USER MANUAL LQT40M

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The LQT40M is a programmable multi transducer for power systems. All electrical quantities for AC current and voltage (True RMS) are covered by one single unit. It can measure single phase systems up to 4-wire unbalanced load systems. Serial communication with Modbus TCP.

Our free transducer configuration software "ConfigLQT" is used to easily program the LQT40M via its USB-port.

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1 Instructions

1.1 Purpose of this document

This document describes how to use the LQT40M multi transducer. The user manual is intended to be used by:

• installation personnel and commissioning engineers

• service and maintenance personnel

• planners

1.2 Intended use

The transducer is intended to measure electrical quantities, 1 to 3-phases (alternating voltage and currents). The measured electrical quantities are then available via different serial interface, depending of versions.

1.3 Mounting

	The transducer shall be installed into a protecting cabinet on a 35 mm top hat rail (DIN rail) according IEC 60715. The enclosure shall not be accessible without tools.

1.4 Installation and maintenance

The installation, operation and maintenance shall only be made by qualified electrical engineering personnel and in accordance with applicable regulations. Before the installation, please check that the transducer is the correct type and complies with the installation needs.

1.4.1 Safety notes

	Attention: Danger to life! Ensure that all leads are free of potential when connection them!
	AUX-supply need to have an external circuit breaker and it must be installed and located easily reached close to the device. The OFF-position shall be clearly marked.
	Voltage measurements (U_{L1}, U_{L2}, U_{L3}) inputs must have circuit breaker or fuses rated 10 Amps or less.
	No fuses should be used on the currents inputs (I_{L1}, I_{L2}, I_{L3}). The current measuring circuits from the current transformers must be short-circuited before disconnection.

1.5 Operation

The transducer is intended for operation at an altitude not exceeding 2000 m and in an environment that is not considered as wet location.

Operation temperature: -10…22…24…+55°C

Proper function is only guaranteed if the USB is not connected to the transducer and all the instructions in this manual are followed for safety reasons.

If the equipment is used in a manner not specified by this instruction, the protection provided by the equipment may be impaired.

1.6 Safety

All inputs and outputs are galvanically isolated from each other.

Protection class:	II, protective insulation, voltage inputs via protective impedance.
Communication interfaces:	Only connect the communication interfaces of the device to circuits with extra-low voltage (max. 30VAC, 42.4V peak, 60VDC). Only connect the communication interfaces of the device to circuits which provide double or reinforced insulation to mains or other hazardous voltages.
Protection:	IP40 (housing), IP20 (terminals)

1.7 Warning!

	Connection must comply with current regulations for systems with rated voltage up to 1000 V. Before switching on or off and if the housing is removed, all voltages to the equipment must be switched off and external currents circuit shorted before disconnected.

1.8 Maintenance

The transducer requires no maintenance. Any repairs shall be performed by trained personnel, or the equipment shall be returned to the supplier for repair.

Wipe the device using a clean, dry and soft cloth if necessary. Do not use solvents.

1.9 Symbols

Warning for life-threatening or hazardous for properties situations.
Indicates situations where careful reading of this manual is required to avoid potential HAZARD situations.

Caution, possibility of electric shock

Read the manual before use

The device must be discarded in a professional way

CE conformity mark

1.10 FCC Part 15 information

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that

interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

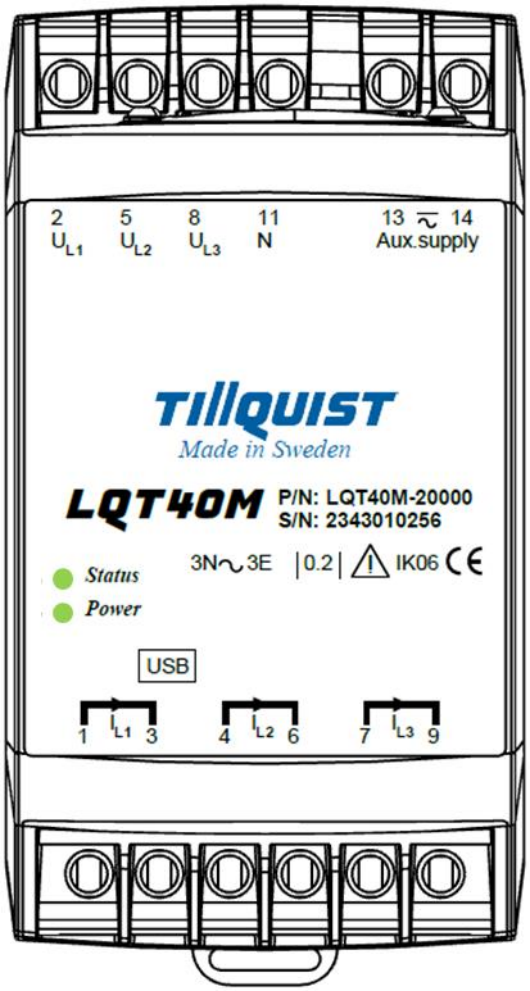
1.11 Disclaimer of liability

The content of this document has been reviewed to ensure correctness. Nevertheless it may contain errors or inconsistencies and we cannot guarantee completeness and correctness. This is especially true for different language versions of this document. This document is regularly reviewed and updated. Necessary corrections will be included in subsequent version and are available via our webpage http://www.tillquist.com.

2 Connections

2.1 Connection diagram

Voltage input		
U_{L1}	2	
U_{L2}	5	
U_{L3}	8	
N	11	
Current input	In	Out
I_{L1}	1	3
I_{L2}	4	6
I_{L3}	7	9
Aux Power Supply		
	13	
	14	



2.2 Electric connection

The plug-in terminals needs to be removed before accessing the input terminals.

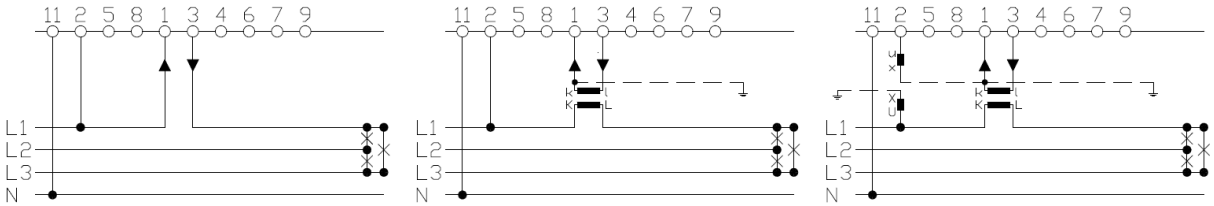
Inputs L1, L2, L3, N, I1, I2, I3, Aux.supply	
Wire section:	6.0 mm² / 10 AWG solid and stranded copper
Clamp opening size:	3.2 × 3.9 mm
Wire stripping:	max 9 mm
Recommended torque:	0.8 - 0.88 Nm / 7.2 - 7.9 in.lbs

2.3 Connection diagrams – System connection

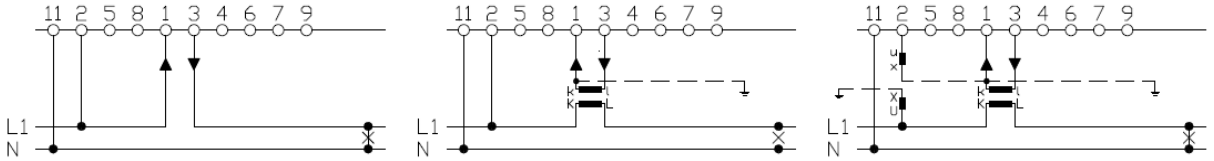
LQT40M system connection is programmable from single phase to 4-wire balanced or unbalanced connection.

Configurable System Connection											
System connection	**Application**	**I1**	**I2**	**I3**	**U1**	**U2**	**U3**	**N**	**U12**	**U23**	**U31**
-00	4wire, 3 phase symmetric load	X	-	-	X	-	-	X	-	-	-
-01	1-wire, 1 phase	X	-	-	X	-	-	X	-	-	-
-02	3-wire, 3 phase symmetric load	X	-	-	-	-	-	-	X	-	-
-03	3-wire, 3 phase symmetric load	X	-	-	-	-	-	-	-	X	-
-04	3-wire, 3 phase symmetric load	X	-	-	-	-	-	-	-	-	X
-05	3-wire, 3 phase symmetric load	X	-	-	X	X	X	-	X	X	X
-09	3-wire, 3 phase asymmetric load	X	-	X	X	X	X	-	X	X	X
-11	4-wire, 3 phase asymmetric load	X	X	X	X	X	X	X	X	X	X
-11	4-wire, 3 phase asymmetric load Open Delta	X	X	X	X	X	X	-	X	X	X

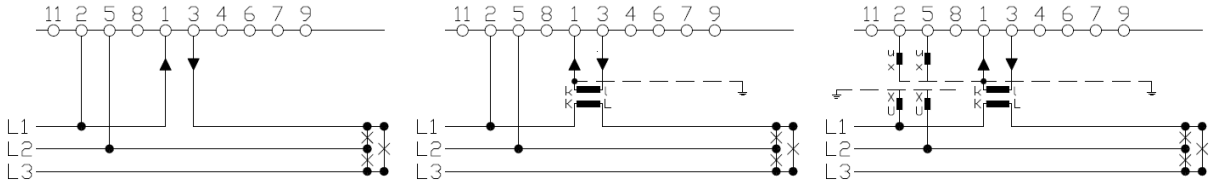
-00 1-phase 4-wire
1 element 3-phase symmetric load



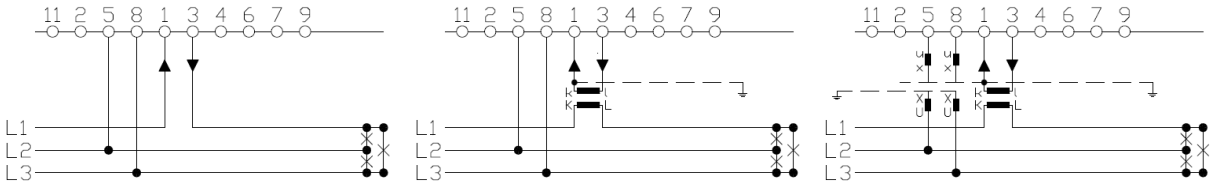
-01 1-phase 2-wire
1 element Single-phase AC



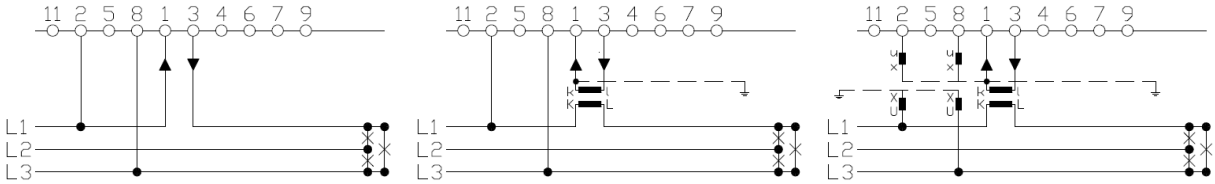
-02 1-phase 3-wire
1 element 3-phase symmetric load phase-shift U12-I1



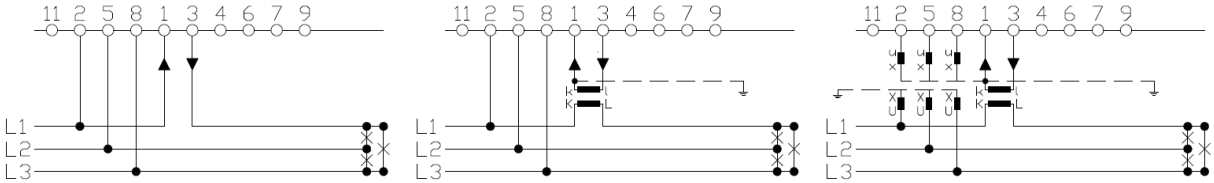
-03 1-phase 3-wire
1 element 3-phase symmetric load phase-shift U23-I1



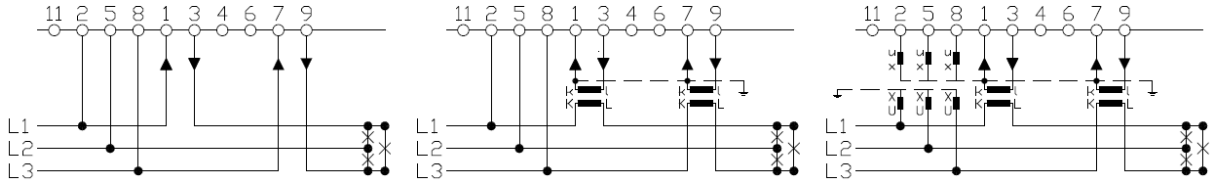
-04 1-phase 3-wire
1 element 3-phase symmetric load phase-shift U31-I1



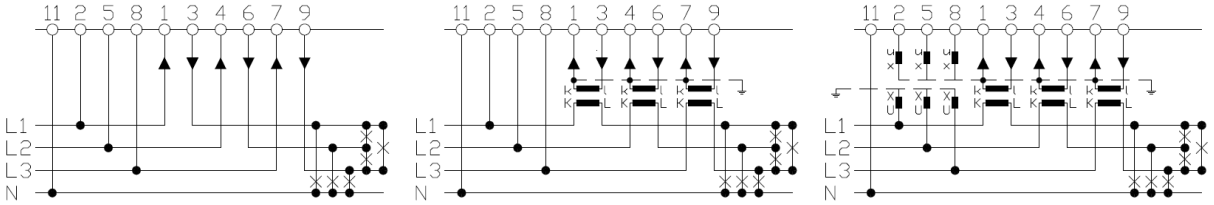
-05	3-phase 1 element	3-wire 3-phase symmetrical load



-09	3-phase 2 elements	3-wire 3-phase asymmetrical load



-11	3-phase 3 elements	4-wire 3-phase asymmetrical load



3 Measuring

3.1 Measured quantities

Prefix	Quantity	Calculation	System / Phase
I	Input current	(I1+I2+I3)/3	System
I1	Phase current L1		L1
I2	Phase current L2		L2
I3	Phase current L3		L3
U	Input voltage	(U1+U2+U3)/3	System
U1	L1 Phase voltage		L1
U2	L2 Phase voltage		L2
U3	L3 Phase voltage		L3
P	Active power	P1+P2+P3	System
P1	Active power L1		L1
P2	Active power L2		L2
P3	Active power L3		L3
Q	Reactive power	Q1+Q2+Q3	System
Q1	Reactive power L1		L1
Q2	Reactive power L2		L2
Q3	Reactive power L3		L3
S	Apparent power	S1+S2+S3	System
S1	Apparent power L1		L1
S2	Apparent power L2		L2
S3	Apparent power L3		L3
U12	Main voltageL1-L2		L1 - L2
U23	Main voltage L2-L3		L2 - L3
U31	Main voltage L3-L1		L3 - L1
PF	Active power factor	P/S	System
PF1	Active power factor	COS(φ1)=P1/S1	L1
PF2	Active power factor	COS(φ2)=P2/S2	L2
PF3	Active power factor	COS(φ3)=P3/S3	L3
QF	Reactive power factor	Q/S	System
QF1	Reactive power factor	SIN(φ1)=Q1/S1	L1
QF2	Reactive power factor	SIN(φ2)=Q2/S2	L2
QF3	Reactive power factor	SIN(φ3)=Q3/S3	L3
LF	LF factor	sign(Q)*(1-|PF|)	System
LF1	LF factor	sign(Q1)*(1-|PF1|)	L1
LF2	LF factor	sign(Q2)*(1-|PF2|)	L2
LF3	LF factor	sign(Q3)*(1-|PF3|)	L3
PA	Phase angel	PA=(PA1+PA2+PA3)/3	System
PA1	Phase angel	φ1=ARCCOS(P1/S1)/PI*180*sign(P1)	L1
PA2	Phase angel	φ2=ARCCOS(P2/S2)/PI*180*sign(P2)	L2
PA3	Phase angel	φ3=ARCCOS(P3/S3)/PI*180*sign(P3)	L3
IS	Input current with sign	(IS1+IS2+IS3)/3	System
IS1	Phase current with sign	I1*sign(P1)	L1
IS2	Phase current with sign	I2*sign(P2)	L2
IS3	Phase current with sign	I3*sign(P3)	L3
P_I1_U12	Active power, System connection-02		System
P_I1_U23	Active power, System connection -03		System
P_I1_U31	Active power, System connection -04		System
Q_I1_U12	Reactive power, System connection -02		System
Q_I1_U23	Active power, System connection -03		System
Q_I1_U31	Active power, System connection -04		System
F	Frequency		System

3.2 Meassuring system

3.2.1 Phase-Locked loop - PLL

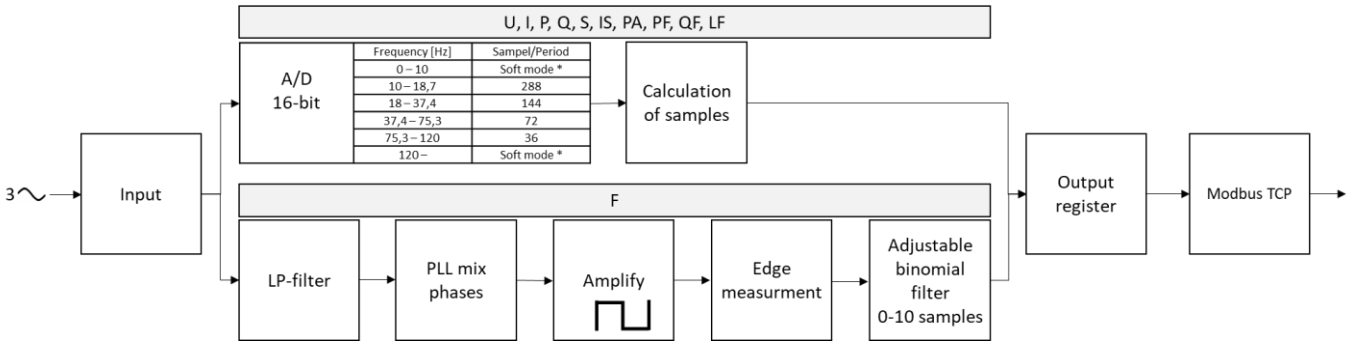
The measuring system use a phase-locked loop (PLL) between 10-120 Hz. All quantities are being measured. The number of samples per period is deppending of the frequency.

3.2.2 Soft mode

A fixed sample rate of 1800 samples/second (soft mode) is used when the frequency is lower than 10 Hz or higher than 120 Hz. Measured quantities in soft mode are voltage (U), current (I) and frequency (F).

3.2.3 Block diagram

Schematic block diagram of measure process.



* *Soft mode = 1800 samples / second*

3.2.4 Frequency filter

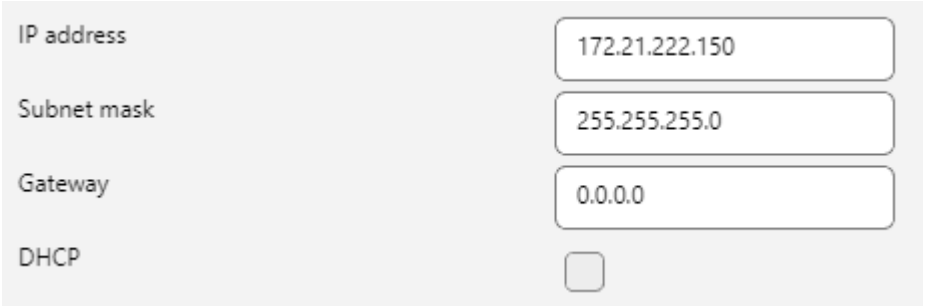
The frequency measurement is low-pass filtered with a binomial filter. This setting determines the length of the filter in periods of the measured frequency. A shorter length gives a more responsive measurement. A longer length gives a slower, more stable measurement.
Frequency filter is adjustable between 0 – 10.

4 Output – Modbus TCP

LQT40M has a Modbus TCP output for serial communication. Three different set of ”Process Data Set Mapping”” are availble.

4.1 Ethernet configuration

Ethernet parameters are set in ConfigLQT v3.



4.2 Process Data Set Mapping

A: Basic

Parameters						
Parameter	**Range**		**Bus value**	**Type**	**Byte**	**Note**
Bus Inc Num	-	-	0-65535	Unsigned Word	1-2	-
Data Inc Num	-	-	0-65535	Unsigned Word	3-4	-
I_RMS	0-12	A	0-65535	Unsigned Word	5-6	(I1+I2+I3)/3
U_RMS	0-300	V	0-65535	Unsigned Word	7-8	(U1+U2+U3)/3
P_RMS	±10800	W	±10800000	Signed Double Word	9-12	P=P1+P2+P3
Q_RMS	±10800	var	±10800000	Signed Double Word	13-16	Q=Q1+Q2+Q3
F	0-300	Hz	0-65535	Unsigned Word	17-18	-
				Bus Increment Number increase with every new message. *Data Increment Number* increase with every new measured		

B: Bassic + High Resolution F

Parameters						
Parameter	**Range**		**Bus value**	**Type**	**Byte**	**Note**
Bus Inc Num	-	-	0-65535	Unsigned Word	1-2	-
Data Inc Num	-	-	0-65535	Unsigned Word	3-4	-
I_RMS	0-12	A	0-65535	Unsigned Word	5-6	(I1+I2+I3)/3
U_RMS	0-300	V	0-65535	Unsigned Word	7-8	(U1+U2+U3)/3
P_RMS	±10800	W	±10800000	Signed Double Word	9-12	P=P1+P2+P3
Q_RMS	±10800	var	±10800000	Signed Double Word	13-16	Q=Q1+Q2+Q3
F	0-300	Hz	0-65535	Unsigned Word	17-18	-
F_HIRES	0-300	Hz	0-300000	Unsigned Double Word	19-22	-
				Bus Increment Number increase with every new message. *Data Increment Number* increase with every new measured		

C: Extended

Parameters							Data Set
Parameter	**Range**		**Bus value**	**Type**	**Byte**	**Note**	**C**
Bus Inc Num	-	-	0-65535	Unsigned Word	1-2	-	X
Data Inc Num	-	-	0-65535	Unsigned Word	3-4	-	X
I_RMS	0-12	A	0-12000	Unsigned Double Word	5-8	(I1+I2+I3)/3	X
U_RMS	0-300	V	0-300000	Unsigned Double Word	9-12	(U1+U2+U3)/3	X
P_RMS	±10800	W	±10800000	Signed Double Word	13-16	P=P1+P2+P3	X
Q_RMS	±10800	var	±10800000	Signed Double Word	17-20	Q=Q1+Q2+Q3	X
F	0-300	Hz	0-300000	Unsigned Double Word	21-24	-	X
I1	0-12	A	0-12000	Unsigned Double Word	25-28	-	X
I2	0-12	A	0-12000	Unsigned Double Word	29-32	-	X
I3	0-12	A	0-12000	Unsigned Double Word	33-36	-	X
U1	0-300	V	0-300000	Unsigned Double Word	37-40	-	X
U2	0-300	V	0-300000	Unsigned Double Word	41-44	-	X
U3	0-300	V	0-300000	Unsigned Double Word	45-48	-	X
U12	0-520	V	0-520000	Unsigned Double Word	49-52	-	X
U23	0-520	V	0-520000	Unsigned Double Word	53-56	-	X
U31	0-520	V	0-520000	Unsigned Double Word	57-60	-	X
P1	±3600	W	±3600000	Signed Double Word	61-64	-	X
P2	±3600	W	±3600000	Signed Double Word	65-68	-	X
P3	±3600	W	±3600000	Signed Double Word	69-72	-	X
Q1	±3600	var	±3600000	Signed Double Word	73-76	-	X
Q2	±3600	var	±3600000	Signed Double Word	77-80	-	X
Q3	±3600	var	±3600000	Signed Double Word	81-84	-	X
LF	±1		±1000	Signed Double Word	85-88	-	X
PA	±180	°	±180000	Signed Double Word	89-92	-	X
C: Extended				*Bus Increment Number increase with every new message.* *Data Increment Number* increase with every new measured			

D: Full map

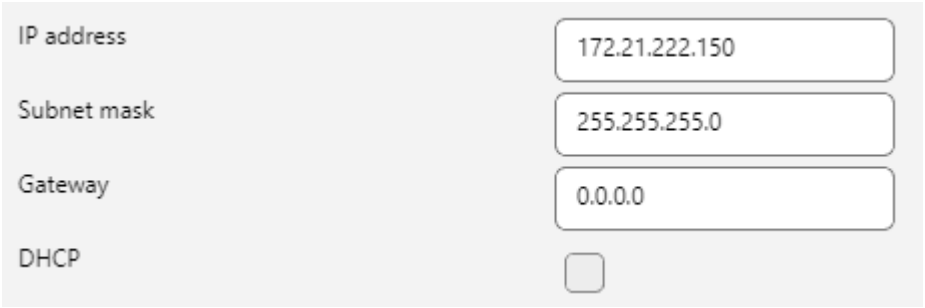
adr	format	parameter			explanation	
0	binary32	F	Hz	Frequency	system	
2	binary32	I	A	Input current	system	I = (I1+I2+I3)/3
4	binary32	I1	A	Phase current	L1	
6	binary32	I2	A	Phase current	L2	
8	binary32	I3	A	Phase current	L3	
10	binary32	U	V	Input voltage	system	U = (U1+U2+U3)/3
12	binary32	U1	V	Phase voltage	L1-N	
14	binary32	U2	V	Phase voltage	L2-N	
16	binary32	U3	V	Phase voltage	L3-N	
18	binary32	U12	V	Main voltage	L1-L2	
20	binary32	U23	V	Main voltage	L2-L3	
22	binary32	U31	V	Main voltage	L3-L1	
24	binary32	P	W	Active power	system	P = P1+P2+P3
26	binary32	P1	W	Active power	L1	
28	binary32	P2	W	Active power	L2	
30	binary32	P3	W	Active power	L3	
32	binary32	Q	var	Reactive power	system	Q = Q1+Q2+Q3
34	binary32	Q1	var	Reactive power	L1	
36	binary32	Q2	var	Reactive power	L2	
38	binary32	Q3	var	Reactive power	L3	
40	binary32	S	VA	Apparent power	system	S = S1+S2+S3
42	binary32	S1	VA	Apparent power	L1	S1 = U1*I1
44	binary32	S2	VA	Apparent power	L2	S1 = U1*I2
46	binary32	S3	VA	Apparent power	L3	S1 = U1*I3
48	binary32	LF	-	LF factor	system	LF = sign(Q)*(1-|PF|)
50	binary32	LF1	-	LF factor	L1	LF1 = sign(Q1)*(1-|PF1|)
52	binary32	LF2	-	LF factor	L2	LF2 = sign(Q2)*(1-|PF2|)
54	binary32	LF3	-	LF factor	L3	LF3 = sign(Q3)*(1-|PF3|)
56	binary32	PF	-	Active power factor	system	PF = P/S = COS(ϕ) = COS(PA)
58	binary32	PF1	-	Active power factor	L1	PF1 = P1/S1 = COS(ϕ1) = COS(PA1)
60	binary32	PF2	-	Active power factor	L2	PF2 = P2/S2 = COS(ϕ2) = COS(PA2)
62	binary32	PF3	-	Active power factor	L3	PF3 = P3/S3 = COS(ϕ3) = COS(PA3)
64	binary32	QF	-	Reactive power factor	system	QF = Q/S = SIN(ϕ) = SIN(PA)
66	binary32	QF1	-	Reactive power factor	L1	QF1 = Q1/S1 = SIN(ϕ1) = SIN(PA1)
68	binary32	QF2	-	Reactive power factor	L2	QF2 = Q2/S2 = SIN(ϕ2) = SIN(PA2)
70	binary32	QF3	-	Reactive power factor	L3	QF3 = Q3/S3 = SIN(ϕ3) = SIN(PA3)
72	binary32	PA	°el	Phase angle ϕ	system	PA=(PA1+PA2+PA3)/3
74	binary32	PA1	°el	Phase angle ϕ1	L1	PA1 = ARCCOS(P1/S1)/PI*180*sign(P1)
76	binary32	PA2	°el	Phase angle ϕ2	L2	PA1 = ARCCOS(P2/S2)/PI*180*sign(P2)
78	binary32	PA3	°el	Phase angle ϕ3	L3	PA1 = ARCCOS(P3/S3)/PI*180*sign(P3)
80	binary32	IS	A	Input current with sign	system	IS = (IS1+IS2+IS3)/3
82	binary32	IS1	A	Phase current with sign	L1	IS1 = I1*sign(P1)
84	binary32	IS2	A	Phase current with sign	L2	IS2 = I2*sign(P2)
86	binary32	IS3	A	Phase current with sign	L3	IS3 = I3*sign(P3)
88	binary32	CTR	A/A	primary to secondary current transformer ratio (i.e. 600A/1A)		
90	binary32	PTR	V/V	primary to secondary potential (voltage) transformer ratio (i.e. 220kV/110V)		

The data format used is IEEE 754 single-precision binary floating-point format: binary32. Parmeters are represented as two consecutive Modbus registers. The value of a parameter is represented in SI unit as secondary values on transducer input. To calculate primary values, use the primary to

secondary transformer ratio of parameter CTR, PTR. The CTR and PTR parameter can be configured by the user by editing primary to secondary current- and voltage-ratio in ConfigLQT.

4.3 Ethernet settings for Modbus TCP

Ethernet parameters are set in ConfigLQT v3.



5 Commissioning

5.1 Programming of the transducer

”ConfigLQT” is a free configuration software, it is availible for download from Tillquist homepage, www.tillquist.com. The software connects to the transducer and make it possible to change the configuration of adjustable parameters and to visualize live readings.

ConfigLQT supports offline configuration of adjustable parameters.

Save and load configuration file.

Functionality of ConfigLQT

ConfigLQT allows the user to:

- See online readings of measured values
- Adjust the functionality of the outputs
- Save parameter settings to a file
- Load parameter settings from a file
- Print settings report
- Upgrade firmware

5.2 USB configuration interface

The USB interface serves for configuration and commissioning of the transducer. It is not intended for measurement processing during normal operation!

5.3 LED functionality

LQT40M have two LEDs at front, *Power* and *Status*.

State	Power	Status
Start-up	Flashing - On 1 sec / Off 0.5 sec	Flashing - On 1 sec / Off 0.5 sec
Normal operation	On	Flashing - On 200 ms / Off 200 ms
Error	Flashing - On 100 ms / Off 100 ms	Off

6 Technical Data

	Technical Data	Details
Input	Voltage range (Un)	100 – 400 V (L-L) main voltage (nominal)
	Measuring range	1 – 520 V_{L-L} TRMS 50/60 Hz or 16⅔ Hz CAT III 1 - 300 V_{L-N} TRMS 50/60 Hz or 16⅔ Hz CAT III
	Frequency	50/60 Hz (10…40….70…120 Hz) 16⅔ Hz (10…15….18…120 Hz)
	Overload voltage	1.5 x Un – continuously, 2 x Un – 10 s
	Consumption	≤U² / 1.32 MΩ
	Impedance	1.32 MΩ per phase
	Current (In)	1 – 5 A
	Measuring range	5 mA – 10 A TRMS
	Overload current	2 x In continuously, 10 x In 15 s, 40 x In 1 s
	Consumption	<0.05 VA / phase
	Auxiliary power supply	24 – 230 VDC / 90 – 230 VAC 50/60 Hz ±10 %
	Burden	max 7.1 W / 15 VA
Output	Serial communication	Modbus TCP
General Data	Accuracy class	0.2 (Ref. temp. 23 °C)
	Galvanic isolation	Supply, in- and output are galvanically isolated
	Connection terminals / Torque	Input and Auxiliary power supply: 6 mm^2 / 0.8 Nm Output: 2.5 mm^2 / 0.5 Nm
	Humidity	95 % non-condensing
	USB	USB Micro-B, port for configuration
	Temperature	-10…+55 °C (operation) -40…+70 °C (storage) Temperature coefficient < 0.1 % / 10 °C
	Test voltage	4 kV AC /1 min
	Measurement category	Cat. III
	Overvoltage category	Cat. III
	Pollution degree	2
	Dimension (W x H x D)	70 x 132 x 101 mm
	Weight	330 gr
	Protection	IP40 (housing), IK07
	Flammability class	UL94 V-0
	Standards	SS-EN 60688 Transducers SS-EN 61010-1 Safety IEC 61010-2-030 EN 61000-6-2 / -6-4 / -6-5

**Depending on the version*

7 Ordering Codes

	LQT40M-	X	X	XXX
Communication				
Modbus TCP		2		
Frequency				
50/60 Hz			0	
16⅔ Hz			1	
Other Requirements				
Standard configuration				000
Customer configuration (to provide ERF)				001
High precision with Frequency Test Certificate				201

LQT40M-20000	LQT40M Modbus TCP 50/60 Hz
LQT40M-20001	LQT40M Modbus TCP 50/60 Hz with ERF and Test Protocol
LQT40M-21000	LQT40M Modbus TCP 16⅔ Hz
LQT40M-20201	LQT40M Modbus TCP 50 Hz with Frequency Test Protocol