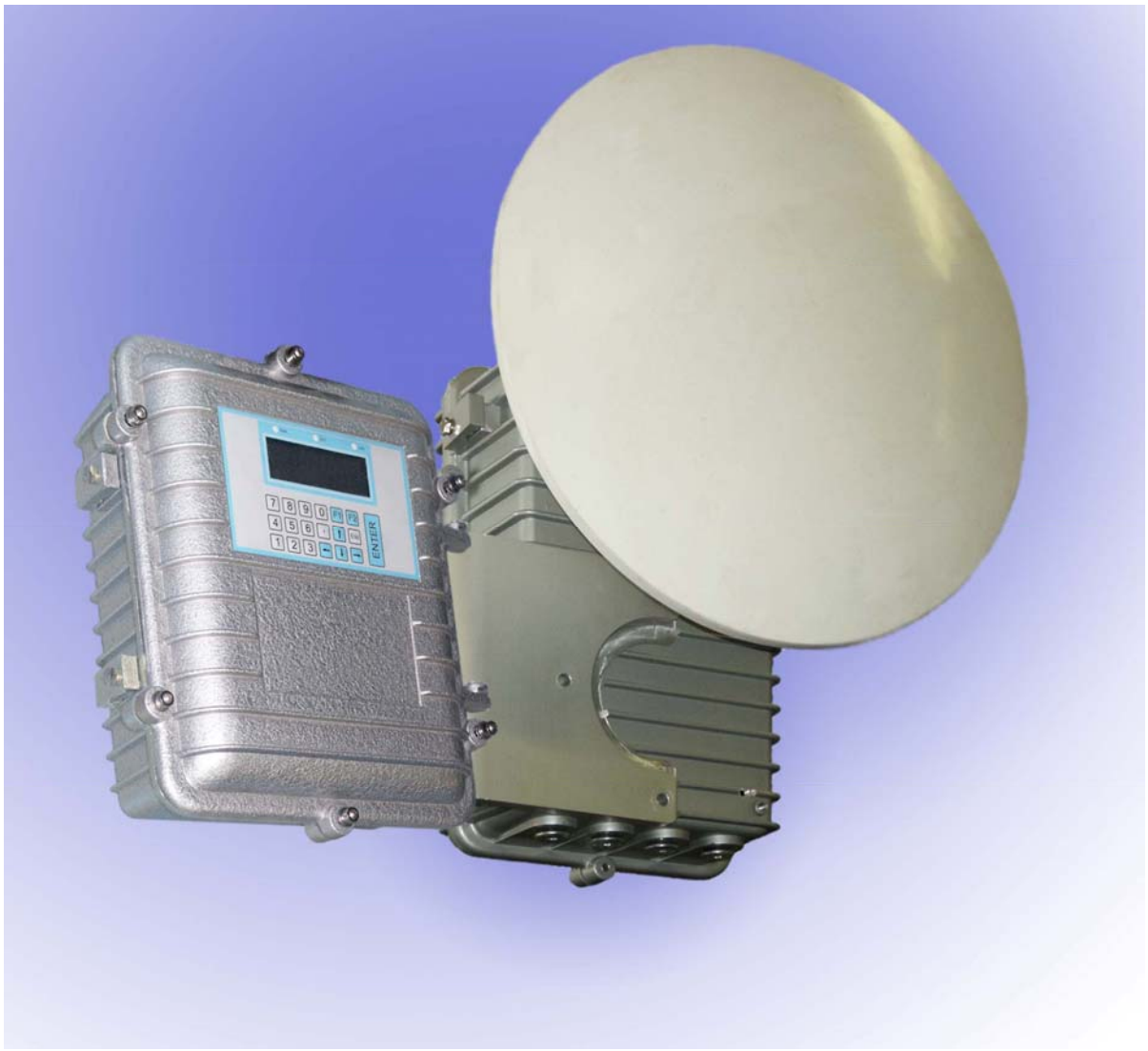
46 Robezu str. • LV-1004 Riga • Latvia
Phone: +371-7-065-100, Fax: +371-7-065-102
Mm-wave Division in St. Petersburg, Russia
Phone: +7-812-326-5924, Fax: +7-812-326-1060

MILLIMETER WAVE
INDUSTRIAL DISTANCE SENSOR
FMCW 94/10/X



Operation manual
(2nd edition, 2007)

CONTAINS.

1. **Introduction ……..…….. 2**
2. **Specifications ……..……. 2**
3. **Put into operation ……... 3**
4. **Connection of the controller to PC …… 4**
5. **SUPPLEMENT No.1 Dimensions ……..…… 6**
6. **SUPPLEMENT No.2 Support system…… 7**

1. Introduction

FMCW 94/10/x Millimeter Wave Distance Sensor (option X: 100 - 600mm Cassegain antenna) is a high-accuracy non-contact level measurement of large volumes of bulk materials in hoppers and silos at minerals and chemical industries. The examples of use are hard-rock mines, cement hoppers, and other bunkers with adverse environmental conditions such as dust, corrosive gas, fog, high level noise. The Distance Sensor can also be used for liquid level measurement at huge industrial tanks where there is a fuzzy edge of liquid because of foam or vapor. The example of that application is volume measurement in tanks at large breweries.

The Distance Sensor is based on millimeter wave FMCW (frequency-modulated continuous wave) radar principles. It is free from laser, acoustic, and microwave radar shortcomings. It is characterized by a narrow beam that's good for enclosed areas like ore passes, because of 94 GHz FMCW radar operational frequency that is equivalent to 3mm wave length, the sensor provides an excellent penetration of dust and water vapour. The Distance Sensor works well even with a dust sticking on antenna. With a narrow beam, the Distance Sensor can build a precise surface profile at a hopper (mechanical scanning required). The operation range of Distance Sensor is 500m, that allowing using it at deep mines, where typical passes are up to 300m but rarely even longer.

To facilitate installation, mounting and alignment at field condition, the sensor is built as two modules; a front end and a separate signal processor connected by a shielded cable. A local graphics display and keypad are incorporated into the control unit. The front end and antenna are housed in robust metal case. The signal processor and power supplies are built into a commercially available housing with signal access via cable glands.

To use Distance Sensor within complete data acquisition system on an enterprise, the sensor has RS-485 interface using MODBUS protocol RJ-45 socket made in dust and moisture-proof embodiment. The radar transmitter at the Distance Sensor complies with international safety regulations.

2. Distance Sensor Specifications

Distance Sensor Performance	
Distance Sensor resolution	0.005 m
Range of heights of Sensor position above the surface of material	0.6 to 500 m
Main reflector diameter size	300 and 600 mm
Distance Sensor radar transmitter emission power	10 mW
Distance Sensor radar operating frequency	94 GHz
Power supply voltage	+18 - +36 DCV optionally 110/220V AC
Distance Sensor radar power consumption	20W
Operation mode	CW
Distance Sensor Head Specification	
Sweep Range, MHz	505.472 962686326
Sweep time, ms	12.285
Interface protocol	IP 192.168.1.1
Sampling rate	4096 points per 12.285 ms
Data range	14 bits
Power supply voltage	External Power supply
Enclosure	IP65
Communication connector	RJ-45
Ambient temperature	-30 to +50°C
Atmospheric pressure	84.0-106.7 kPa (630-800 Torr)
Relative humidity at 35°C and lower, no more than	95%
Vibration amplitude at 5Hz to 25Hz band, no more than	0.1mm
Controller NZ6100 Specifications	
Display	20 digits, 4.75 mm height 4 lines Liquid Crystal Display
Indicators	Power LED
Control Unit Power Supply	85-265 VAC, 47-63Hz, 15W optionally +18 - +36 DCV
Membrane Keypad	27 keys including 8/18 function keys
Communications:	RS-485 or TBD
Communication protocols	MODBUS RTU
Dimensions	290mm W x 240 mm H x 13mm D

3. Put into operation.

The distance measurement system consists of radar (with external power supply), that measures the distance and controller that processes the radar signal, calculates the distance and presents the result to operator. This hand-book covers controller performance capabilities and operation modes. Dimensions of system units is presented on Supplement No1.

3.1. Controller link-up

RS-485 interface (7) is connected to the system via HAN connector. The pinout is:
Pin 1 – Data (-),
Pin 2 – Data (+),

The RAW DATA cable terminates in RJ-45 connector.

Controller casing and supplied along with it connectors guarantee protection against dust and humidity according to IP-65.

3.2. Controller start up

After switching-on the power supplies, initialization of the controller occurs, diagnostic information appears on the controller display and the controller comes into normal operating mode when the distance measurements are realized. It is marked with the word "**working**" on the display:

```
Low=48
Freq=562.35 D=163.53m
V=0.0 m/c
(Line Power Indicator)
```

Where is,
Low - min detected distance 48*0.29m.

Reflected frequency
Freq – maximum intermediate frequency of the reflected signal displayed in kHz with 0.01 kHz accuracy.

Distance
D – measured distance in meters with 0.01 m accuracy.

Velocity
V - Velocity of object in m/c.

3.3. Controller operating modes

The radar is able to measure distances within the range of 0.6 to 500 m. User can set via RS-485 interface the following:

- min measured distance;
- max measured distance;
- type of analyse.

Rate communication and address of device are set from digital keyboard on controller.

4. Connection of the controller to PC

4.1. Communication interfaces

Operator can retrieve digitized values of the measured distances from the controller to his PC, as it were described in Section 1.1, using the interfaces RS-485 interface with protocols Modbus RTU.

4.2. Communication parameters setting

4.2.1. Switching the controller on the setting mode

Controller communication parameters and address are set up using the controller keyboard. To see the settings or to change them, press key **F1.** At the setting mode, different parameters can be seen and set with the aid of up/down arrows of the keyboard. Exit from the mode is realized with pressing **Esc** key. If some parameters have been changed the controller will be re-initialized with new parameters. The re-initialization takes about 30 sec.

4.4. Modbus RTU data transfer

Available parameters:

- 8 data bits
- even parity
- 2 stop bits
- (8E2)

Rates: 1200, 4800, 9600, 19200, 38400, 57600, 115200.

Supported MODBUS functions:

- 3 (read registers)
- 6 (write single register)

Registers description:

REGISTER (read/write)	ADDRESS	WORDS	COMMENT / (FORMAT)
Max Distance	0	1	Unsigned integer (9999.9)
Min Distance	1	1	Unsigned integer (9999.9)
Power level	2	1	Unsigned integer (9999.9)
ADC range10/(2^X) Volts	3	1	Unsigned integer(0..3)
Mode	4	1	Unsigned integer(0..5)
Write 1: Save 0..7 registers Write 0: Load last saved values	5	1	Unsigned integer
Contains distance unit to interpret spectrum	6	1	Unsigned integer. (9.9999)
Reserved	7	1	Unsigned integer.
REGISTER (read only – write operation is void)			
Distance	8	2	Value*10000 (999999.9999)
Speed	10	2	Value*10000 (999999.9999)
Power	12	2	Value*10000 (999999.9999)
Spectrum	14	64	Structure: 32 words harmonic numbers; 32 words power values Data valid while non-zero harmonic number

To request the data registry from device with address 01, activate the Modbus function 3 as following:

Request	Controller Modbus address	Function code	Registry address		Number of registries to transfer		Checksum CRC16	
	byte	byte	High	Low	High	Low	Low	High
Distance	01	03	00	08	00	02	??	??
Speed	01	03	00	0A	00	02	??	??
Power	01	03	00	0C	00	02	??	??
All data	01	03	00	08	00	06	??	??
Max set distance	01	03	00	00	00	01	??	??

Example: assume that the distance at the moment of the Modbus request is 21.05 m. Then the controller will respond:

Distance = 21.05m *10000=210500=00 03 36 44 hex

Speed = -0.0007m/s *10000=12200=FF FF FF F9 hex (the only signed value!)

Power = 2345.235*10000=23452350=01 65 DA BE hex

Response	Controller Modbus-address	Function code	Number of transferred bytes	High word		Low word		Checksum CRC16	
				High	Low	High	Low		
Distance	01	03	04	00	3	36	44	??	??
Speed	01	03	04	FF	FF	FF	F9	??	??
Power	01	03	04	01	65	DA	BE	??	??
All data	01	03	0C	12 bytes sequence				??	??

Read Max Distance=310.5m *10=3105=0C 21 hex

Response	Controller Modbus-address	Function code	Number of transferred bytes	word		Checksum CRC16	
				High	Low		
Max distance	01	03	04	0C	21	??	??

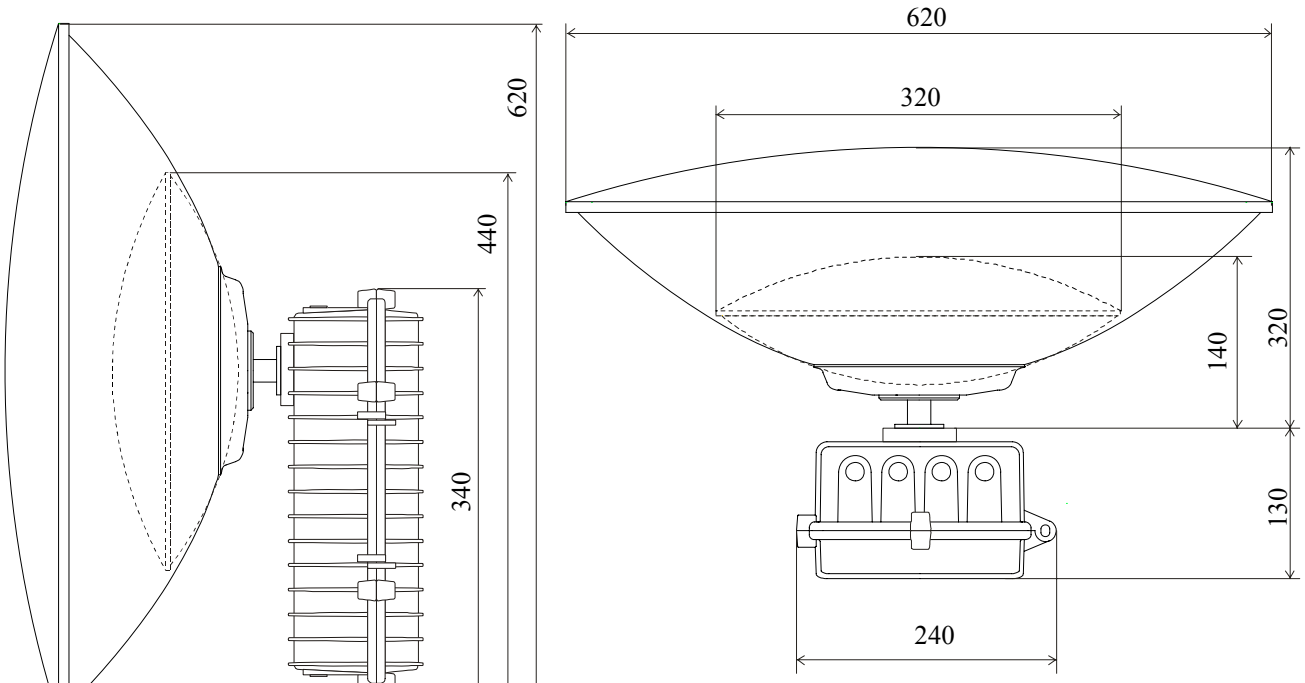
Using function 6: Set Max Distance=310.5m *10=3105=0C 21 hex

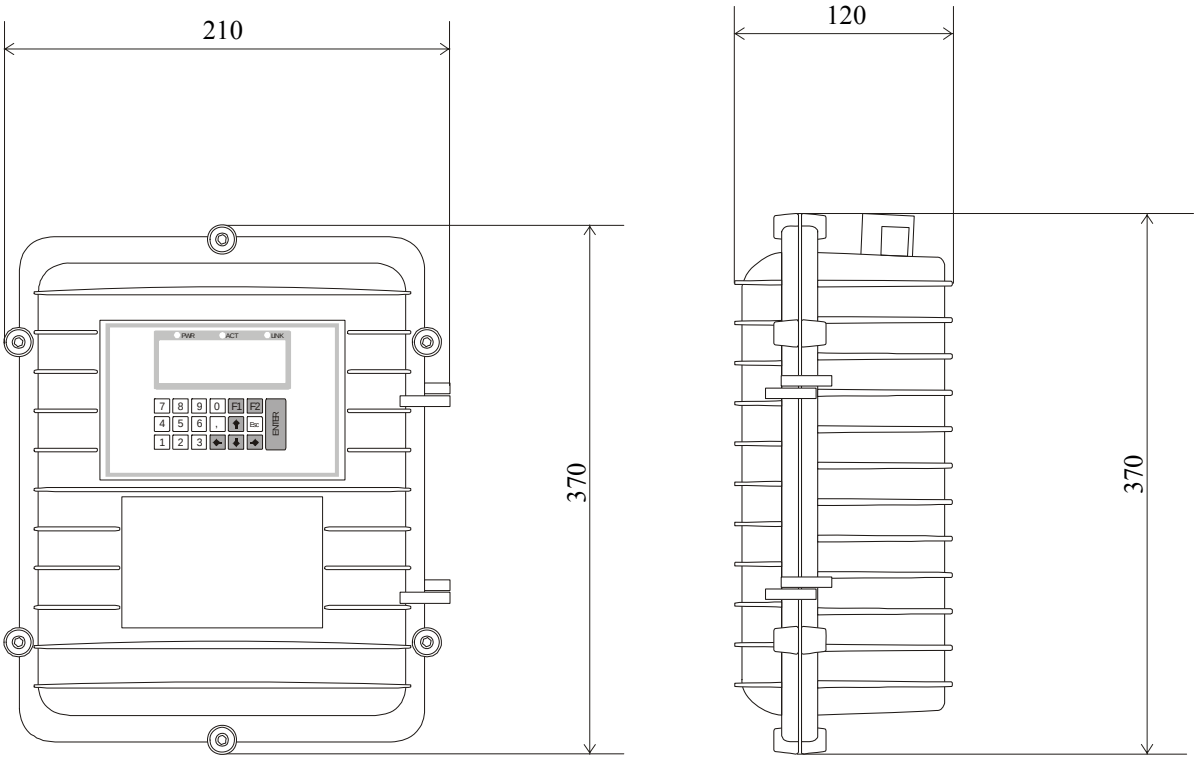
Command	Controller Modbus-address	Function code	Register address		word		Checksum CRC16	
			High	Low	High	Low		
Set Max distance	01	06	00	00	0C	21	??	??

Example of C function to calculate CRC16 (CmdLen doesn't include CRC bytes):

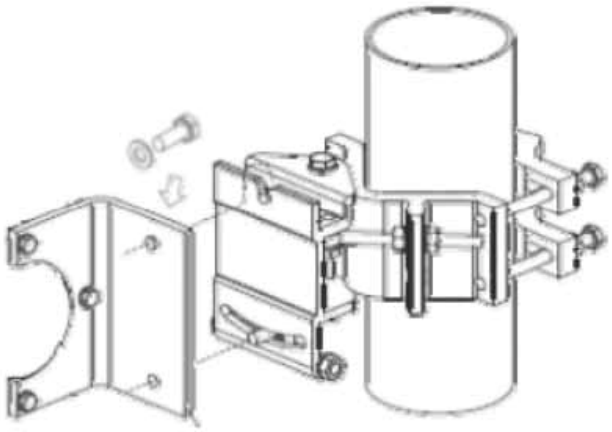
```
WORD crc_count (uchar * Cmd, DWORD CmdLen)
{
	WORD crc = 0xFFFF;
	int i, j;
	BOOL register odd;
	for (j=0; j<CmdLen; j++)
	{
		crc^=(WORD) Cmd[j];
		for (i=0; i<8; i++)
		{
			odd= crc & 0x0001;
			crc >>= 1;
			if (odd) crc^=0xA001;
		}
	}
	return crc;}
```

SUPPLEMENT No.1
Dimensions.

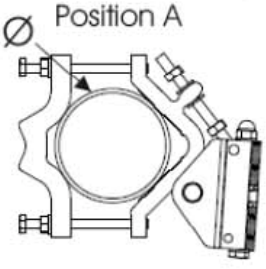




SUPPLEMENT No.2
Support system.



The Mast Mount and different poles



Ø	Pos.
40-75	B
76-95	A / B
96-130	A