ELTIME CONTROLS

LCC
THREE PHASE
MULTIFUNCTION MONITOR

TECHNICAL DESCRIPTION, COMMUNICATION PROTOCOL AND INSTRUCTION MANUAL

INDEX.

1.- GENERAL DESCRIPTION.

The LCC is a low cost measuring instrument housed in a small DIN 96x96 enclosure. It receives the current and voltage signals from an electric power line, and measures all its main variables, displaying them in a custom LCD screen. Multiple measurements can be displayed at the same time, and can be sent by means of an optional serial communication line to an adequate receiver. Additionally, two optocouplers are provided, and can be configured as digital outputs, representing energy pulses or alarms. Through the serial output all measurements are accessible, enabling sending them to a computer to provide recording and statistical processes.

The unit uses a 16 bit microprocessor, including a twelve bit A/D converter. This enables the unit to have a very high accuracy, great flexibility in input range programming, and powerful communication capabilities. Special care has been taken in the design, not only to provide good accuracy, but also high reliability, a strong immunity to EMC - in order to be used in industrial environments - and high isolation characteristics. The devices are prepared for panel mounting and all the connections are done by detachable connectors. It's small dimensions make it very useful for control panels with space constraints.

2.- TECHNICAL DESCRIPTION.

2.1.- MEASURING PRINCIPLE.

The measuring is done in a totally digital way. After passing through the voltage dividers and current transformers, the signals are sampled by the A/D converter. The microprocessor controls the A/D sampling, following the network frequency in order to get 32 samples per period for each signal, stores them and processes them calculating the values as the following:

$V_i = \mathrm{sqr}(\ \Sigma V_{ij}^{\,2} / 32\ )$ $\qquad I_i = \mathrm{sqr}(\ \Sigma I_{ij}^{\,2} / 32\ )$

$P_i = \Sigma (\ V_{ij} * I_{ij}\ ) / 32$ $\qquad Q_i = \Sigma (\ V_{i\,j-8} * I_{ij}\ ) / 32$ $\qquad S_i = \mathrm{sqr}(\ P_i^2 + Q_i^2\ )$

$P_t = \Sigma (P_i)$ $\qquad Q_t = \Sigma (Q_i)$ $\qquad S_t = \mathrm{sqr}(\ P_t^2 + Q_t^2\ )$

Line voltages are calculated from the phase voltages. For example, V31 is calculated as

$$V31^2 = V1^2 + V3^2 + V1 * V3$$

This fact means that in the case a single phase signal is applied both to V1 and V3, although there is not a voltage difference between them, the device will give a value corresponding to this calculation.

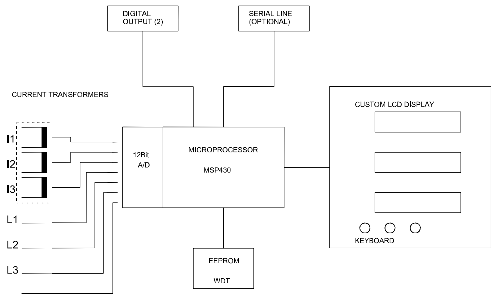
The frequency is measured using the microprocessor internal timers. Its value is used when the energy is computed, as well as to provide the sample synchronization, which must be exactly 32 samples per signal and period. The rest of the parameters are calculated from these basic measurements, totaling up to the table shown. As the sampling is fully synchronized to the network frequency, the instrument can be used both for 50 and 60Hz supplies.

PARAMETER	Present	Max	Min	Mdem	L1	L2	L3
Phase voltage	X	X	X		V1	V2	V3
Line voltage	X	X	X		V12	V23	V31
Line current	X	X		X	I1	I2	I3
Neutral current	X	X		X			
Active power	X				P1	P2	P3
Active power total	X	X		X			
Reactive power	X				Q1	Q2	Q3
Reactive power total	X	X		X			
Apparent power	X				S1	S2	S3
App. power total	X	X		X			
Power factor	X				PF1	PF2	PF3
Power factor total	X						
Frequency	F				-	-	-
Active energy (pos.)	Ep+				-	-	-
Active energy (neg.)	Ep-				-	-	-
Reactive energy (ind.)	Eqind(+)				-	-	-
Reactive energy (cap.)	Eqcap(-)				-	-	-

The max. demand values are calculated by the mean over a programmable of time, 5, 15, 30, 60, 300, 480, 600, or 900 seconds. In this way, a constant value for a variable will give a constant measurement. If at the end of the period the mean is higher than the value stored, this one will be replaced with the new one. If not, the new value will be discarded.

2.2.- BLOCK DIAGRAM.

A block diagram is shown in the following figure.



LCC. BLOCK DIAGRAM.

2.2.1.- Input transformers.
Internal current transformers are used. No internal voltage transformers are used as the signal level change is done by dividing resistors.

2.2.2.- Multiplexer and A/D converter.
A twelve-bit A/D converter and a multiplexer, included in the microprocessor, are used to digitize the six input signals. The sampling is done exactly at 32 samples per signal cycle. The microprocessor changes the timing accordingly to the supply frequency, and the device can work both at 50 and 60Hz.

2.2.3.- Microprocessor.
The device used is the MSP430F149 from TEXAS. It is a 16 bit unit, including 60Kbytes FLASH, 2 Kbyte RAM, one serial port, a twelve bit A/D converter, and timers.

2.2.4. – EEPROM.
The configuration data, as full scale definition, or identity, are stored in an 1Kbit Flash memory included in the microprocessor. In this memory are stored also the calibration data, as the calibration process is done by means of SW commands. Max-min values, energy counters and Max-demand values are also stored in this memory.

2.2.5. - WDT.
A watchdog timer is used to reset the microprocessor in the case of SW failure due to a strong electrical perturbation.

2.2.6. – SERIAL OUTPUT.
A serial output communication line is available for data transfer. In order to provide isolation from the voltage inputs, an optocoupled system is used, requiring a current loop line. This serial line must be connected to an external interface unit, - the MC-LCC, or the IF-LCC -, which provide both level change and supply for the line. The MC-LCC changes from RS485 to current loop, while the IF-LCC changes from RS232 to current loop. Several LCCs can be connected to the same interface, forming a communication bus in which the XX-LCC is the master, and any LCC is a slave. As this side is isolated, the line can be left floating, and can be connected to earth in only one point if needed. The RS485 link must be a 2 wire

connection, and several baud rates can be selected. The physical connection is made through a two pin connector located on the back of the instrument.

2.2.7.- DIGITAL OUTPUTS.
Two digital outputs are provided. The operation mode is selectable as :
A.- Energy pulses.
B.- Alarms.
C.- General outputs commanded by the computer.

2.2.8.- POWER SUPPLY.
The power supply provides the different voltages needed for the internal electronics to operate. As the power is obtained directly from the voltage inputs, the measuring range is restricted to the operational range, as defined in 3.

2.3.- APPLICABLE STANDARDS.

The device fulfills the applicable paragraphs pertaining to the following standards.

EN 60068	Environmental tests.
CEI 255-4	Insulation tests.
CEI 801	High frequency disturbance tests.
EN 61000	Electro magnetic Compatibility
EN 61010	Safety requirements for electrical equipment.
EN 61036	Static energy meters class 1.
EN 60259	Protection class.
DIN 43864	Pulse interface requirements.
EN 50081	Emission.
EN 50082	Immunity.
UL 94	Flammability tests.

2.4.- PRECISION.

2.4.1.- Reference conditions.

Unless otherwise specified, the working, use, operation, and calibration are as per standard EN 60688/IEC 688. The usage group is defined as group III, that is, for ambient operation from –5 and 55ºC. For error definition, the following reference conditions are applicable:

Temperature	23ºC ±1
Voltage input	80-120% Un.
Current input	4-120% In.
Frequency	50 - 60 Hz.
Power factor	1 (0 for reactive power).
Waveform	Sinusoid .

Under these conditions, the maximum errors are specified as follows.

Magnitude	Range	Max. Error
Input voltage	80-120%	.3%Reading +.3%Range
Input current	4-120%	.3%Reading +.3% Range
Active power	10-150%	.3%Reading +.3% Range
Reactive /apparent power	10-150%	.5%Reading +.5% Range
Power factor	-.5/+.5	.5%Reading +.5% Range
Frequency	45-65	.3% Nominal Frequency
Active energy	10-150%	1% Reading
Reactive energy	10-150%	2% Reading

2.4.2.- Working conditions.

The following conditions are applicable for the normal operation of the device.

Temperature	-5 to 55ºC
Voltage input	80-120% Un.
Current input	0-120% In.
Frequency	50 (60) Hz.
Power factor	-.2 – 1 - +.2
Waveform	THD less than 10% (active). THD less than 1% (reactive).

2.4.3.- Overloads.

Duration	Continuously	10 sec	3 sec	1 sec
Current input	2 In	-	5 In	10 In
Voltage input	1.2 Un	1.5 Un	-	-

2.5. – INSULATION CHARACTERISTICS.

Insulation degree: Double
Installation category: II.
Pollution degree: 2.

Nominal voltages:	Voltage inputs 500V (350 V to ground).
	Current inputs 300V.
	Serial line 50V.
	Relay outputs 500V.

2.5.1. – Dielectric tests (kV).

	Current	Voltage	Serial line	Relays
Current	-	2.5	2.5	2.5
Voltage	-	-	2.5	2.5

3.- VARIANTS.

The instrument is not intended to be modified in the field. Each option must be defined when ordering. The electrical connection is three phase four wire unbalanced.

3.1.- VOLTAGE INPUT.

100, 230, or 400 V ±20% (phase to phase value). 1mA per phase.

3.2.- CURRENT INPUT.

1 or 5 A. 0,2 VA per phase.

- Transformer input.

The standard instrument is equipped with internal current transformers. The shunt input version is available, but there is no isolation between the transformers, output and the supply wires. See the safety note in 8.7.

4.- KEYBOARD PROGRAMMING.

The instrument is provided with three keys to program the nominal values, alarms, etc., and a multiple line backlit LCD display. When it is powered up for the first time, all segments are on, allowing to test they are working. After four seconds, the display shows a message indicating the model, LCC, and software version. After two seconds, the instrument begins the measuring process. When the instrument is switched on, page 1 always appears. Pressing the front keys displays the different pages, as well as enables programming of the unit.

4.1.- MEASURING MODE.

The variables measured are displayed on sequential pages in the LCD. To go from one page to the following, press “UP”. To come back, press “DOWN”. The appearance order is as follows:

Page No.	Variables Displayed	Symbols	Unit	Meaning
1	V1, V2 V3	L1 L2 L3	V	Phase to neutral voltage
2	V12,V23,V31	L12 L23 L31	V	Line voltage
3	I1, I2, I3	L1 L2 L3	A	Line current
4	In	In	A	I neutral
5	P, Q, S	P Q S	kW, kVar, kVA	Total Act.,React., and App. Power
6	P1, P2, P3	P L1 L2 L3	kW	Act.Power for each phase
7	Q1, Q2, Q3	Q L1 L2 L3	kVar	React.Power for each phase
8	S1, S2, S3	S L1 L2 L3	kVA	App. Power for each phase
9	Cos1, Cos2, Cos3	Cos L1 L2 L3		Cos for each phase
10	Cos, Id, Freq	Cos, Hz		Total cos, Identity, Frequency
11	COn, xxxxxxxxx		kWh	Consumed energy counter
12	GEn, xxxxxxxxx		kWh	Generated energy counter
13	Ind, xxxxxxxxx		kVarh	Inductive energy counter
14	CAP, xxxxxxxxx		kVarh	Capacitive energy counter

4.2.- MAXIMUM/MINIMUM MODE.

To enter into the max/min mode, press “ENTER”, and after, press “DOWN”. The values stored will appear in pages in a similar way as in the measuring mode. To change the page, press “UP” or “DOWN”.

Page No.	Variables Displayed	Symbols	Unit	Meaning
1	V1, V2, V3	Max, L1, L2, L3	V	Max stored values
2	V1, V2, V3	Min, L1, L2, L3	V	Min stored values
3	V1, V2, V3	Max, L12, L23, L31	V	Max stored values
4	V1, V2, V3	Min, L12, L23, L31	V	Min stored values
5	I1, I2, I3	Max, L1, L2, L3	A	Max stored values
6	In	Max In	A	Max stored value
7	P, Q, S	Max, P, Q, S	kW, kVar, kVA	Max total stored values

To reset the values, press “ENTER” and “UP”. Both max and min values will be set to the current value, and the max/min calculation process begins again.

4.3.- MAX DEMAND MODE.

To enter into this mode, press “ENTER”, and after, press “UP”. The values stored will appear in pages as follows. Each value is displayed in the three lines, as Present value, Last period value, and Max. Peak reached.

Page No.	Variables displayed	Symbols	Unit	Meaning
1	Peak, ---- , present value	MD, L1	A	MD stored values
2	Peak, ---- , present value	MD, L2	A	MD stored values
3	Peak, ---- , present value	MD, L3	A	MD stored values
4	Peak, ---- , present value	In	A	MD stored values
4	Peak, ---- , present kW	MD	kW	MD stored values
5	Peak, ---- , present kVar	MD	kVar	MD stored values
6	Peak, ---- , present kVA	MD	kVA	MD stored values
7	Int, ---- , time	-	-	Interval selected and time elapsed

Pressing “ENTER” and “UP” resets the MD values, and starts a new integrating period. Pressing “MD” sets the instrument again to the normal display mode.

4.4.- RESET ENERGY COUNTERS MODE

To reset a counter, first display it. Then pressing “ENTER” and “DOWN”, resets the counter to zero.

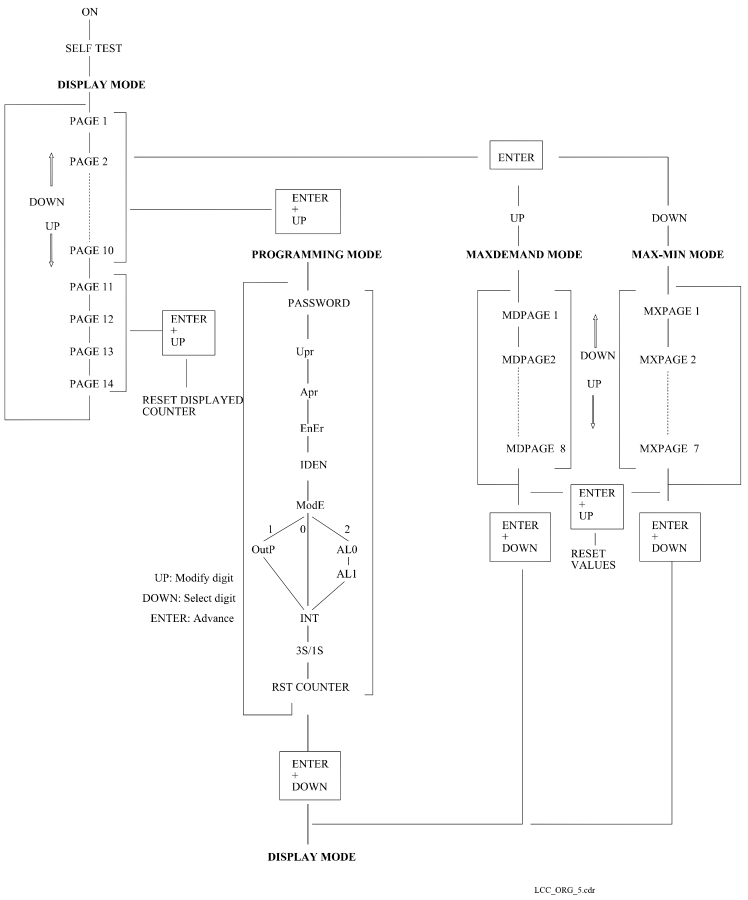
4.5.- PROGRAMMING MODE.

To enter the programming process, press “ENTER” and “UP”. It is structured also in pages as detailed below. Pressing ENTER advances to the following page without changing the value. “DOWN” selects the digit to be changed, which will be flashing. “UP” modifies the digit upwards.

Page No.	Upper display	Lower Display (Example)	Action
1	PASS	- - - -	Set password to the right value If not set, the instrument reverts to the measuring mode. Default value is 0010.
2	U Pr	00000400.0	Voltage in tenths of volt. Change, and press ENTER when OK
3	A Pr	000005000	Primary Current in Amps assuming a 5A secondary, e.g. for 100/1A, enter 500. Press ENTER when OK
4	EnEr	00001000	Energy value in Wh (100 or 1000). “
5	IdEn	0002	Identity. Change and press ENTER
6	Mode	000X	Output relays mode: 0, 1, and 2. Change, and press ENTER.
6’	OUTP (Mode=1)	00XX	X=1 activates the relay. Change and press ENTER.
6’’	Al0(Mode=2)	Variable + Value	Change Variable and press ENTER Change mode Max / Min and press ENTER Change value and press ENTER
7’’	Al1(Mode=2)	Variable + Value	“
8	Int	Value in seconds	Integration period. Change between 5 and 900 sec. Press ENTER.

9	3S/1S	3S1S, Value	Unbalanced (3S) or Balanced (1S) Change and press ENTER
10	RST CNT	RST, CNT, YES/NO	Reset all energy counters
11	PASS	xxxx	Passcode. Change value and press ENTER. Go back to 1.

A detailed flow chart is shown below.



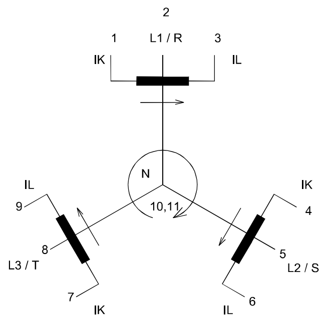
4.6.- ALARM DEFINITION.

Both alarms can be set to a level between 1 and 120% of the nominal value for V1, V2, V3, V12, V23, V31, I1, I2, I3, In, Ptotal, Qtotal, Stotal. The alarm triggering can be selected as low or high level.

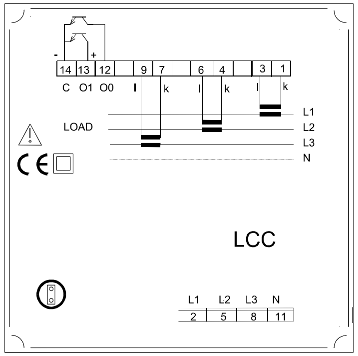
5.- CABLING.

5.1.- ELECTRICAL CONNECTIONS.

The instrument must be connected as per the standard drawing for electrical lines, as shown below.



The label on the reverse of the unit is shown in the following picture, and is self-explanatory.

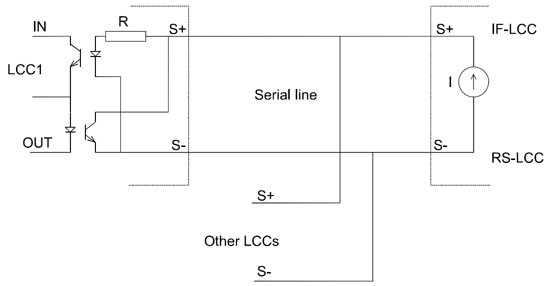


See connection diagrams in Annex 6.

5.2.- SERIAL LINE.

The serial communications line uses a two pin connector on the reverse side of the instrument.

The serial line is isolated from the rest of the electronic circuits by means of optocouplers. The basic diagram is shown in the figure.



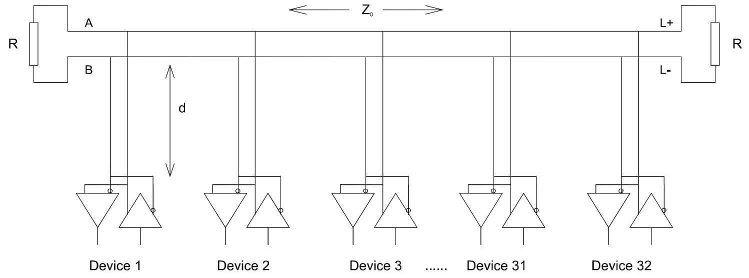
The LCC's, up to a maximum of 16 units, can be connected to the serial bus. This bus is supplied from a constant current source. At every LCC, the optocouplers provide both reception and transmission of the signal, using only two wires. The bus can be left floating, or connected to ground at any chosen point.

5.2.- SERIAL INTERFACES.

Two different units can be used, IF-LCC, and MC-LCC. The first one changes the signal levels from RS232 to current loop, and the second from RS485 to current loop. RS232 units can be selected for small number of LCCs, up to 16, as this is the maximum allowed to connect to the current loop. If there are more than 16, it is better to use a MC-LCC. The RS485 bus allows connection of up to 32 of these units. In this case, up to 256 LCCs could be connected, this limit imposed not for physical constraints, but for the logical MODBUS addressing limitations..

RS232 pins are named as per the computer being connected to. TD means data transmitted by the computer, and received by the IF-LCC.

RS485 connections are named L+ and L-. They must be connected to homologous terminals in the network, that is, the same wire goes to all terminals marked L+, and the other wire goes to all terminals marked L-. These terminals are marked as DATA A or DATA B in some RS485 converters. A schematic diagram is shown as a guide in the figure below.



RS485 TWO WIRE CONNECTION

If the transmission line length is more than a few hundred meters, termination resistors (typically 120 ohms) must be used. It is always better to terminate the line than leave it without resistors.

5.3.- DIGITAL OUTPUTS.

The two optocouplers provided have several operating modes, as shown in the table.

MODE	O0	O1
0	Reactive energy pulses	Active energy pulses
1	Output 0	Output 1
2	Alarm 0	Alarm 1

For mode 0, an energy pulse value must be defined. Each time this amount of active or reactive energy is consumed, a 150 ms pulse is sent through the related output.

For mode 1 there is no need to program anything. The status of each relay can be changed manually, - when in programming mode -, pressing the “UP” or “DOWN” keys, to check the external connections.

For alarms, the variable, mode, and level must be defined in the programming process. The level is expressed as the percentage of the variable nominal value, and can be any value from 1 to +120 %. The trip point is always positive, as the comparison is done on the figure only and not on the polarity.

The outputs have a common point. No protection devices have been included and the manufacturer's characteristics must be carefully respected. The user must provide any means of an external protective device.

6.- COMMUNICATION PROTOCOL.

The LCC's are provided with MODBUS protocol communication, type RTU. The IF-LCC or the MC-LCC interfaces must be used, as they are needed to convert the signal levels to those required by the LCC's. The communication is always started by the master and no spontaneous messages are allowed. The standard transmission rate is 9600 Bps, 8 bits, no parity, and one stop bit.

Each transaction consists of one request frame, generated by the master, and one reply frame, generated by the slave. In the case the master sends a writing command, the slave sends an acknowledge message. If any command is received in a correct way, it will be executed. If not, no answer will be generated.

Function codes accepted are:

03H	Read Holding Registers (3xxxx)
04H	Read Input Registers (4xxxx)
06H	Preset Single Register (6xxxx)
10H	Preset Multiple Registers

6.1.- FRAME DESCRIPTION.

6.1.1.- DATA POLLING (Commands 03h or 04H)

Each frame consists of:

- Identity number	one byte
- Command code	04H or 03H
- Data address	two bytes: H, L
- Number of registers to be read	two bytes: H, L
- CRC	two bytes: L, H

6.1.2.- WRITING COMMANDS.

Preset Single Register.

- Identity number	one byte
- Command code	06H
- Data address	two bytes: H, L
- Variable value	two bytes
- CRC	two bytes: L, H

Preset Multiple Registers

- Identity number	one byte
- Command code	10H
- Data address	two bytes: H, L
- Number of words to be written	two bytes: H, L
- Number of bytes to be written	one byte
- Variable value	four bytes
- .	.
- .	.
- Variable value	four bytes
- CRC	two bytes: L, H

6.1.3.- ANSWER FRAME

Each frame consists of:

- Identity	one byte
- Command code (the same as received)	04H
- Number of bytes sent	one byte
- Variable value	four bytes
- .	.
- .	.
- .	.
- Variable value	four bytes
- CRC	two bytes: L, H

6.1.4.- ACKNOWLEDGE FRAME.

It consists of:

- Identity	one byte
- Command code (the same as received)	10H
- Data address (the same as received)	two bytes: H, L
- Number of words written (the same as received)	two bytes: H, L
- CRC	two bytes: L, H

6.2. - ADDRESS MAP.

The addressing mode for the LCC is relative to the Base Address Register. This base register is situated at the top of the map in absolute address 0000H, and its content is BASE_ADD. The actual address for a variable is formed by summing the content of this position and the offset address stated in the following tables. For instance, the address for the Network ID, (offset value = 205), will be equal to [BASE_ADD] + 205. This applies not only to any variable to be read or written, but also to the BAS_REG itself. Then it can be accessed directly through the absolute address 0000, or using the same convention, through the [BASE_ADD] + 0000. Any value can be programmed for the BASE_ADD, from 0 to 61440D (0 to 0F000H). In this way, the map can be situated in any physical position, avoiding the problems found in the connection to some PLC's which are not able to address positions higher than 9999D.

There is a small difference between the LCC protocol and the standard MODBUS protocol, referring to the reading and writing commands accepted. In this version both 03H and 04H commands are valid for reading a value, and 06H and 10H commands are valid for writing. Command 06H can be used for writing 16 bit wide variables (WORD type), and command 10H can be used to write any single variable.

The addressing scheme totally fulfils the MODBUS requirements for length of registers. The MODBUS protocol considers each register as a 16 bit word. Then, the difference between two consecutive address numbers is two bytes. If the variable is four bytes long, the difference will be four bytes, or two digits.

The variables used in the LCC are explained as follows.

6.2.1.- CONFIGURATION VARIABLES.

OFFSET (DEC)	VARIABLE (NAME)	TYPE	R/W	USER	CODE	BLOCK R/W
0	BASE_REG	WORD	R/W	YES	NO	NO
1	ESCALAV	IEEE	R/W	YES	NO	NO
5	ESCALAI	IEEE	R/W	YES	NO	NO
9	REF_ENER	IEEE	R/W	YES	NO	NO
13	ESCALAP	IEEE	R	YES	NO	NO
15	VAL_AL0	IEEE	R/W	YES	NO	NO
17	VAL_AL1	IEEE	R/W	YES	NO	NO
200	SER_NUM	WORD(5)	R	YES	NO	NO
205	ID	WORD(1)	R/W	YES	NO	NO
206	TIPO	WORD(3)	R/W	YES	NO	NO
209	MODE_OUT	WORD	R/W	YES	NO	NO
210	OUTP	WORD	R/W	YES	NO	NO
211	TIP_PROT	WORD	R/W	YES	NO	NO
212	PERIOD_MD	WORD	R/W	YES	NO	NO
213	ALARM0	WORD	R/W	YES	NO	NO
214	ALARM1	WORD	R/W	YES	NO	NO
215	PASSWORD	WORD	R/W	YES	YES	NO
216	3S_1S	WORD	R/W	YES	NO	NO
930	RESET SW	WORD	W	YES	YES	NO
932	RST_MAXMIN	WORD	W	YES	YES	NO
582	RST_ MDEMAND	WORD	W	YES	YES	NO

ESCALAV: Means the primary nominal voltage value. If voltage transformers are not used, this value must equal the hardware nominal voltage.

ESCALAI: Means the primary nominal current value. If current transformers are not used, this value must equal the hardware nominal current, (i.e. 1A or 5A).

REF_ENER: Means the energy value to produce an energy pulse by the digital output. This value applies equally to the Active or Reactive energy. Its value can be any number, but it is recommended to use a multiple of ten, in relation with the power nominal value, in order not to generate a very high or very low pulse rate. (For instance, if the primary power was 200kW, a possible value for this variable could be 1kWh, which gives 200 pulses per hour. A value of 0.1 kWh gives a very high rate. A value of 10 kWh is also adequate).

VAL_ALx : Means the alarm value above which the digital output will switch. This value is expressed as a relative value to the associated variable, and can be any number between 1 and 120%.
CAUTION: If the alarm is used for cos, the setpoint value must be between 1 and 100%.

SERIAL NUMBER is a string of ten characters, specifying the number stored during manufacturing.

ID represents the identity number when the instrument is connected in a communication network. It is a binary number, and its value can be from 0 to 255. Identity 199 must be reserved, and cannot be used, as it is a generic address. This means that all devices will answer to this number, as if it was theirs. Special care must be taken when the meters are connected forming a network, as every write command will be understood by all of them.

TIPO stores the current SW version.

MODE_OUT indicates the optocouplers operating mode, as in table 5.3.

OUT_P indicates the relay status. It is a byte with the following content.

B7	B6	B5	B4	B3	B2	B1	B0
0	0	0	0	0	0	OUTPUT 1	OUTPUT 0

Writing 1 activates the relevant output.

TIP_PROT: This is a one bit variable where =1 means MODBUS and =0, means JBUS.
The difference is only in the order in which floating point format data are sent. In mode JBUS, data is sent as

S+EXP Mantissa H Mantissa M Mantissa L

In mode MODBUS, data is sent as

Mantissa M Mantissa L S+EXP Mantissa H

PERIOD_MD selects the max. demand period, in seconds.

ALARM0 and ALARM1 are two bytes long. Their content is as follows.

B15	B14	B13	B12	B11	B10	B9	B8
MAX/ MIN	STATUS	-		APP POWER	REACT. POWER	ACTIVE POWER	I3
B7	B6	B5	B4	B3	B2	B1	B0
I2	I1	V31	V23	V12	V3	V2	V1

Writing a 0 in RST_SW restarts the unit in the same way as an OFF-ON switching.

To start the maximum/minimum process, a 0 must be written in RST_MAXMIN. The moment this command is received, the maximum and minimum values are set at the actual values, and the process begins.

To start the maximum demand period, a 0 must be written in RST_MDMAND. The calculation period is then closed, the value is stored if needed, and the process begins again.

6.2.2.- READING VARIABLES.

These variables can be read at any moment. Their meanings are self explanatory. The variable SEQUENCE when =0, indicates the correct connection of the three phase voltages. Any value different from zero indicates an incorrect sequence. The sequence test is done only after a reset, and is intended as an aid to installation.

OFFSET (DEC)	VARIABLE (NAME)	TYPE	R/W	USER	CODE	BLOCK R/W
120	VFR	IEEE	R	YES	NO	YES
122	VFS	IEEE	R	YES	NO	YES
124	VFT	IEEE	R	YES	NO	YES
126	VRS	IEEE	R	YES	NO	YES
128	VST	IEEE	R	YES	NO	YES
130	VTR	IEEE	R	YES	NO	YES
132	PFR	IEEE	R	YES	NO	YES
134	PFS	IEEE	R	YES	NO	YES
136	PFT	IEEE	R	YES	NO	YES
138	QFR	IEEE	R	YES	NO	YES
140	QFS	IEEE	R	YES	NO	YES
142	QFT	IEEE	R	YES	NO	YES
144	IFR	IEEE	R	YES	NO	YES
146	IFS	IEEE	R	YES	NO	YES
148	IFT	IEEE	R	YES	NO	YES
150	SFR	IEEE	R	YES	NO	YES
152	SFS	IEEE	R	YES	NO	YES
154	SFT	IEEE	R	YES	NO	YES
156	COSR	IEEE	R	YES	NO	YES
158	COSS	IEEE	R	YES	NO	YES
160	COST	IEEE	R	YES	NO	YES
162	PRST	IEEE	R	YES	NO	YES
164	QRST	IEEE	R	YES	NO	YES
166	SRST	IEEE	R	YES	NO	YES
168	COS	IEEE	R	YES	NO	YES
170	FREQ	IEEE	R	YES	NO	YES
172	In	IEEE	R	YES	NO	YES

6.2.3.- ENERGY COUNTERS.

OFFSET (DEC)	VARIABLE (NAME)	TYPE	R/W	USER	CODE	BLOCK R/W
302	ACT_POS	LONG	R/W	YES	NO	NO
304	ACT_NEG	LONG	R/W	YES	NO	NO
306	REACT_POS	LONG	R/W	YES	NO	NO
308	REACT_NEG	LONG	R/W	YES	NO	NO

6.2.4.- Max-Min Values.

OFFSET (DEC)	VARIABLE (NAME)	TYPE	R/W	USER	CODE	BLOCK R/W
19	V1_MAX	IEEE	R	YES	NO	YES
21	V2_MAX	IEEE	R	YES	NO	YES
23	V3_MAX	IEEE	R	YES	NO	YES
25	V12_MAX	IEEE	R	YES	NO	YES
27	V23_MAX	IEEE	R	YES	NO	YES
29	V31_MAX	IEEE	R	YES	NO	YES
31	I1_MAX	IEEE	R	YES	NO	YES
33	I2_MAX	IEEE	R	YES	NO	YES
35	I3_MAX	IEEE	R	YES	NO	YES
37	In_MAX	IEEE	R	YES	NO	YES
39	P_MAX	IEEE	R	YES	NO	YES
41	Q_MAX	IEEE	R	YES	NO	YES
43	S_MAX	IEEE	R	YES	NO	YES
45	V1_MIN	IEEE	R	YES	NO	YES
47	V2_MIN	IEEE	R	YES	NO	YES
49	V3_MIN	IEEE	R	YES	NO	YES
51	V12_MIN	IEEE	R	YES	NO	YES
53	V23_MIN	IEEE	R	YES	NO	YES
55	V31_MIN	IEEE	R	YES	NO	YES

6.2.6.- Max Demand Values.

OFFSET (DEC)	VARIABLE (NAME)	TYPE	R/W	USER	CODE	BLOCK R/W
560	PTOT_PEAK	IEEE	R	YES	NO	YES
562	QTOT_PEAK	IEEE	R	YES	NO	YES
564	STOT_PEAK	IEEE	R	YES	NO	YES
566	I1_PEAK	IEEE	R	YES	NO	YES
568	I2_PEAK	IEEE	R	YES	NO	YES
570	I3_PEAK	IEEE	R	YES	NO	YES

Writing 0 in any of the peak registers, resets all six registers.

6.3. - COMMANDS.

6.3.1.- READING COMMANDS.

Any reading command consists of

ID---Command type---Address---Number of words---CRCL---CRCH

ID is the identity number. Command type's accepted are 03H or 04H. Address corresponds to the summation of Base Reg. content plus the offset. Number of words is the number of registers to be read, and has a two byte length. If only one byte is needed, the number of words written is 1. Every data value is accessible by a specific command to its respective address. However, the habitual reading values can be accessed by means of block commands, with the following limitations:
The values read must be all the same type, i.e. IEEE variables, or binary variables.
The total reading command must not exceed 12 variables.

In the following examples it is assumed the Base Reg. content is 1000D (3E8H), and the protocol is MODBUS ("Big-endian" mode).

6.3.2.- EXAMPLES OF READING COMMANDS.

Serial number reading.

Q.:	01H	04H	04H	0B0H	00H	05H	30H	0DEH		
	ID	CMD	ADDRESS		No. WORDS		CRCL	CRCH		
A.:	01H	04H	0AH		53H	41H	43H	49H	31H	30H
	ID	CMD	NºBYTES		S	A	C	I	1	0
	31H	32H	35H	41H	0BEH	0F7H				
	1	2	5	A	CRCL	CRCH				

Nominal Voltage. (ESCALAV)

Q.:	01H	04H	03H	0E9H	00H	02H	0A0H	07BH		
	ID	CMD	ADDRESS		No.WORDS		CRCL	CRCH		
A.:	01H	04H	04H		0	0	43H	0C8H	0CBH	22H
	ID	CMD	No.BYTES		------------- 400 V -------				CRCL	CRCH

Multiple reading

Q.:	01H	04H	04H	60H	00H	18H	0E0H	48H
	ID	CMD	ADDRESS		NO.WORDS		CRCL	CRCH
A.:	01H	04H	30H		5H	0H	43H	5EH
	ID	CMD	N.BY		----------- Vfr=222 V ---------			
	2BH	0H	43H	5EH	0AH	0H	43H	5EH
	----------Vfs=222,2 V ----				----------Vft=222 V -------------			
	55H	0H	43H	0C0H	57H	0H	43H	0C0H
	----------- Vrs= 384,7-------				---------Vst=384,7----------------			
	47H	0H	43H	0C0H	0BEH	0H	44H	31H
	-----------Vtr= 384,6---------				----------Pfr= 710,9 --------------			
	0AAH	0H	44H	31H	9BH	0H	44H	31H
	------------Pfs= 710,6 -------				----------Pft= 710,4 --------------			
	0ABH	0H	0C2H	86H	68H	0H	0C2H	89H
	--------- Qfr= - 67,3 ----------				---------Qfs= -68,7 --------------			
	2H	0H	0C2H	80H	13H	0EEH		
	----------Qft= -64,0 --------				CRCL	CRCH		

6.4.- DATA FORMATS.

The following data formats are used in the data transmission from the LCC.

ASCII: As characters, for serial number, etc. They are sent in the order specified.

BYTE: Eight bits. For status or control parameters. They are sent as words.

WORD: Two bytes. They are sent as MSB-LSB.

LONG: Four bytes. They are sent as MSB-___-___-LSB. (See annex 3).

IEEE: Four bytes. They are sent as S+EXP-Mh-Mm-ML. (See annex 3).

7.- RELATED SOFTWARE.

LCDA V 1.05 is available. It allows the user to configure the device and to read all the measurements taken.

8. - SAFETY REQUIREMENTS.

The following safety precautions must be observed at all times during operation, installation, service or repair. Failure to comply with these precautions, or with any other warning indications stated in this manual, violates the intended safety standards of design, manufacture and use of the product. The manufacturer does not assume any liability in the case that these precautions are not followed.

8. 1. - Do not connect or disconnect the device to or from any live voltage. Do not install the equipment in field installations unless another person is present.

8.2. - Do not use the device in an explosive atmosphere, or in wet or damp areas.

8.3. - Do not open the equipment. In the case of repair, follow the service instructions, and do not substitute any part or modify the circuits.

8.4. - Do not operate the equipment if the front panel is broken, as electrical isolation can be void.

8.5. - The units are not provided with any type of protection device to the voltage or current circuits. An external switch or circuit breaker must be provided in the installation, close to the unit. The general protective device must have a rating of less than 10 Amps.

8.6. - Do not disconnect the current inputs without first shorting the associated current transformers, as dangerous high voltages can be produced.

8.7. - The user must also be aware that the current transformer secondary terminals can be at live voltages if the neutral wire is disconnected, or during installation.

ANNEX 1. CRC ALGORITHM TYPE "CRC16".

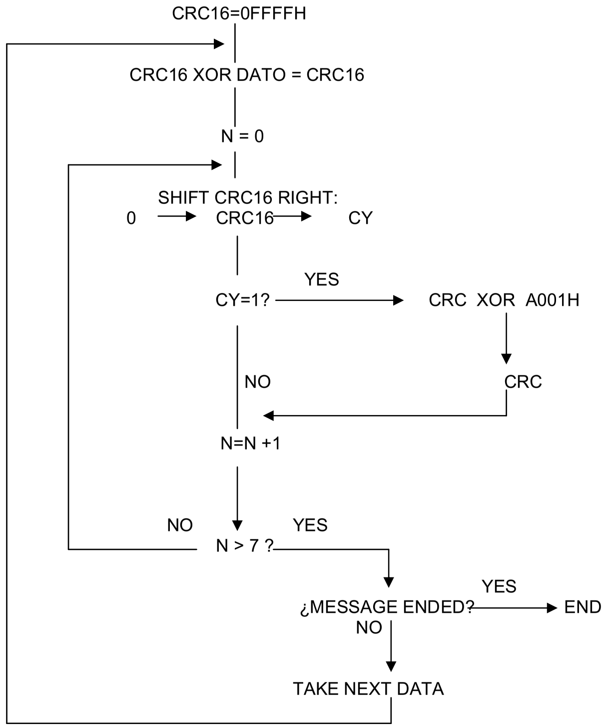
1. - GENERATOR POLYNOMIAL.
El polynomial used is:
$X^{16} + X^{15} + X^{2} + 1 = 18005H$

To get the CRC, this polynomial must be inverted, omitting the least significant bit.

CRC16 POLYNOMIAL: 1 1000 0000 0000 0101 = 18005H

WORKING POLYNOMIAL : 1010 0000 0000 0001 = A001H.

2. - ALGORITHM.



"DATA" is the byte received/or to be transmitted.
"CRC16" is a 16 bit word. The result is left in CRC16. If the received CRC characters are included in the algorithm, the final result will be zero.

ANNEX 2. IEEE NOTATION USED. (IEEE 754).

Notation IEEE754 is followed in floating point numbers. As extremely high precision is not required, the mantissa least significant byte is always zero. This could produce some disagreements between for instance, the value written and read for a high number, as 220,000 V, which can be read as 219,987.

BYTE1	BYTE2	BYTE3	BYTE4
SIGN+	MANTISSA	MANTISSA	MANTISSA
EXPONENT	HIGH	MEDIUM	LOW

SIGN: sign of the number.
0H means a positive number.
1H means a negative number.

```
MANTISSA:  FRACTION  0, XXX XXXX  XXXX  XXXX  XXXX  XXXX
                        |                             |
                        M1                           M23
```

EXPONENT: Number exponent, with offset 127.
0: 127. (7FH)
1: 128. (80H)
-1: 126. (7EH)

To find the value:

$$\text{VALUE: } (-1)^{S} * 2^{EXP-127} * (1+\text{FRACTION})$$

$$\text{FRACTION: } \sum_{i=1}^{i=23} 2^{-i} * M(i)$$

THE BYTE CONFIGURATION IS AS FOLLOW:

```
  BYTE1:
   7    6    5     4     3     2     1     0
 SIGN  -------    EXPONENT      ----------
        E7   E6    E5    E4    E3    E2    E1

  BYTE2:
   7     6     5     4     3     2      1      0
 EXP ---------  MANTISSA HIGH     --------
  E0    M1    M2    M3    M4    M5    M6   M7

  BYTE3:
   7     6     5     4     3     2      1      0
-------------- MANTISSA MIDDLE -------
  M8    M9    M10    M11  M12   M13   M14  M15

   BYTE4: (Always null).
    7    6     5     4     3     2      1      0
   -------------- MANTISSA LOW         --------
   M16  M17  M18  M19  M20  M21  M22    M23
```

ANNEX 3. IEEE FLOATING POINT AND LONG INTEGERS DATA TRANSMISSION FORMAT.

IEEE data are sent in the following order:

1. SIGN + EXPONENT BYTE
2. HIGH MANTISSA
3. MEDIUM MANTISSA
4. LOW MANTISSA (ALWAYS ZERO)

This mode of transmission is referred as JBUS mode.

In certain applications, data is required in the following order:

1. MEDIUM MANTISSA
2. LOW MANTISSA (ALWAYS ZERO)
3. SIGN + EXPONENT BYTE
4. HIGH MANTISSA

This mode of transmission is referred as MODBUS mode.

Both formats are supported in the LCC protocol. The standard way is the JBUS mode.

This is applicable also to the long integer format. They are sent as MSB, msb, LSB, lsb in JBUS mode, and as LSB, lsb, MSB, msb in MODBUS mode.

To select the protocol type, the one byte variable, named TIPO_PROT, must be used.
00H select the JBUS mode
01H selects the MODBUS mode

ANNEX 4. CRC CALCULATION.

Example of CRC calculation in BASIC

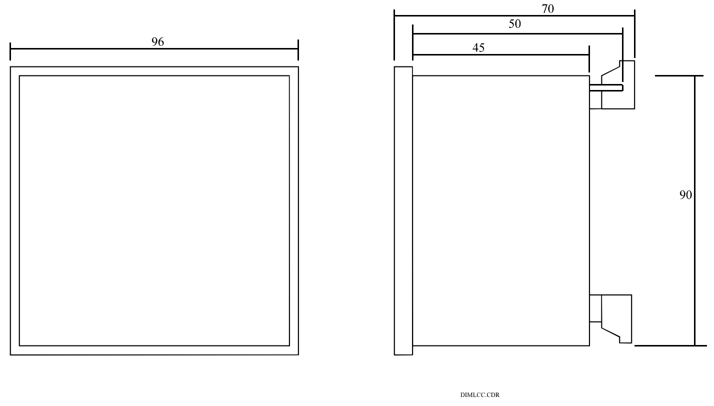
```
function crc16 (txt, lon) AS INTEGER
        DIM flag AS LONG
        DIM crc AS LONG
        DIM car AS INTEGER
        DIM bit AS INTEGER
        CRC= &HFFFF&
        FOR car =1 TO LON
                crc = crc XOR ASC(MID$ ( txt, car, 1))
                FOR bit = 0 TO 7
                        flag = crc AND 1&
                        crc = crc\ 2&
                        IF flag = 1 THEN
                                crc= crc XOR &HA001&
                END IF
        NEXT bit
        NEXT car
        crc16 = INT (crc AND &HFFFF&)
END FUNCTION
```

En C:

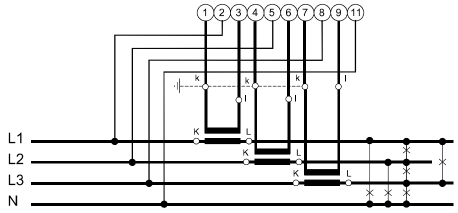
```
        Void Saci_CalculoCRC ( unsigned char *Mensaje, int NumeroDeElementos)
{
        long flag, crcx;
        int car,bit;
        unsigned char v1,v2;
        crcx= 0xffff;
        for (car=0; car < NumeroDeElementos; car++)
        {
                crcx = crcx ^ Mensaje[car];
                for (bit=0; bit <8; bit++)
                {
                        flag= crcx & 1
                        crcx = crcx >>1 ;
                        if ( flag== 1 ) { crcx = crcx ^ 0xa001; }
                }
        }
        crcx= crcx & 0xffff;
        v1 = ( unsigned char)  abs (crcx / 256 );
        v2 = ( unsigned char ) crcx – (v1*256);
        Mensaje [NumeroDeElementos] = v2;
        Mensaje [NumeroDeElementos+1] = v1;
```

To check the message, calculate the CRC, including the CRC bytes received. If the result is zero, the message has been correctly received.

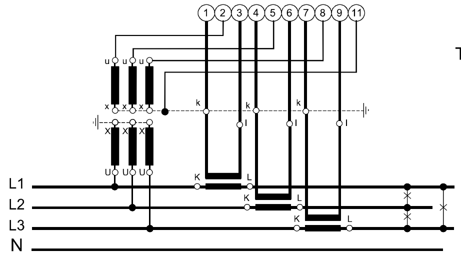
ANNEX 5. DIMENSIONS.



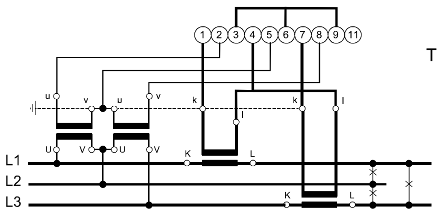
ANNEX 6. CONNECTION DIAGRAMS.



THREE PHASE, UNBALANCED
FOUR WIRES
(THREE SYSTEMS)



THREE PHASE, UNBALANCED
THREE OR FOUR WIRES
(STAR CONNECTION)



THREE PHASE, UNBALANCED
THREE WIRES

Note: Voltage transformers are shown only for MV and HV applications.

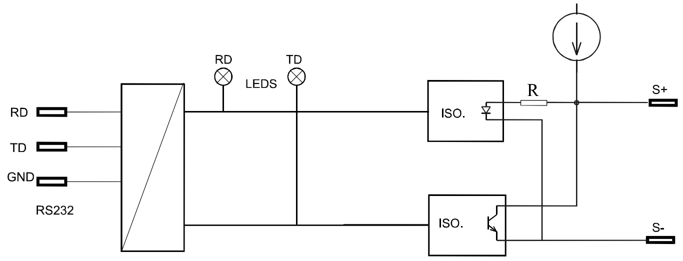
esqlca3l.cdr

ANNEX 7. COMMUNICATION MODULES.

In order to be able to communicate, the LCC's need a special communication module.

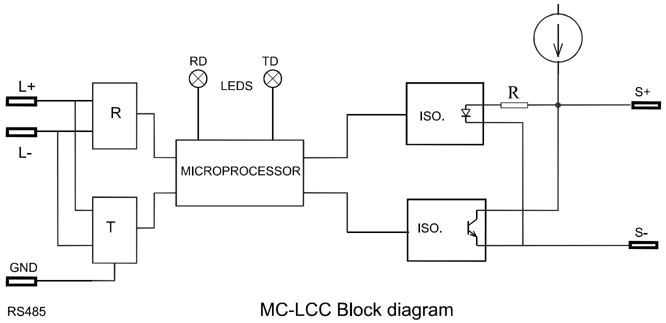
IF-LCC: Changes from RS232 to current loop.
MC-LCC: Changes from RS485 to current loop.

A simplified block diagram is shown below.



IF-LCC Block diagram

The IF-LCC interface is totally transparent to the protocol. Each character received is sent to the current loop line, and the same in the opposite direction. As the receiver from the current line is always connected, when a character is sent to this side it is also received by the RD pin in the RS232 line. The master must then eliminate this echo, as if not, the sent command could be considered as an answer.



MC-LCC Block diagram

The MC-LCC interface, however, is able to eliminate the echo which is produced in the current loop line. The master must not worry about any back characters but just the answer itself.