# APPLICATION NOTE

# MODBUS PROTOCOL – SMARTSCAN® 50

**Revision Record:**

| Date | Description | Written by | Rev. |
|---|---|---|---|
| 25/6/2007 | 1st release | Erez Segev | 1.00 |

## Table of contents

## 1. OVERVIEW

As a part of our ongoing efforts to improve our competitive advantage, Solid Applied Technologies **Smart***Scan*® 50 will now support a subset of the bi-directional MODBUS-RTU Protocol. This new feature will allow the user to improve productivity and increase the level of control in his facility.

## 2. PURPOSE

The purpose of this document is to provide specific definitions of the MODBUS-RTU protocol for the **Smart***Scan*® 50 unit.

The MODBUS-RTU protocol is bi-directional. The **Smart***Scan*® 50 sends the measurement parameters according to the MODBUS-RTU application and can be configured via the MODBUS-RTU.

## 3. OBJECTIVES

MODBUS-RTU is an application layer communication protocol that provides client (**Smart***Scan*® 50) and server communication. The MODBUS-RTU communication capabilities enable users to monitor the **Smart***Scan*® 50 status using the standard MODBUS-RTU protocol.

## 4. SYSTEM DESCRIPTION

The following diagram describes the connection of **Smart***Scan*® 50 units (slaves) with the MODBUS-RTU application (master). The master can be either PC or PLC via RS485 physical layer multi drop connection.

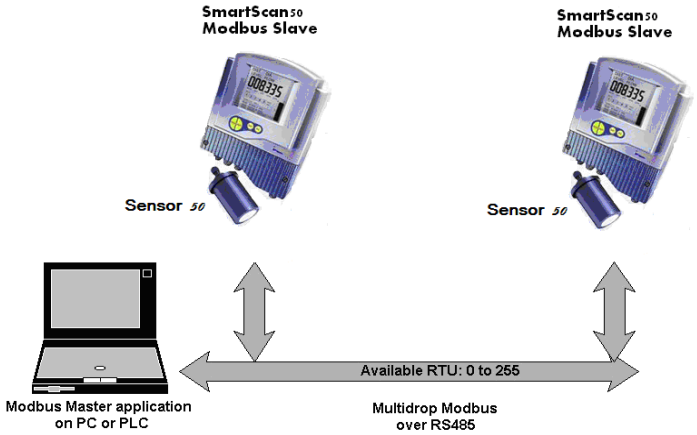


**Figure 1**

# 5. GENERAL CONFIGURATION

## 5.1 DATA TRANSFER

The PLC controller or the PC application acts as a master device and the **Smart***Scan*® 50 acts as a slave device.
The master and slave connect via RS485 or RS232 serial physical layer communication protocols.
The MODBUS-RTU protocol consists of master periodical requests and slave responses.

## 5.2 SERIAL PHYSICAL LAYER COMMUNICATION

The serial physical layer RS485 or RS232 settings must be configured on the **Smart***Scan*® 50 unit and in the master application.
The settings described in the table below are the default values of The **Smart***Scan*® 50.

| Communication port | RS 232 / RS 485 |
|---|---|
| Bound rate | 9600 bit/sec |
| Start bit | 1 |
| Data bit | 8 |
| Stop bit | 1 |
| Parity | None |

**Table 1**

## 5.3 MULTI-DROP CONNECTION

MODBUS-RTU supports multi-drop connection. The master device can control anywhere between 1-255 slaves. Each slave has its own address number. The **Smart***Scan*® 50 address can be defined by the user (distributor menu).
Multi-drop connection is an option only when communicating via RS-485.

**Note**: Address No. 3 is reserved and not recommended for use. Using this address may result in unpredictable behavior.

## 5.4 Smart*Scan*® 50 – Menu Configuration

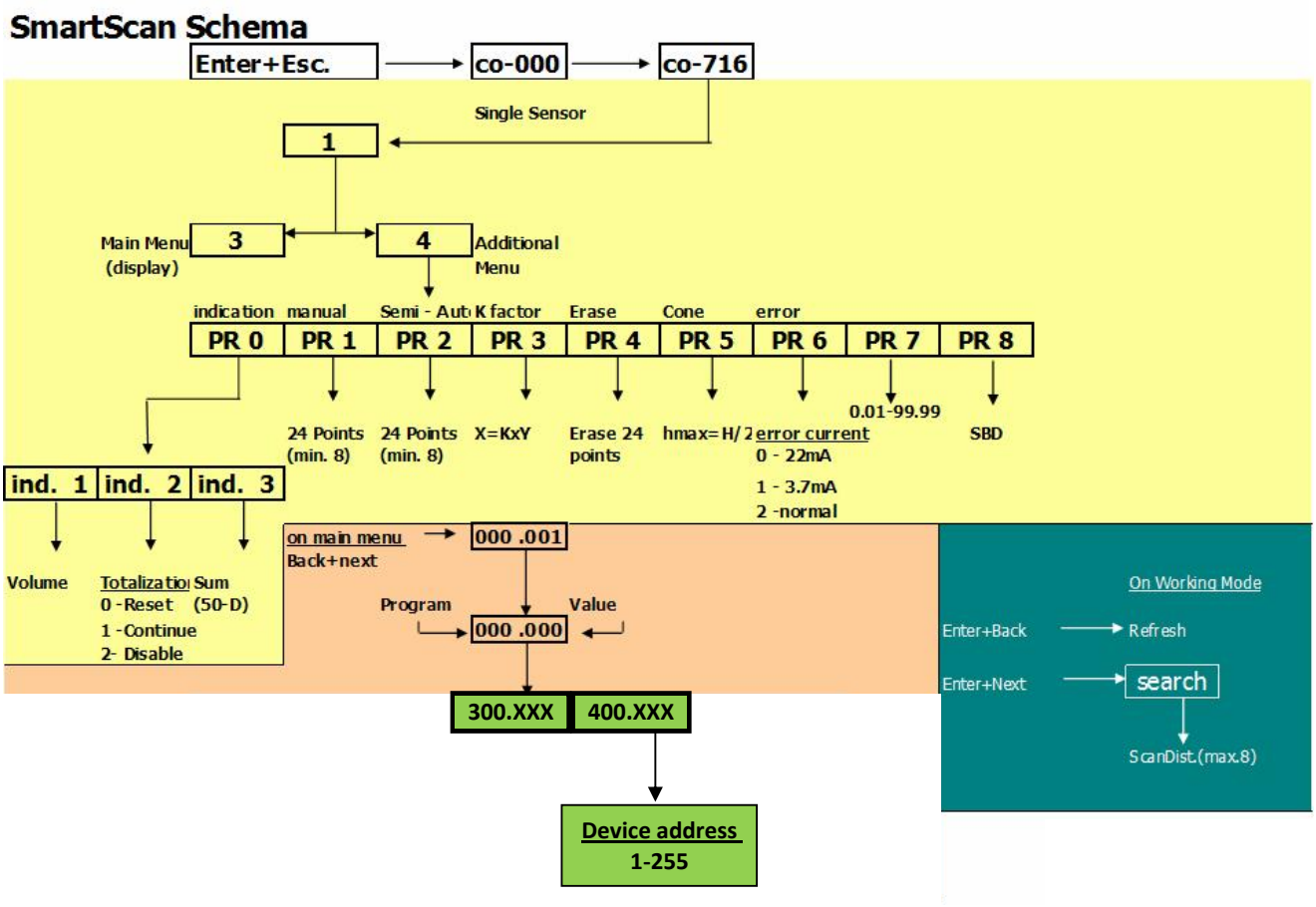


**Figure 2**

## 6. PARAMETERS CONFIGURATION

The following parameters can be configured via MODBUS-RTU:

| | Parameter | Read | Write |
|---|---|---|---|
| Static Parameters | Indication Mode | √ | √ |
| | Unit of Measurement | √ | √ |
| | Tank Height | √ | √ |
| | 4mA | √ | √ |
| | 20mA | √ | √ |
| | SBD | √ | √ |

**Table 2**

| | Parameter | Read only |
|---|---|---|
| Dynamic Parameters | Error status | √ |
| | Device Address | √ |
| | Distance | √ |
| | Level | √ |
| | Temperature | √ |
| | Relay status | √ |

**Table 3**

| | Parameter | Read only |
|---|---|---|
| Device Information | Communication type | √ |
| | SW Version | √ |

**Table 4**

## 6.1 MEASUREMENT UNITS

The User can configure the **Smart***Scan*® 50 with various measurement units (Meter/Inch/Feet/ M^3/h GPM).

| Param. / Unit | Flow | Distance, Level, Tank Height, Scan Distance | SBD | 4mA | 20mA |
|---|---|---|---|---|---|
| **Meter** | ----- | 1/1000 of meter (millimeters) | 1/1000 of Meter (millimeters) | 1/1000 of Meter (millimeters) | 1/1000 of Meter (millimeters) |
| **Inch** | ----- | 1 Inch (with round up to 0.5) | 1 Inch (with round up to 0.5) | 1 Inch (with round up to +/-0.5) | 1 Inch (with round up to +/-0.5) |
| **Feet** | ----- | 1/10 feet | 1/100 feet | 1/10 feet | 1/10 feet |
| **M^3/H** | 1/10 of M^3/H | ----- | ----- | 1 unit of M^3/H | 1 unit of M^3/H |
| **GPM** | 1/10 of GPM | ----- | ----- | 1 unit of GPM | 1 unit of GPM |

**Table 4**

**Note**: When setting Tank height, SBD and 4-20mA values must be entered in millimeters

# 7. MODBUS-RTU – SMART*SCAN*® 50 RESTRICTIONS

## 7.1 MULTIPLE PARAMETERS

The master unit can write only 1 static parameter per packet. Multiple parameters are not allowed.

## 7.2 SIMULTANEOUS WRITING

It is not possible to configure static parameters via the master device and **Smart***Scan*® 50 simultaneously.

## 7.3 WRITE REQUEST TIME

MODBUS-RTU 'write' request process can take up to 3 seconds. Do not check **Smart***Scan*® 50 parameters before the 'write' request process has been finished.

## 7.4 MULTI-DROP CONNECTION

It is strongly recommended not to use device address 3 with 'multi-drop' connection.

## 7.5 CONFIGURATION MODE

It is recommended to check that the **Smart***Scan*® 50 is in measurement mode prior to the MODBUS-RTU configuration. If **Smart***Scan*® 50 is not in measurement mode and the user is trying to change some parameters in the MODBUS-RTU protocol one of the following situations can occur:

- When the user is situated in the device menu but is not yet in configuration mode, the MODBUS-RTU command will automatically exit the menu and move to the measurement screen while the MODBUS-RTU communication continues.

- While trying to configure the MODBUS-RTU, the user might receive an error **"ERR_DEV_CONFIG_MODE"**. In this case, the user must change the **Smart***Scan*® 50 to measurement mode.

# APPENDIX A

## Design or Configuration of the Master Unit

The purpose of this appendix is to provide the necessary information for configuring an existing master unit, or designing a new one that will work successfully with **Smart***Scan*® 50.

## 1. MODBUS-RTU CONFIGURATION

### 1.1 MODBUS-RTU REGISTERS DESCRIPTION

The number of consecutive MODBUS-RTU registers that can be retrieved (in one Master request) is limited to 20 (a request with 21 registers would succeed but a report will be generated only for 20 registers.)

### 1.2 REGISTER GROUPS (HOLDING REGISTERS)

| | |
|---|---|
| Dynamic Parameters (holding registers): | 40001 – 40051 |
| Static Parameters (holding registers): | 40052 - 40067 |
| Device Info. Parameters (holding registers): | 40193 - 40202 |

## 2. MODBUS-RTU PROTOCOL DATA

### 2.1 DATA MODEL

All **Smart***Scan*® 50 static and dynamic parameters can be reached via holding registers data access. The **Smart***Scan*® 50 will display device parameters and can be configured with a single parameter or with a set of parameters.

**Reading Parameters:**

| Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 | Byte 7 |
|---|---|---|---|---|---|---|
| Dev. Address | Func. Code | Start Addr. | Start Addr. | Nreg | Nreg | CheckSum |
| 1-255 | 3 | 0 | 1-68 | 0 | 0 – 16 | |

**Table 5**

**Device Configuration (Single Register):**

| Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 | Byte 7 |
|---|---|---|---|---|---|---|
| Dev.addr | Func. Code | Start Addr. | Start Addr. | Reg Value | Reg Value | Check Sum |
| 1-255 | 6 | 0 | 52-68 | | | |

**Table 6**

### Device Configuration (Multiple Registers):

| Byte 1 | Byte 2 | Byte 3 | Byte 4 | Byte 5 | Byte 6 | Byte 7 | | |
|---|---|---|---|---|---|---|---|---|
| Dev.addr | Func. Code | Start Addr | Start Addr | Nreg | Nreg | NByte | Data | CheckSum |
| 1-255 | 16 | 0 | 52-68 | | | | | |

**Table 7**

| Func. Code | Rd/Wr Access | Func. Code Description | Functional Description |
|---|---|---|---|
| 3 | Read | Read Holding Registers | Read One or Set of Parameters |
| 6 | Write | Write Single Register | Configure Device with one parameter |
| 16 | Write | Write Multiple Registers | Configure Device with a set Of Parameters (Used for 4-20 mA configuration) |

**Table 8**

### Write Statistic Parameters Table:

| | Parameter | MODBUS-RTU Function Code | |
|---|---|---|---|
| Write Static Parameters | | Write Single Register | Write Multiple Registers |
| | Indication Mode | √ | |
| | Unit of Measurement | √ | |
| | Tank Height | √ | |
| | 4mA | | √ |
| | 20mA | | √ |
| | SBD | √ | |

**Table 9**

## 3. MEASUREMENT UNITS

| Parm. + Reg. / Unit | **Flow/Total.** 40007 + 40008 | **Dist:** 40002<br>**Level**: 40003<br>**Tank Height:** 40052<br>**Scan Dist Values:** 40060 – 40067 | **SBD**: 40058 | **4mA:** 40053 + 40054 | **20mA:** 40055 + 40056 |
|---|---|---|---|---|---|
| **Meter** | ----- | 1/1000 of meter (millimeters) | 1/1000 of Meter (millimeters) | 1/1000 of Meter (millimeters) | 1/1000 of Meter (millimeters) |
| **Inch** | ----- | 1 Inch (with round up to 0.5) | 1 Inch (with round up to 0.5) | 1 Inch (with round up to +/-0.5) | 1 Inch (with round up to +/-0.5) |
| **Feet** | ----- | 1/10 feet | 1/100 feet | 1/10 feet | 1/10 feet |
| **M^3/H** | 1/10 of M^3/H | ----- | ----- | 1 unit of M^3/H | 1 unit of M^3/H |
| **GPM** | 1/10 of GPM | ----- | ----- | 1 unit of GPM | 1 unit of GPM |

**Table 10**

*Maximum value for Totalization is 0xFFFFFFFF / 10

**Note**: When working in Flow mode with GPM units, tank height will appear in inches. When working in Flow mode with M^3/H units, tank height will appear in Meters.

# 4. DYNAMIC PARAMETERS 40001 – 40051

| Parameter | Relative address | Field description | Data size | Range |
|---|---|---|---|---|
| Device Address | 40001 | Device number - Can be set in the distributor menu (figure 2) | 16 bit unsigned | Valid device addresses are in the range of 1 to 247 decimals.<br>A message addressed to a nonexistent slave device will cause a timeout |
| Distance | 40002 | Distance from sensor to bottom of a Silo | 16 bit unsigned | 600 up to 12000 millimeter<br>23.6 up to 472.440 Inch<br>1.96 up to 39.370 feet |
| Level | 40003 | Level of the material:<br>e.g.:<br>Tank Height – Distance | 16 bit unsigned | 600 up to 12000 millimeter<br>23.6 up to 472.440 Inch<br>1.96 up to 39.370 feet |
| Temperature | 40004 | Temperature of the air near the sensor | 16 bit signed | -40 C to + 100<br><br>The Temperature is multiplied by 100. |
| Device Status bits | 40005 | See Appendix A, p. 4.1 | 16 bit unsigned | Device Status indicates a problem with the unit<br><br>1 – OK (MSB)<br>2 - Tank Full<br>4 - Tank Empty<br>8 – Noise |
| Relay Status | 40006 | | 16 bit unsigned | <br>Bit 0 - Relay's Status No.1<br>Bit 1 - Relay's Status No.2<br>Bit 2 - Relay's Status No.3<br>Bit 3 - Relay's Status No.4<br>Bit 4 - Relay's Status No.5<br><br>0 – close<br>1- open |

**Table 11**

| Parameter | Relative address | Field description | Data size | Range |
|---|---|---|---|---|
| General Measurement Purpose | 40007 LSB + 40008 MSB | General Purpose according to device Indication Mode which is configured by the user<br><br>Flow:<br>Calculated from the measurements. Refer to the flume/weir dimensions<br><br>Volume:<br>Calculated from the measurements based on tank characteristics<br><br>Totalization:<br>For flow mode.<br>The value is for accumulative flow, calculated from the point of entering the mode, and updates every 30 seconds | 32 bit unsigned<br><br>DATA HEX Representation | <br><br>0 up to 55500 m^3/hour<br>up to 244200 GPM<br><br>0 up to 0xFFFFFFFF / 10<br>**The Dynamic Volume is multiplied by 10.<br><br>0 up to 0xFFFFFFFF / 10 m^3/hour<br>0 up to 0xFFFFFFFF / 10 GPM |
| N/A | 40009-40051 | Not in use | | |

**Table 12**

** Dynamic Volume value (registers 40007 + 40008) presented as a calculated value multiplied by 10.

## 4.1 DEVICE STATUS REGISTER

When an error (Empty, Full, Noise) appears in register **40005**, all other errors in dynamic parameters must be ignored.

| LSB | | | Status and Error bit register | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Bit 0** | **Bit 1** | **Bit 2** | **Bit 3** | **Bit 4** | **Bit 5** | **Bit 6** | **Bit 7** | **Bit 8** | **Bit 9** |
| Device Status | Device Status | Device Status | Device Status | Device Status | Device Status | ---- | ---- | ---- | ---- |
| OK | Tank Full | Tank Empty | Noise | No Table | Device In Configuration Mode | N/A | N/A | N/A | N/A |

**Table 13**

| Status and Error bits register | | | | | | MSB |
|---|---|---|---|---|---|---|
| **Bit 10** | **Bit 11** | **Bit 12** | **Bit 13** | **Bit 14** | **Bit 15** | ----- |
| N/A | N/A | N/A | N/A | N/A | N/A | ----- |

**Table 14**

Statuses:

**Bit 0** – **OK**. Device is working properly without a problem.
**Bit 1** - **Tank Full**
**Bit 2** - **Tank Empty**
**Bit 3** – **Noise**. The unit has identified acoustic noise. Measurement may be erroneous or impossible. AUTO icon appears on the LCD.
**Bit 4 - No Table**. (Empty Strapping Table)
**Bit 5** - Device status is in configuration mode menu

## 5. STATIC PARAMETERS 40052 – 40127

The table below describes the **'write'** parameters for **Smart***Scan*® 50.

| Parameter | Relative address | Field description | Data size | Range |
|---|---|---|---|---|
| Tank Height | 40052 | Distance from sensor to the Silo's bottom. | 16 bit unsigned | Distance measurement<br>600 up to 12000 millimeter<br>23.6 up to 472.440 Inch<br>1.96 up to 39.370 feet |
| Level for 4mA | 40053 LSB + 40054 MSB | Level according to 4mA | 32 bit unsigned<br><br>DATA HEX Representation | Distance measurement:<br>0 up to 12000 millimeter<br>0 up to 472.440 Inch<br>0 up to 39.370 feet<br><br>Flow:<br>0 up to 55500 m^3/hour<br>0 up to 244200 GPM<br><br>Volume and Totalization:<br>0 up to 999999999 m^3/hour<br>0 up to 999999999 GPM |
| Level for 20mA | 40055 LSB + 40056 MSB | **Level according to 20mA** | 32 bit unsigned<br><br>DATA HEX Representation | Distance measurement:<br>0 up to 12000 millimeter<br>0 up to 472.440 Inch<br>0 up to 39.370 feet<br><br>Flow:<br>0 up to 55500 m^3/hour<br>0 up to 244200 GPM<br><br>Volume and Totalization:<br>0 up to 999999999 m^3/hour<br>0 up to 999999999 GPM |

| Parameter | Relative address | Field description | Data size | Range |
|---|---|---|---|---|
| Mode Indication | 40057 | **DIST**: (Default setting) Distance from the sensor to the tank surface of the application<br><br>**LEVEL**:<br>Height of the application measured from the bottom of the tank<br><br>**FLOW**:<br>Flow according to the Flume Type<br><br>**VOLUME**:<br>Calculated from the measurements based on tank characteristics<br><br>**Totalization**:<br>For flow the accumulative flow calculated from the point of entering the mode and updates every 30 seconds. | 16 bit unsigned | 0 - Displays the distance from the sensor to the surface of the application.<br>1 - Displays the level of the application from the bottom of the tank<br>3 - Flow<br>5 - Totalization<br>6 - Volume |
| Shift Blocking Distance | 40058 | Ignores short range echoes | 16 bit unsigned | Distance measurement<br>0 up to 1500 millimeter<br>0 up to 59 Inch<br>0 up to 4.92 feet |
| Measurement units | 40059 | | 16 bit unsigned | 0-METER<br>1-INCH<br>2-FEET<br>3-M3/HR<br>4- G.P.M |
| N. 1-8 Passive Interference Echo * | 40060<br>40067 | Passive interferences echoes if found after 'Scan Distance' function. | 16 bit unsigned | From 0 up to Tank Height According to the required measurement unit |
| N/A | 40068-400127 | | | |

**Table 15**

**Note**: ***During the 'Scan Distance' process, there is a loss of communication to the COP chip. Do not configure static parameters before the 'Scan Distance' process has been finished.

## 6. DEVICE INFORMATION PARAMETERS 40193 – 40202

| Parameter | Relative address | Field description | Data size | Range |
|---|---|---|---|---|
| Comm.-Type | 40193 | Communication Type (RS-485/ 232) | 16 bit unsigned | 0 – RS 485<br>1 – RS 232 |
| CoPro | 40194 | Software Revision of coprocessor | 16 bit unsigned | |
| MainPro | 40195 | Software Revision of main processor | 16 bit unsigned | |
| LcdProcessor | 40196 | Software Revision of LCD processor | 16 bit unsigned | |
| HwRevision | 40197 | Hw Revision of Smart Scan | 16 bit unsigned | |
| N/A | 40198-40202 | | | |

**Table 16**

## 7. EXCEPTION RESPONSES

When a client device sends a request to a server device, it expects a normal response. 1 of 5 possible options can occur from the master's query:

1) If the server device receives the request without a communication error and can handle the query, it returns a **normal response**.

2) If the server does not receive the request due to a communication error, no response is returned. The client program will process a timeout condition for the request.

3) If the server receives the request, but detects a communication error (parity, LRC, CRC), no response is returned. The client program will process a timeout condition for the request.

4) If the server receives a request without communication error and takes a long time to process it, the returned response will prevent a timeout error to occur in the master. **This response is a STANDART normal response for all 'Write' commands**.

| Code | NAME | Meaning |
|---|---|---|
| 5 | ACKNOWLEDGE | **normal response** for SMART50 |

**Table 17**

5) If the server receives the request without a communication error and cannot handle it (for example, if the request is to read a non–existent register), the server will return an exception response and inform the client of the nature of the error.

The following exception responses are available in **Smart***Scan*® 50:

| Code | Name | Meaning |
|---|---|---|
| 1 | ILLEGAL FUNCTION | Only Functions 3, 6, 16 (see 2.1) are applicable to **Smart***Scan*® 50 |
| 2 | ILLEGAL DATA ADDRESS | The data address received in the query is not an acceptable address (see sections 5 and 6). This means that the received register has a value outside the expectation of the application program. |
| 3 | ILLEGAL DATA VALUE | A value contained in the query data field is not an acceptable value for the **Smart***Scan*® 50 application |
| 12 | ERR_DEV_CONFIG_MODE | The **Smart***Scan*® 50 is in the middle of a local configuration when the MODBUS-RTU server attempted to write a message to the device. In this case, the user must change the **Smart***Scan*® 50 to measurement mode |

**Table 18**