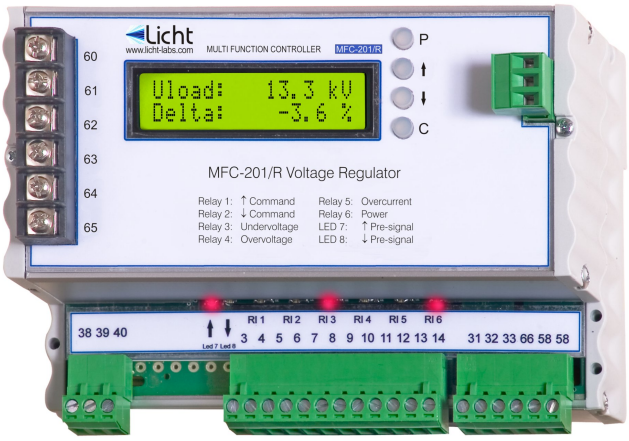
Voltage Regulator model MFC-201/R



Technical Manual

Licht

Contents

1 Introduction

The MFC-201/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-201/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-201/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-201/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.

2 Operation

2.1 Front panel indication

During normal operation, the MFC-201/R alternates every 10 seconds between the 4 screens represented below. They can also be accessed directly by pressing ↑ or ↓.

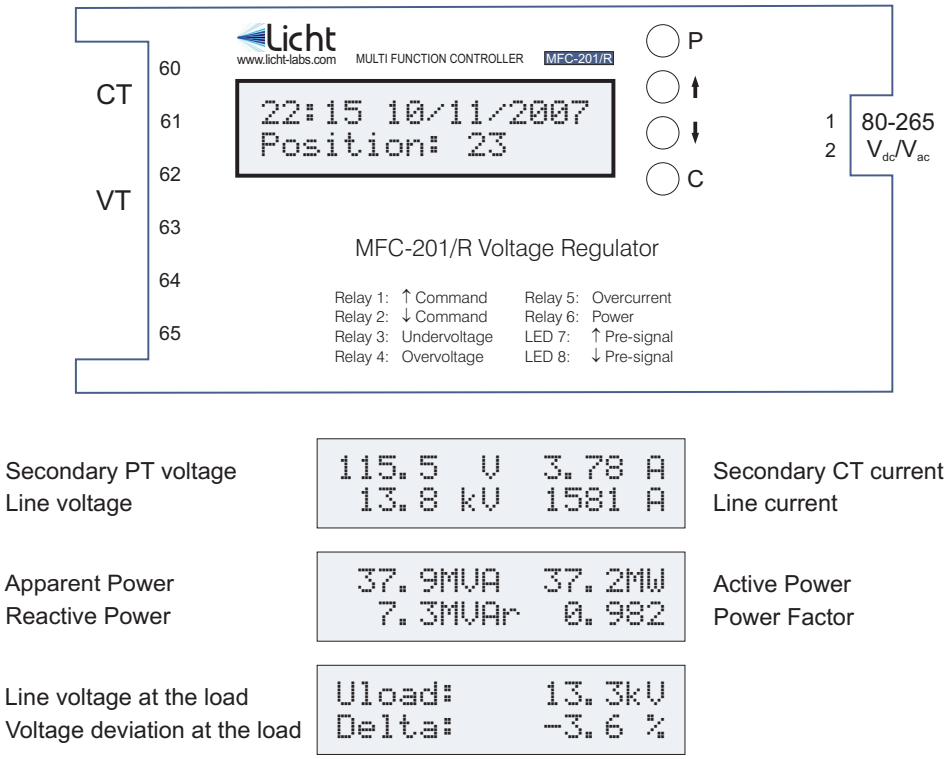


Figure 2.1 Front Panel

2.2 Configuration

The MFC-201/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**.

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

3 Programmable parameters

The MFC-201/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.

3.1 Regulation

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-201/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.

3.2 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-201/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-201/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-201/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.

3.3 Current loop outputs (option)

The MFC-201/R features up to two current loop outputs which can be used to retransmit the measured RMS voltage and current values. Its parameters are defined 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.

3.4 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:

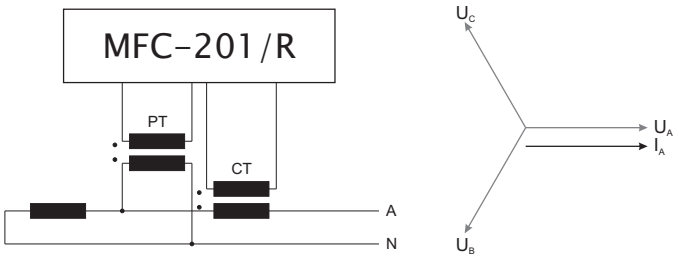


Figure 3.1 Monophase circuit, 0 ° phase difference

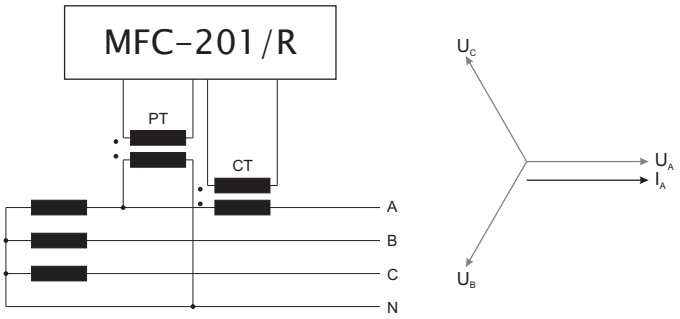


Figure 3.2 Phase-Neutral circuit, 0 ° phase difference

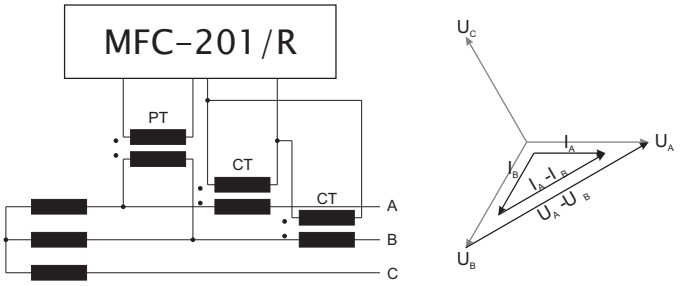


Figure 3.3 Phase-Phase circuit, 0 ° phase difference

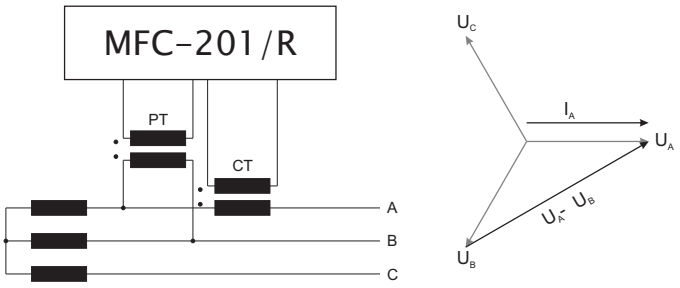


Figure 3.4 Phase-Phase circuit, 30 ° phase difference

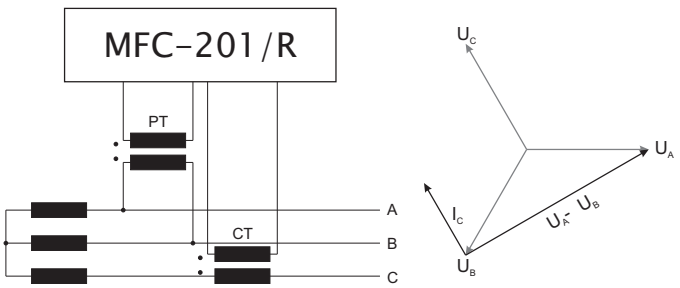


Figure 3.5 Phase-Phase circuit, 270 ° phase difference

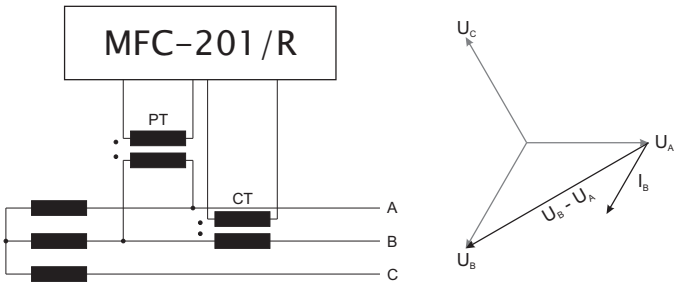


Figure 3.6 Phase-Phase circuit, 330 ° phase difference

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.

3.5 Alarms

Parameter: U< (undervoltage)
Options: 10 to 99%, referred to the nominal voltage, in 1% steps.
Description: voltage value under which the MFC-201/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-201/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-201/R activates an alarm relay and blocks tap changes.

3.6 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: Address
Options: 1 to 247.
Description: MODBUS address for the MFC-201/R.

3.7 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-201/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-201/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-201/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-201/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-201/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.

3.8 Date/Time

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

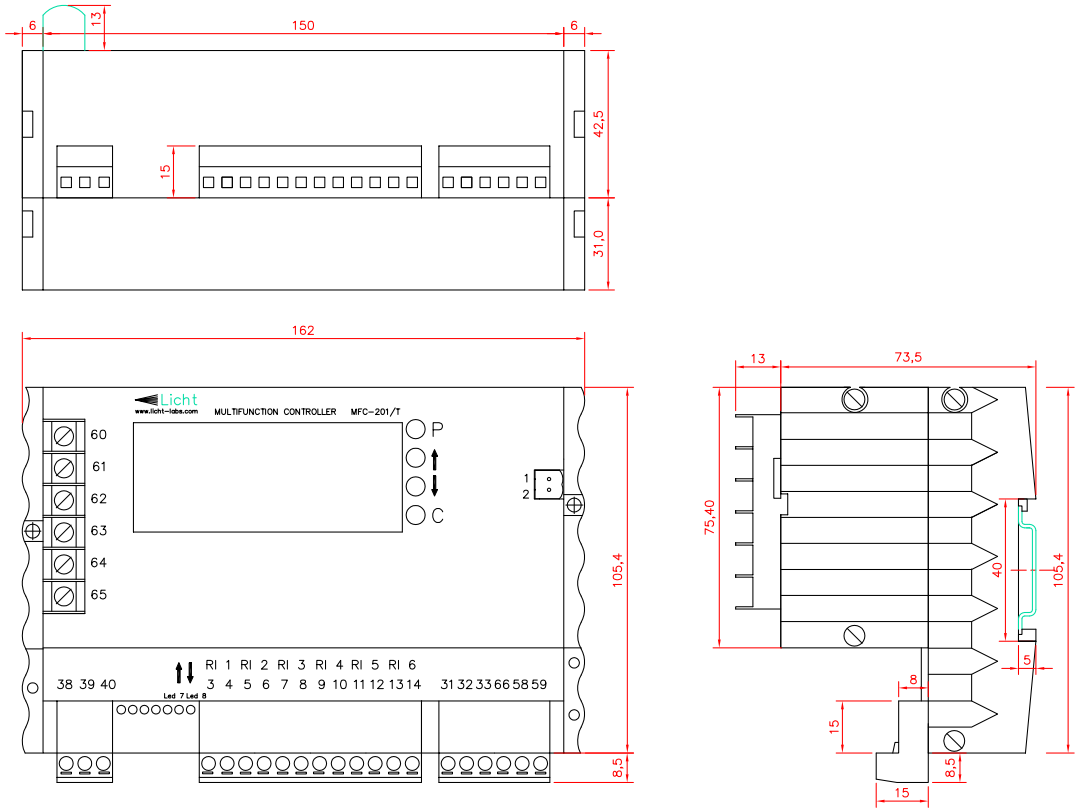
3.9 Language

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

A Specifications

Power Supply	Isolated, 80-260 Vac/Vdc.
Power Consumption	8 W
Operating Temperature	-20 to 70 °C (LCD display) -40 to 85 °C (VFD display)
Enclosure Rating	IP20
Mounting Option	35 mm DIN rail
Dimensions	162 x 105 x 87 mm
Weight	750 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/Non-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 2.5 kV Outputs 2.5 kV Communication 2.5 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: 2.5 kV, 60 Hz, 1 min.

B Housing diagrams



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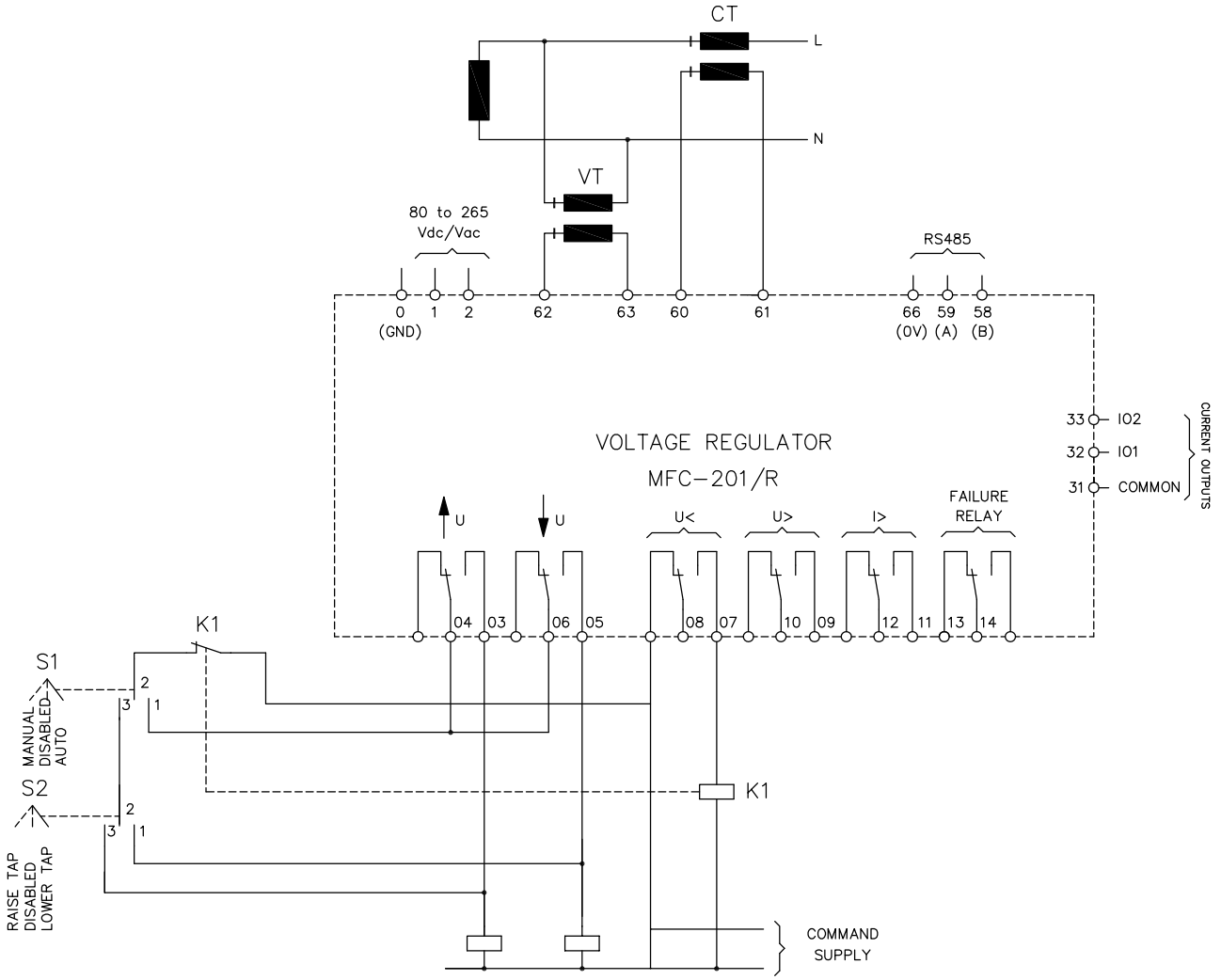
C Connection diagrams



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.

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
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

Register	Description	Values	Multiplier
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