Signal processing unit CYSPU-F98A for frequency and speed measurement

The signal processing unit CYSPU-F98A uses a low-power processor to process periodic analog signals and is used to determine the frequency of rotational speed sensors and gear tooth sensors, e.g. CYGTS101DC, CYGTS101DC-S, CYGTS102DC and CYGTS102OR, which provide a square-wave pulse, a sine wave signal or both square and sine wave signals at the same time. For frequency measurement, this signal processing unit has a large frequency measuring range from 0.1Hz to 1MHz with a measuring accuracy of 0.1%. The frequency value can be easily converted into rotational speed as output value.
The measurement results can be displayed via the LCD module or communicated via the RS485 interface based on the MODBUS protocol. The device works with a supply voltage of 4.5V to 24VDC.

1. Specifications

Features

- Processing of analog square and sinusoidal signals
- Wide frequency measuring range from 0.1Hz to 1MHz
- Very high measuring accuracy 0.05% ~ 0.1%
- Excellent real-time performance for low frequency measurements
- Intuitive reading of the frequency and rotational speed values on the LCD
- Output of the frequency and speed values via RS-485 Modbus
- EMI resistant
- Wide operating temperature range: -20°C ~ +70°C (with display), -40°C ~ +85°C (without display)

Application

- Frequency measurement of square and sine waves
- Speed measurement using speed sensors or gear tooth sensors
- Equipment for precise speed measurement and control
- Speedometer
- Drive control and blocking protection

Technical Data

Part number	CYSPU-F98A
Supply voltage	+4,5V ~ +24V
Frequency measurement range F	Sine signal input: 0,1Hz ~ 50KHz
	Square wave input: 10Hz ~ 1MHz
	Square wave and sine signal inputs: 0,1Hz ~ 1MHz
Speed measuring range ω	ω =60F/N (RPM), with N as pulse/period number per revolution
Measuring accuracy	Sine signal input: 0,1Hz ~ 50KHz, 0.1%
	Square wave input: 10Hz ~ 1MHz, 0.05%
	Square wave and sine signal inputs: 0,1Hz ~ 1MHz, 0.05%~0.1%
Response time	Max. 100ms
Data Output	LCD display or RS485 interface
Display	16-digit LCD
Baud rate for RS485	1200, 2400, 4800, 9600 (Default), 19.2K, 38.4K, 57.6K, 115.2K bps
Power consumption	<1200mW (under power supply + 12V)
Galvanic isolation	2500V rms for 1 min. according to UL 1577
Bus protection	±15kV ESD protection on RS-485 input/output pins, open- and short circuit, fail-safe receiver inputs

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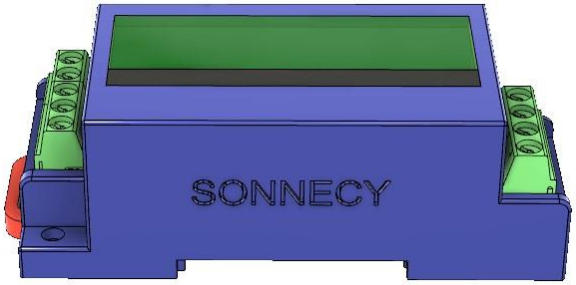
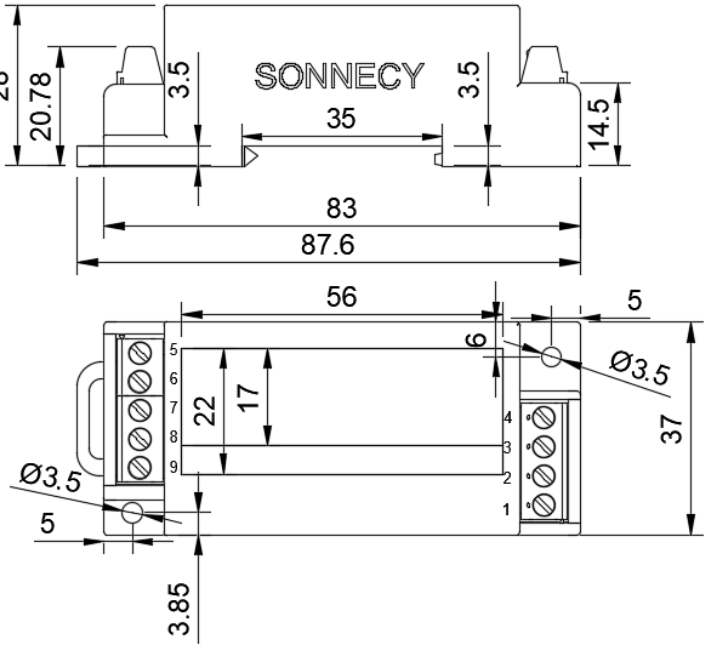
Absolute Grenzwerte

Supply voltage	+4.5V ~ +30V DC
Reverse protection voltage (max)	-30V
Input voltage (Sine Wave)	0V ~ +3.3V
Input voltage (Square Wave)	0V ~ +22V
Operating temperature range	-20°C ~ +70°C (with display), -40°C ~ +85°C (without display)

2. Case Style and Connection

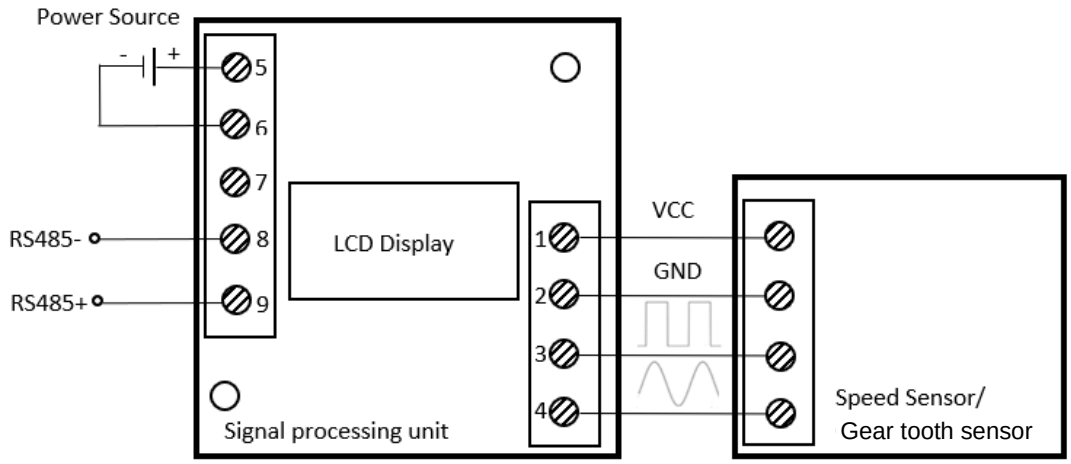




Case: 83 X 37 X 28 mm

LCD module: 22 X 56 mm

Connection to the speed sensor / gear tooth sensor with square and sine inputs



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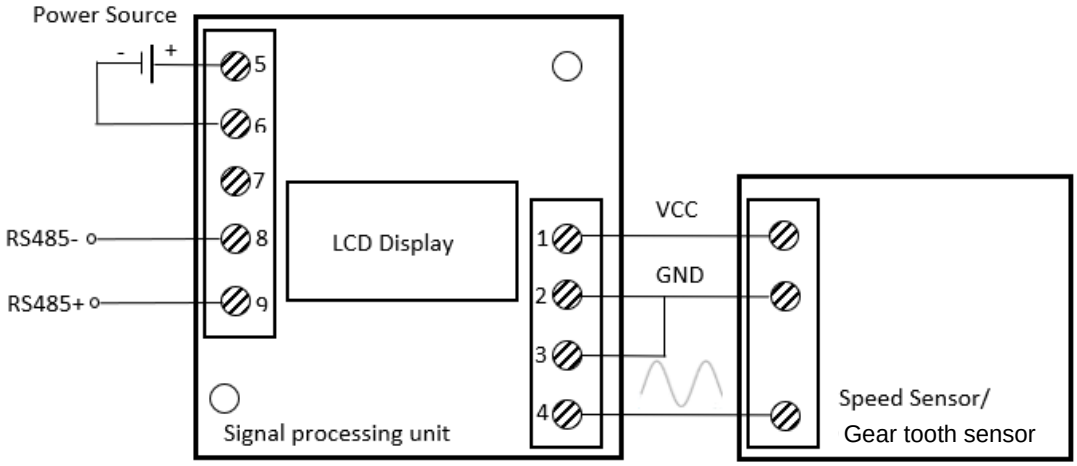
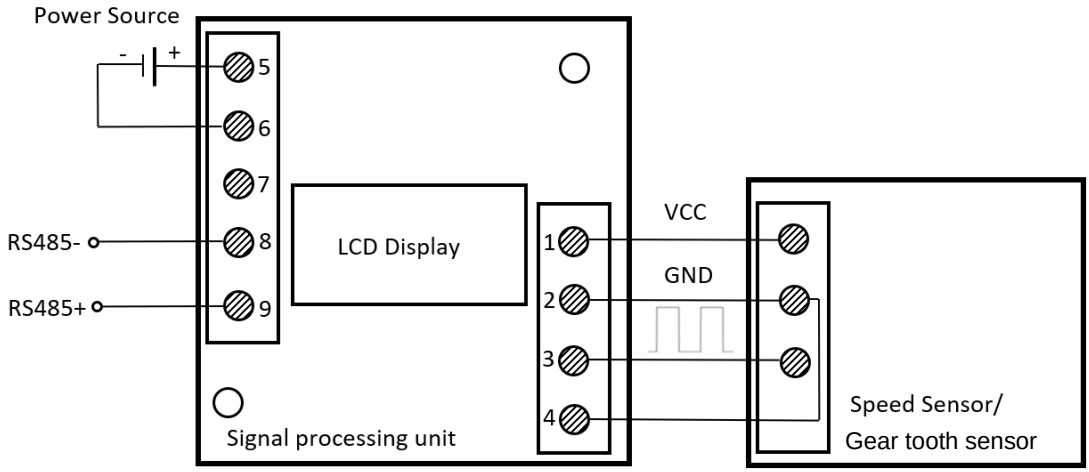
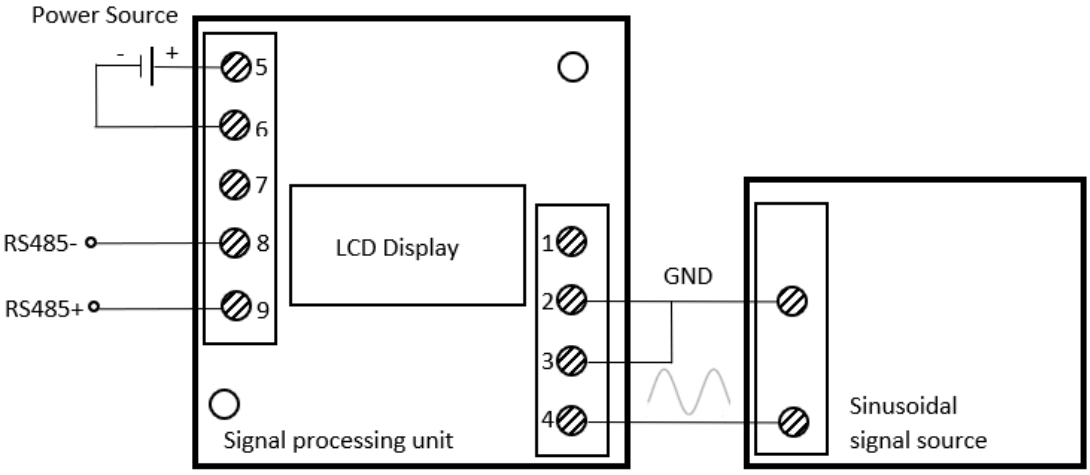
Connection to the speed sensor / gear tooth sensor with sinusoidal signal input



Connection to speed sensor / gear tooth sensor with square wave signal input



Connection to a sinusoidal signal source



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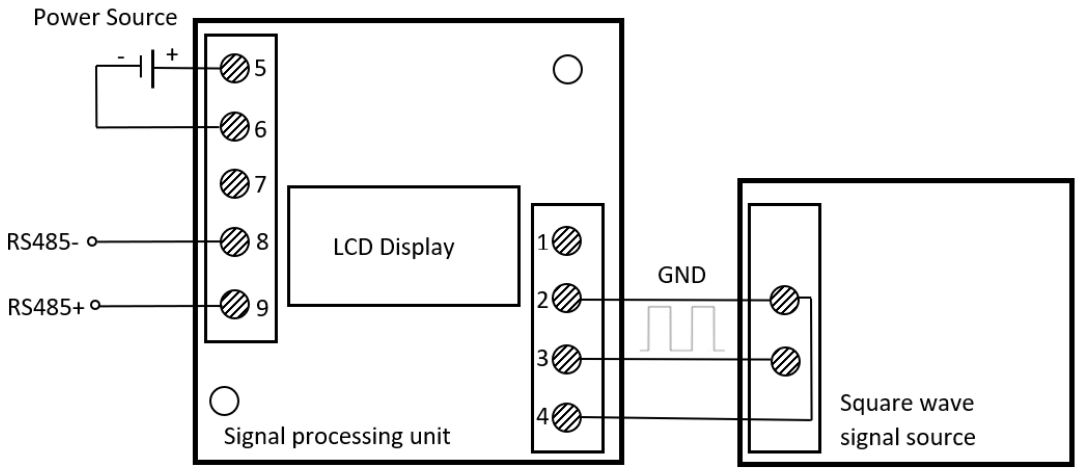
Connection to square wave signal source



3. Communication Protocol and Order Sets

This digital signal processing unit uses MODBUS-RTU protocol format and has RS485 output interface for long distance data transmission.

3.1 Register Address Table

Register Address	Content	Register Number	R/W	Data Range
0x0010	Frequency (Hz)	3	R	According to the Measuring range
0x0013	Rotational Speed (RPM)	3	R	According to the formula for speed conversion
0x0016 - 0x001F	Reserved	13	-	-
0x0020	Address und baud rate	1	R/W	Address 0x01 - 0x07 Baud rate 0x03 - 0x0A
0x0021	Device designation	5	R	"CYSPU-F98A "
0x0026	Serial data format	1	R/W	Parity check 0x00 - 0x02 Length of stop bit 0x00-0x02
0x0027	Number of teeth	1	R/W	Positive integers
0x0028	Mode selection	1	R/W	Display mode 0x00 - 0x01 Measurement mode 0x01 - 0x03
0x0029 - 0x002F	Reserved	7	-	-

Note: 0x means the number is hex number, as described below.

3.2 Frame format and example

3.2.1 Function code 0x03 - read data from the signal processing unit

Request frame of master equipment

Address of the signal processing unit	0x01 - 0XF7	1 byte
Function code	0x03	1 byte
Start register address	2 bytes	
Register number	2 bytes	
CRC	2 bytes	

Note: CRC means Cyclic Redundancy Check. In this product CRC is calculated according to CRC-16 (Modbus) standard, as described below.

Examples:

(1) Read frequency value

Address	Function	Register address		Register number		CRC-L	CRC-H
0x01	0x03	0x00	0x10	0x00	0x03	0x04	0x0E

(2) Read rotational speed value

Address	Function	Register address		Register number		CRC-L	CRC-H
0x01	0x03	0x00	0x13	0x00	0x03	0xF4	0x0E

(3) Read device name and settings

Address	Function	Register address		Register number		CRC-L	CRC-H
0x01	0x03	0x00	0x20	0x00	0x09	0X84	0x06

Answer frame of the signal processing unit

Address of the signal processing unit	0x01 - 0XF7	1 byte
Function code	0x03	1 byte
Data byte length	2 x register number	1 byte
Data read from register	Register content	2 x register number bytes
CRC	2 bytes	

Examples:

(1) Receive frequency value

Address	Function	Data byte length	Data			CRC-L	CRC-H
0x01	0x03	0x06	0x000f	0x4240	0x0000	0x60	0xD8

Frequency value format

6 bytes: The first four bytes are the integer part of the frequency value, the last two bytes are the decimal part of the frequency value. Here 0xf4240 as integer part and 0x0000 as decimal part is converted to decimal as 1000000.0000Hz.

Data range: 0.1Hz ~ 1MHz

(2) Receive speed value

Address	Function	Data byte length	Data			CRC-L	CRC-H
0x01	0x03	0x06	0x004c	0x4b40	0x0000	0x26	0x8B

Rotational speed value format

6 bytes: The first four bytes are the integer part of the rotational speed value, the last two bytes are the decimal part of the rotational speed value. Here 0x4c4b40 (integer part) and 0x0000 (decimal part) are converted to decimal as 5000000.0000RPM if the gear for the gear tooth sensor has 12 teeth.

Conversion to speed value: $\omega=60F/N$ (ω: Speed value, F: Frequency value, N: Number of teeth)

Data range: 0.5RPM ~ 5MRPM (For gears with 12 teeth)

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(3) Receive device name and settings

Address	Function	Length	Data					CRC-L	CRC-H
0x01	0x03	0x14	0x0106	D*	0x0000	0x000C	0x0001	0x59	0x10

Explanation:

0x0106 is address of the signal processing unit and baud rate.
Valid addresses: 0x01 to 0xF7
Baud rate: 0x03 -- 1200 bps, 0x04 -- 2400 bps, 0x05 -- 4800 bps,
0x06 -- 9600 bps (Default), 0x07 -- 19.2 kbps, 0x08 -- 38.4 kbps,
0x09 -- 57.6 kbps, 0x0A -- 115.2kbps

The ASCII code D* (10 bytes) describes the name of the device, namely “CYSPU-F98A ".

0x0000 is parity check and length of stop bit:
Parity check: 0x00 -- none (default), 0x01 -- odd, 0x02 -- even
Length of stop bit: 0x00 -- 1 bit (default), 0x01 – 1.5 bit, 0x02 -- 2 bit

0x000C is the number of teeth of the target gear for the speed sensor. This value is converted to a decimal number and results in a number of teeth to 12. If it is 0x0000 (default) there is no conversion from frequency value to speed value (speed value equals the frequency value when N=1).

0x0001 describes the display mode and the measurement mode.
Display mode: 0x00 -- Frequency value (default), 0x01-- Rotational speed value
Measurement mode: 0x01 -- Square wave input (default),
0x02 -- Sine signal input
0x03 -- Square wave and sine signal inputs.

3.2.2 Function code 0x10 --- write data to the signal processing unit

Request frame of master equipment

Address of the signal processing unit	0x01-0XF7	1 byte
Function code	0x10	1 byte
Start register address	2 bytes	
Register number	2 bytes	
Data byte length	2 x register number	1 Byte
Data write to register	2 x register number bytes	
CRC	2 bytes	

Examples:

(1) Change address and baud rate

Address from 01 (default) to 02, baud rate from 9600 (default) to 19.2K.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x20	0x00	0x01	0x02	0x02	0x07	0xE1	0x92

Explanation:

The data 0x0207 are written into the register 0x0020. The high byte 0x02 means the address of the signal processing unit on the RS485 bus. The low byte 0x07 means the communication baud rate.

(2) Change serial data format

Parity check is from none (default) to even, length of stop bit from 1 bit (default) to 2 bits.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x26	0x00	0x01	0x02	0x02	0x02	0x21	0xF7

Explanation:

Data 0x0202 is written into register 0x0026. The high byte 0x02 means the parity check. The low byte 0x02 means the length of stop bit.

(3) Change the number of teeth on the target gear

The standard register value is 0x0000, which means that the frequency value is not converted to the speed value. The number of teeth 12 is written into the corresponding register according to the lower instruction.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x27	0x00	0x01	0x02	0x00	0x0C	0xA0	0x82

Explanation:

For the signal processing of the speed sensor, there is a mathematical relationship between the signal frequency and the speed value. By giving the number of teeth of the target wheel, the signal frequency can be converted into the speed value. If the conversion is not needed, this register value can be set to the value 0x0000.

(4) Change the display mode and the measurement mode

There are two types for displaying the measurement results, i.e., frequency value and speed value. In addition, three measurement modes are available, namely measurement using sine signal, measurement using square wave and measurement using both sine signal and square wave.

Displayed value: Frequency value (default), Measurement mode: Mode 1 Square wave input (default).

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x00	0x01	0x61	0xB8

Displayed value: Frequency value (default), Measurement mode: Mode 2 Sine signal input.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x00	0x02	0x21	0xB9

Displayed value: Frequency value (default), Measurement mode: Mode 3 Square wave & sine signal inputs.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x00	0x03	0xE0	0x79

Displayed value: Speed value, Measurement mode: Mode 1 Square wave input (default).

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x01	0x01	0x60	0x28

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Displayed value: Speed value, Measurement mode: Mode 2 Sine signal input.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x01	0x02	0x20	0x29

Displayed value: Speed value, Measurement mode: Mode 3 Square wave & sine signal inputs.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x01	0x03	0xE1	0xE9

Answer frame of the signal processing unit

Address of the signal processing unit	0x01 - 0XF7	1 byte
Function code	0x10	1 byte
Start register address	2 bytes	
Register number	2 bytes	
CRC	2 bytes	

Examples:

(1) Receive correct answer of changing address and baud rate

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x20	0x00	0x01	0x00	0x03

(2) Receive correct answer of changing serial data format

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x26	0x00	0x01	0xE0	0x20

(3) Receive correct answer of changing the number of teeth of the target wheel

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x27	0x00	0x01	0xB1	0XC2

(4) Receive correct answer of changing the display mode and measurement mode

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x81	0XC1

3.2.3 Error frame from the signal processing unit

Error frame of the signal processing unit

Address of the signal processing unit	0x01-0XF7 (0x00)	1 byte
Function code	0x80 I function code (0x00)	1 byte
Error code	0x10-0x04	1 byte
CRC	2 bytes	

The symbol "|" means logic "OR"

Error code

0x01: illegal function
0x02: illegal register address
0x03: illegal data value or register number
0x04: wrong device address or wrong CRC

Examples:

(1) Wrong function code has been sent

For example, the function code 0x04 has been sent in a sending frame. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x01	0x84	0x01	0x82	0xC0

(2) Wrong register address has been sent

The sending frame is for reading the current value as showed in paragraph 3.2.1, but the register address is 0x0001. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x01	0x83	0x02	0xC0	0xF1

(3) Wrong register number has been sent

The sending frame is for reading device name and settings as showed in paragraph 3.2.1, but the register number is 0x0010. In this situation, the last register address that should be written is 0x0030, which is beyond the valid address range 0x0010 to 0x002F. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x01	0x83	0x02	0xC0	0xF1

(4) Register number must be greater than 0

The sending frame is for reading the current value as showed in paragraph 3.2.1, but the register number is 0x0000. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x01	0x83	0x03	0x01	0x31

(5) Wrong data number has been sent

The sending frame is used to write data in the signal processing unit, as shown in section 3.2.2. If the data number does not match the register number x 2, an error occurs. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x01	0x90	0x03	0x0C	0x01

(6) Data written is beyond valid data range

The sending frame is for changing device address and baud rate as showed in paragraph 3.2.2, but the data is 0xF807, which is beyond the valid device address range 0x01-0xF7. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x01	0x90	0x03	0x0C	0x01

(7) Wrong device address or wrong CRC have been sent

The sending frame has the wrong device address or the wrong CRC. If a device address of 0x01 is mistaken for address 0x02 to send it a command, an error will occur. Received error message is:

Address	Function	Error code	CRC-L	CRC-H
0x00	0x00	0x04	0x70	0x03

Notes:

1. Low byte of CRC is transmitted first. In the case of register address, register number and data, the high byte is transferred first.

2. Register word length is 16 bits (2 bytes).

3. Every valid request frame has a corresponding answer. The master equipment should send the next request after the answer has been received. The maximum waiting time for data reading equals to the data refreshing period. The waiting time for configuration changing is up to 25ms.

4 Display Selection

The signal processing unit CYSPU-F98A uses an LCD module with 2 x16 characters. There are two display modes available for this product, namely frequency and speed display.

For speed calculations the conversion factor is required, e.g. for gear tooth sensors the number of teeth of the target wheel. This value should be written into the register (register address 0x0027) (see section 3.2.2 (3)).

The display mode depends on the high 8-bit byte stored in this register (register address 0x0028). In the default, the LCD display of the signal processing unit shows the frequency value when the high 8-bit byte in this register is 0x00. For speed display, the high 8-bit byte is 0x01. If the display mode needs to be converted, this byte must be changed (see section 3.2.2 (4)).

Examples:

(1) Write conversion factor N for speed calculations into register 0x0027

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x27	0x00	0x01	0x02	0x00	0x0C	0xA0	0x82

0x0C is the conversion factor N, then the conversion to speed value can be derived: ω=60F/N (ω: speed value, F: frequency value, N: number of teeth).

(2) Write display mode 0x01 for speed display into register 0x0028

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x28	0x00	0x01	0x02	0x01	0x01	0x60	0x28

The high 8-bit byte of data for speed display must be 0x01. The low 8-bit byte of data determines the measurement mode. Here mode 1 stands for measurement with the square wave signal input.

The measurement results are displayed on the LCD as follows.

Startup, it takes 3s

Frequency display in mode 1

Speed display in mode 1
(With number of teeth N=12)

Application Notes:

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1. Connect the connections of the voltage source, the input or the output correctly, never make a wrong connection.
2. The signal processing unit with LCD indicator should avoid contact between the screen and hard objects to avoid damaging the LCD. To ensure a long life of the LCD screen, please also make sure that the LCD screen is tidy, especially to avoid long-term stains and water droplets on the LCD module.
3. The better the signal-to-noise ratio of the input signals, the higher the measurement accuracy.
4. The ambient temperature used should be controlled within the operating temperature range of the product.