MLF400

CARELAY MLF400 is a frequency and "Loss of Mains"-relay (ROCOF -type). Additionally MLF400 measures a rotational speed of an asynchronous generator when generator is not connected to grid (generator circuit breaker open). The device is microprocessor controlled and functional parameters can be changed with a computer program or with industrial PLC using RS-485 bus and MODBUS-RTU protocol.

The MLF400 indicate mains loss when the derivative of frequency or frequency deviation exceeds the adjustable set value.

The device has three output relays: over frequency (and df/dt >0), under frequency (and df/dt <0) and frequency window relay.

Technical specification

General data:

Power consumption	3.0 W max
Auxiliary voltage	24 VDC
or MLF400-**L**-x	17..40 VDC

Measurement voltage isolation	3.5 kV
Programming protocol:	MODBUS RTU *
Programming device:	PC, PLC
PC-program	CCRMLF400

Mechanical properties

Operational temperature		5 .. 70 °C
Size	h x w x d	75x100x110
Case, polycarbonate		IP20
Fixing		DIN-bar
Wire connectors		max 4 mm^2

Input signals :

Measurement input:

Input impedance	min. 440 kΩ
Voltage	30mV.. 500V RMS
Frequency	0.2 .. 1000 Hz
Voltage max. continuous	400 V RMS
Voltage max. 10s	1000 V RMS

Generator-and mains circuit breaker position:

Optical isolation	1 kV
Input type (IEC 1131-2)	Type 1 (sinking)
Maximum current	100 mA
at rated voltage (24 VDC)	3 mA
OFF-state current max	240 µA

Output signals :

Frequency indication: pulse output:
The amplitude of output pulse equals the auxiliary voltage and it is square shaped. The polarity of measurement voltage is not indicated.
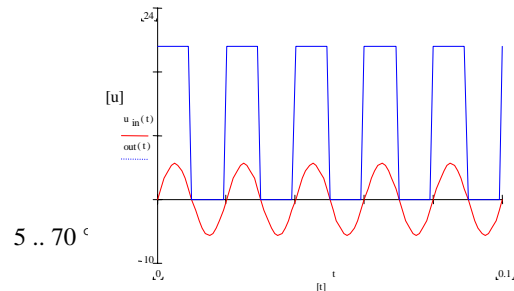

Figure 1. Measured voltage and frequency pulse output

Rated voltage	Auxiliary voltage
Current	0…100 mA
Output impedance	10 Ω
Voltage loss	see. Figure 2
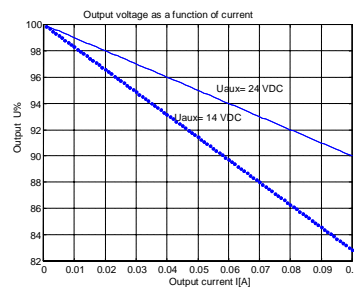
Figure 2. Frequency pulse output voltage

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Frequency indication: current output:

Current	4..20 mA
Allowed load	0...500 Ω
No galvanic isolation type:	MLF400-x-**n**
isolation 1kV	MLF400-x-**i**
no current output	MLF400-x-**w**

Supervisory output:

Open collector-type	
conducting state current	150 mA max
open state voltage	10..30 V DC

Relay outputs:

Maximum operational voltage	250 VAC / 30 VDC
Maximum current	5 A continuous
Isolation	2 kV

Serial communication:	RS-485 5VDC
MODBUS RTU	(no parity, 2 stop)
LED indicators:	
Yellow	serial communication
Red	supervisory on
Green	power on /operational

Connection examples

Figure 3 represents the connection of MLF-400 relay in system where start-up and shutdown procedures of asynchronous generator is controlled by PLC.

Start-up , connection to grid:

See figure 3. When the MLF400 is powered for at least 50 ms, and the init-signal is pulsed (min 10 ms, pulse length adjustable) f<, f> relays are set to 'grid normal' position. When the turbine inlet valve is opened the MLF400 measures the rotational speed of the generator. When synchronous speed is achieved the output relay 1 closes contact between pins 16 and 18. This contact can be used directly to close the generator circuit breaker or can be used as as input for the controlling PLC. This then control the generator circuit breaker. The supervision of the grid frequency begins when generator circuit breaker (GCB) and mains circuit breaker (MSB) have been closed (auxiliary contacts are open) for the adjustable time delay of 10 ms…10 min.

If, because of the loss of mains situation, the grid frequency exceeds the set value or the rate of the frequency exceeds its set value the contact of relay 2 or relay 3 (f< tai f>) opens. This switches the voltage of from the under voltage release of GCB opening the main circuit. The contacts of voltage relay can be connected to this same protection circuit. When the grid is restored, the relays 2 and 3 can be set again to 'grid normal' position with the init input signal in order to start the new start-up procedure. If shunt release is used instead of the under voltage release, the relays 2 and 3 should be connected in parallel.

If there is no need for the rotational speed information the measurement input pins 29 and 30 of MLF400 can be connected in phase conductors between MCB and GCB. In that case, mains-loss protection of the whole plant can be done using one MLF400 protection relay.

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Figure 3. Example connection of MLF400 protection relay.

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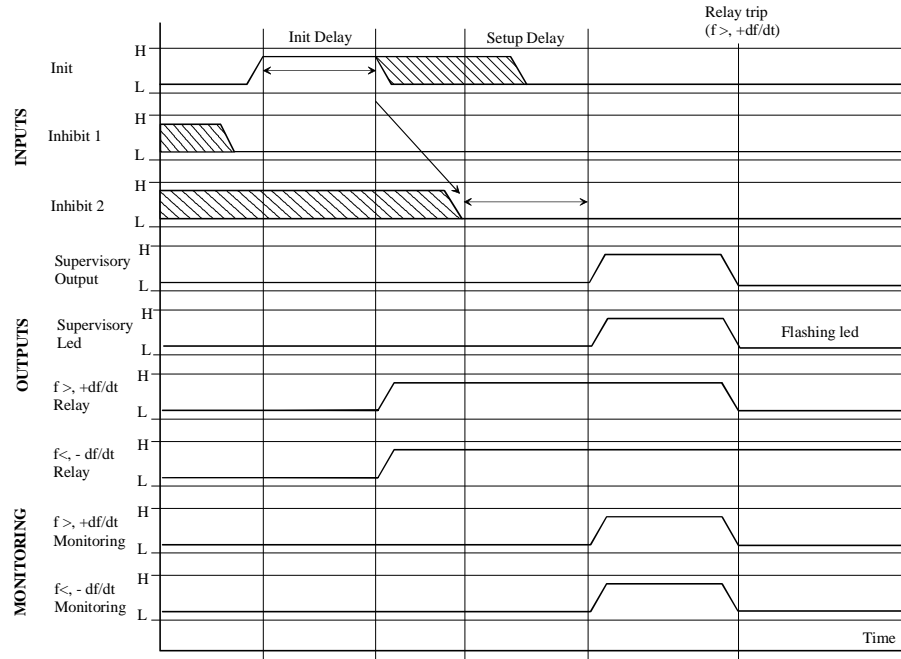
Figure 4. Timing diagram of the MLF400 relay activation.
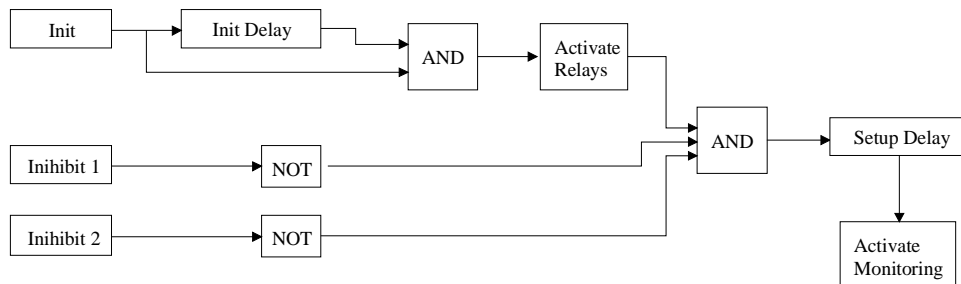
Figure 5. Block diagram of the relay activation for the supervisory (monitoring).
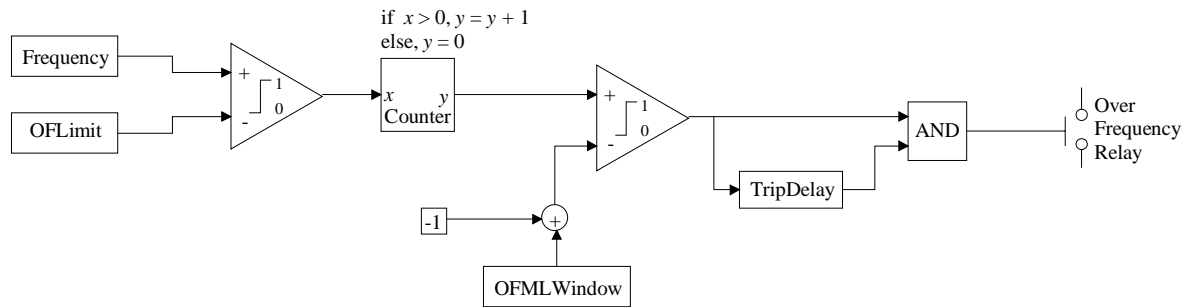
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OVER FREQUENCY TRIPPING DIAGRAM

if $x > 0$, $y = y + 1$
else, $y = 0$

Figure 6. Block diagram of the over frequency trip.

UNDER FREQUENCY TRIPPING DIAGRAM

if $x > 0$, $y = y + 1$
else, $y = 0$
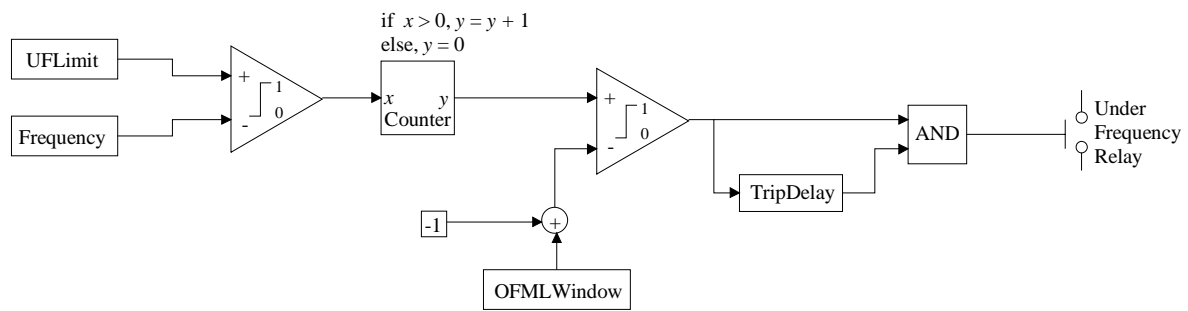
Figure 7. Block diagram of the under frequency trip.

MAINS-LOSS DETECTION

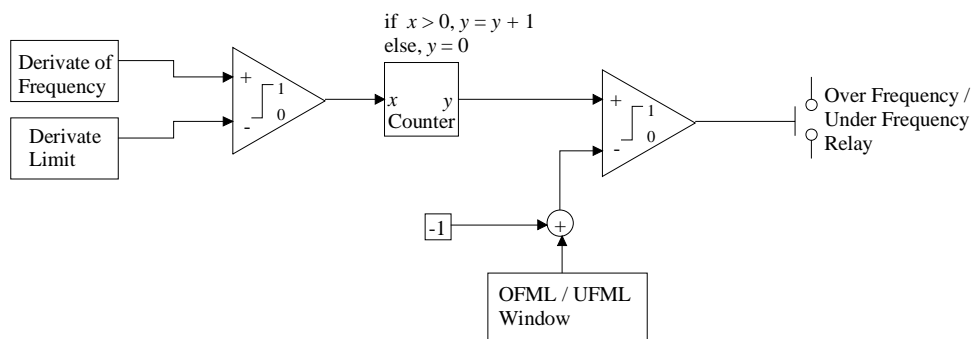if $x > 0$, $y = y + 1$
else, $y = 0$

Figure 8. Block diagram of df/dt tripping.

Rpm –meter output 4..20 mA
Models MLF400-x-**n** ja MLF400-x-**i**
The output current signal relates to measured frequency. The current signal can be read with PLC or with 4..20mA panel meter. The output signal relates to the rotational speed of an asynchronous generator when generator is not connected to grid. The scaling of the output is programmable.

Obs: The frequency information can also be obtained from the pulse output (connector 26, 1 pulse/Hz) with a tachometer (counter).
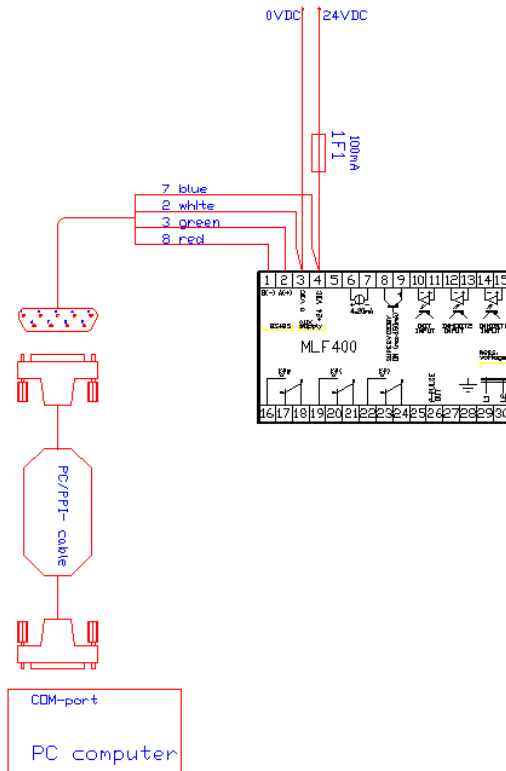
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Relay settings with MODBUS RTU-bus

All operational parameters of MLF400 can be changed with CCRMLF400 program. The program is delivered with the device and can also be downloaded at www.carelay.com. If the computer do not include the RS-485 port (normal PC), the RS485/RS232-converter is required in addition to the connection cable delivered with MLF400. A suitable converter is for example SIEMENS PC-PPI-cable (6ES7 901-3BF00-0XA0).

MLF400 can be connected to MODBUS-RTU as slave, if master uses two stop-bits without parity check. The MODBUS- registers of MLF400 that are needed in order to change principal operaationl parameters are presented in Table 1. The registers are described in detail in appendix 1.

Holding Register	Parameter
0	DeviceID
1	InitDelay
2	SetupDelay
3	TripDelay
4	RPMFMin
5	RPMFMax
6	RPMWindow
7	OFLimit
8	OFMLLimit
9	OFMLWindow
10	OFMLDerivateLimit
11	UFLimit
12	UFMLLimit
13	UFMLWindow
14	UFMLDerivateLimit
15	PWMOffset
16	PWMConstant
17	BaudRate
18	Parity
19	Flags

Input Register	Parameter
0	FrequencyH
1	FrequencyL
2	Derivate

Coil Register	Parameter
0	RPMRelay
1	OFMLRelay
2	UFMLRelay
3	OKOutput
4	PowerLed
5	ActiveLed
6	WEEPROM
7	Testbit

The default factory address for MLF400 is 1 and baud rate 9600.

Attention!
The MLF400 has to be connected into the low impedance input such as between phase conductors or motor terminals. When the inputs of the devices are as open circuit the MLF400 easily measures the frequency of interfering magnetic field that is generally 50 Hz.

Special Models
MLF400 is a versatile relay. Almost all device parameters may be modified and customized by programming. The special models may be delivered with extra price.

CARELAY is trademark of Power Factor Ay.

HOLDING REGISTER
All the register values and addresses are 16 bit

DeviceID:
The Modbus address of MLF400 device. The address is used to indentify the device connected to field bus. The slave devuce address value may be in the range of 1…128. The address 0 is reserved for the master. The default factory setting for the device is 1.

InitDelay:
The minumum time delay that init signal has to be active in order to activate the relays of MLF400. The delay value is represented in holding register as tens of milliseconds. The value may be in the range of 1…65535. The default value is 100, which represents time delay 1 second.

Setup Delay:
The time delay that is required after the activation of relays and deactivation of inhibit signals when the MLF400 goes to the supervisory state and starts the monitoring of distribution network frequency. The delay value is represented as tens of milliseconds. The value may be in the range of 1…65535. The default value is 100, which represents time delay 1 second.

Trip Delay:
The time delay that affects the functionality of both frequency relays. If the over or underfrequency in detected, the MLF400 waits trip delay again. If the same crossing of frequency limit is detected again, the relay will be tripped. The value may be in the range of 1…65535. The default value is 100, which represents time delay 1 second.

RPMFMin:
The lower frequency of frequency window relay. The default value is 49 Hz. The frequency is calculated with equation:

$$value = \frac{5 \cdot 10^6 \, Hz}{4 \cdot f} , \tag{1}$$

where f is frequency.

RPMFMax:
The upper frequency of frequency window relay. The default frequency value is 51 Hz. The value is calculated using equation 1.

RPMWindow
The length of window, which defines how many subsequent frequency limit crossings is required to activate the RPM relay. The default value is 4.

OFLimit:
The tripping limit of over frequency+mainsloss relay. The value is calculated using equation 1. The default frequency value is 50.3 Hz.

OFMLLimit:
The upper frequency after which the supervising of frequency starts. The value is calculated using equation 1. The default value is 50.1 Hz.

OFMLWindow:
The length of window, which defines how many subsequent crossings of over frequency or derivate limits is required in order to determine that frequency or derivate limit is crossed. Only positive derivate values are calculated. The default value is 4.

OFMLDerivateLimit:
The frequency derivate limit for over frequency+mains loss relay. The default derivate value is 5 Hz/s. The value may be calculated using equation:

$$value = \frac{df}{dt} * 10 . \qquad\qquad (2)$$

UFLimit:
The under frequency limit for the under frequency+mains loss relay. The frequency is calculated using equation 1. The default value is 49.7 Hz.

UFMLLimit:
The upper frequency limit for under the frequency+mains loss relay. At the lower frequencies, the relays starts monitoring distribution network frequency.

UFMLWindow:
The length of window, which defines how many subsequent crossings of under frequency or derivate limits is required in order to determine that frequency or derivate limit is crossed. Only negative derivate values are calculated. The default value is 4.

UFMLDerivateLimit:
The setting for under frequency+ mains loss relay. The default absolute value is 5 Hz/s. The register values are determined using equation 2.

PWMOffset:
The offsett coefficient for current output. The value is set such that at frequency 0 Hz, the output current is 4 mA. The default value is 209.

PWMConstant:
The coefficient that determines the scale of current output. The default value is 40000. Using it the current scale 4-20 mA corresponds the frequency scale 0-100 Hz.

BaudRate:
The baud rate of Modbus protocol. The possible rates are 9600, 19200, 28800 and 33600. The default value is 9600.

Parity:
The used parity in serial communications: 0 no parity, 1 odd parity, 2 even parity. Currenly only setting: no parity 0 is used. In this case, the number of stop bits is two.

Flags:
The flags that affect functionality of relay. The value 1 set MLF400 into autoinit mode.

INPUT REGISTER
All the register values and addresses are 16 bit

FrequencyH:
The highest 16 bits of 32 bit counter value representing the measured frequency.

FrequencyL:
The lowest 16 bis of 32 bit counter representing the measured frequency. The counter value may be converted to frequency using equation:

$$f = \frac{5 \cdot 10^6 \ Hz}{4 \cdot \left(FrequencyH + FrequencyL \right)}. \tag{3}$$

Derivate:
The measured frequency derivate

INPUTS
All Inputs are single bits

Init:
The init input. It is used to initialize the under frequency+mains loss and over frequency + mains loss relays. The intialization has to be performed after every tripping. The duration of initialization pulse has to be at minimum the initialization delay. After that the pulse has to be deactivated.

Inhibit 1 & 2:
The inhibits prevent the frequency+mains loss and over frequency + mains loss relays to go into the supervisory state. When both inhibit signals are deactivated, the MLF400 will enter into the supervisory state after the setup delay.

COILS
All coils are single bit outputs

RPMRelay:
The state of frequency window relay. The relay is active, when the measured frequency is inside the set frequency window limits.

OFMLRelay:
The status of over frequency+ mains loss relay. The coil is active, when the relay is in supervisory state.

UFLMRelay:
The status of under frequency+ mains loss relay. The coil is active, when the relay is in supervisory state.

OKOutput:
The status of MLF400. The status is high when the both relays are active and in supervisory state.

PowerLed:
Power switched on and microprosessor in operational state

ActiveLed:
The status of MLF400. The status is high when the both relays are active and in supervisory state.

WEEPROM:
When activated, the contents of holding register are save into the EEPROM memory. Correspondingly, in the power-up the device parameters are read from the EEPROM.

TestBit:
When activated, the relays and outputs of the MLF400 can be controlled through Modbus. The initialisation of the MLF400 restored the device into the normal state.

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