Voltage Regulator
model MFC-300/R

Technical Manual

Licht

Contents

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 undervoltage.

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/undervoltage 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.

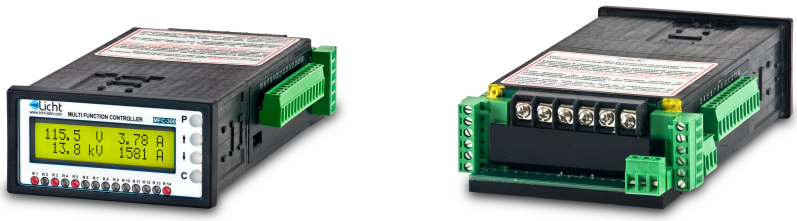


Figure 1.1 MFC-300/R Voltage Regulator (96x48 version)

2 Operation

2.1 Front panel 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 ↓.

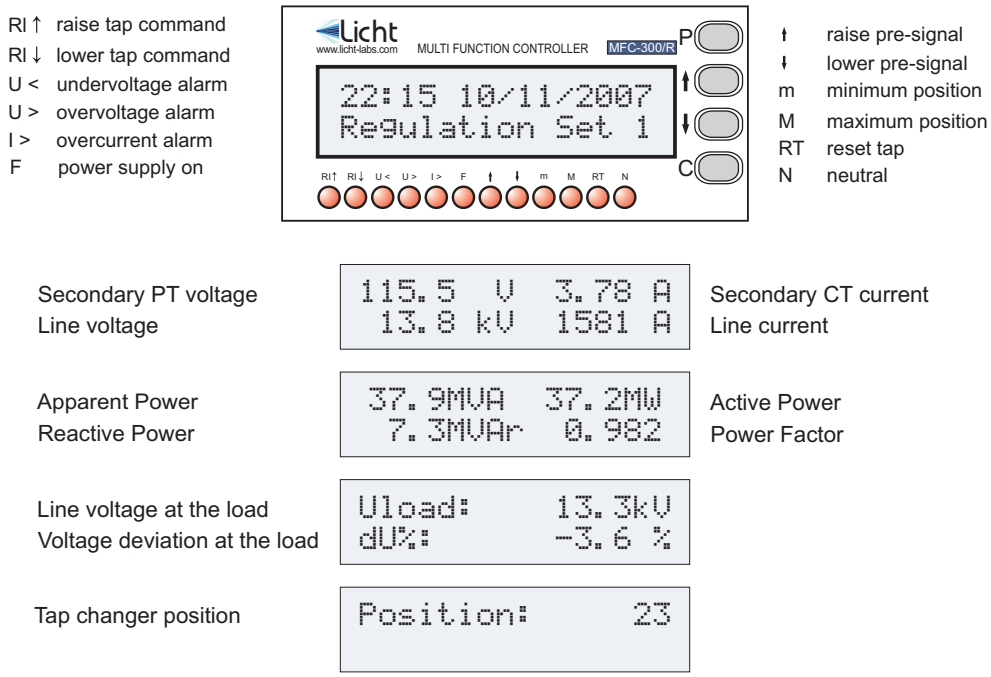


Figure 2.1 Front Panel

In devices with the tap readout and inference options, the neutral (**N**) and reset tap (**RT**) LEDs are also included. They have the following behavior:

- Neutral [**N**]: turns on whenever the tap position is neutral.
- Reset tap [**RT**]: see section 4 (Tap memory).

2.2 Configuration

The MFC-300/R features 4 keys to access its functions. The procedure to configure any parameter is as follows:

1. Press the **P** key to enter the parameters menu.
2. Using the ↑ and ↓ keys, choose the desired parameter.
3. Press **P** to confirm the parameter's selection.
4. Choose the desired value with the ↑ and ↓ keys.
5. Confirm pressing **P**.

Menu options can be advanced quickly by holding down ↑ or ↓.

The configuration sequence can be cancelled at any time by pressing **C**.

2.3 Parameter reset

The MFC-300/R can be reset to default parameters if turned on with the **C** key held down. This procedure also resets its password to AAAA.

3 Tap control

The MFC-300/R features three operation modes that can be chosen inside the 'Operation Mode' menu.

3.1 Automatic mode

The MFC-300/R samples the transformer voltage and current 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 undervoltage.

The MFC-300/R continuously computes the difference between the reference voltage and the inferred voltage at the load. If this difference exceeds a threshold (configurable between 1 and 10 %) for a sufficiently long time (configurable between 1 and 180 seconds), the MFC-300/R issues raise or lower commands. During normal operation, the MFC-300/R issues OLTC commands until the deviation falls inside the configured bandwidth. No commands are issued if it detects overcurrent, overvoltage or undervoltage scenarios.

3.2 Manual mode

The MFC-300/R allows one to issue manual raise/lower commands to the on-load tap changer.

To issue a manual command, press **P** to enter the configuration mode, and choose the "Manual Command" option. The device will then prompt for a raise or lower command, which can be issued by pressing ↑ or ↓.

After ↑ or ↓ is pressed, the corresponding pre-signal LED will light up, indicating that the command was received. If the command can be issued, the corresponding command LED will light up and its associated relay will close, effectively commanding the on-load tap changer.

Manual commands are ignored if the MFC-300/R detects a voltage variation exceeding the configured bandwidth.

3.3 Blocked mode

In this mode, the MFC-300/R does not issue raise or lower commands for voltage regulation. Nevertheless, the MFC-300/R will issue any applicable raise or lower commands if the Auto-Zero command is given.

4 Optional functions

The MFC-300/R features two optional methods of OLTC position measurement. Given their different applications, these options are mutually exclusive.

4.1 Tap readout

With this option, the device directly reads the tap position from a potentiometric sensor.

4.2 Tap inference

With this option, the MFC-300/R infers the tap position using the digital NEUTRAL and EVEN/ODD inputs. These inputs are set by OLTC microswitches, which must be connected to the EVEN/ODD Acquisition Module, as shown in the Connection Diagram.

Its understood that the OLTC is in the neutral position while the NEUTRAL microswitch is closed. The EVEN/ODD microswitch remains open whenever the OLTC is on an even position, and closed otherwise. When the MFC-300/R issues a raise command, the OLTC activates its motor and performs the command. When the OLTC effectively changes the tap, the EVEN/ODD microswitch changes state. An analogous behavior occurs for lower commands. The neutral position is defined as even. Thus, when the OLTC is in the neutral position, its EVEN/ODD microswitch must remain open.

The MFC-300/R considers that the OLTC is in the neutral position while the NEUTRAL microwitch is closed and the EVEN/ODD microswitch is open. This condition is indicated using the **N** LED located on the device front panel.

After the MFC-300/R is powered on, the OLTC position is only known when it reaches neutral. From this moment on, all positions are inferred. If any unexpected behavior is detected (see below), the tap position becomes unknown, and is only reacquired when the OLTC returns to neutral.

Unexpected behaviours:

- ▷ EVEN/ODD state change without an OLTC command
- ▷ Neutral position inferred while the NEUTRAL microswitch is open
- ▷ Even tap position inferred while the EVEN/ODD microswitch is closed
- ▷ Odd tap position inferred while the EVEN/ODD microswitch is open

- ▷ The MFC-300/R infers a position greater than the OLTC's number of positions
- ▷ The MFC-300/R infers a position lower than 1.

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 non-volatile 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.

For devices with the position inference option, the detection of an unexpected behavior (defined above) will cause the maximum and minimum position values to be displayed with a '?' suffix. This suffix can only be removed by reseting the device's tap memory.

Whenever the memory is cleared, the reset tap **RT** relay is closed for one second. This contact can be used to reset a external tap change counter.

Auto-zero

Upon receiving the Auto-zero command, the MFC-300/R issues raise or lower commands to the OLTC until the tap position is neutral. The operating mode is also switched to blocked, in order to avoid conflicting commands. The device remains in blocked mode until configured otherwise by an operator.

5 Programmable parameters

The MFC-300/R was developed to provide the user with the greatest possible flexiblity, 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.

5.1 Regulation

Parameter: Operation Mode
Options: Automatic, manual or blocked.
Description: see Section 3 (tap control).

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 140V_{CA}, 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., $V_1 = V_2 \cdot N_{VT}$, where N_{VT} is the VT's turns ratio. For example:

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

Parameter: Bandwidth
Options: 0 to 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 step

(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: 150V/13.8kV = 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:

i. **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.
ii. **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 ↑ and ↓ delays are given by $T_{\uparrow} \cdot \frac{BW}{\Delta V}$ and $T_{\downarrow} \cdot \frac{BW}{\Delta V}$, where:
   - $T_{\uparrow}$ and $T_{\downarrow}$ are the Raise Delay and Lower Delay parameters;
   - BW is the Bandwidth parameter;
   - ΔV is the measured deviation in relation to the reference voltage;
   - BW and ΔV 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 ↑ 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 ↓ command.

Parameter: Repetition Delay
Options: 0 to 30 seconds, in 1 second steps.
Description: delay between consecutive ↑ or ↓ 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.

5.2 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 Ur and Ux 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 Ur and Ux parameters.

Parameter: Ur
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:

$$U_r = I_N \cdot \frac{N_{CT}}{N_{VT}} \cdot r \cdot L$$

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 Ω/km.
- L: the line's length, in km.

Parameter: Ux
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:

$$U_x = I_N \cdot \frac{N_{CT}}{N_{VT}} \cdot x \cdot L$$

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 Ω/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:

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

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: Maximum Compensation
Options: 0 to 25%.
Description: limits the transformer's voltage increase due to the LDC.

5.3 Current loop outputs (option)

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.

5.4 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:

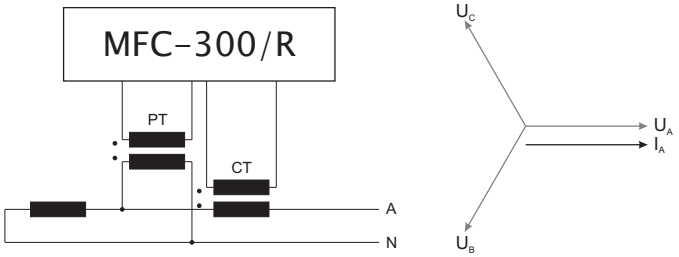


Figure 5.1 Monophase circuit, 0 ° phase difference

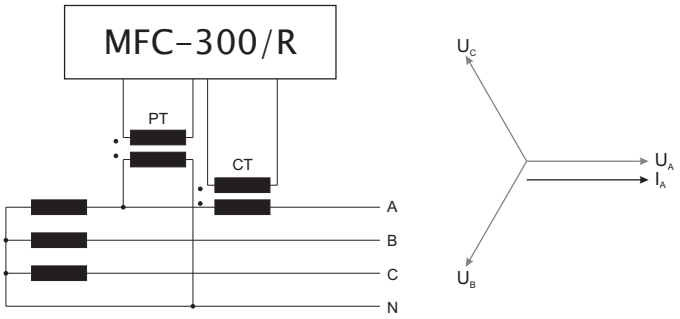


Figure 5.2 Phase-Neutral circuit, 0 ° phase difference

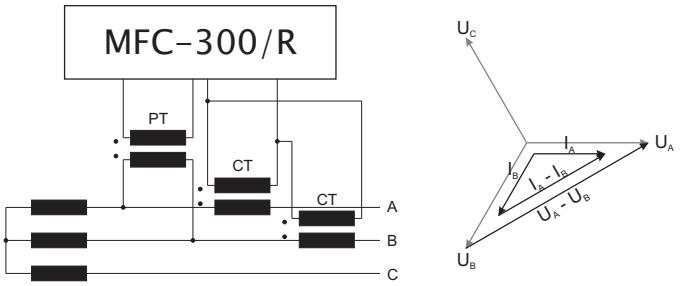


Figure 5.3 Phase-Phase circuit, 0 ° phase difference

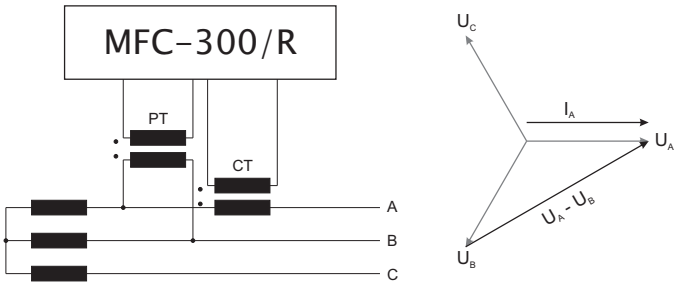


Figure 5.4 Phase-Phase circuit, 30 ° phase difference

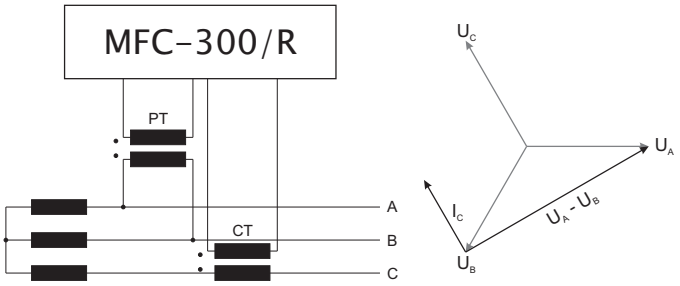


Figure 5.5 Phase-Phase circuit, 270 ° phase difference

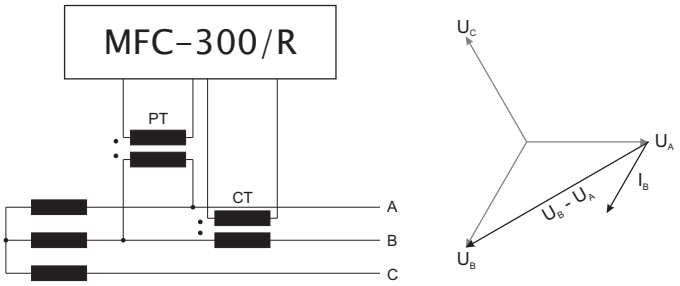


Figure 5.6 Phase-Phase circuit, 330 ° phase difference

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.

5.5 Alarms

Parameter: U< (undervoltage)
Options: 10 to 99%, referred to the nominal voltage, in 1% steps.
Description: voltage value under which the MFC-300/R activates an alarm relay and blocks tap changes.

Parameter: U> (overvoltage)
Options: 101 to 199%, referred to the nominal voltage, in 1% steps.
Description: voltage value over which the MFC-300/R activates an alarm relay and blocks tap changes.

Parameter: I> (overcurrent)
Options: 10 to 199%, referred to the nominal current, in 1% steps.
Description: current value over which the MFC-300/R activates an alarm relay and blocks tap changes.

5.6 On-load tap changer (option)

Note: this menu is only available in devices with the position readout or inference option.

Parameter: Resistance per position
Options: 3.0 Ω to 20.0 Ω, in increments of 0.1 Ω.
Description: the potentiometric sensor's resistance per position.

Parameter: Number of positions
Options: 2 to 50.
Description: the on-load tap 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).

- ▷ xL ... N ... yR: positions below neutral are suffixed with L, positions above neutral are suffixed with R, and the neutral is indicated as N.
- ▷ xR ... N ... yL: positions below neutral are suffixed with R, positions above neutral are suffixed with L, and the neutral is indicated as N.

Parameter: Neutral position
Options: 1 to 50.
Description: defines the neutral position.

Parameter: Minimum position
Options: 1 to 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 to 50.
Description: defines the maximum position that the MFC-300/R can place the tap changer in order regulate the voltage at the load.

5.7 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: Address
Options: 1 to 247.
Description: MODBUS address for the MFC-300/R.

5.8 DNP3 protocol (option)

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 Backoff 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.

5.9 Date/Time

Parameter: Date/Time
Options: HH:MM:SS DD/MM/YYYY
Description: sets the local date and time.

5.10 Language

Parameter: Language
Options: English (US), Portuguese (BR)
Description: selects the language in which messages are displayed.

5.11 Password

Parameter: Password
Options: AAAA to ZZZZ
Description: defines a new 4 letter password.

6 Additional versions

Figure 6.1 MFC-300/R Controller (96x96 version)

Figure 6.2 MFC-300/R Controller (with weatherproof enclosure)

A Specifications

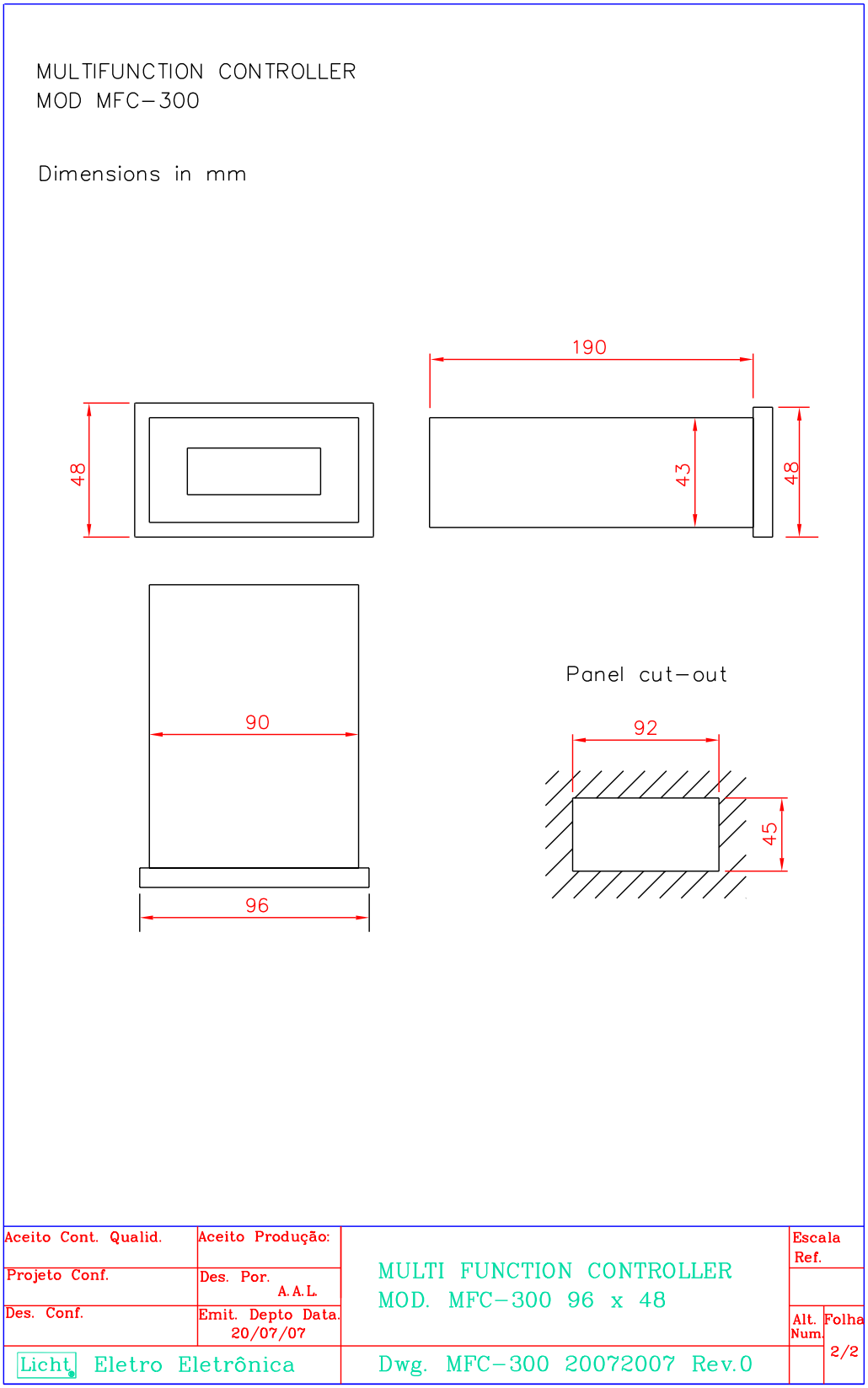
Power Supply	Isolated, 80-260 Vac/Vdc.
Power Consumption	8 W
Operating Temperature	-10 to 70 °C (LCD display) -40 to 70 °C (VFD display)
Enclosure Rating	IP20 (96x48 and 96x96 formats) IP65 (with weatherproof enclosure)
Mounting Option	Panel-mounted
Dimensions	96 x 96 x 190 mm or 96 x 48 x 190 mm
Weight	550 g
V_{AC} **Scale**	Scale: 0-200 V Error/Non-linearity: 0.5% + 0.1% / 10 °C
I_{AC} **Scale**	Scale: 0-5 A Error/Não-linearity: 0.5% + 0.1% / 10 °C
Current Loop Outputs	Scales: 0-1, 0-5, 0-10, 0-20, 4-20 mA Error/Non-linearity: 0.2% + 0.1% / 10 °C

Galvanic Isolation (60 Hz, 1 min.)

AC Inputs	2.0	kV
Outputs	2.0	kV
Communication	2.0	kV

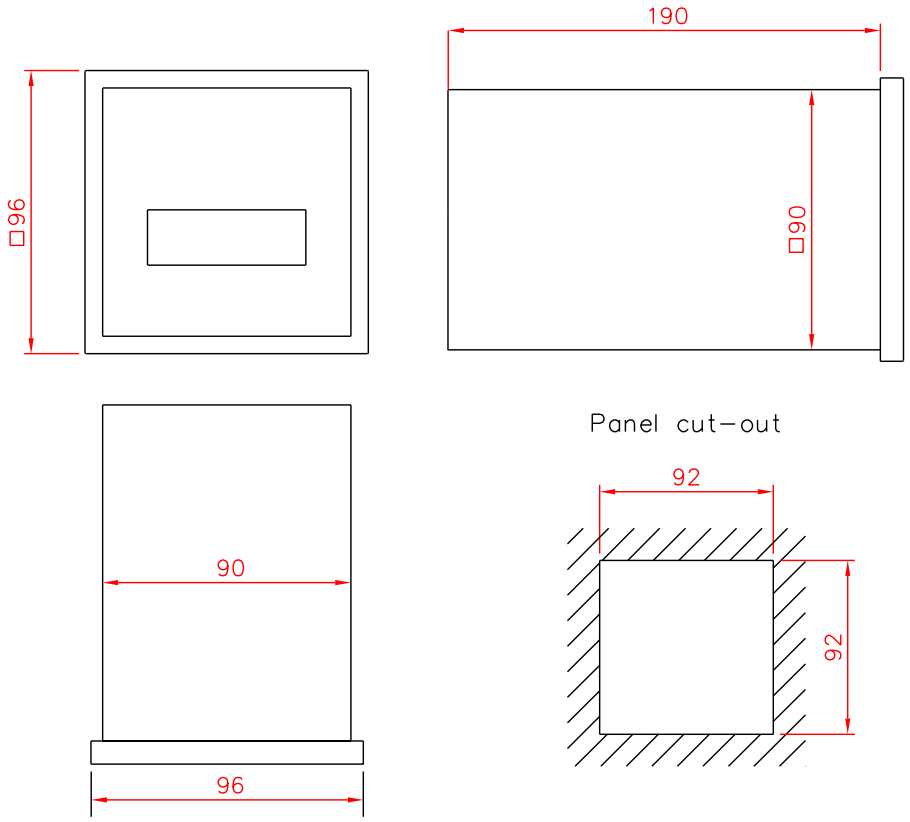
Communication	RS-485 - MODBUS RTU or DNP3 9600, 19200, 38400, 57600, 115200 bps 8N1, 8E1, 8O1, 8N2
Displays	2 lines, 16 characters each (5 mm). LCD with backlight or VFD.
Relays	10 A @ 250 Vac, 0.5 A @ 125 Vdc Galvanic Isolation: 2.0 kV, 60 Hz, 1 min.

B Housing diagrams



MULTIFUNCTION CONTROLLER
MOD MFC-300

Dimensions in mm



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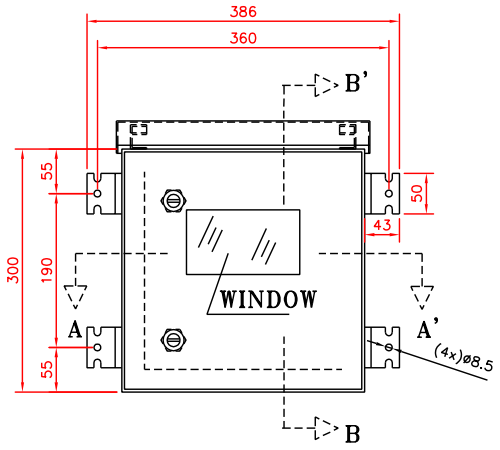
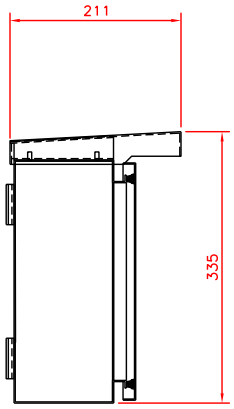
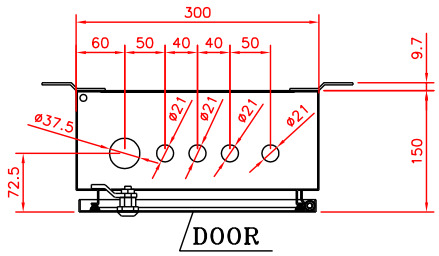


Frontal View



B–B' Cross–section

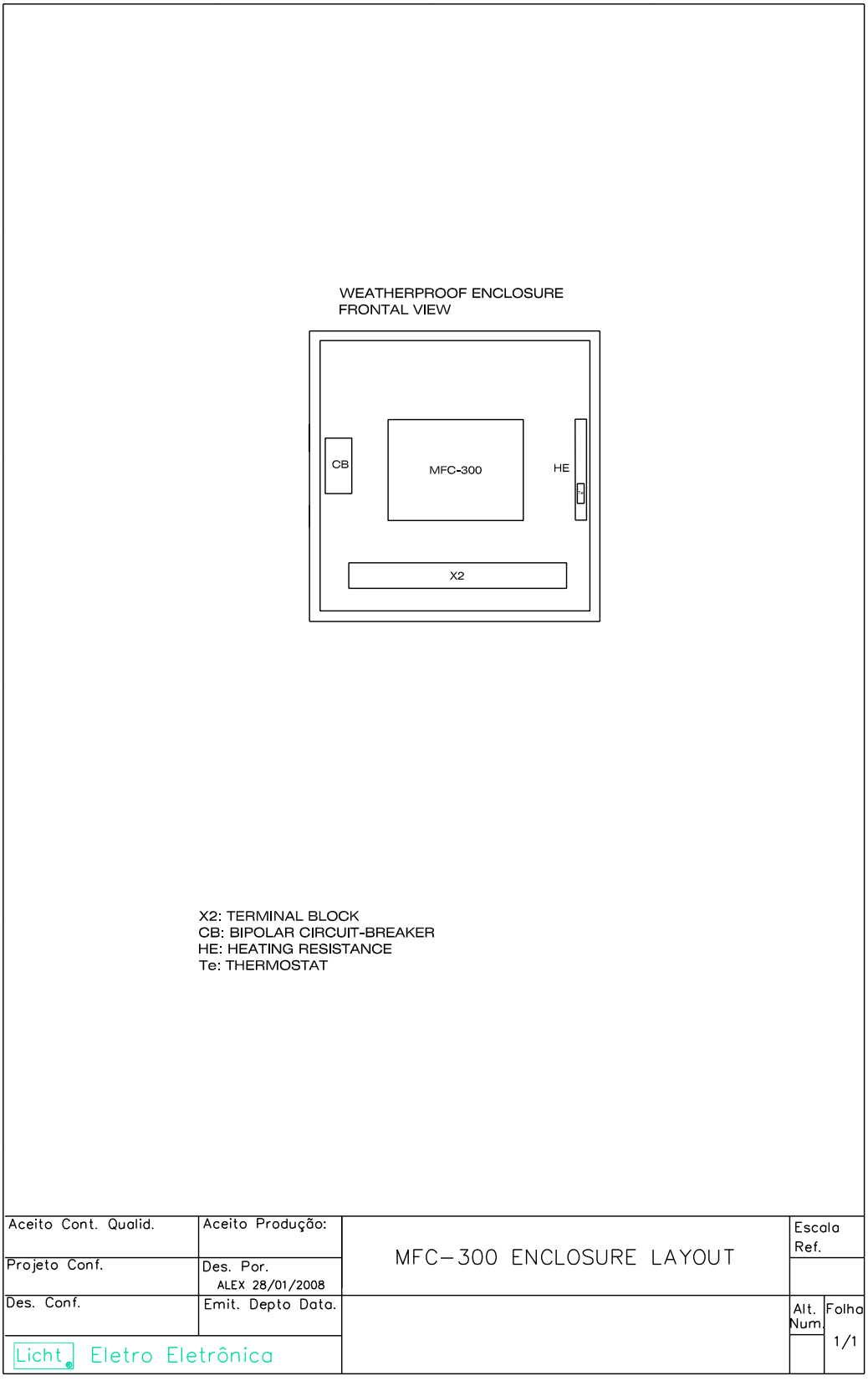


A–A' Cross–section

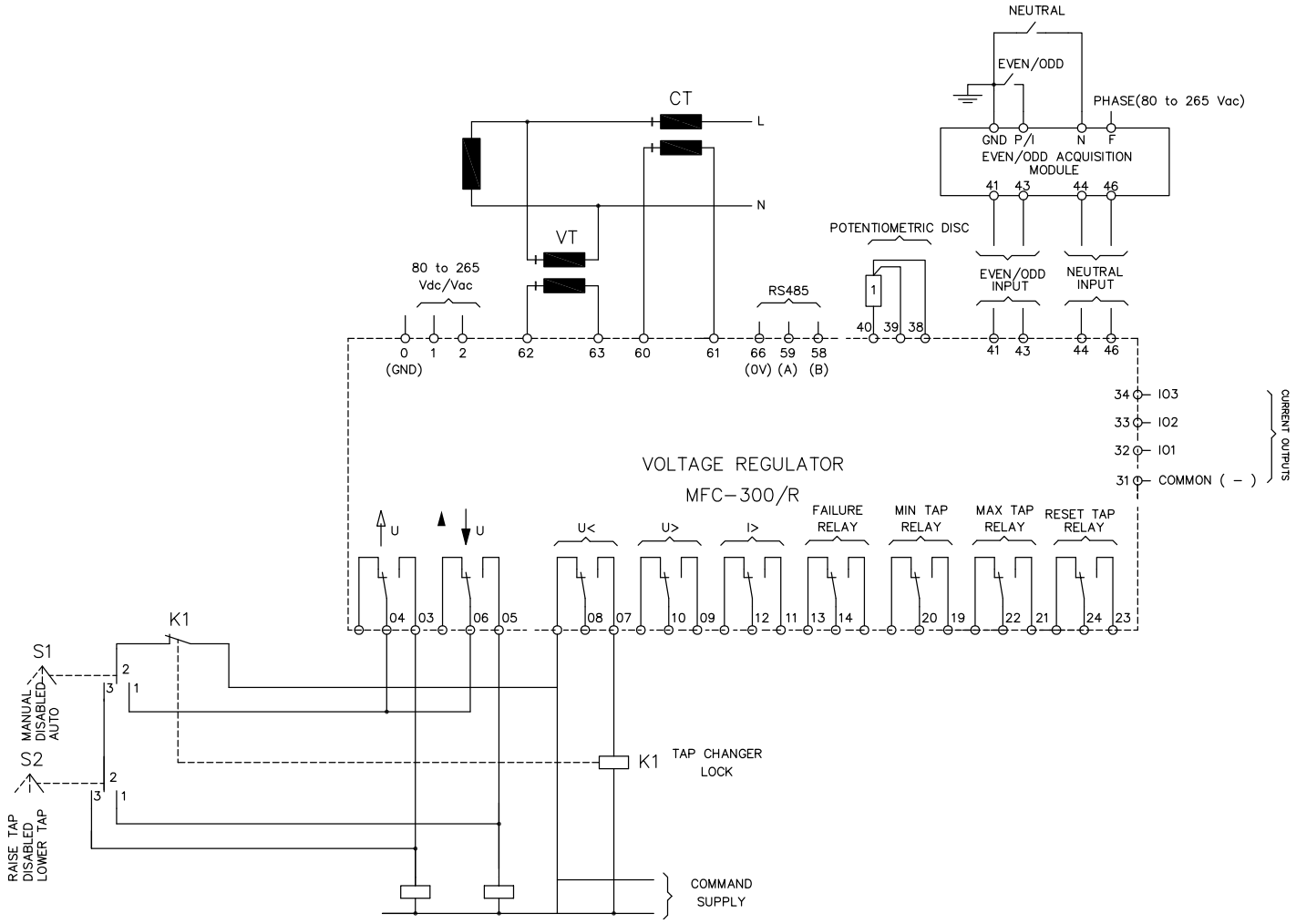
Material: Steel Plate
Thickness: 1,25 mm
Paint: 40 micron epoxy power coating, RAL 7032 color
Rating: IP 65

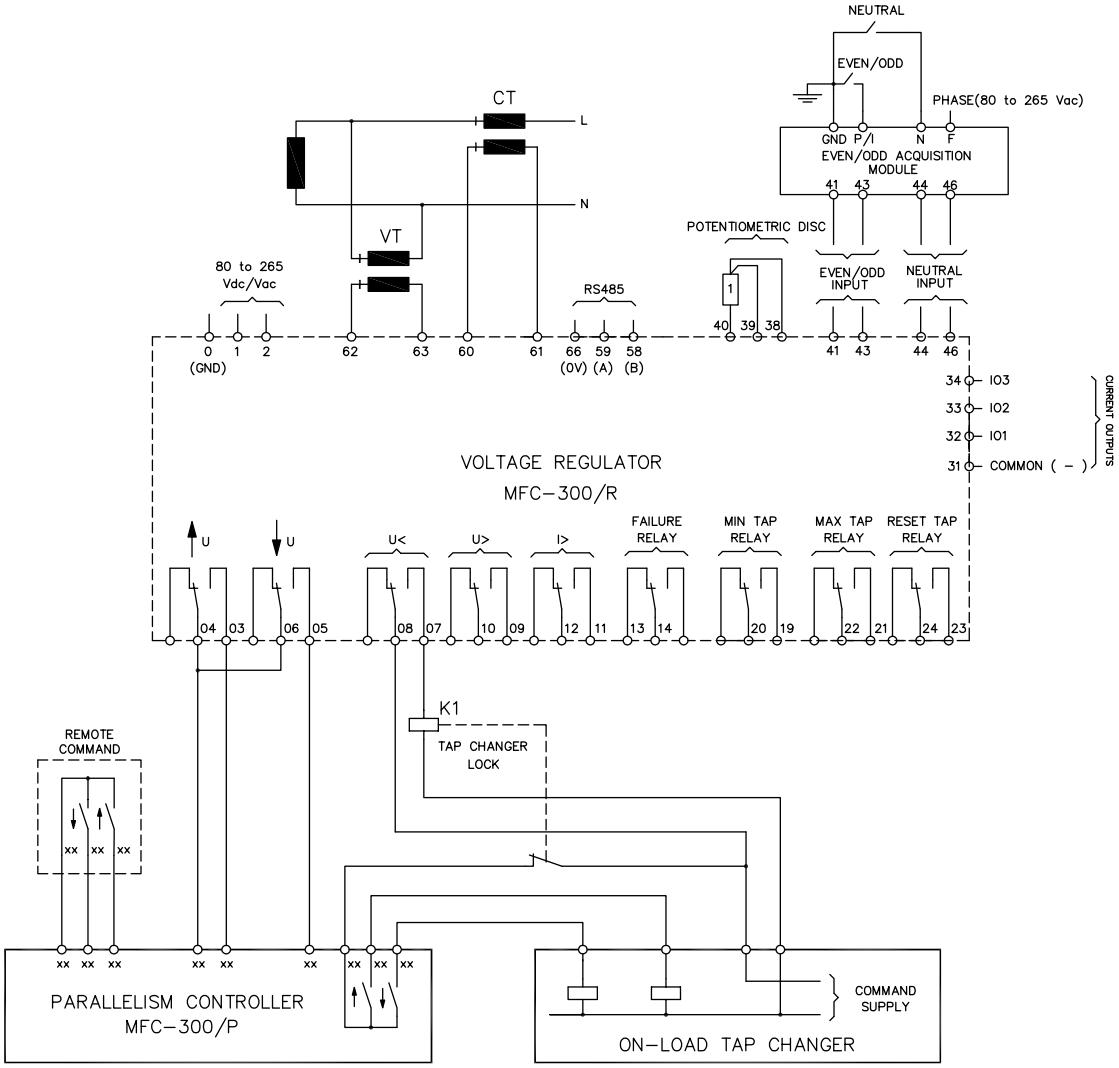
Aceito Cont. Qualid.	Aceito Produção:	MFC-300 HOUSING WEATHERPROOF ENCLOSURE	Escala S/ ESC.
Projeto Conf.	Des. Por. ALEX 28/01/08		
Des. Conf.	Emit. Depto Data.		Alt. Num. / Folha 1/1
Licht Eletro Eletrônica			

C Weatherproof enclosure layout



D Connection diagrams




NEUTRAL
EVEN/ODD
PHASE(80 to 265 Vac)
CT
L
N
VT
GND P/I N F
EVEN/ODD ACQUISITION MODULE
41 43 44 46
POTENTIOMETRIC DISC
80 to 265 Vdc/Vac
RS485
EVEN/ODD INPUT
NEUTRAL INPUT
1
40 39 38
0 1 2 62 63 60 61 66 59 58
(GND) (0V) (A) (B)
41 43 44 46
34 I03
33 I02
32 I01
31 COMMON (–)
CURRENT OUTPUTS
VOLTAGE REGULATOR
MFC–300/R
U U U< U> I>
FAILURE RELAY
MIN TAP RELAY
MAX TAP RELAY
RESET TAP RELAY
04 03 06 05 08 07 10 09 12 11 13 14 20 19 22 21 24 23
K1
TAP CHANGER LOCK
REMOTE COMMAND
xx xx xx
PARALLELISM CONTROLLER
MFC–300/P
COMMAND SUPPLY
ON–LOAD TAP CHANGER

Important considerations

The installation of electronic devices in substations should conform with 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 condutor, 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 Ω 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.

E 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 Ω to 20.0 Ω	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		
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.