

# TDL104 Manual

**Power Analyzer, Data logger**

[www.mashhadtabir.com](http://www.mashhadtabir.com)

## 1- Features

TDL104 the recording device of electrical parameters for power systems is designed for measurement and recording RMS voltage, RMS current, power factor, active and reactive power, RMS voltage, voltage and current THD, total active and reactive power specifications, frequency, Null current, asymmetry voltage, 3 phase average voltage and current and environmental temperature.

The active and reactive power is calculated by the area under voltage and current curves. Null current is the sum of 3 current vectors. Asymmetry voltage is the sum of 3 voltages considering the constant angle. The calculation of voltages and currents are True RMS and Power Factor is gained by dividing each phases power (P) to apparent power (S).

Total Harmonic Distortion (THD) for each input voltage and current is the result of calculating the 2<sup>nd</sup> to ninth harmonic and is calculated for each input.

ADE7758, the Analog Devices energy metering IC, directly measures voltages, currents, active, reactive and apparent phase powers, offset calibration and gain of these parameters.

The record period is 1 min to 1 hour which is adjustable. The Data Logger is able to record instantaneous and average maximum and minimum value of every parameter mentioning the time and date, also daily maximum and minimum values are stored in the memory by date. The period for maximeter average is adjustable between 1 min to 1 hour.

The counter of TDL104 uses ADE7758 energy metering IC and contains four tariffs, which the fourth tariff is for holidays. The counter can also work with 3, 2 and 1 tariffs and is able to record positive and negative, active and reactive energies separately.

The output relay can be operated by any change in the defined parameters or a compound of them. TDL104 calibration works for voltage, current,

active, reactive and apparent power, power factor of each phase and the environmental temperature, and is based on software and also would be stored in the internal memory.

The PT and CT factors are always selectable by the software and the current inputs are protected by isolation.

Supply Voltage	80-500 VAC , 80-300 VDC
Input voltage range (Phase)	0-300 V
Input current range	0-5 A
Temperature	-10 to 60 °C
Dimensions	100 x 100 x 56 mm
Weight	470 gr

The tolerance of voltage and current inputs are 1.2 times more than the nominal value for long term and respectively 1 KV and 10 times more than the nominal current for less than 1 sec.

## 2- Front Panel

### 2-1 Key Guide

#### 2-1-1 ESC key:

For exiting the main menu and canceling the previous function.

#### 2-1-2 OK key:

For confirming the setting and entering different menus.



### 2-1-3 UP, DOWN keys:

For going up and down and choosing different lines in the menus, also selecting YES for confirming or NO for canceling.

### 2-2 Display:

The display is a 128x64 graphical LCD.

### 2-3 USB PORT:

A USB flash can be used for transferring the stored data on TDL104 to the computer. The USB port is designed in the front of TDL104.

## 3- Back Panel

### 3-1 Supply Inputs (V+, V-)

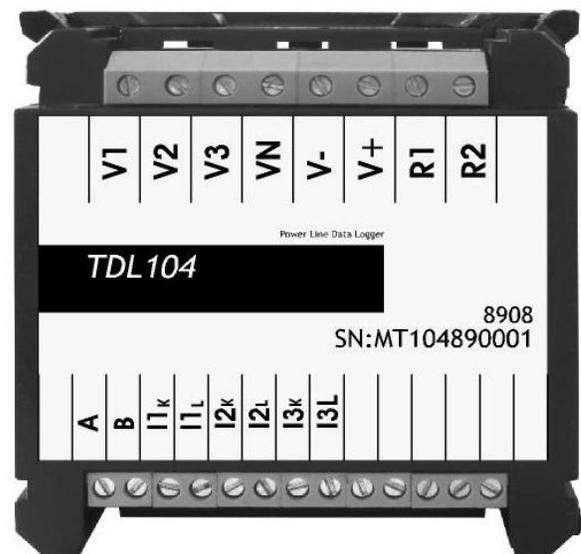
The supply voltage is 80-500 VAC or 80-300 VDC which is connected via the supply terminals.

### 3-2 Voltage and Null Inputs

Four inputs, V1, V2, V3 are connected directly or through one of the diagrams in section 4 to the power line. Maximum 300 volt for each phase can be connected to these inputs.

### 3-3 Current Inputs:

Six terminals are shown in the image as current inputs. These inputs are connected to different types of CTs with 5 A outputs. The connections are in 3 pairs respectively I1, I2, I3. The CTs output should be connected to the appropriate input on TDL104. The nominal current for each input is 5 A.

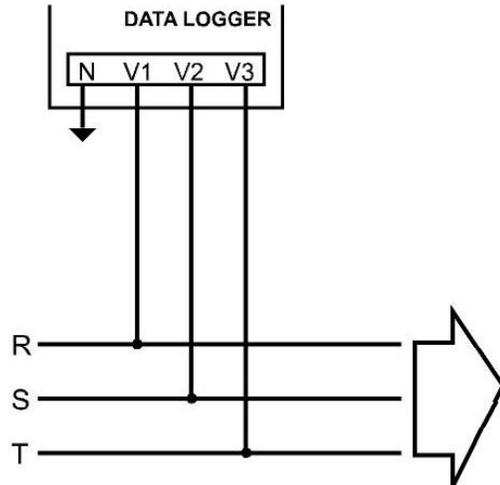


### 3-4 RS485 PORT

It is two terminals shown in the image as A and B. For connection method and network capabilities.

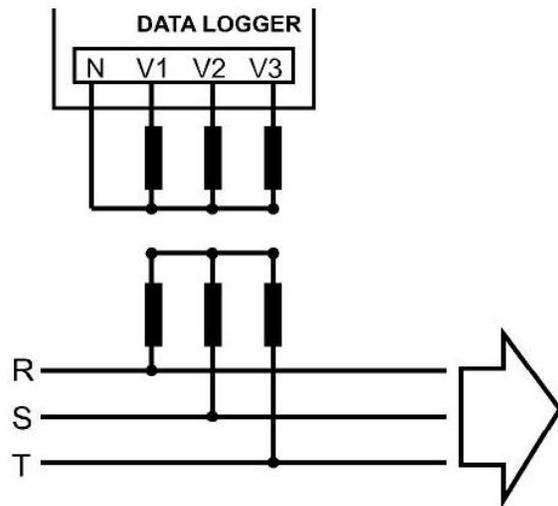
## 4- Wiring Diagram

### 4-1 Voltages direct connection:

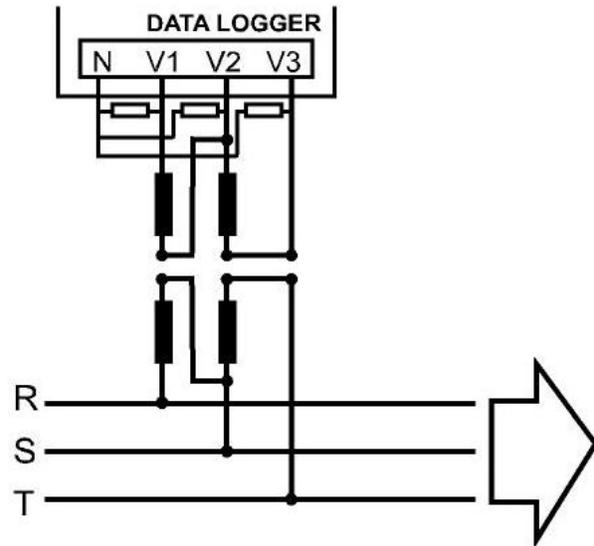


### 4-2 Three voltage transformer (PT) connection:

Star-star connection:

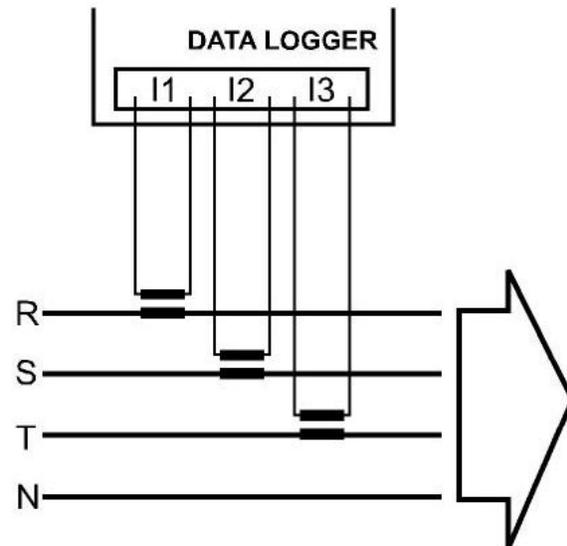


#### 4-3 Two voltage transformer (PT) connection:



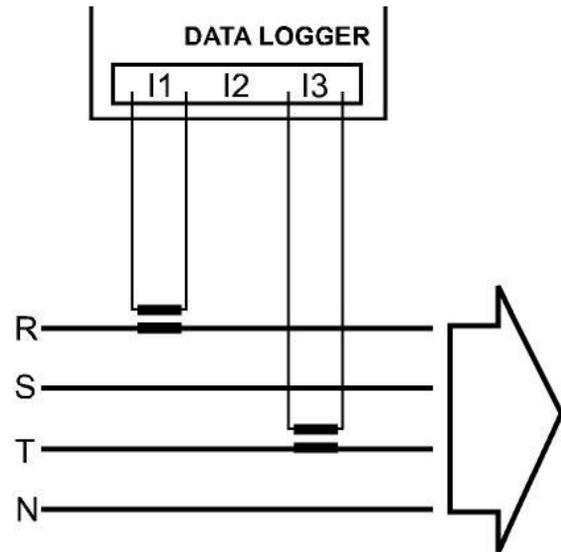
#### 4-4 Three current transformer (CT) connection:

$I_n$  is calculated.

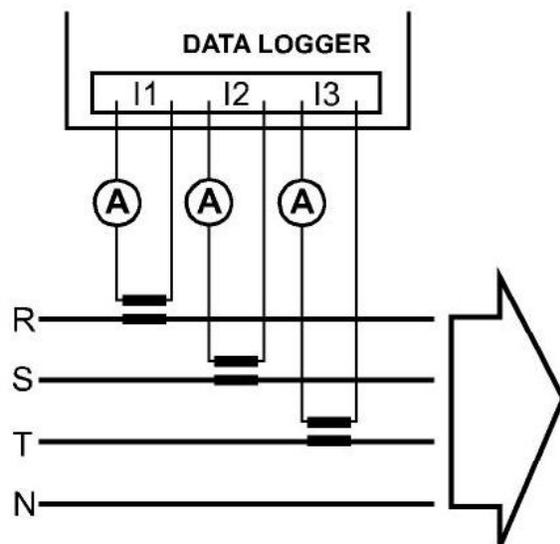


#### 4-5 Two current transformer (CT) connection:

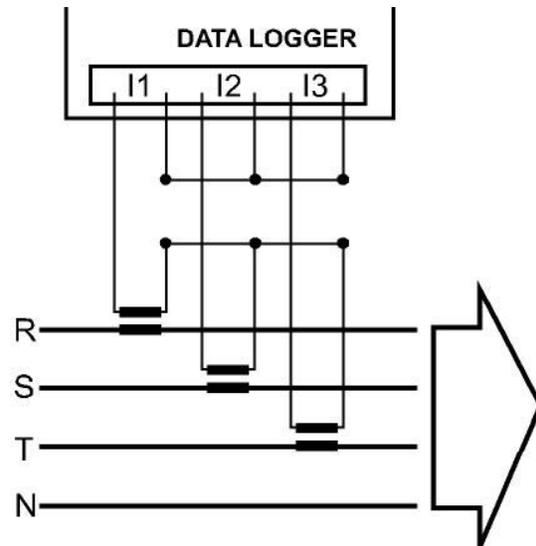
$I_2$  is calculated.



#### 4-6 Connecting TDL104 and the current input of another metering device to the CTs output.

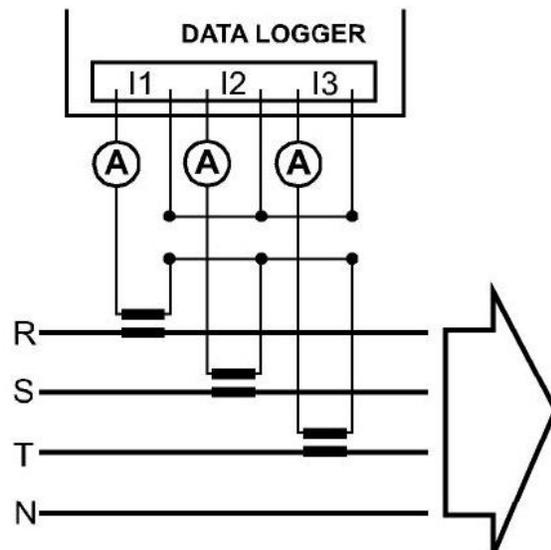


#### 4-7 Connecting to the output of star connection CTs



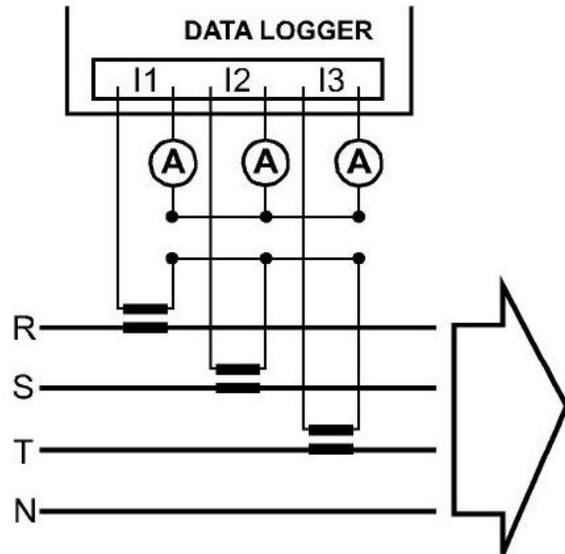
#### 4-8 Connecting TDL104 and the current input of another metering device to the CTs output:

In this method, the CTs are in star connection and the other metering device is not previously connected.



#### 4-9 Connecting TDL104 and the current input of another metering device to the CTs output:

In this method, the CTs are in star connection and the other metering device is connected beforehand.



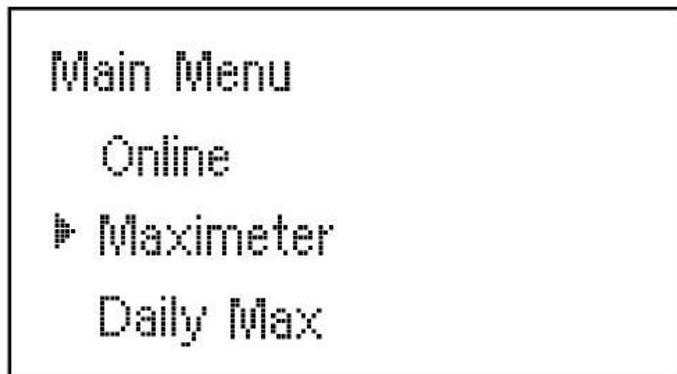
### 5- TDL104 Menus and Operation:

#### 5-1 Reset

At power up, first the tests related to setup, time, counter and records are performed. These tests take about 3 seconds.

#### 5-2 Main Menu

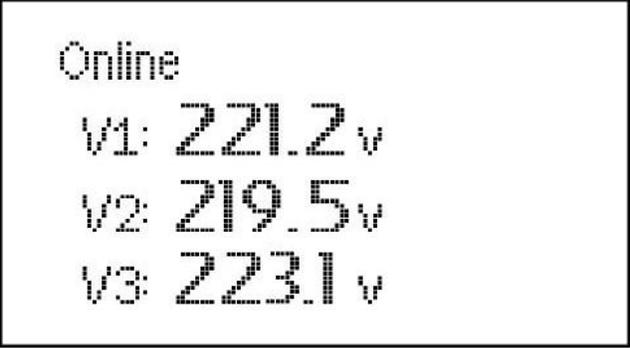
After power up, the main menu is displayed. Using UP and DOWN keys, different options are shown and can be chosen by OK key. The online menu is used to display measured parameters. In the maximeter menu, maximeter information is displayed.



Daily max is the menu which shows the daily maximeter information. In the record menu, stored records are displayed. In the counter menu, the consumed active and reactive, positive and negative energy can be seen in one of the quadruplet tariffs. Any OFF and then ON occurrence in power supply or one of the input voltages is shown in the Event menu. It should be mentioned that if no value is stored in the maximeter, record or Event Recorder menu, they cannot be opened. The Sys Info menu is for displaying time, date and serial number, and system configurations can be done in Setup menu.

### 5-3 Online:

Measured currents, phase and line voltages, active, reactive and apparent power, 3 phase power factor, voltage and current THDs, Null current and asymmetry voltage, average voltage and current, total active, reactive and apparent power, frequency and



```
Online
V1: 221.2 v
V2: 219.5 v
V3: 223.1 v
```

environmental temperature are displayed in this menu. To enter this menu, setup should be chosen from the main menu by pressing OK key. Different pages of parameters could be displayed by pressing UP and DOWN keys. The pages are respectively, phase voltages, line voltage, currents, active 3 phase powers, reactive 3 phase powers, apparent 3 phase powers, 3 phase power factors, 3 phase voltage THDs, 3 phase current THDs, total active, reactive and apparent powers, average and asymmetry voltages, average and Null currents, frequency and environmental temperature.

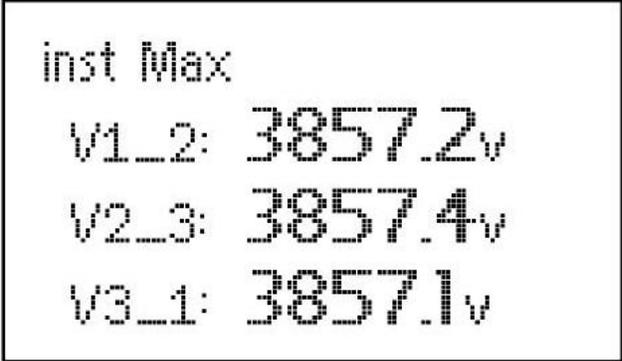
### 5-4 Rotating online menu

10 minutes after pressing the last key, if any of the Main, Online, Maximeter, Daily Max, Record, Counter and Event menus were open, online menu would be displayed and every 10 seconds one of the 3 phase

voltages, currents, 3 phase power factors, total active, reactive and apparent power of the main menu is displayed rotating.

### 5-5 Maximeter:

In TDL104 both instant and average minimum and maximum of all parameters are recorded in one time interval. OK key should be pressed on the Maximeter option in the main menu to enter Maximeter menu. If any data is available in the Maximeter, this menu will



```
inst Max
V1_2: 3857.2v
V2_3: 3857.4v
V3_1: 3857.1v
```

be opened. The first line represents four different types, Instant Max, Instant Min, Average Max and Average Min which recorded data on each one of these types can be seen and the pages are changed by UP and DOWN keys. The displayed record doesn't contain date and time but after transferring them to the computer date and time is available in the file. Although the instant maximeter operates for all measured values, it is saved in the flash at the same time as the average maximeter, so for recording an instant maximum or minimum, the record period of average maximeter should be passed. Exit this menu is possible by ESC key.

#### 5-5-1 Inst Max

Shows the instant value of Max. Each time TDL104 measures the parameters each parameter bigger than the instant Max stored in the temporary memory will replace the instant Max, including time and date. When the time comes to record the Average Maximeter in the temporary memory, the data stored in the temporary memory is compared with the data stored in the flash and will be replaced if needed.

### 5-5-1 Inst Min

It shows the instant value of Min. Each time TDL104 measures the parameters each parameter less than the instant Min stored in the temporary memory will replace the instant Min, including time and date. When the time comes to record the Average Maximeter in the temporary memory, the data stored in the temporary memory is compared with the data stored in the flash and will be replaced if needed.

### 5-5-3 Average Max

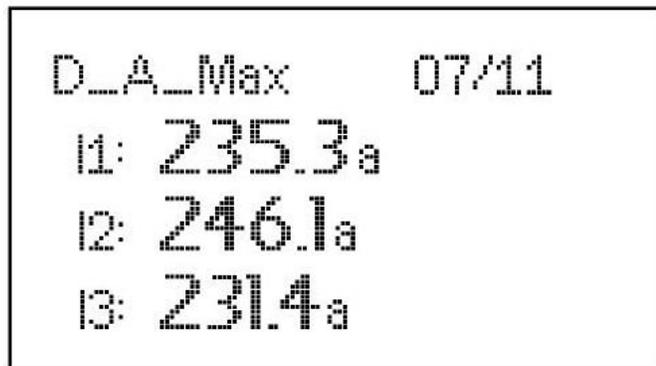
The average of measured parameters are calculated in a time interval (between 1 and 60 minutes, could be set in Max period menu of Setup menu), if any of the average values are bigger than the average Max parameter, it will be replaced in the flash, including time and date.

### 5-5-3 Average Min

The average of measured parameters are calculated in a time interval (between 1 and 60 minutes, could be set in Max period menu of the Setup menu), if any of the average values are less than the average Min parameter, it will be replaced in the flash including time and date.

### 5-6 Daily Max

In TDL104 in addition to Maximeter which works absolutely, regardless of the date, the instant maximum and minimum and average parameters are recorded, these values are also stored daily.

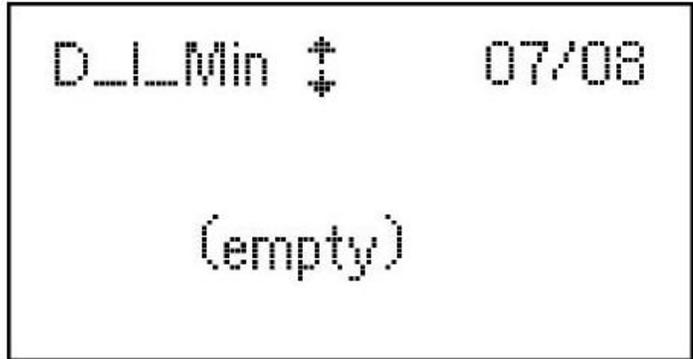


```
D_A_Max    07/11
1: 235.3a
12: 246.1a
13: 231.4a
```

In this state, the function of TDL104 is exactly the same as absolute maximeter (5-5) except that in the regarding menu, maximum values are displayed in order of their production date. For entering the daily Maximeter menu, Daily Max should be selected in the main menu.

According to the first line which displays four different values, Inst Max, Inst Min, Average Max and Average Min, the recorded value in each group could be displayed in the desired date. Different pages of this menu can be reviewed using UP and DOWN keys. If in a specific day, no data is saved in maximeter, it will be announced as Empty.

To view the Maximeter in different days, first put the menu in day select mode using the OK key. In this situation  $\updownarrow$  will be shown in front of the date. Using UP and DOWN keys, different days can be selected. Fast moving on the dates is possible by keeping UP or DOWN keys pressed.

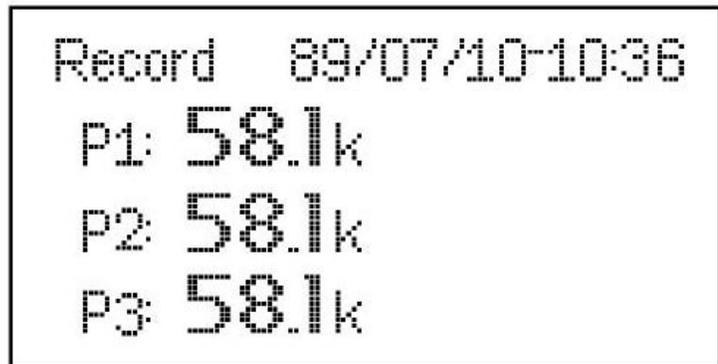


### 5-7 Record Parameters

In TDL104, the average of all measurable parameters are calculated in a time interval (between 1 and 60 minutes, could be set in Record Period menu of the main menu) and at the end of the period – which the system is checked considering the averaging time and the time – will be saved in the flash. 18000 records could be stored in TDL104, and when the memory is full, each time 3 records are deleted from the memory and the new records will replace them.

#### 5-7-1 Viewing Records:

Record should be selected from the Main Menu to view the stored records on TDL104. In this menu, phase voltages, line voltages, phase currents, 3 phase active power, 3

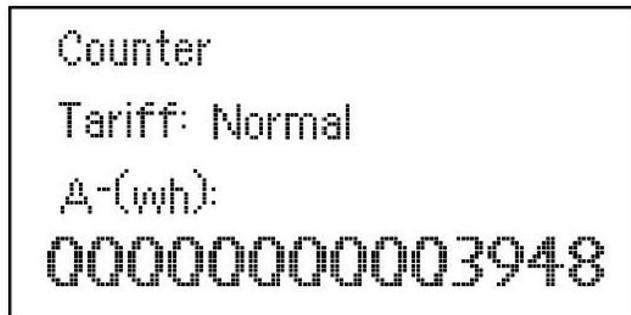


phase reactive power, 3 phase apparent power, 3 phase power factors, 3

phase voltage THDs, 3 phase current THDs, total active, reactive and apparent power, average voltage, asymmetry voltage, average and Null current, frequency and environmental temperature of the desired record can be seen. Date and time of the record is in the first line of each page. Different pages showing recorded parameters in a record can be selected using UP and DOWN keys. To view other stored records, first put the menu in select viewable record state by pressing OK key.  $\updownarrow$  will be displayed in front of date, and the viewable record can be selected by UP and DOWN keys. Fast moving on the Records is possible by keeping UP or DOWN keys pressed. To exit record menu, ESC key is used. Each time while entering Record menu, the first page of records contain phase voltages information of the last record and this menu cannot be accessed if no record is stored.

#### **5-8 Four tariff counter:**

The counter option should be selected from the Main Menu to see the consumed energy. This menu is arranged in 16 pages while each page represents one counter in all four Peak,



```
Counter
Tariff: Normal
A-(wh):
000000000003948
```

Normal, Low and Day Off tariffs and is operated separately for positive and negative, active and reactive energies. In each page, tariff, Energy polarity, Energy type and unit – active 'A' or reactive 'R' – is specified. Tariff times for Peak, Normal and Low are set in tariff menu of setup. Also the weekly holiday can be set in the '4<sup>th</sup> Tariff' menu of setup. Annually holidays are set by computer and stored in setup. Measured energy in different counters can be viewed using UP and DOWN keys.

#### **5-9 Event Recorder**

All parameters are recorded including date and time as an Event if one of the following situations happen: The supply voltage goes Off and then On, or the same happens to one of the phases, 10% decrease in the voltage

compared to the last 3 seconds or 10% increase in the voltage after a decrease event. TDL104 has the capacity of 500 Events, and when the memory is full, it will be replaced starting from the beginning.

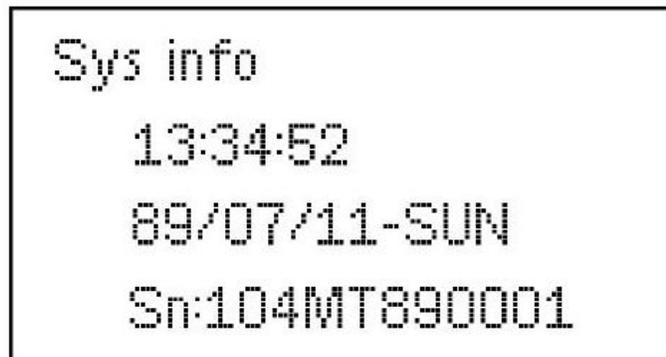
### 5-9-1 View the Events

To view the recorded events, the Event should be chosen from the Main Menu. In this menu, each Events specification containing Event description and the occurrence time and date are displayed. Different Events can be viewed using UP and DOWN keys. Fast moving on the Events is possible by keeping UP or DOWN keys pressed. It should be mentioned that Event.TXT file which contains complete Event records information is created while transferring data. Date, time, Event description and measured parameters of the Event occurrence time is included in each line of this file.

**Note:** Voltage decrease Event, is shown as OFF in TDL104 but in Event.TXT file is shown by *sag* sign. Also normal voltage increase in shown as ON in TDL104 and as *sag(P)* in the file.

### 5-10 Sys Info

Sys Info in the Main Menu shows time, date and serial number. Time and date is set in the Setup menu. The serial number of TDL104 is a unique code with 104MTyyaaaa format (yy is the production year) and



```
Sys info
13:34:52
89/07/11-SUN
Sn:104MT890001
```

based on this code, there is an ID card in Mashhad Tadbir company. Test procedures and any customer services are recorded. The serial number is a software specification and is not changeable; exit from this menu is possible by ESC key.

### 5-11 Setup

In the setup menu, date, time, type and the quantity of CTs, PT ratio, calibration, relay function, recording state, record period, maximeter period, tariff hours, weekend, 4<sup>th</sup> tariff and its status,

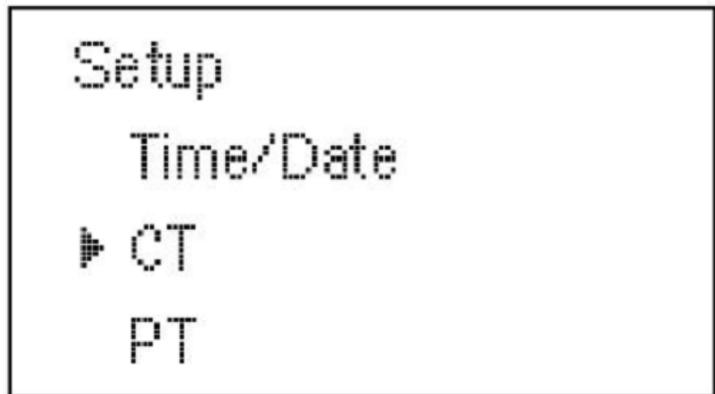


backlight status, day-light saving, net number, modbus baud rate and setup passwords are available. Also for erasing the memory of maximeter, records, counter and event recorder this menu should be used. The password will be required for entering the setup menu. The password contains a 4 digit number and can be configured in the setup menu.

After appearing the password request, the first number should be entered from the left. The digit could be changed by UP/DOWN keys. The digit would be Entered by pressing OK key, and it will turn hidden and the next digit would be requested. By entering the last digit, the entered password would be evaluated and if its valid, the setup menu would be opened otherwise it will return to the main menu. The default password is 0000.

### 5-11-1 Setup main menu

After entering the password, if its valid the setup main menu will be shown as the figure. Different lines could be highlighted by pressing UP/DOWN keys. ESC key should be pressed for exiting the setup menu, and it would be asked from the



user if he wants to save the changes in setup. The answer can be changed by UP/DOWN keys and it would be entered by OK key. If YES is selected, the changes would be saved and in order of selecting NO, they will be discarded. For both answers, the flash will be read before returning to the

setup main menu and replaced in the memory. If ESC key is pressed in the SAVE menu, it would be returned to the setup main menu.

### 5-11-2 Date and Time

By selecting the **Time/Date** from the main menu, it will enter the time and date adjusting menu. By entering the menu, the SEC can be adjusted first. It is done by pressing UP/DOWN keys. By pressing OK key, the next parameter can be selected for adjusting. It should be noted that changing the time and date will be applied immediately after adjusting and there is no need to save the changes. ESC key would exit this menu. The function of daylight saving is described in 5-11-12.



### 5-11-3 CT

This device supports different CTs with 5A output. For selecting the CT ratio and also the number of input CTs, CT should be selected in setup main menu. In the CT menu, the ratio of the input CT could be selected first. By the UP/DOWN



keys, the ratio of the CT can be increased or decreased and by each pressing of the key, the numerator will be changed 2.5 units (equal to 0.5 unit in the ratio). If any of these keys are pressed and held down, the CT ratio will change fast. The ratio will be applied for all 3 current inputs, and if its applied by pressing the OK key, the menu will turn to selecting the number of CTs menu and the new CT ratio will be replaced in the temporary memory. For saving the CT ratio in the flash, the setup procedure should also be done. By the OK key, the number of used CTs would be selected and by UP/DOWN keys the value of 2 or 3 could be selected. In the 2 CT mode, I2 input current will be assumed as 0 and the I2

current will be calculated by vector summation of I1 and I3 so that the vector summation of the 3 currents considering constant angle for voltages become 0. In this case  $I_n$  is 0. PF, P and Q parameters are calculated from the extracted value for I2 (Aron connection). In this case the accuracy of the device will be decreased a little considering the lower number of CTs used. In 3 CT mode, currents of the 3 phases are measured separately, then  $I_n$  would be calculated by vector summation of 3 currents, taking into account a constant angle for the 3 voltages. Also the rest of the parameters related to the second phase are measured directly. The circuit of each of the above states are discussed in chapter 3 (wiring diagram). By pressing the OK key it would exit the CT menu after applying the changes. Also in the next stage, Setup should be saved according to 5-11-1. By the ESC key, it would exit the CT menu without saving any changes.

#### 5-11-4 PT

The ratio of PT is a coefficient which is applied to the read voltage from the input voltages so that during usage of the PT, the voltage numbers would be displayed and saved correctly. The ratio of PT is selectable from 1/1 for



direct voltage connection up to 300V (direct connection to distribution network) to 4000/1 (400 KV network) continuously. To change this coefficient, PT menu should be selected from the main setup menu. By appearing the PT menu, the numerator which shows the type of the PT used for input of the device could be changed by UP and DOWN keys. Each unit change would increase or decrease the ratio of the PT and thus the numerator. By holding the UP/DOWN keys, the PT ratio would change fast. By the OK key, the changes would be applied and exit the PT menu. Also in the next stage, Setup should be saved according to 5-11-1. Using the ESC key, it would exit the menu without saving.

#### 5-11-5 Calibration

The calibration of voltage, current, active and reactive power, power factor and temperature are done with the software. Calibration means making changes in the offset registers and the coefficients of each input voltage, current, power and



temperature which is done under a calibrated reference. The main menu of calibration contains 3 items which considering the selection routine, are similar to main setup menu. In the custom state, the stages are done under the devices instructions, and finally by adjusting the internal registers of the metering IC, ADE7758, the calibration will be done automatically. Because of the simplicity, this method is recommended. In the *Advanced* state, the expert user who is familiar to the internal registers of ADE7758-Analog Devices, would apply the required changes in these registers. Finally, the temperature could be calibrated independently in the *Temperature* menu from main calibration menu.

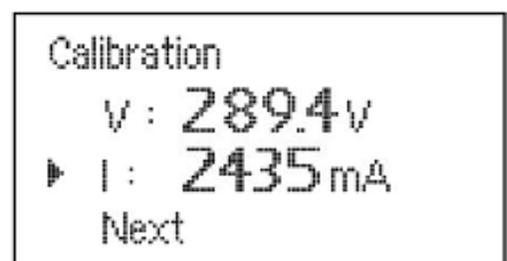
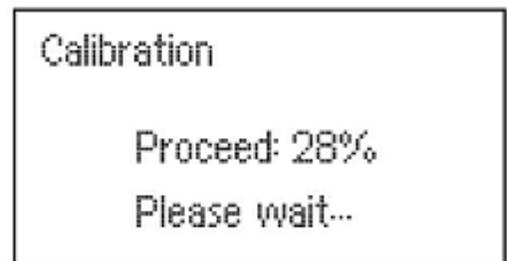
In the calibration menu, the measured parameters are displayed regardless to the type of the used CT and PT.

**Note:** before shipment, each device is adjusted with calibrated devices.

**Caution:** In normal situations, there is no need to adjust the calibration parameters, and because of the sensitivity, non-expert users should avoid seriously from making any changes in this part.

#### 5-11-5-1 Normal calibration (Custom)

The device will enter the automatic calibration process by choosing *Custom* from the main menu of calibration. In this process, the 3 voltage inputs are connected to a variable AC voltage source, and the 3 current inputs are connected to a variable current source, and are adjusted together.

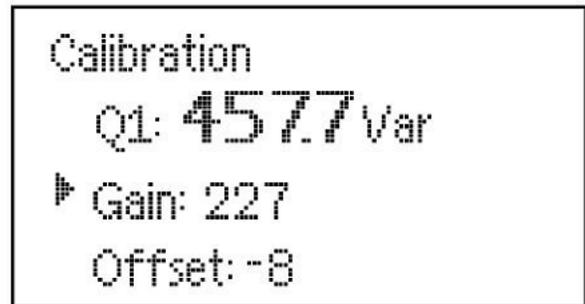


In the first stage it will be requested from the user to disconnect the currents and adjust the voltages between 30V and 50V and then press the OK key to continue. By pressing the OK key, V1 voltage is displayed as the indicator. By pressing UP and DOWN keys the displayed value could be increased or decreased. After carefully adjusting the voltage according to the reference, the OK key should be pressed. There would be a delay before measuring the required information and adjusting the currents and powers offset registers (in this situation, the input currents are disconnected thus the currents and powers will become zero). After that required calculations are done, and after the declaration of the device, the voltage should be adjusted around 300V and the current around 5A with a power factor near 75% and then the OK key should be pressed. In the next stage, V1 voltage and I1 current would be displayed as the index which each one could be selected by UP/DOWN keys. After pressing the OK key, the menu will turn to parameter changing mode and  $\uparrow$  would be displayed in front of the changeable parameter. In this state,  $\updownarrow$  the voltage and current parameters could be adjusted using UP/DOWN keys. If the user presses the OK key again, the menu would be in selected row changing state and finally by selecting *Next* it would pass this state. Now the voltage and current values are extracted for all the phases and the related registers are adjusted in ADE7758. In the next stage, P1, Q1 and PF1 values are displayed as the index and each one could be moved to the selecting line using UP/DOWN keys. Adjusting each of the parameters is the same as adjusting voltage and current in the previous stage. Using *Next*, the last stage of calibration would be done and would exit this menu by OK key. In the next stage, the *Setup* should be saved according to 5-11-1. Pressing ESC key in each stage, would exit this process and return to the calibration main menu.

### **5-11-5-2 Calibration by direct register adjusting (Advanced)**

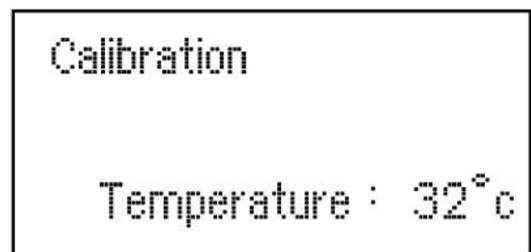
Analog devices metering IC ADE7758 has been used for measuring voltage, current, active and reactive power in TDL104. The catalog and technical notes of this IC could be found in the manufacturer's website

[www.analog.com](http://www.analog.com). The measuring method of each parameter and the role and influence measure of *Offset* and *Gain* registers for all measuring parameters are described on pages 8 to 25 of the datasheet, and also on pages 31 to 33 which the table of registers, initial value, register length and read/write capability are available according to their address, the access method to the measured parameters such as voltages, currents, active, reactive and apparent powers and offset angle of currents and voltages are surveyed. These registers are directly accessed by selecting the *Advanced* menu from calibration main menu and adjusting them carefully will improve the devices measurement precision. A parameter with *Offset* and *Gain* registers is displayed in each page of this menu. Changing these registers would be applied directly to the parameters. Pressing UP and DOWN keys will take each registers to the select line. The OK key will turn the menu to changing register mode and  $\updownarrow$  would be shown in front of the displayed value. This value could be increased or decreased by UP and DOWN keys. Pressing OK key again would take the menu from changing register to appointing register mode and finally ESC key should be pushed to exit this menu. The user should answer if he wants to apply the changes to ADE7758 or exit without any changes, before quitting. Selecting Yes would apply the changes. Note that for apparent powers, only Gain register and for angle, only Offset register exists. In the next stage the devices Setup should be saved according to 5-11-1.



### 5-11-5-3 Temperature calibration

*Temperature* menu should be selected from the main calibration menu to adjust the temperature offset. In this menu the current measured temperature is shown



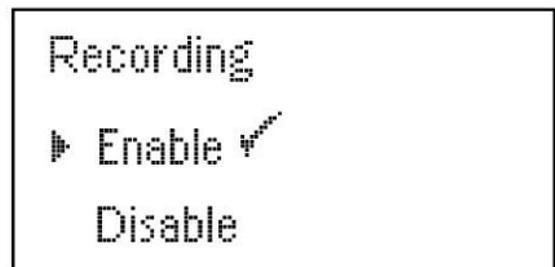
and it could be changed using UP and DOWN keys. Pressing OK key would apply the specified value as the current temperature and it could be adjusted using UP and DOWN keys.

In the next stage the devices Setup should be saved according to 5-11-1. ESC key would quit this menu without any changes in temperature offset.

**Note:** The temperature sensor is installed in the device, so the device should have complete heat exchange with the environment in order to adjust the temperature correctly.

### 5-11-6 Recording

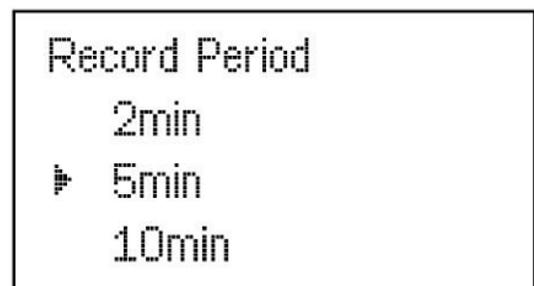
There are 2 states, Enable and Disable for Recording, in order to prevent unwanted information storage. In Enable state, the system would save the minimum and maximum parameters and records in the flash but in Disable



state, Maximeter, Recorder and Event Recorder are disabled. *Recording* should be selected from the Setup main menu to specify the record state. Each state could be selected using UP/DOWN keys after entering the state menu. The OK key would apply the state and the ESC key would return to the Setup main menu without any changes. After quitting the state select menu and in the next stage the devices Setup should be saved according to 5-11-1.

### 5-11-7 Record Period

As specified in 5-7, in order to record the measured parameters, the average of parameters are calculated in a time frame which the time could be defined by the user, and finally by the end of the period, the average of the parameters are

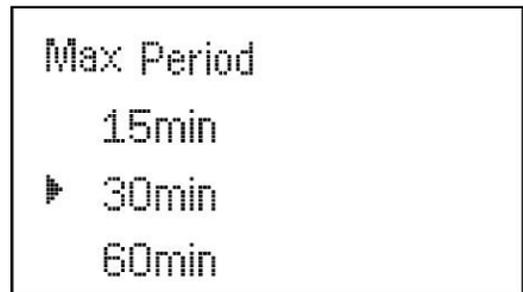


recorded. The time frame could be defined as 1, 2, 5, 10, 15, 30 and 60

minutes which would be defined in Select Period Menu. *Record Period* should be selected from the main menu in order to enter this menu. There is a check mark for the record period. Each amount could be selected using UP/DOWN keys after entering the state menu and the OK key would apply the new value. In the next stage the devices Setup should be saved according to 5-11-1. ESC key would quit this menu without any changes.

### 5-11-8 Maximeter Period (MAX Period)

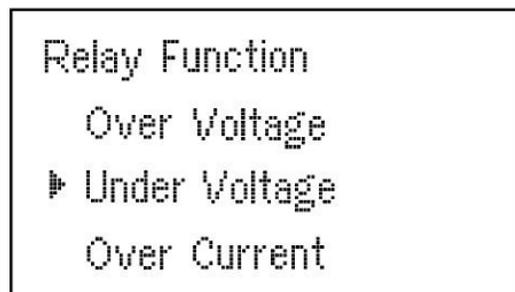
As specified in 5-5, in order to record the average maximum and minimum, the average of all parameters are calculated in a time frame which the time could be defined by the user. The average of each parameter is compared with the values



saved in the memory individually (compared to the current days saved value for the daily maximeter), if the parameter is more than the maximum saved value it would replace the previous average maximum and if its lower than the previous average minimum, it would replace the average minimum. At the same time, the values saved in the RAM as instant maximeters, would be compared to the values saved in the flash and would be replaced if needed. 1, 2, 5, 10, 15, 30 and 60 minutes are available for the time frame which could be adjusted in *MAX Period* menu. The current period of the average maximeter is displayed by a checkmark. Each line could be selected using UP/DOWN keys, the OK key would apply the new value and ESC key would quit this menu without any changes. In the next stage the devices Setup should be saved according to 5-11-1.

### 5-11-9 Relay Function

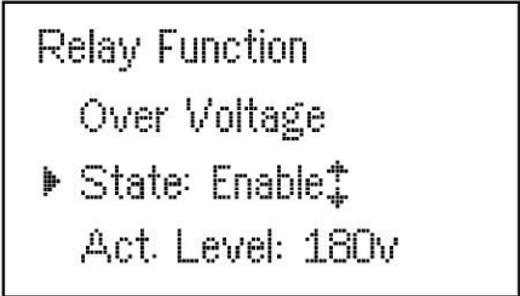
There is a programmable relay with one normally open contact at the back of the device(refer to chapter 3). The relay could be programmed with these



conditions: Over Voltage, Under Voltage, Over Current, Over active Power, Under active Power, Over reactive Power, Over THD(v) and Over THD(I). The relay action time is also adjustable. The threshold level of each condition and the delay time could be modified in the *Relay Function* menu of the setup main menu. The main menu of relay function contains 9 items which the first 8 items are the conditions and the 9<sup>th</sup> item is the relay delay time. Each line could be selected using UP/DOWN keys. The OK key would apply the new value and ESC key would quit this menu without any change.

### 5-11-9-1 Over Voltage

When this item is enabled, if the average input voltage is more than the threshold, the relay would go on considering the delay time. The activation and threshold level could be adjusted in the *Over Voltage* menu of the relay main function



```
Relay Function
Over Voltage
▶ State: Enable‡
Act. Level: 180v
```

menu. In the first state, making the condition Enable or Disable could be set. Either of the modes could be selected using UP/DOWN keys and be applied by OK key, and then it will go to the second state which is for threshold level selection. The level could be changed using UP/DOWN keys. By keeping these keys pressed down, the level would change faster. The OK key would apply the changes and quit the menu. In the next stage the devices Setup should be saved according to 5-11-1. ESC key would quit this menu without any changes.

**Note:** This condition is only applied with 1/1 ratio PT and its limited to maximum 300V.

### 5-11-9-2 Under Voltage

When this item is enabled, if the average input voltage is less than the threshold, the relay would go on considering the delay time. The activation and threshold level could be adjusted in the *Under Voltage* menu of the relay function main menu. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

**Note:** This condition is only applied with 1/1 ratio PT and its limited to maximum 300V.

### **5-11-9-3 Over Current**

When this item is enabled, if the average input current is more than the threshold, the relay will go on considering the delay time. The activation and threshold level could be adjusted in the *Over Current* menu of the relay function main menu. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

### **5-11-9-4 Over Active Power**

When this item is enabled, if the total active power is more than the threshold, the relay will go on considering the delay time. The activation and threshold level could be adjusted in the *Over Active Power* menu of the main menu of relay function. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

**Note:** The threshold level parameter in this condition is limited to maximum 1000 KW.

### **5-11-9-5 Under Active Power**

When this item is enabled, if the total active power is less than the threshold, the relay will go on considering the delay time. The activation and threshold level could be adjusted in the *Under Active Power* menu of the relay function main menu. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

**Note:** The threshold level parameter in this condition is limited to maximum 1000 KW.

### **5-11-9-6 Over Reactive Power**

When this item is enabled, if the total active power is less than the threshold, the relay will go on considering the delay time. The activation and threshold level could be adjusted in the *Over Reactive Power* menu of

the relay function main menu. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

**Note:** The threshold level parameter in this condition is limited to maximum 1000 KW.

#### **5-11-9-7 Over THD(v)**

When this item is enabled, if any of the 3 input voltage THDs are more than the threshold, the relay will go on considering the delay time. The activation and threshold level could be adjusted in the *Over THD(v)* menu of the relay function main menu. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

**Note:** The threshold level parameter in this condition is limited to maximum 50%.

#### **5-11-9-8 Over THD(i)**

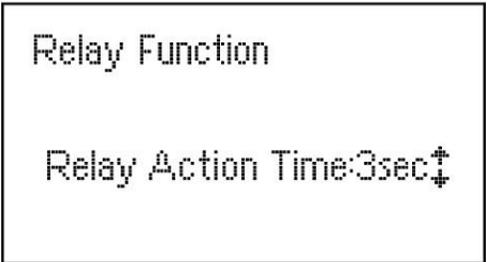
When this item is enabled, if any of the 3 input current THDs are more than the threshold, the relay will go on considering the delay time. The activation and threshold level could be adjusted in the *Over THD(i)* menu of the relay function main menu. The menu and keys functions are similar to *Over Voltage* menu (5-11-9-1).

**Note:** The threshold level parameter in this condition is limited to maximum 50%.

#### **5-11-9-9 Relay Act. Time**

in the case of any of the relay activation conditions occurrence, its stability would be considered in a period of time, and if the condition is available during the period, the relay command will be performed. If

the condition is eliminated, the stability is also considered during the same period of time and then the relay command will be omitted. This time is



Relay Function

Relay Action Time:3sec↑

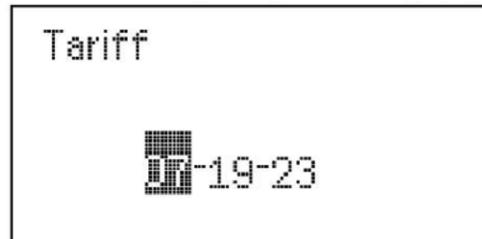
equal for all the conditions and could be changed in *Relay Act. Time* of the relay function main menu.

**Note:** if several conditions are enabled at the same time, each one will have its own time period individually. At least one stable condition occurrence will lead to relay command.

In *Relay Act. Time* menu the time period could be changed using UP/Down keys. The range is between 0 to 30 seconds. The OK key would apply the selected time and the ESC key would quit this menu without any change. In order of any changes, in the next stage the devices Setup should be saved according to 5-11-1.

### 5-11-10 Tariff

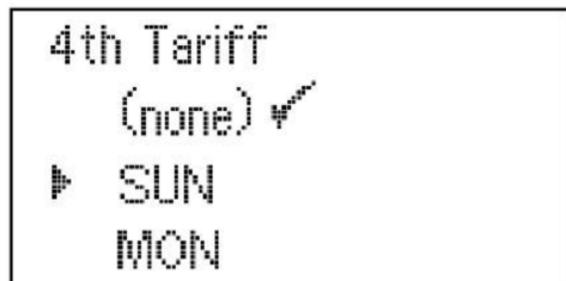
The device divides the 24-hour into 3 sections. The consumed energy from 0 O'clock until the first time tag is recorded as Low tariff, between the first and second time tag as Normal tariff, between the second and third time tag as Peak tariff and between the third time tag and 24 O'clock



as Low Tariff. The time tags are assumed 7,19 and 23 O'clock respectively by default. To change these values, *Tariff* should be selected from the main setup menu. The changeable time would be displayed in negative color. By pressing OK key, the next time tariff would be activated and changes would be applied to the previous time tariff. In order of any changes in the tariff time, in the next stage the devices Setup should be saved according to 5-11-1. It should be noted that  $t_1 \leq t_2 \leq t_3$ .

### 5-11-11 4<sup>th</sup> Tariff

The 4<sup>th</sup> tariff is defined independently from the 3 other tariffs. On the holidays, the consumed energy could be calculated without the 3 usual time sections. The consumed energy would be recorded in the device as the 4<sup>th</sup>

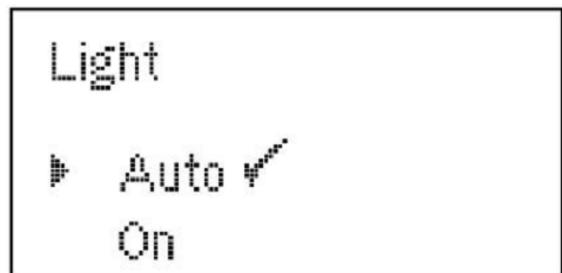


tariff. The holidays are defined in two ways, the weekends and the annual holidays. The annual holidays are transferred and saved in the SETUP via a computer. While calculating the energy, if the current day is one of the holidays, the 4<sup>th</sup> tariff would be activated. Otherwise the daily tariffs would be used. Both weekend and annual holidays are disabled by default. Any of the days could be defined as the weekend or it could be disabled.

For changing the status and also defining the weekend, 4<sup>th</sup> *Tariff* should be selected from the setup main menu. In this menu (as shown in the image) the current state of 4<sup>th</sup> tariff is shown by check mark. *None* shows that the weekend state is disabled. Each of the days and *None* could be in the select line using UP/DOWN keys. Pressing the OK key would quit this menu after saving the changes. The ESC key would quit without any changes. In order of any changes, in the next stage the devices Setup should be saved according to 5-11-1.

### 5-11-12 Backlight

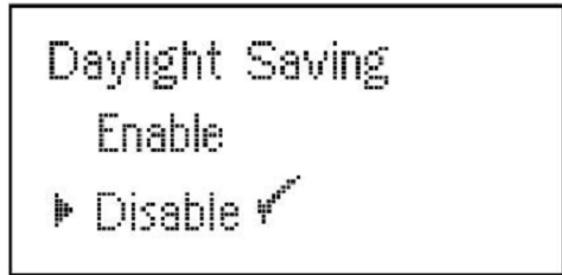
To adjust the backlight, *Light* should be selected from the setup main menu. The backlight could have 3 states. *Auto* would turn of the backlight 30 minutes after the last key



pressed, and pressing any key would turn it on again. *ON* will keep the backlight always on. *OFF will keep the backlight always off*. The current state of backlight is displayed by a check mark. Each state could be in the select line using UP/DOWN keys. Pressing the OK key would quit this menu after saving the changes. The ESC key would quit without any changes. In order of any changes, in the next stage the devices Setup should be saved according to 5-11-1.

### 5-11-13 Daylight Saving

To make the daylight saving enabled or disabled, *Daylight Saving* should be selected from the Setup main menu. The current state is displayed by a check mark. Each state could be in the select line using UP/DOWN keys.



Pressing OK key would quit this menu after saving the changes. The ESC key would quit without any changes.

**5-11-13-1** changing the hour would be applied when the minute changes, so after changing the daylight mode, it would be applied after the minute is changed.

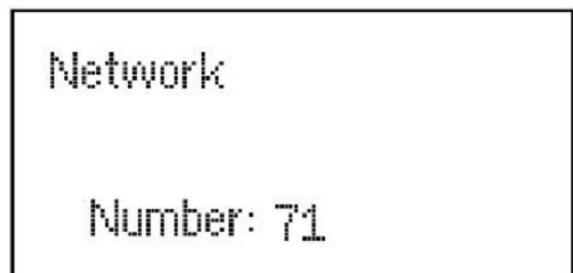
**5-11-13-2** In the first 6 months of the year, whenever this option is enabled, the time would have one hour increase considering 5-11-13-1.

**5-11-13-3** If this option is enabled, In the first 6 months of the year, whenever its disabled, the time would have one hour decrease considering 5-11-13-1.

**5-11-13-4** If the option is enabled, adjusting the date would affect the time.

#### **5-11-14 Net Number**

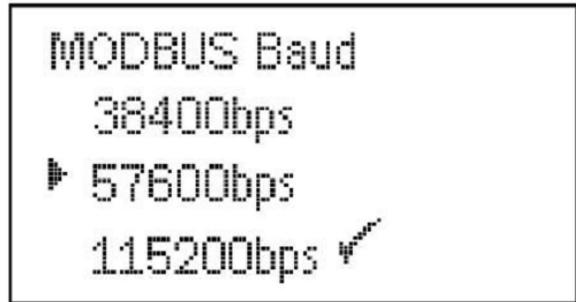
Net number is between 1 to 95, which is used as an index in the network. The communication protocol is MODBUS. *Net Number* should be selected from the setup main menu to specify the



net number. The Net number is changed using UP/DOWN keys, the changing speed would increase by keeping the key pressed down and by OK key, the selected number would be applied. It would quit the menu without any changes by pressing ESC key. In order of any changes, in the next stage the devices Setup should be saved according to 5-11-1.

#### **5-11-15 MODBUS Baud**

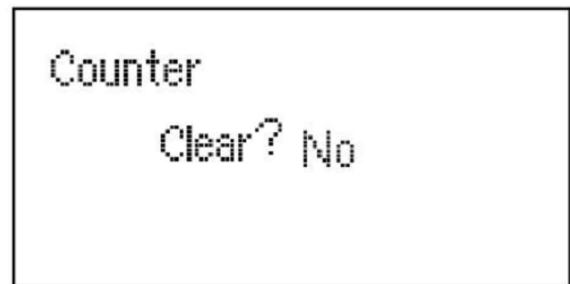
The modbus baudrate (RS485 communication) could be 2400, 4800, 9600, 19200, 38400, 57600 and 115200 bit per second. *MODBUS Baud* should be selected from the setup main menu to specify the baudrate.



The current baudrate is displayed by a checkmark in this menu. Different baudrates could be in the select line using UP/DOWN keys. The OK key would quit this menu after applying the changes. The ESC key would quit the menu without any changes. In order of any changes, in the next stage the devices Setup should be saved according to 5-11-1.

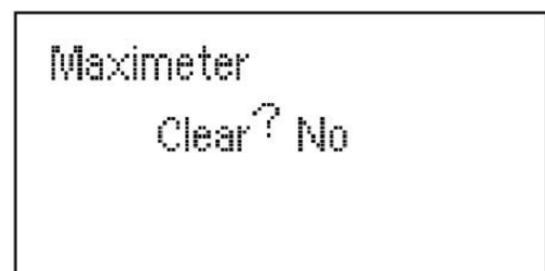
#### **5-11-16 Clear counter memory**

*Clear Counter* should be selected from the setup main menu to clear the counter memory. The device would ask if it should clear the counter memory or not. *Yes* or *No* could be selected using UP/DOWN keys and be applied by OK key.



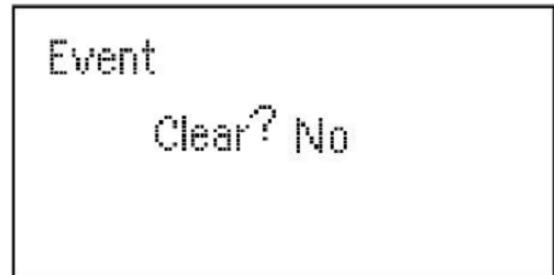
#### **5-11-17 Clear maximeter**

*Clear Max* should be selected from the setup main menu to clear the maximeter. The daily and total maximeter would be cleared by selecting this item. The device would ask if it should clear the maximeter or not. *Yes* or *No* could be selected using UP/DOWN keys and be applied by OK key.



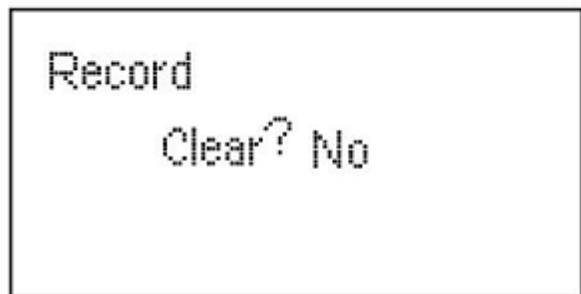
#### **5-11-18 Clear event records**

*Clear Event* should be selected from the setup main menu to clear the event recorder memory. The device would ask if it should clear the event records or not. *Yes* or *No* could be selected using UP/DOWN keys and be applied by OK key.



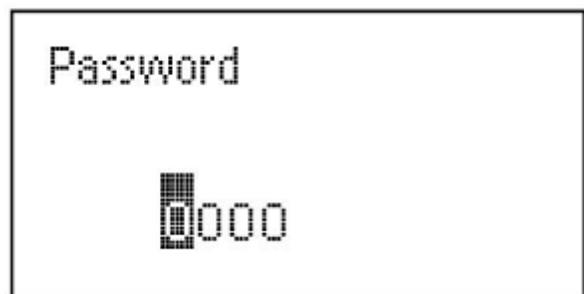
### **5-11-19 Clear Records**

*Clear Record* should be selected from the setup main menu in order to clear the records. The device would ask if it should clear the event records or not. *Yes* or *No* could be selected using UP/DOWN keys and be applied by OK key.



### **5-11-20 Set Password**

*Password* is selected from the setup main menu to set a password for the setup. Each of the four digits could be selected between 0 and 9. The digit which could be changed would be displayed with negative color and could be changed using UP/DOWN keys. OK key would put the next digit in changing mode and in the last digit it would quit this menu saving the changes. The ESC key would quit this menu without any changes. In order of any change, in the next stage the devices Setup should be saved according to 5-11-1.



## **6- Data Download**

TDL104 is equipped with a USB port in order to download the recorded data on a USB flash disk. The USB flash disk could be formatted with FAT32 or FAT16. After attaching the USB flash into the port, the stages of downloading data and creating the files would be displayed on the LCD.

## **6-1 Data saving method**

While downloading data on the USB flash, a folder named TDL104 (if such a folder doesn't exist) would be created and in this folder, a folder named with a part of the devices serial number, and in the serial number folder, another folder named with the current date would be created. The data files in this folder would be as followed:

### **6-1-1 SPEC.TXT**

The major information of the device including serial number, net number, current time and date, record period and average maximeter, record state, tariff times and the number of records are saved in this file.

### **6-1-2 REC.TXT**

This file includes the saved records. The first line specifies the title of each column. The columns are seperated by a TAB and in each column one parameter is saved. This file could be used in Exel or curve drawing software's.

### **6-1-3 COUNTER.TXT**

A table of consumed positive and negative, active and reactive energy in each 4 tariff's is saved in this file.

### **6-1-4 MAXAVE.TXT**

The data saved in average maximeter of the device is saved in this file. The data is in a table consisting of two main maximum and minimum columns which each contains information and occurrence time and date columns.

### **6-1-5 MAXINS.TXT**

The instant maximeter information of the device is saved in this file. The data is in a table consisting of two main maximum and minimum columns which each contains information and occurrence time and date columns.

#### **6-1-6 MAXAVE\_D.TXT**

The saved parameters in the average maximeter of the devices daily maximeter are saved in this file. Beside each column there is another column showing the occurrence time, and the rows shows the days of the year. This file could be opened in Exel and the data could be used for curve drawing or making tables.

#### **6-1-7 MINAVE\_D.TXT**

The saved parameters in the average minimum of the devices daily maximeter are saved in this file. The first row of this file specifies the parameter of each column. Beside each column there is another column showing the occurrence time, and the rows shows the days of the year. This file could be opened in Exel and the data could be used for curve drawing or making tables.

#### **6-1-8 MAXINS\_D.TXT**

The saved parameters in the instant maximum of the devices daily maximeter are saved in this file. The first row of this file specifies the parameter of each column. Beside each column there is another column showing the occurrence time, and the rows shows the days of the year. This file could be opened in Exel and the data could be used for curve drawing or making tables.

#### **6-1-9 MININS\_D.TXT**

The saved parameters in the instant minimum of the devices daily maximeter are saved in this file. The first row of this file specifies the parameter of each column. Beside each column there is another column showing the occurrence time, and the rows shows the days of the year. This

file could be opened in Excel and the data could be used for curve drawing or making tables.

### **6-1-10 EVENT.TXT**

This file contains the saved Event records. The first row of this file specifies the title of each column. The record Number in the memory is saved in the first column, occurrence time in the columns 2 to 4, the creation state in the columns 5 to 8 and the rest of columns specify the measured parameters in the Event occurrence time. The columns are separated by a TAB and could be used in Excel.

### **6-2 Curve fitting software**

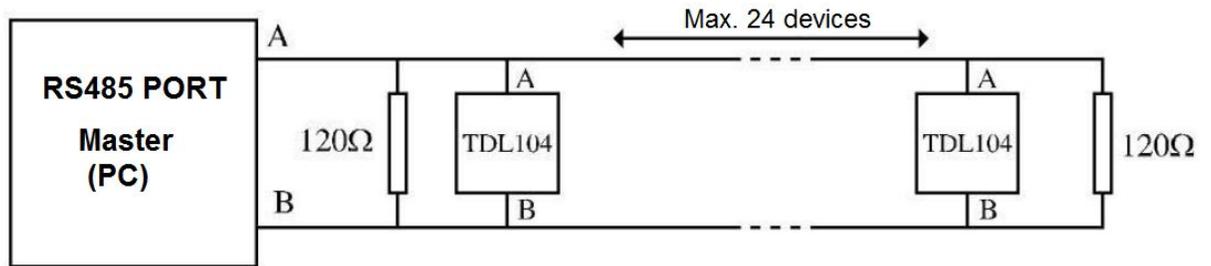
The curve fitting software in the devices software CD could be used to observe and print the recorded parameters curves and tables. This software has the ability to select the files, parameters, time range, and variation range, zoom in, zoom out, display and print the recorded parameters tables.

## **7 RS485 port and MODBUS protocol**

The device has been equipped with RS485 communication port and MODBUS protocol in order to be used in a network, sending online measured parameters to the computer, determination of annual holidays and some parameters remote modification. The connector is placed behind the device which detailed description could be found in 3-4.

### **7-1 specifications**

RS485 port for using the device in a modbus network has a baud rate of 2400 to 115200 bps, 2 stop bits and no parity. 120  $\Omega$  resistors should be installed as terminators. The wiring diagram of the devices in the network is illustrated in the figure below.



## 7-2 MODBUS protocol

MODBUS is a standard protocol for communication between several devices in a common bus. Many softwares are available for communication under this protocol, so considering TDL104 specifications, these softwares could be used to communicate with this device. Functions 3,4 and 6 of MODBUS protocol are supported in TDL104.

### 7-2-1 Function 3 (Read R/W registers):

This function is used to read some specifications from the device.

In the below table, R/W registers, their length and address are mentioned.

Parameter	Bytes	Address
Time - Minute	2	0
Time - Hour	2	1
Time - Day	2	2
Time - Month	2	3
Time - Year	2	4
Record Period	2	5
Average maximeter period	2	6
PT factor x 10	2	7
CT factor x 10	2	8
CT quantity	2	9
1 <sup>st</sup> tariff time	2	10
2 <sup>nd</sup> tariff time	2	11
3 <sup>rd</sup> tariff time	2	12
Day of holiday tariff	2	13

Daylight saving situation	2	14
Holiday date – reserve 1	2	15
Holiday date – reserve 2	2	16
Holiday date – reserve 3	2	17
Holiday date – reserve 4	2	18
Holiday date – reserve 5	2	19
Holiday date – reserve 6	2	20
Holiday date – reserve 7	2	21
Holiday date – reserve 8	2	22
Holiday date – reserve 9	2	23
Holiday date – reserve 10	2	24
Holiday date – reserve 11	2	25
Holiday date – reserve 12	2	26
Holiday date – reserve 13	2	27
Holiday date – reserve 14	2	28
Holiday date – reserve 15	2	29
Holiday date – reserve 16	2	30
Holiday date – reserve 17	2	31
Holiday date – reserve 18	2	32
Holiday date – reserve 19	2	33
Holiday date – reserve 20	2	34
Holiday date – reserve 21	2	35
Holiday date – reserve 22	2	36
Holiday date – reserve 23	2	37
Holiday date – reserve 24	2	38
Password (read only)	2	39
Date - Day	2	40
Date – Month	2	41
Date – Year	2	42
Date – Week day	2	43
Relay – Status byte	2	44
Relay – Parameter level for	2	45

voltage increase condition		
Relay – Parameter level for voltage decrease condition	2	46
Relay – Parameter level for current increase condition	2	47
Relay – Parameter level for active power increase condition	2	48
Relay – Parameter level for active power decrease condition	2	49
Relay – Parameter level for reactive power increase condition	2	50
Relay – Parameter level for voltage THD increase condition	2	51
Relay – Parameter level for current THD increase condition	2	52
Relay – Contact on delay	2	53
Relay – Contact off delay	2	54
Relay – Prompt time	2	55
Relay – Prompt status byte	2	56
Device prompt via modbus	2	57
Read all registers from address 0 to 14	30	256
Read all registers from address 15 to 38	48	257
Read all registers from address 40 to 57	36	258

7-2-1-1- Minute values are valid from 0 to 59, hour values from 0 to 23, day values from 1 to 31, month values from 1 to 12 and year values from 0 to 99. Week days are valid from 0 for Sunday to 6 for Saturday.

7-2-1-2- Valid values for record period and average maximeter are as mentioned in the table below.

0	1 min
1	2 min
2	5 min
3	10 min
4	15 min
5	30 min
6	60 min

7-2-1-3- The coefficients of CT and PT are multiplied to 10 and are able to be read or written in 7 and 8 registers. Note that the coefficient should be less than 4000 for PT and less than 1000 (5000/5) for CT.

7-2-1-4- The times for tariff 1 could be equal to or less than 2 and for tariff 2 could be equal to or less than 3, which all three values are valid from 0 to 23.

7-2-1-5- Weekly holidays for the fourth tariff is as the below table.

0	(none)
1	SUN
2	MON
3	TUE
4	WED
5	THU
6	FRI
7	SAT

The quantity of CTs used in the circuit (according to section 4 wiring diagram) could be seen and modified in register 9. Zero means using two CTs in the circuit and one means using three CTs.

7-2-1-6 zero for Daylight Saving register means Disabled and one means enabled.

7-2-1-7- The format of annual holidays status registers from 1<sup>st</sup> to 16<sup>th</sup> of each month:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

and for 17<sup>th</sup> to the end of each month:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17

In these registers, one means holiday for that day. If the month does not have 31 days, the extra bytes is considered Unused.

7-2-1-8- The LSB byte of the register with address 44 (relay-status byte) and the register with address 56 (relay- prompt status byte) has the below format. A one for these bits mean Enable for the corresponding condition.

7	6	5	4	3	2	1	0
Over THD(i)	Over THD(v)	Over Reactive Power	Under Active Power	Over Active Power	Over Current	Under Voltage	Over Voltage

7-2-1-9- Parameter levels in registers 45 to 52 and relay delay time in register 53 have the same conditions and limitation of section 5-11-9.

7-2-1-10- register with address 57 in function 3 shows the current prompt status and if the device is in prompt status, the value is one. in function 6, sending one to this register, sets the device into prompt status via modbus. The prompt time in this situation is Prompt Time (section 5-11-9-11).

7-2-1-11- the format of Master command in function 3 is:

0	Slave network No.
1	3
2	Register address(Hi)
3	Register address(Low)
4	Registers quantity(Hi)
5	Registers quantity(Low)
6	CRC code(Low)
7	CRC code(Hi)

In this format, the calculation method of CRC in modbus is specified. As an example, for a device with net number=1, the following command would be sent to the slave for reading the minute register.

1
3
0
0
0
1
132
10

7-2-1-12- The slave response to function 3 is:

0	Slave Net number
1	3
2	Number of bytes
3	Data (Hi)
4	Data (Low)
	.
	.
	.
	.
	CRC code (Low)

	CRC code (Hi)
--	---------------

### 7-2-2 Function 4 (Read read-only registers)

This function is used for reading measured parameters in the device.

In the following table, read-only registers and their length and address are mentioned.

Parameter	Bytes	Address
$V_1$	4	0
$V_2$	4	1
$V_3$	4	2
$V_{ave}$	4	3
$V_u$ (unbalancy voltage)	4	4
$V_{12}$	4	5
$V_{23}$	4	6
$V_{31}$	4	7
$I_1$	4	8
$I_2$	4	9
$I_3$	4	10
$I_{ave}$	4	11
$I_n$	4	12
$P_1$	4	13
$P_2$	4	14
$P_3$	4	15
$Q_1$	4	16
$Q_2$	4	17
$Q_3$	4	18
$S_1$	4	19
$S_2$	4	20
$S_3$	4	21
$P_{tot}$	4	22
$Q_{tot}$	4	23
$S_{tot}$	4	24

PF <sub>1</sub>	2	25
PF <sub>2</sub>	2	26
PF <sub>3</sub>	2	27
Frequency (Fx10)	2	28
Temperature (T)	2	29
THD <sub>V1</sub>	2	30
THD <sub>V2</sub>	2	31
THD <sub>V3</sub>	2	32
THD <sub>I1</sub>	2	33
THD <sub>I2</sub>	2	34
THD <sub>I3</sub>	2	35
Relay-active condition	2	36
Peak tariff counter	24	44
Daily tariff counter (Normal)	24	45
Night Tariff counter	24	46
Fourth tariff counter (holidays)	24	47
Read all registers from address 0 to 35	122	256
Read all registers from address 44 to 47	96	257

Voltages and currents are saved with V and A units and P,Q and S are saved with W, VAR and VA units respectively. PF from 0 to 100 doesn't have decimals and the frequency is multiplied to 10 so that it could be displayed with one digit decimal.

Some of RTUs don't support 4 byte registers. There are other addresses for 4 byte registers:

Parameter	Bytes	Address
$V_1$ (High Word)	2	512
$V_1$ (Low Word)	2	513
$V_2$ (High Word)	2	514
$V_2$ (Low Word)	2	515
$V_3$ (High Word)	2	516
$V_3$ (Low Word)	2	517
$V_{ave}$ (High Word)	2	518
$V_{ave}$ (Low Word)	2	519
$V_u$ (High Word)	2	520
$V_u$ (Low Word)	2	521
$V_{12}$ (High Word)	2	522
$V_{12}$ (Low Word)	2	523
$V_{23}$ (High Word)	2	524
$V_{23}$ (Low Word)	2	525
$V_{31}$ (High Word)	2	526
$V_{31}$ (Low Word)	2	527
$I_1$ (High Word)	2	528
$I_1$ (Low Word)	2	529
$I_2$ (High Word)	2	530
$I_2$ (Low Word)	2	531
$I_3$ (High Word)	2	532
$I_3$ (Low Word)	2	533
$I_{ave}$ (High Word)	2	534
$I_{ave}$ (Low Word)	2	535
$I_n$ (High Word)	2	536
$I_n$ (Low Word)	2	537
$P_1$ (High Word)	2	538
$P_1$ (Low Word)	2	539
$P_2$ (High Word)	2	540
$P_2$ (Low Word)	2	541
$P_3$ (High Word)	2	542

P <sub>3</sub> (Low Word)	2	543
Q <sub>1</sub> (High Word)	2	544
Q <sub>1</sub> (Low Word)	2	545
Q <sub>2</sub> (High Word)	2	546
Q <sub>2</sub> (Low Word)	2	547
Q <sub>3</sub> (High Word)	2	548
Q <sub>3</sub> (Low Word)	2	549
S <sub>1</sub> (High Word)	2	550
S <sub>1</sub> (Low Word)	2	551
S <sub>2</sub> (High Word)	2	552
S <sub>2</sub> (Low Word)	2	553
S <sub>3</sub> (High Word)	2	554
S <sub>3</sub> (Low Word)	2	555
P <sub>tot</sub> (Low Word)	2	556
P <sub>tot</sub> (High Word)	2	557
Q <sub>tot</sub> (High Word)	2	558
Q <sub>tot</sub> (Low Word)	2	559
S <sub>tot</sub> (High Word)	2	560
S <sub>tot</sub> (Low Word)	2	561

7-2-2-1 LSB byte of the register with address 36 (relay-ON condition)