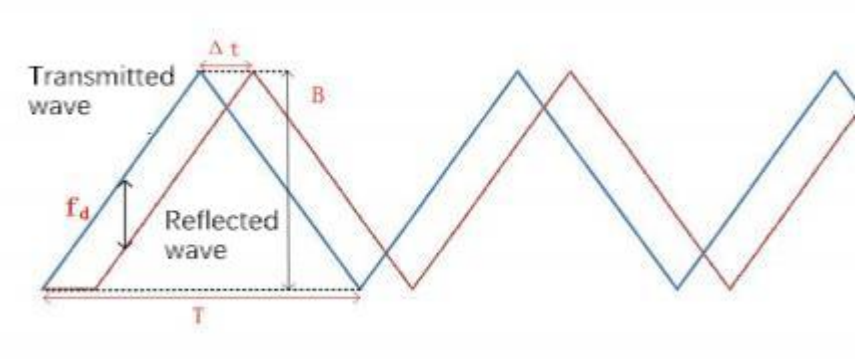
When measuring the speed on the water surface of a river, the radar velocity sensor emits microwave to the water surface. After encountering water waves, bubbles, and floating objects (moving objects to be measured), the microwave will be absorbed and reflected, and part of the reflected waves will be received by the probe and converted into electrical signals, which will be processed by the measuring circuit and measured the Doppler frequency shift. According to the above principle, the flow velocity of water can be calculated by FFT floating point operation. Since the direction of radar wave transmission and the direction of water flow usually have a certain Angle, and the transmission and reception need distance round trip, the above results need to be corrected, and the corrected actual water flow speed is (α represents the Angle between the direction of radar wave transmission and the horizontal direction) :

$$v = \frac{1}{2} \left(\frac{f'_{\text{reception}}}{f_0} - 1 \right) \cdot c_0 / \cos\alpha \qquad 1.6$$

The water velocity can be obtained according to the above formula.

1.3.2 Principle of water level measurement

The water level adopts FMCW modulation, with a triangular wave as the modulation signal. The working process is as follows: First, the voltage modulation circuit generates a triangular wave voltage input to the VCO (voltage-controlled oscillator) to generate an electromagnetic wave with a changing frequency. The change of the electromagnetic wave frequency changes according to the modulation voltage law. The electromagnetic wave emitted by the antenna is reflected by the object to be measured and then generates an echo. The radar transmission frequency has changed during the time period from the electromagnetic wave being emitted to the target, reflected by the target and then returned to the antenna. The radar antenna couples the echo signal and the transmission signal to obtain a difference frequency signal. The distance and speed information of the target are contained in the frequency of the difference frequency signal. Since the difference frequency signal is very weak, it is processed by the preamplifier and filter circuit of the radar sensor and sent to the ADC (analog-to-digital converter) of the MCU. The MCU analyzes the waveform collected by the ADC through the FFT algorithm to obtain the frequency of the difference frequency. Finally, the distance from the measured target to the sensor is calculated by the derived formula.



When the radar wave source and the target are relatively stationary, the radar transmission frequency bandwidth is B, the time taken for the radar wave to be transmitted and returned to the radar antenna is Δt, the frequency of the triangular wave is f, and the frequency of the difference frequency signal is fd. The derivation is as follows: (S: distance from the radar board to the target, T: period of the triangular wave)

$$\Delta t = \frac{2S}{c_0}$$

$$T = \frac{1}{2f}$$

$$S = \frac{f_d C_0}{4fB}$$

In the above formula, C0 is the speed of light, f is the frequency of the modulated triangle wave, B is the radar sweep bandwidth, and fd is the difference frequency signal obtained by MCU analysis. Therefore, the only fd can calculate the distance from the radar board to the target.

1.3.3 Principle of flow measurement

The average velocity can be obtained and converted through the radar velocity probe, and the water depth can be obtained and converted through the radar water level probe. The cross-sectional flow rate is equal to the average velocity × water flow cross-sectional area × shore coefficient. In the open channel of the irrigation area, the common cross-sectional types of the irrigation area open channel are rectangular, trapezoidal or U-shaped; the commonly used slopes are the longitudinal slopes of the main and branch channels; the two commonly used roughness are concrete channel wall and mortar-laid stone channel wall. For these common open channels, their bottom slope and roughness are determined. In the velocity distribution of the cross section, the velocity has a strong symmetry, and the straight sections of the upper and lower reaches of the irrigation area section are long, and the cross section is symmetrical, and the velocity distribution has the characteristics of good symmetry. The velocity field distribution is corrected according to the cross-sectional form, bottom (longitudinal) slope and roughness; the turbulence mathematical model used is mainly the RNG (renormalization group) κ - ε model, which has high calculation accuracy, good numerical stability, and moderate calculation data volume.

2 Serial port connection instructions

2.1 Connection

As shown in the figure below, the brown line is the positive input of the power supply, the black/white line is the GND line, TX (green A+) is the RS232 output interface of the radar flowmeter or the positive pole of RS485, RX (red B-) is the RS232 input interface of the radar flowmeter or the negative pole of RS485, the maximum transmission distance of the RS232 communication interface is about 15m; the maximum transmission distance of the RS485 interface is about 1.5km, and the yellow line is the positive pole of 4-20mA (reserved).

Pin	Color	Description
1	Brown	7-32V DC power supply
2 , 6	Black, White	GND
3	Green	TXD_A (232_TX/485_A+)
4	Red	RXD_B (232_RX/485_B-)
5	Yellow	IOUT (4-20 mA positive, reserved)

Connection line color and signal comparison chart

2.2 Setting

Communication format

Communication interface: RS485

Baud rate: configurable (default 9600)

Parity bit: NONE Data bit: 8bit

Stop bit: 1

2.3 Wired Mode Description

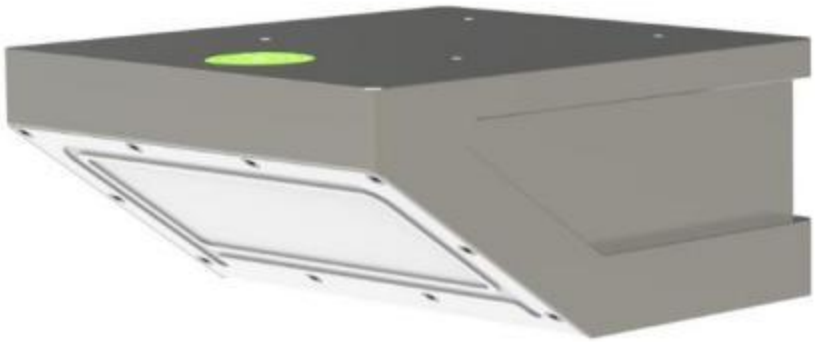
MRCM600 radar flowmeter is compatible with standard MODBUS-RTU communication protocol. Our company can also provide customized communication protocol for users).

MRCM600 radar flowmeter has two working modes: normal working mode and timed sleep mode. When the sleep time register is set to 0, the device is in normal working mode. When it is greater than 0, it enters timed sleep mode. After the device completes the measurement, it sleeps according to the set sleep time (minutes). When the sleep time is up, it continues to measure.

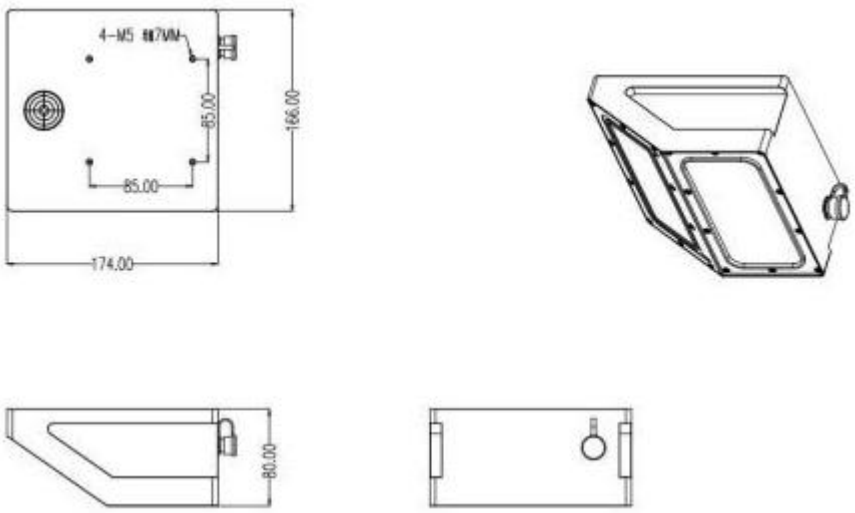
3 Product Installation

3.1 Instrument structure and appearance dimensions

3.1.1 MRCM600 Appearance and size of the instrument



MRCM600 Appearance structure diagram



MRCM600 The external dimensions are 174×166×80 (unit: mm)

3.2 On-site installation

3.2.1 Instrument installation method and direction



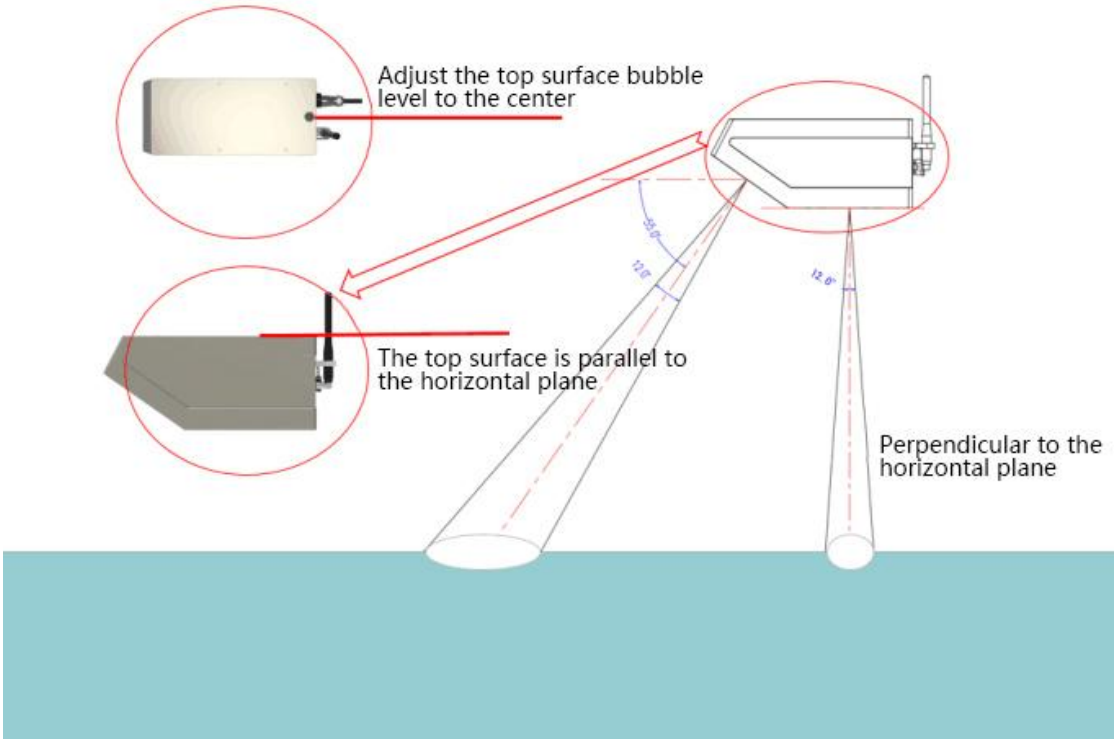


Adjust the level so the bubble is centered.

The installation direction is shown in the figure above. Three clamps fix the bracket and the instrument on the crossbar (crossbar diameter range: 40mm-85mm). During installation, keep the upper surface of the instrument and the river surface level (Note: adjust the bubble of the level to the center). The installation direction is recommended: the water flow is facing the relative flow velocity measurement direction.

3.2.2 Test point selection

When choosing the installation site, ensure that the radar wave covers the water surface, avoid the influence of floating objects, whirlpools and aquatic plants, and avoid riverbed siltation during low water periods, main channel swing, etc., which may cause the radar wave to cover the ground and cause measurement errors. The radar water level meter has a transmission angle of 12° and a coverage area that is approximately circular; the radar current meter has a transmission angle of 12° and a coverage area that is approximately elliptical, as shown in the figure below;



The relationship between the diameter and distance of a circle is shown in the following table:

Installation height (m)	Current velocity meter coverage diameter range (m)	Water level meter coverage diameter range (m)
5	1.994	1.051
10	3.977	2.102
15	5.960	3.153
20	7.943	4.204
25	9.925	5.255
30	11.994	6.036
35	13.891	7.357
40	15.874	8.408

The selection of channel measuring points should follow the following main principles:

1) The channel is straight, the channel foundation is fixed, and the cross-section is regular and stable, which is convenient for equipment installation;

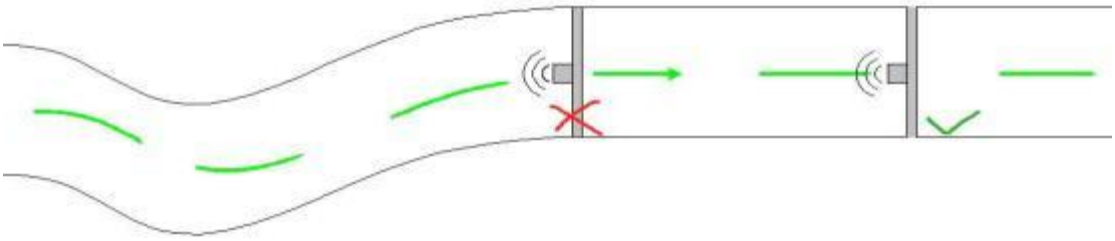
2) The water flow is smooth and uniform, and is not affected by vortexes, gate opening and closing, and waterlogging of channel system buildings;

3) The measuring section is perpendicular to the water flow direction;

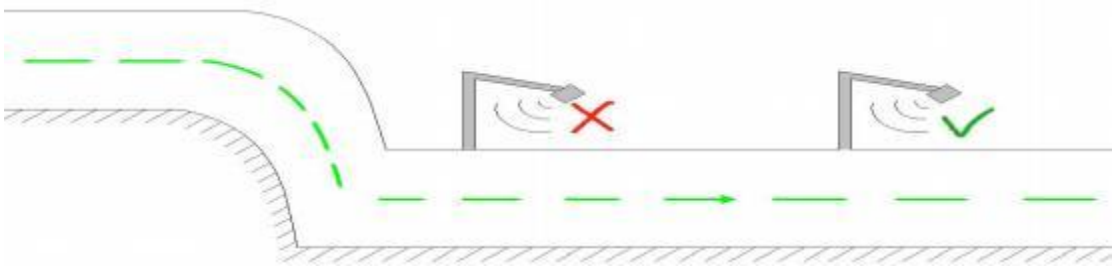
4) There should be no buildings, trees or weeds that affect the water flow near the section, and it should not be affected by the discharge when it is downstream of the building;

5) It is not suitable to install in places with severe siltation, aquatic plants or debris.

For non-contact measuring devices such as radar flowmeters, avoid the following locations when installing them:
1) Avoid places where the flow direction of rivers or channels changes, and try to ensure that the flow direction is parallel to the installation direction of the radar flowmeter;



2) Avoid placing the radar meter flow probe directly in front of a large drop in water flow.



3) Avoid installing above the gate or above a reservoir with undercurrent. The typical feature of this scenario is that the water level is lowered, but the undercurrent under the water surface cannot cause a stable flow rate on the surface, so it is not a suitable installation point.

4) Avoid installing at locations where wind is easily generated, such as culvert outlets and mountain pass wind tunnels. Wind has a certain impact on low flow rate measurements.

3.2.3 Precautions

- When installing the instrument, keep the upper surface level with the river surface;
- Do not install the instrument at a bend;
- Do not install the instrument at a height difference;
- Do not install the instrument on a water surface with vortices.

4 Technical Parameters

Items	Value
Flow measurement system	
Measuring principle	Planar microstrip array antenna CW+FMCW
Working mode	Manual, automatic
Applicable environment	24 hours, rainy day
Working temperature	-30~80°C
Working voltage	7-32 V DC
Working current	12VDC input, working mode: ≤120mA standby mode: <1mA
Protection level	IP68
Lightning protection level	6KV
Appearance size	174×166×80 (mm)
Weight	Less than 1.5kg
Radar wave speed sensor	
Radar frequency	24 GHz
Maximum range	0.1m-40 meters(vertical distance)
Speed range	0.03~20m/s
Speed accuracy	±0.01m/s; ±2%FS
Antenna angle	12°
Measurement direction	Automatically identify water flow direction, built-in vertical angle correction
Radar water level gauge	
Radar frequency	80 GHz
Measurement range	0.2-40 meters
Measurement accuracy	±3mm; ± 0.05%FS
Antenna angle	8°
Wireless configuration	Bluetooth
Data transmission system	
Digital transmission method	RS485/ RS232, 4-20mA, LoRa/4G(Wireless optional)

5 Warranty

The supplier guarantees that the MRCM600 instrument is free of defects in performance and quality at the time of sale. For problems that occur during use, the company will only repair or replace instruments that fail under correct use conditions. Before returning the instrument for repair, please contact the supplier first; the returned product must be well packaged to ensure that the instrument is not damaged during transportation.

5.1 Warranty period

The free warranty period for users is one year (calculated from the date of purchase). For instruments beyond the warranty period, the company will provide paid repairs.

5.2 Warranty coverage

During the warranty period, the company will only repair products that fail under correct use conditions free of charge. Failures caused by the following circumstances are not covered by the warranty:

- Expiration of the warranty period;
- Damage caused by failure to use and maintain the product in accordance with the product manual;
- Damage caused by unauthorized repairers (private dismantling and repair);
- Other non-quality failures such as natural disasters, mechanical damage, etc.

Appendix A Shipping List

NO	Name	Specifications and models	QTY	Remarks
1	Radar flowmeter	MRCM600	1	/
2	Cable with plug	Six-core cable	1	Standard 10 meters
3	Instructions	PDF electronic file	1	/
4	Mounting bracket, screws, clamps	Stainless steel + aluminum alloy	1	/
5	Warranty card, certificate of conformity	Special for MRCM600	1	/

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