

TECHNICAL MANUAL

Voltage Regulator

# MFC-300/R

 **Licht**  
[www.licht-labs.com](http://www.licht-labs.com)





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# 1. Introduction

The MFC-300/R voltage regulator was developed by Licht for the automatic control of power transformers with on-load tap changers. In order to regulate the voltage at the load, the MFC-300/R issues "raise" and "lower" commands to the transformer's associated tap changer, effectively adjusting its secondary voltage. Given voltage and current samples at the source, user-programmable parameters such as the line's resistance and reactance allow the regulator to estimate the voltage at the load. The MFC-300/R then controls the tap changer in order to keep the load voltage within an optimum interval, also activating alarms in the events of overcurrent, overvoltage and under voltage.

For maximum flexibility under the many possible service conditions, the MFC-300/R is highly configurable. Up to 8 regulation sets can be stored, each associated with a daily time interval, such that different settings may match daily periods of high and low demand.

Among its parameters, we highlight: 2 delay types (linear and inverse), line drop compensation, configurable relays, current loop outputs, line monitoring (voltage, current, power factor, active, reactive and apparent power), configurable voltage-current phase difference, undercurrent blocking, over/under voltage blocking and RS485 communication.

The MFC-300/R also features options for tap readout or tap inference, and up to 3 current loop outputs. The MFC-300/R shares its form factor with other Licht controllers for transformers, such as the MFC-300/T temperature controller and the MFC-300/P parallelism controller. All signals that enter and exit the controller are pairwise galvanically isolated, preventing potentially damaging noise and transients from being transferred between subcircuits or retransmitted to other devices.



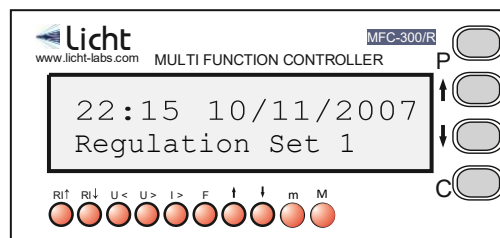
**Figure 1.1** MFC-300/R Voltage Regulator

## 2. Operation

### 2.1. Front Paineel Indication

During normal operation, the MFC-300/R alternates every 10 seconds between the 5 screens represented below. They can also be accessed directly by pressing ↑ or ↓.

R↑ raise tap command  
R↓ lower tap command  
U< undervoltage alarm  
U> overvoltage alarm  
I> overcurrent alarm  
F power supply on



↑ raise pre-signal  
↓ lower pre-signal  
M minimum position  
M Maximum position

Secondary PT voltage  
Line voltage

115.5 V	3.78 A
13.8 kV	1581 A

Secondary CT current  
Line current

Apparent Power  
Reactive Power

37.9MVA	37.2MW
7.3MVAr	0.982

Active Power  
Power Factor

Line voltage at the load  
Voltage deviation at the load

U <sub>LOAD</sub> :	13.3kV
dU%:	-3.6 %

Tap changer position

Position:	23
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**Figure 2.1** Front Panel

## 3. Relays

The MFC-300/R is supplied with up to 6 relays. An actuation of 06, power failure and automatic supervision, acts as follows: it is activated, by software, as the MFC-300 / R is energized, and it is deactivated when the MFC-300 / R loses auxiliary power, or presents internal failure. As soon as 06 is activated, the LED (R6) on the panel is simultaneously activated. Therefore, this led is permanently on when the MFC-300 / R is in normal operating conditions. The contacts in reports 1 to 5 are NA, or they stay open in the unacted state. The contact of number 06 is NC: they are open under normal equipment operating conditions, and can occur in the event of failure. Table 2.2 illustrates the functions of each of the relays and their respective connectors:

RELÉ	FUNÇÃO	BORNES
1	Command to climb	3, 4
2	Command to descend	5, 6
3	Under voltage blocking	7, 8
4	Overvoltage blocking	9, 10
5	Overcurrent blocking	11, 12
6	Auxiliary power failure and self-supervision	13, 14

Table 2.2

## 4. Position Reading (Optional)

The MFC-300 / R obtain a switch position by reading a potentiometric sensor.

### Minimum and maximum tap indication

The MFC-300/R indicates with two reserved relays whenever the tap changer reaches a user-configurable minimum or maximum position. Two LEDs on the frontal panel (**m** and **M**) indicate whenever the minimum or maximum position is reached.



## Tap memory

In devices with the position readout or inference options, the MFC-300/R stores in nonvolatile memory the maximum and minimum positions reached by the on-load tap changer during operation, as well as the total number of tap changes. These values can be accessed or reset using the configuration menus.

### i. To visualize the tap memory:

Using the configuration menu (accessible using the **P** key), choose the "Visualize Memory" option. The device will then show the maximum and minimum positions reached since the last tap memory reset and the total number of tap changes.

### ii. To reset the tap memory:

Using the configuration menu (accessible using the **P** key), choose the "Reset Memory" option. Press **P** again to confirm. The "Memory Cleared" message will be displayed.

Note: the tap memory is not cleared when the device is powered off. However, it is cleared if it is reset to default parameters.

# 5. Configuration

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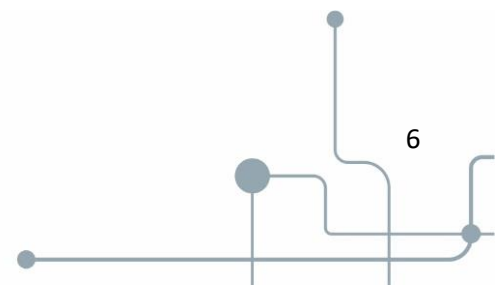
The MFC-300 / R have 4 keys that allow access to all its functionality. The procedure for configuring any parameter is as follows:

1. Write a 4-letter password one letter at a time, using the ↑ and ↓ keys to choose each letter and the P key to move between letters. The default password is AAAA.
2. Press the P key to enter the programming mode.
3. Using the ↑ and ↓ keys, choose or select the parameters.
4. Press P again to confirm the parameter choice.
5. Choose the selected setting using ↑ and ↓.
6. Confirm by pressing P.

The configuration options can be quickly changed by pressing the ↑ or ↓ key. Any time in the programming can be canceled by pressing the C key.

## 5.1. Parameter Reset

The MFC-300/R can be reset to factory settings. This procedure also resets its password to AAAA. To reset, turn the device on with the C key pressed.



## 6. Programmable Parameters

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The MFC-300/R was developed to provide the user with the greatest possible flexibility, such that all supervision and configuration can be executed on-site or remotely through the existing communication channels. We define all user-configurable parameters below.

### PARAMETER: Regulation Set

Options: 1 to 8.

Description: selects which set of regulation parameters to configure. A regulation set is composed of the Regulation Menu parameters, associated with a daily time interval. Regulation Sets identified by lower numbers have greater priority – if time intervals overlap, the active regulation set is the one that comes first. If no regulation set is associated with a given daily interval, the parameters from set 1 apply, regardless of its associated interval.

### PARAMETER: Nominal Voltage

Options: 80 to 140VCA, in 0.1V steps.

Description: Optimal voltage value at the load, referenced to the VT's secondary. Ignoring any line drop, the load's voltage will match the VT's primary voltage, i.e.,  $V_1 = V_2 \cdot NVT$ , where NVT is the VT's turns ratio. For example:

- Nominal voltage at the load:  $V_1 = 14.04\text{kV}$
- VT's turns ratio:  $NVT = 13.80\text{kV}/115\text{V} = 120$
- Nominal voltage:  $V_2 = V_1/NVT = 14.04\text{kV}/120 = 117\text{V}$

### PARAMETER: Bandwidth

Options: 0 a 10%, in 0.1% steps.

Description: allowable deviation between the measured and nominal voltages. Deviations greater than the bandwidth trigger the tap changer command timer.

**Attention:** verify that the configured bandwidth is greater than half the voltage (difference between two consecutive taps). If this condition is not fulfilled, there will be unstable regulation scenarios. For example:

- Nominal voltage at the load: 13.8kV
- Voltage step: 150V
- Deviation per step:  $150\text{V}/13.8\text{kV} = 1.09\%$





- Bandwidth >  $1.09\%/2 = 0.54\%$

**PARAMETER: Command Type**

Options: Pulse, Constant.

Description: Type of command issued to the on-load tap changer. If set to Pulse, command relays will close for 1 second, and the delay between commands will be given by the Repetition Delay parameter. If set to constant, command relays will remain closed as long as the voltage deviation exceeds the configured Bandwidth.

**PARAMETER: Delay Type**

Options: Constant, Inverse.

Description: the regulation delay's purpose is to reduce the influence of brief voltage fluctuations, eliminating unnecessary tap changes. The MFC-300/R implements two types of delays:

1. **Constant**, where the interval between the detection of a large enough deviation (as defined by the Bandwidth parameter) and a tap change is fixed, and given by the parameters Raise Delay and Lower Delay.
2. **Inverse**, where the interval between the detection of a large enough deviation (as defined by the Bandwidth parameter) and a tap change is inversely proportional to the deviation's magnitude. In other words, this option produces faster corrections to larger deviations. Whenever the voltage deviation exceeds the configured bandwidth, the  $\uparrow$  and  $\downarrow$  delays are given by  $T_{\uparrow} \cdot BW/\Delta V$  and  $T_{\downarrow} \cdot BW/\Delta V$ , where:

- $T_{\uparrow}$  and  $T_{\downarrow}$  are the Raise Delay and Lower Delay parameters;
- $BW$  is the Bandwidth parameter;
- $\Delta V$  is the measured deviation in relation to the reference voltage;
- $BW$  and  $\Delta V$  are measured in %.

**PARAMETER: Raise Delay**

Options: 0 to 180 seconds, in 1 second steps.

Description: delay between a deviation that exceeds the bandwidth and the first  $\uparrow$  command.

**PARAMETER: Lower Delay**

Options: 0 to 180 seconds, in 1 second steps.

Description: delay between a deviation that exceeds the bandwidth and the first  $\downarrow$  command.

**PARAMETER: Repetition Delay**



Options: 0 to 30 seconds, in 1 second steps.

Description: delay between consecutive  $\uparrow$  or  $\downarrow$  commands, should the deviation condition persist after one tap change.

**PARAMETER: Initial Time**

Options: 00:00 to 23:59, in 1 minute steps.

Description: starting time for this regulation set.

**PARAMETER: Final Time**

Options: 00:00 to 23:59, in 1 minute steps.

Description: ending time for this regulation set.

## 6.1. LDC

**PARAMETER: LDC Type**

Options: RX, Z.

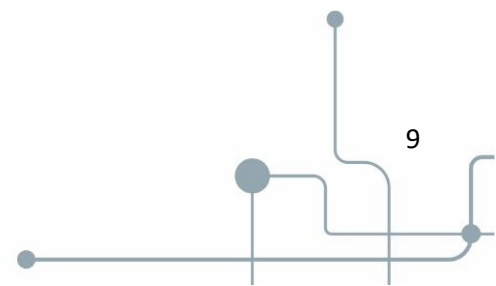
Description: defines the type of line drop compensation used. When correctly configured, the LDC estimates the voltage at the load, such that regulation is treated from the consumer's point of view and not directly considering the transformer's secondary voltage. Traditionally there are two types of LDC:

- **RX:** estimates the voltage drop given the line's series model, composed of an equivalent resistance and reactance. This requires programming the  $U_r$  and  $U_x$  parameters. Ignores the Z Compensation parameter.
- **Z:** simplified method in which only a line drop percentage is supplied. Since this method ignores the power factor (or rather, supposes the line and load are resistive), it has lower precision than the RX option. However, it can be adequate when the line drop is relatively small. Requires programming the Z Compensation parameter. Ignores the  $U_r$  and  $U_x$  parameters.

**PARAMETER:  $U_r$**

Options: -25 to 25V, in 0.1V steps.

Description: resistive line drop component, in Volts, adjusted to the MFC-300/R's nominal current (5A). The resistive line drop is defined by:



$$U_r = I_N \cdot (N_{ct}/N_{vt}) \cdot r \cdot L$$

Where:

- $U_r$ : the LDC's resistive line drop, in V.
- $I_N$ : the CT's nominal current (5A).
- $N_{ct}$ : the CT's turns ratio.
- $N_{vt}$ : the VT's turns ratio.
- $r$ : the line's resistance, in  $\Omega/\text{km}$ .
- $L$ : the line's length, in km.

#### PARAMETER: $U_x$

Options: -25 to 25V, in 0.1V steps.

Description: inductive line drop component, in Volts, adjusted to the MFC-300/R's nominal current (5A). The inductive line drop is defined by:

$$U_x = I_N \cdot (N_{ct}/N_{vt}) \cdot x \cdot L$$

Where:

- $U_x$ : the LDC's inductive line drop, in V.
- $I_N$ : the CT's nominal current (5A).
- $N_{CT}$ : the CT's turns ratio.
- $N_{VT}$ : the VT's turns ratio.
- $X$ : the line's reactance, in  $\Omega/\text{km}$ .
- $L$ : the line's length, in km.

#### PARAMETER: Z Compensation

Options: 0 to 15%, in 0.1% steps.

Description: total line drop, as a percentage of the transformer's secondary voltage, adjusted to the MFC-300/R's nominal current (5A). The Z compensation setting is given by:

$$\Delta U(\%) = 100 \cdot (U_{Tr} - U_{load}/U_{load}) \cdot (I_N \cdot N_{ct}/I)$$

Where:

- $U_{Tr}$ : the transformer's voltage, under the current  $I$ .
- $U_{load}$ : the voltage at the load, under the current  $I$ .
- $I_N$ : the CT's nominal current (5A).

- $N_{ct}$ : the CT's turns ratio.

**PARAMETER: COMPENSAÇÃO MÁXIMA**

Options: 0 to 25%.

Description: limits the transformer's voltage increase due to the LDC.

## 6.2. Current Loop Outputs (Optional)

The MFC-300/R can be produced with two current loop outputs, designed to retransmit the sampled values of RMS voltage and current. Devices with the position readout option can also feature a third current output, which retransmits the measured position. The current loops can be configured with the parameters below.

**PARAMETER: Output Scale**

Options: 0-1, 0-5, 0-10, 0-20, 4-20 mA

Description: the various configurable current loop scales.

**PARAMETER: Voltage Full Scale**

Options: 80 to 200 V, in 1 V steps.

Description: defines the voltage value corresponding to a full scale current loop output.

**PARAMETER: Current Full Scale**

Options: 1.0 to 10.0 A, in 0.1 A steps.

Description: selects the current value corresponding to a full scale current loop output.

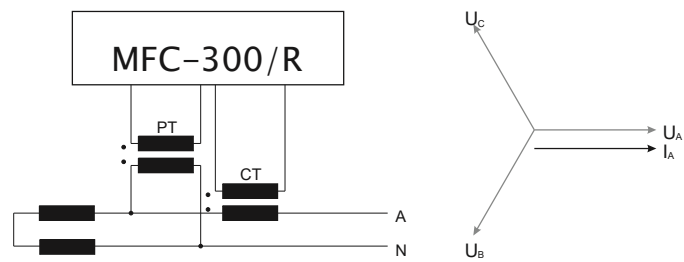
## 6.3. CT/VT

**PARAMETER: Voltage-Current Phase Difference**

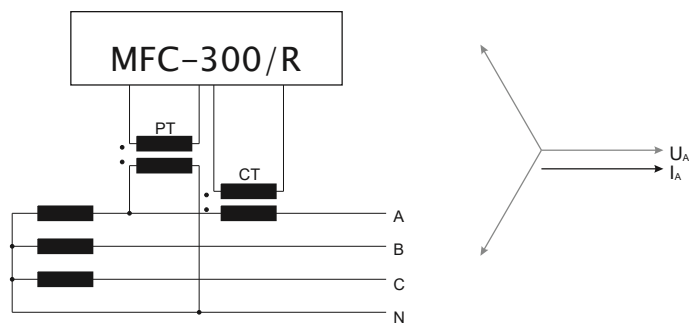
Options: 0 to 359 degrees, in 1 degree steps.

Description: defines the phase difference between the voltage and current waveforms for the TC/TP configuration. We present a few of the many possible configurations below:

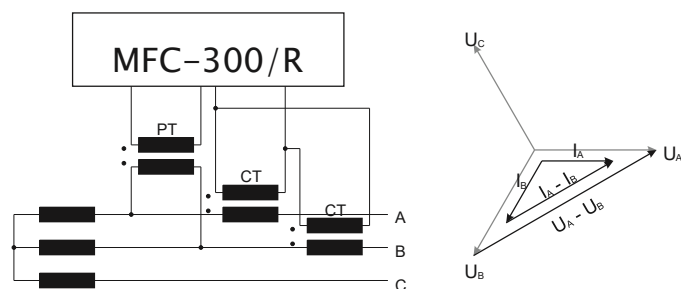




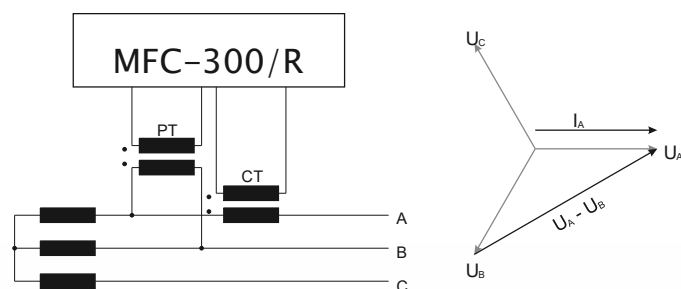
**Figure 6.1** Monophase circuit, 0 ° phase difference



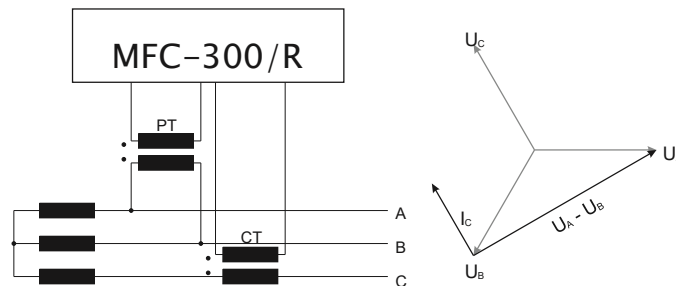
**Figure 6.2** Phase-Neutral circuit, 0 ° phase difference



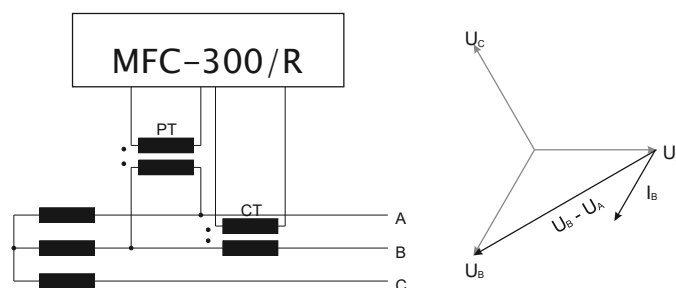
**Figure 6.3** Phase-Phase circuit, 0 ° phase difference



**Figure 6.4** Phase-Phase circuit, 30 ° phase difference



**Figure 6.5** Phase-Phase circuit, 270 ° phase difference



**Figure 6.6** Phase-Phase circuit, 330 ° phase difference

#### PARAMETER: Sampling Circuit

Options: Monophase, 3-Phase (Phase-Neutral), 3-Phase (Phase-Phase).

Description: specifies how the VT is connected. This parameter is required for the proper computation of active, reactive and apparent power values. For example, for the case of apparent power we have:

- Monophase:  $P_{ap} = V \cdot I$
- 3-Phase (Phase-Neutral):  $P_{ap} = 3 \cdot V_{phase} \cdot I_{phase}$
- 3-Phase (Phase-Phase):  $P_{ap} = \sqrt{3} \cdot V_{line} \cdot I_{line}$

#### PARAMETER: VT Turns Ratio

Options: 0 to 9999, in steps of 1.

Description: the VT's turns ratio.

**PARAMETER: CT Turns Ratio**

Options: 0 to 9999, in steps of 1.

Description: the CT's turns ratio.

## 6.4. Alarms

**PARAMETER: U< (undervoltage)**

Options: 10 to 99%, referred to the nominal voltage, in 1% steps.

Descriptions: voltage value under which the MFC-300/R activates an alarm relay and blocks tap changes.

## 6.5. On-Load Tap Changer (optional)

Note: this menu is only available in devices with the position readout

**PARAMETER: Resistance per position**

Options: 3.0  $\Omega$  to 20.0  $\Omega$ , in increments of 0.1  $\Omega$ .

Description: the potentiometric sensor's resistance per position.

**PARAMETER: Number of positions**

Options: 2 a 50.

Description: the on-load taps changer's total number of positions.

**PARAMETER: Indication format**

Options: 1 ... n ; -x ... +y ; +y ... -x ; xL ... N ... yR ; xR ... N ... yL.

Description: defines how the position is shown in the device's display.

- 1 ... n: positions are numbered from 1 to the maximum.
- -x ... +y: positions are indicated relative to the neutral (positions below neutral are negative).
- +x ... -y: positions are indicated relative to the neutral (positions below neutral are positive).

**PARAMETER: Neutral position**

Options: 1 a 50.

Description: defines the neutral position.

**PARAMETER: Minimum position**

Options: 1 a 50.

Description: defines the minimum position that the MFC-300/R can place the tap changer in order regulate the voltage at the load.

**PARAMETER: Maximum position**

Options: 1 a 50.

Description: defines the minimum position that the MFC-300/R can place the tap changer in order regulate the voltage at the load.

## 6.6. MODBUS PROTOCOL

**PARAMETER: BAUD RATE**

Options: 9600, 19200, 38400, 57600, 115200 bps.

Description: baud rate for the RS485 link.

**PARAMETER: FORMAT**

Options: 8N1, 8E1, 8O1, 8N2.

Description: symbol transmission format, where:

- 8N1: 8 data bits, no parity, 1 stop bit.
- 8E1: 8 data bits, even parity, 1 stop bit.
- 8O1: 8 data bits, odd parity, 1 stop bit.
- 8N2: 8 data bits, no parity, 2 stop bits.

**PARAMETER: ENDEREÇO**

Options: 1 a 247.



Description: MODBUS address for the MFC-300/R.

## 6.8. DNP3 Protocol (Optional)

### PARAMETER: BAUD RATE

Options: 9600, 19200, 38400, 57600, 115200 bps.

Description: baud rate for the RS-485 link.

### PARAMETER: FORMAT

Options: 8N1, 8E1, 8O1, 8N2.

Description: symbol transmission format, where:

- 8N1: 8 data bits, no parity, 1 stop bit.
- 8E1: 8 data bits, even parity, 1 stop bit.
- 8O1: 8 data bits, odd parity, 1 stop bit.
- 8N2: 8 data bits, no parity, 2 stop bits.

### PARAMETER: ADDRESS

Options: 0x0000 to 0xFFEF.

Description: DNP3 outstation address in hexadecimal notation.

### PARAMETER: APPLICATION LAYER CONFIRMATION

Options: Only when transmitting events or multi-fragment responses, Always.

Description: Selects when the MFC-300/R outstation should request application layer confirmations.

### PARAMETER: MAXIMUM INTER-OCTET GAP

Options: 2 to 100 ms.

Description: The DNP3 specification states that frames should not have inter-octet gaps. In accordance, the MFC-300/R never inserts inter-octet gaps when transmitting data. However, we allow the option to tolerate gaps in incoming transmissions. Frames featuring inter-octet gaps larger than the Maximum Inter-Octet Gap will be quietly dropped.

### PARAMETER: BACKOFF DELAY (FIXED)

Options: 1 to 100 ms.

Description: See description for Back off Delay (Random).

**PARAMETER: BACKOFF DELAY (RANDOM)**

Options: 1 to 100 ms.

Description: The MFC-300/R is designed for multi-drop scenarios where more than one outstation may transmit over the same line. To handle collision avoidance, a backoff scheme is implemented. Before transmitting, the MFC-300/R always waits for the line to become idle. Once that happens, it waits for  $T_{delay} = T_{fixed} + T_{random}$  ms, where  $T_{fixed}$  is the fixed backoff delay and  $T_{random}$  is a random value, uniformly distributed between 0 and the random backoff delay parameter. If after  $T_{delay}$  ms the line is still idle, then the MFC-300/R begins transmission.

**PARAMETER: INSERT INTER-FRAME GAP**

Options: Never, Always.

Description: The DNP3 specification states that no inter-frame gaps are required. However, some masters have been observed to drop frames when no inter-frame gaps are provided. This option allows communicating with such non-compliant devices. We discourage its use, given that the forced inter-frame gap implies a forced backoff-delay.

## 6.7. Date/Time

**PARAMETER: DATE/TIME**

Options: HH:MM:SS DD/MM/YYYY

Description: sets the local date and time.

## 6.8. Idioma

**PARAMETER: LANGUAGE**

Options: English (US), Portuguese (BR).

Description: selects the language in which messages are displayed.

## 6.9. Password

**PARAMETER: PASSWORD**

Options: AAAA a ZZZZ

Description: defines a new 4 letter password.

## 7. Especifications

<b>Power Supply</b>	Isolated, 80-260 Vac/Vdc.
<b>Power Consumption</b>	8 W
<b>Operating Temperature</b>	-10 to 70 °C
<b>Enclosure Rating</b>	IP20
<b>Mounting Option</b>	Panel-mounted
<b>Dimensions</b>	96 x 48 x 190 mm
<b>Weight</b>	600 g
<b>VAC Scale</b>	Scale: 0-200 V Error/Non-linearity: 0.5% + 0.1% / 10 °C
<b>IAC Scale</b>	Scale: 0-5 A Error/Non-linearity: 0.5% + 0.1% / 10 °C
<b>Current Loop Outputs</b>	Scales: 0-1, 0-5, 0-10, 0-20, 4-20 mA Error/Non-linearity: 0.2% + 0.1% / 10 °C
<b>Galvanic Isolation (60 Hz, 1 min.)</b>	DC Input 2.0 kV AC Input 2.0 kV Current outputs 2.0 kV Communication 2.0 kV Auxiliary power 2.0 kV All terminals - Ground 2.0 kV Relay outputs 3.0 kV
<b>Communication</b>	RS-485 - MODBUS RTU or DNP3 9600, 19200, 38400, 57600, 115200 bps 8N1, 8E1, 8O1, 8N2
<b>Displays</b>	2 lines, 16 characters each (5 mm). LCD with backlight
<b>Relays</b>	10 A @ 250 Vac, 0.5 A @ 125 Vdc Galvanic Isolation: 3.0 kV, 60 Hz, 1 min..

## 8. Important Considerations

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The installation of electronic devices in substations should conform to the recommendations given by recent international standards. The most recent and detailed guide for installations is IEC 61000-5-2:1997, which was based on decades of laboratory and field research. We summarize below some of the guidelines contained in IEC 61000-5-2:1997. For further reading, we recommend the articles and application notes available on our web site.

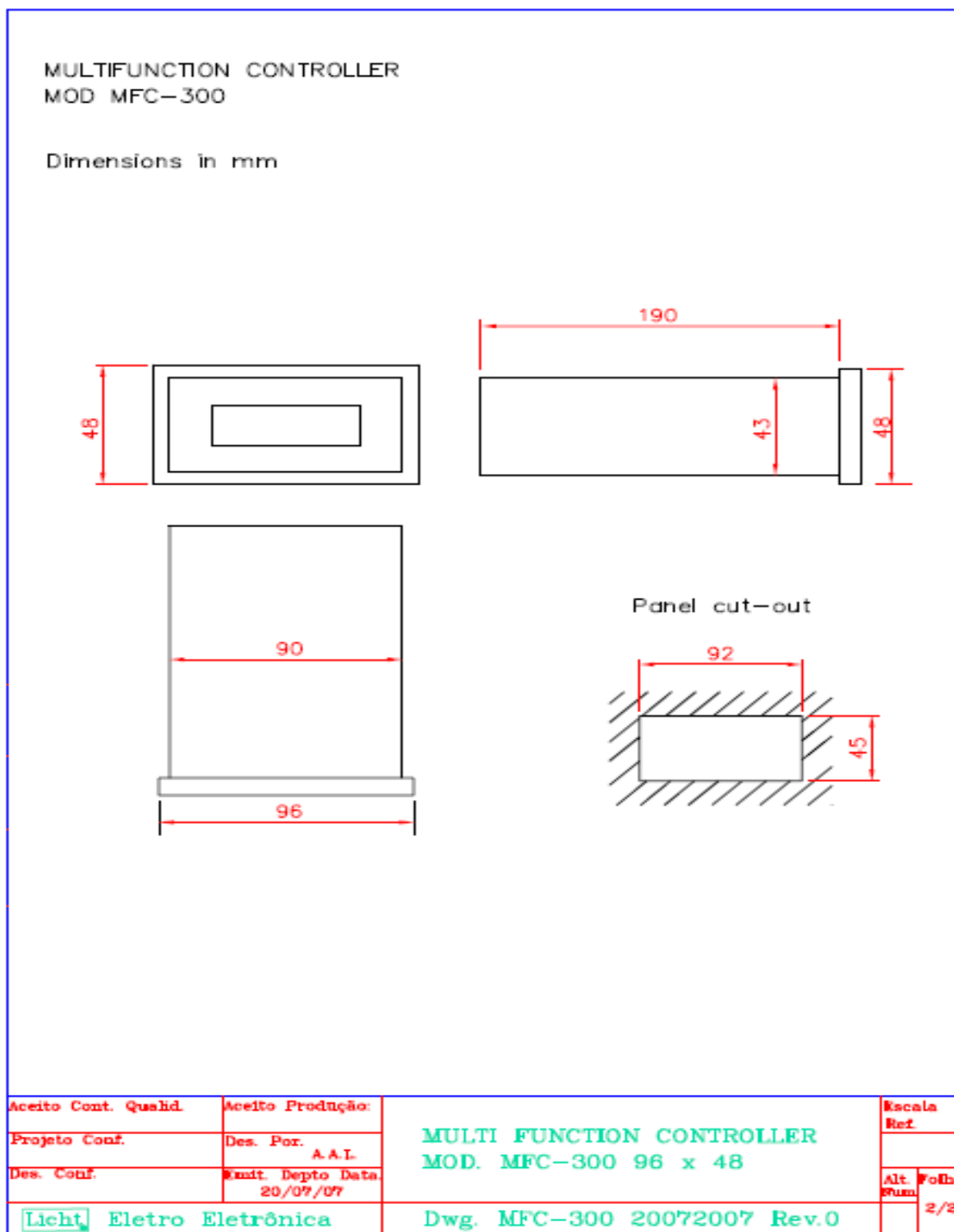
- a.** Shielded cables must be used for connecting potentiometric sensors, current loop outputs, RS-485 links and the auxiliary supply.
- b.** Cables must be segregated in trays, ducts or conduits according to their functions. In particular, power cables must never be routed in the proximity of signal cables, even if these are shielded. The minimum distances which must be observed are described in IEC 61000-5-2:1997 and in articles available on-line at this product's web page.
- c.** The electrical continuity of cables, ducts, trays and conduits must be preserved up to frequencies in the order of MHz, over all their extension, including curves and junctions. In order to guarantee this continuity, joints and bonds should present electrical contact along each cable, duct or tray's transversal section. In particular, trays should be bonded with seam-welded joints (best), U-brackets with multiple fixings (ok) and never with wires.
- d.** Shielded cables should present no gaps in their screens along their lengths. 360° bonding should be performed instead.
- e.** Should there be unshielded sections (for example, near terminal block connections), these should be short as possible.
- f.** Trays, ducts and conduits must be electrically continuous, and must be grounded at both ends. In this configuration, trays, ducts and conduits provide shielding and also perform as parallel earth conductors.
- g.** Shielded cables should also have their screens bonded at both ends. It is extremely important that the tray, duct or conduit which contains each cable is also grounded at both ends, allowing it to perform as a parallel earth conductor. In the absence of a parallel earth conductor, the cable screens will be exposed to extremely high currents which will severely compromise their operation.
- h.** RS-485 pairs must be terminated at both ends by 120  $\Omega$  resistors.
- i.** RS-485 devices must be connected in a bus topology. No other network topology (tree, star, ring, etc.) is acceptable.
- j.** Dry contact inputs (if applicable) must free of potentials.

## 9. Review and History

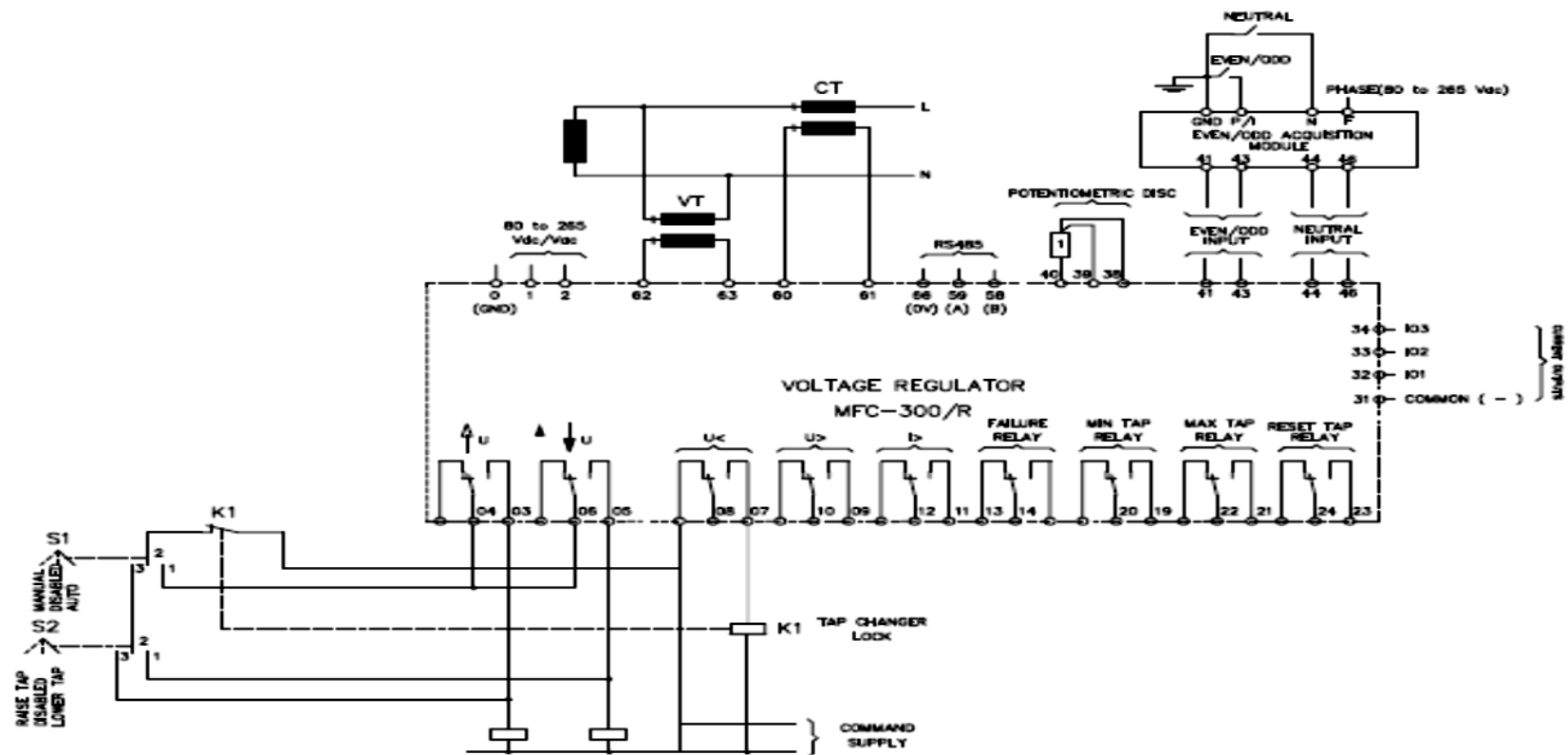
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REVIEW	DATE (dd/mm/yy)	DESCRIPTION/CHANGE PERFORMED	PREPARED BY	APPROVED BY
00	07/04/20	Preliminary version	Ricardo Hemmel	Liscio Ribeiro

## Attachment A – External Dimensions



## Attachment B– Connections Diagram





## Attachment C – Settings Tab

[illegible]

## Anexo D –Modbus Registers

Register	Description		Values	Multiplier
1	Nominal Voltage	Regulation Set 1	80.0 to 140.0 V	10
2	Bandwidth	Regulation Set 1	0.0 to 10.0%	10
3	Command Type	Regulation Set 1	0: pulse 1: step	1
4	Delay Type	Regulation Set 1	0: constant 1: inverse	1
5	Raise Time	Regulation Set 1	0 to 180 s	1
6	Lower Time	Regulation Set 1	0 to 180 s	1
7	Repetition Time	Regulation Set 1	0 to 30 s	1
8	Initial Hour	Regulation Set 1	0 to 23	1
9	Initial Minute	Regulation Set 1	0 to 59	1
10	Final Hour	Regulation Set 1	0 to 23	1
11	Final Minute	Regulation Set 1	0 to 59	1
21	Nominal Voltage	Regulation Set 2	80.0 to 140.0 V	10
22	Bandwidth	Regulation Set 2	0.0 to 10.0%	10
23	Command Type	Regulation Set 2	0: pulse 1: step	1
24	Delay Type	Regulation Set 2	0: constant 1: inverse	1
25	Raise Time	Regulation Set 2	0 to 180 s	1
26	Lower Time	Regulation Set 2	0 to 180 s	1
27	Repetition Time	Regulation Set 2	0 to 30 s	1
28	Initial Hour	Regulation Set 2	0 to 23	1
29	Initial Minute	Regulation Set 2	0 to 59	1
30	Final Hour	Regulation Set 2	0 to 23	1
31	Final Minute	Regulation Set 2	0 to 59	1
41	Nominal Voltage	Regulation Set 3	80.0 to 140.0 V	10
42	Bandwidth	Regulation Set 3	0.0 to 10.0%	10
43	Command Type	Regulation Set 3	0: pulse 1: step	1
44	Delay Type	Regulation Set 3	0: constant 1: inverse	1
45	Raise Time	Regulation Set 3	0 to 180 s	1
46	Lower Time	Regulation Set 3	0 to 180 s	1

Register	Description		Values	Multiplier
47	Repetition Time	Regulation Set 3	0 to 30 s	1
48	Initial Hour	Regulation Set 3	0 to 23	1
49	Initial Minute	Regulation Set 3	0 to 59	1
50	Final Hour	Regulation Set 3	0 to 23	1
51	Final Minute	Regulation Set 3	0 to 59	1
61	Nominal Voltage	Regulation Set 4	80.0 to 140.0 V	10
62	Bandwidth	Regulation Set 4	0.0 to 10.0%	10
63	Command Type	Regulation Set 4	0: pulse 1: step	1
64	Delay Type	Regulation Set 4	0: constant 1: inverse	1
65	Raise Time	Regulation Set 4	0 to 180 s	1
66	Lower Time	Regulation Set 4	0 to 180 s	1
67	Repetition Time	Regulation Set 4	0 to 30 s	1
68	Initial Hour	Regulation Set 4	0 to 23	1
69	Initial Minute	Regulation Set 4	0 to 59	1
70	Final Hour	Regulation Set 4	0 to 23	1
71	Final Minute	Regulation Set 4	0 to 59	1
81	Nominal Voltage	Regulation Set 5	80.0 to 140.0 V	10
82	Bandwidth	Regulation Set 5	0.0 to 10.0%	10
83	Command Type	Regulation Set 5	0: pulse 1: step	1
84	Delay Type	Regulation Set 5	0: constant 1: inverse	1
85	Raise Time	Regulation Set 5	0 to 180 s	1
86	Lower Time	Regulation Set 5	0 to 180 s	1
87	Repetition Time	Regulation Set 5	0 to 30 s	1
88	Initial Hour	Regulation Set 5	0 to 23	1
89	Initial Minute	Regulation Set 5	0 to 59	1
90	Final Hour	Regulation Set 5	0 to 23	1
91	Final Minute	Regulation Set 5	0 to 59	1
101	Nominal Voltage	Regulation Set 6	80.0 to 140.0 V	10
102	Bandwidth	Regulation Set 6	0.0 to 10.0%	10
103	Command Type	Regulation Set 6	0: pulse 1: step	1

Register	Description		Values	Multiplier
104	Delay Type	Regulation Set 6	0: constant 1: inverse	1
105	Raise Time	Regulation Set 6	0 to 180 s	1
106	Lower Time	Regulation Set 6	0 to 180 s	1
107	Repetition Time	Regulation Set 6	0 to 30 s	1
108	Initial Hour	Regulation Set 6	0 to 23	1
109	Initial Minute	Regulation Set 6	0 to 59	1
110	Final Hour	Regulation Set 6	0 to 23	1
111	Final Minute	Regulation Set 6	0 to 59	1
121	Nominal Voltage	Regulation Set 7	80.0 to 140.0 V	10
122	Bandwidth	Regulation Set 7	0.0 to 10.0%	10
123	Command Type	Regulation Set 7	0: pulse 1: step	1
124	Delay Type	Regulation Set 7	0: constant 1: inverse	1
125	Raise Time	Regulation Set 7	0 to 180 s	1
126	Lower Time	Regulation Set 7	0 to 180 s	1
127	Repetition Time	Regulation Set 7	0 to 30 s	1
128	Initial Hour	Regulation Set 7	0 to 23	1
129	Initial Minute	Regulation Set 7	0 to 59	1
130	Final Hour	Regulation Set 7	0 to 23	1
131	Final Minute	Regulation Set 7	0 to 59	1
141	Nominal Voltage	Regulation Set 8	80.0 to 140.0 V	10
142	Bandwidth	Regulation Set 8	0.0 to 10.0%	10
143	Command Type	Regulation Set 8	0: pulse 1: step	1
144	Delay Type	Regulation Set 8	0: constant 1: inverse	1
145	Raise Time	Regulation Set 8	0 to 180 s	1
146	Lower Time	Regulation Set 8	0 to 180 s	1
147	Repetition Time	Regulation Set 8	0 to 30 s	1
148	Initial Hour	Regulation Set 8	0 to 23	1
149	Initial Minute	Regulation Set 8	0 to 59	1
150	Final Hour	Regulation Set 8	0 to 23	1
151	Final Minute	Regulation Set 8	0 to 59	1



Register	Description	Values	Multiplier
201	LDC Type	0: RX 1: Z	1
202	Ur	-25.0 to 25.0V	10
203	Ux	-25.0 to 25.0V	10
204	Z Compensation	0.0 to 15.0%	10
205	Maximum Compensation	0 to 25%	1
301	Current Loop - Output Scale	0: 0-1 mA 1: 0-5 mA 2: 0-10 mA 3: 0-20 mA 4: 0-20 mA	1
302	Voltage Full Scale	80 to 200 V	1
303	Current Full Scale	0.1 to 10.0 A	10
401	Voltage/Current Phase Difference	0 to 359 deg.	1
402	Sampling Circuit	0: Monophase 1: Phase-Neutral 2: Phase-Phase	1
403	VT Turns Ratio	0 to 9999	1
404	CT Turns Ratio	0 to 9999	1
501	U<	10 to 99%	1
502	U>	101 to 199%	1
503	I>	10 to 199%	1
601	Local Hour	0 to 23	1
602	Local Minute	0 to 59	1
603	Local Second	0 to 59	1
604	Local Day	1 to 31	1
605	Local Month	1 to 12	1
606	Local Year (2000-2099)	0 to 99	1
701	Resistance per position	3.0 $\Omega$ to 20.0 $\Omega$	10
702	Number of positions	2 to 50	1
703	Indication mode	0: 1 ... n 1: -x ... +y 2: +x ... -y 3: xL ... N ... yR 4: xR ... N ... yL	1

Register	Description	Values	Multiplier
704	Neutral position	1 to 50	1
705	Minimum position	1 to 50	1
706	Maximum position	1 to 50	1
801	Minimum position memory	1 to 50	1
802	Maximum position memory	1 to 50	1
803	Reserved		
804	Commutation counter (in thousands)	1 to 9999	1
805	Reserved		
806	Total Squared Commuted Current (in $A^2$ )	0 a 9999	1
807	Total Squared Commuted Current (in tens of thousands of $A^2$ )	0 a 9999	1
808	Total Squared Commuted Current (in hundreds of millions of $A^2$ )	0 a 9999	1
809	Total Squared Commuted Current (in trillions of $A^2$ )	0 a 9999	1
810	Partial Squared Commuted Current (in $A^2$ )	0 a 9999	1
811	Partial Squared Commuted Current (in tens of thousands of $A^2$ )	0 a 9999	1
812	Partial Squared Commuted Current (in hundreds of millions of $A^2$ )	0 a 9999	1
813	Partial Squared Commuted Current (in trillions of $A^2$ )	0 a 9999	1
814	Total Commuted Current (in $A$ )	0 a 9999	1
815	Total Commuted Current (in tens of thousands of $A$ )	0 a 9999	1
816	Total Commuted Current (in hundreds of millions of $A$ )	0 a 9999	1
817	Total Commuted Current (in trillions of $A$ )	0 a 9999	1
818	Partial Commuted Current (in $A$ )	0 a 9999	1
819	Partial Commuted Current (in tens of thousands of $A$ )	0 a 9999	1
820	Partial Commuted Current (in hundreds of millions of $A$ )	0 a 9999	1
821	Partial Commuted Current (in trillions of $A$ )	0 a 9999	1

Register	Description	Values	Multiplier
1001	VT Secondary Voltage	0 to 160.0 V	10
1002	CT Secondary Current	0 to 10.00 A	100
1003	Line Voltage	0 to 999.9 kV	10
1004	Line Current	0 to 99999 A	1
1005	Load Voltage	0 to 999.9 kV	10
1006	Voltage-Current Phase Difference	0 to 359.9 deg.	10
1007	Power Factor	0 to 1.000	1000
1008	Apparent Power	0 to 999.9 MVA	10
1009	Active Power	0 to 999.9 MW	10
1010	Reactive Power	0 to 999.9 MVar	10
1011	Nominal Voltage Percentage	0 to 200.0 %	10
1012	Nominal Current Percentage	0 to 200.0 %	10
1013	Voltage Deviation	-100.0 to 100.0 %	10
1014	Active Regulation Set	0 to 7	1
1015	On-load tap changer current position	1 to 50	1

PS: Writing any value in the registers with address from 801 to 804 will reset the parameter.





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