AN045
Z-Tool™

By B.Selvig

Keywords

- *Z-Tool™*
- *Z-Script™*
- *CC2420DB*
- *CC2430DB*
- *SmartRF04EB*
- *ZigBee*

Introduction

This application note describes the Z-Tool application, and how this tool can be used during development and debugging of ZigBee applications. Z-Tool replaces Z-Trace, and for users already familiar with the latter tool most of this document also applies to Z-Trace. The difference between Z-Tool and Z-Trace is that Z-Tool also has support for scripting.

Z-Tool can be used to communicate with a Z-Stack™ target device and provides debug information via the serial port interface on the target. From Z-Tool different kinds of commands can be issued to the target, and responses to the commands from the target can be viewed. The different types of commands are System commands, MAC interface, NWK interface, ZDO interface and User Test commands. The target can be reset from Z-Tool, and memory commands allow the tester to read and write memory locations on the target RAM and Non-Volatile memory. Z-Tool can also subscribe to callbacks at the target and write out the callback information when the callback event happens.

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1 Abbreviations

The following abbreviations are used in this document:

AF	Application Framework
APS	Application Support Sublayer
DB	Development board
EB	Evaluation Board
EM	Evaluation Module
IEEE	Institute of Electrical and Electronics Engineers
MAC	Medium Access Control (layer)
MT	Monitor Test
NV	Non Volatile (memory)
NWK	Network (layer)
PAN	Personal Area Network
PHY	Physical (layer)
RAM	Random Access Memory
SPI	Serial Peripheral Interface
ZDO	ZigBee Device Object

2 Requirements

Z-Tool is designed for installation on a personal computer running Microsoft Windows. The following are the minimum software requirements for using Z-Tool:

1. Windows XP Service Pack 1 (or newer)
2. Windows 2000 Professional Service Pack 4 (or newer)
3. Microsoft .NET 1.1 Framework
4. At least 1 open communication port (serial or USB) for Z-Tool communication to the target development board.

The development boards (DB) and the necessary cabling are included with the respective ZigBee development kit. The target development board should be connected to the computer using an RS-232 cable. The next section will provide information on how to connect Z-Tool to the various development boards.

3 Quick Start

Follow these steps to set up communication between Z-Tool and the target board. Note that there are different versions of IAR for the different hardware platforms. The screen images may look slightly different for the different IAR versions:

1. Program the target board. To set the compile options for the project open the *Project->Options* menu in IAR embedded Workbench. The compile options can be found under *C/C++ Compiler* and the *Preprocessor* button. The *Defined symbols* list box lists the included compile options. Make sure that the MT_TASK option is included for using Z-Tool. MT_TASK enables a monitor test task in the application code which sets up the communication.

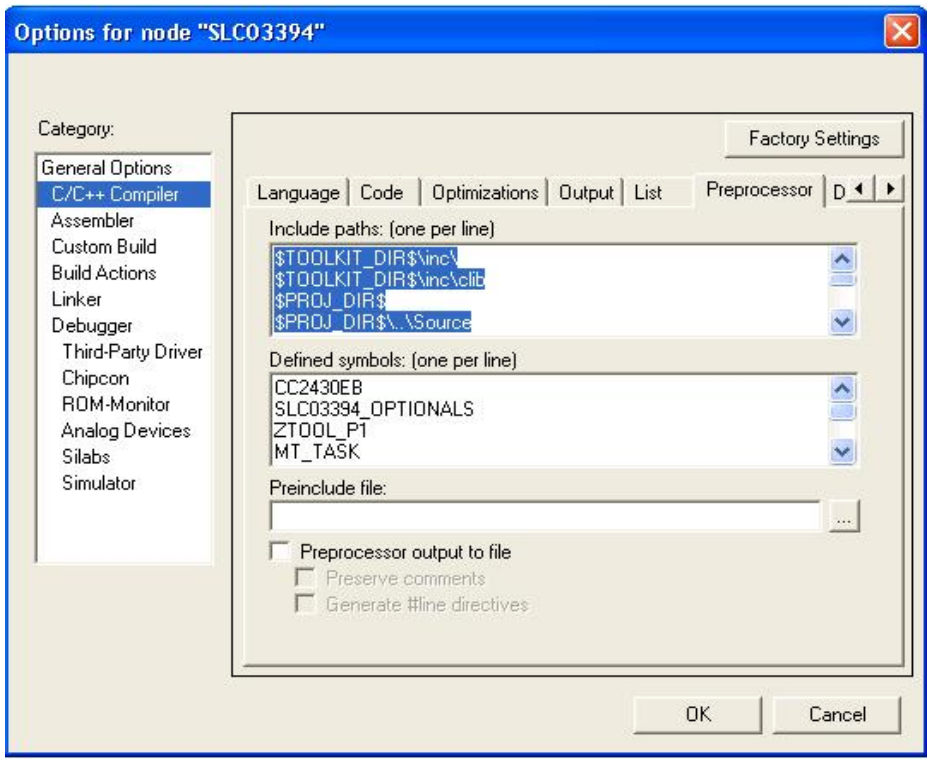

Figure 1 Compile options in IAR embedded workbench

2. Connect a serial cable between the target board and your PC. If you are using CC2420DB see section 3.1, or section 3.2 if you are using CC2430DB.
3. Open the Z-Tool application
4. A successful connection between Z-Tool and the target board results in the following message box being shown:

5. If the communication is not successful the following message box will appear:

In this case check the communication settings by choosing the *settings* menu and the *Communication* tab. These settings should be the same as shown in figure 2. The RS-232 communication uses no parity, 8 data bits and 1 stop bit for each byte. The transmission rate (baud rate) used is 38.4 Kbps. Check also that the right COM port is activated. COM1 is shown is this dialog box. Make sure to set *Active Port* to the connected COM port on your system. If a USB to Serial converter is used, check which COM port is activated with Windows Device Manager.

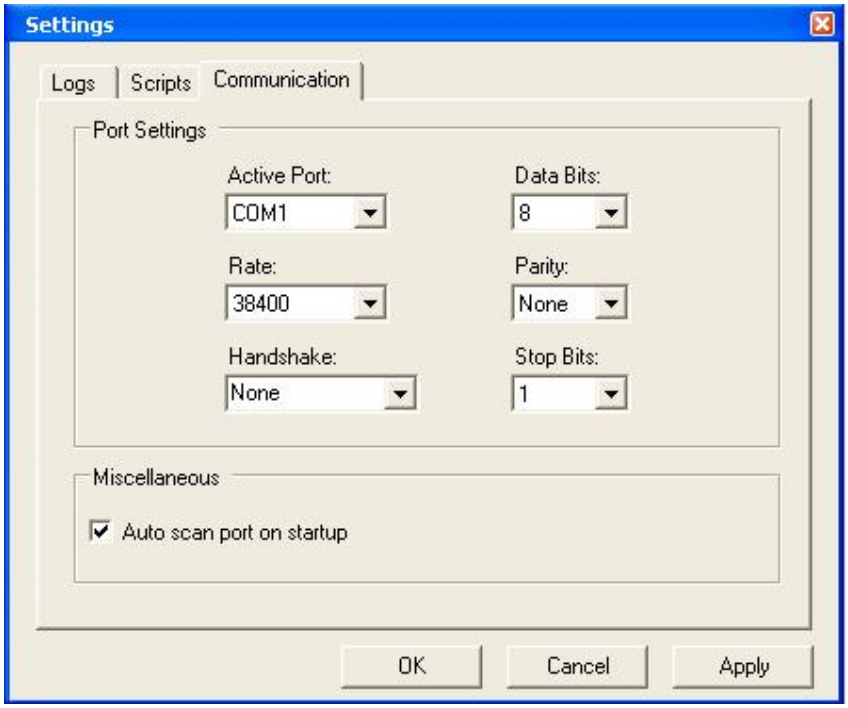

Figure 2 Communication settings

3.1 Z-Tool with CC2420DB

The CC2420DB board has a serial connector integrated on the board. Connect a serial cable directly between the PC and the CC2420DB target board.

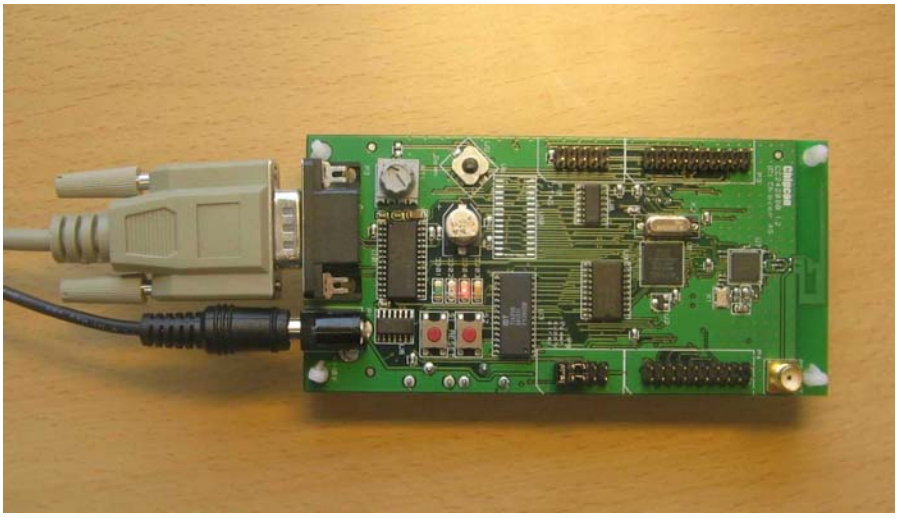

Figure 3 CC2420DB connected to a PC via serial cable

3.2 Z-Tool with CC2430DB

This section describes how to use Z-Tool with CC2430DB as target board. The CC2430DB does not have any RS-232 serial connector so it has to be connected via a SmartRF04EB board. The header pins P6 on the CC2430DB should be connected to header pins P10 on SmartRF04EB. Please see Figure 4 and Table 1 for details.

Follow these instructions for using Z-Tool with CC2430DB:

1. Connect a serial cable from SmartRF04EB to the PC.
2. Connect header pins P6 on CC2430DB to header pins P10 on SmartRF04EB according to table 1.
3. Place a jumper to connect pin 7 with pin 9 on header pins P301 on SmartRF04EB
4. Make sure the power button S3 on CC2430DB is placed in position “USB”, also when powered from an adapter.

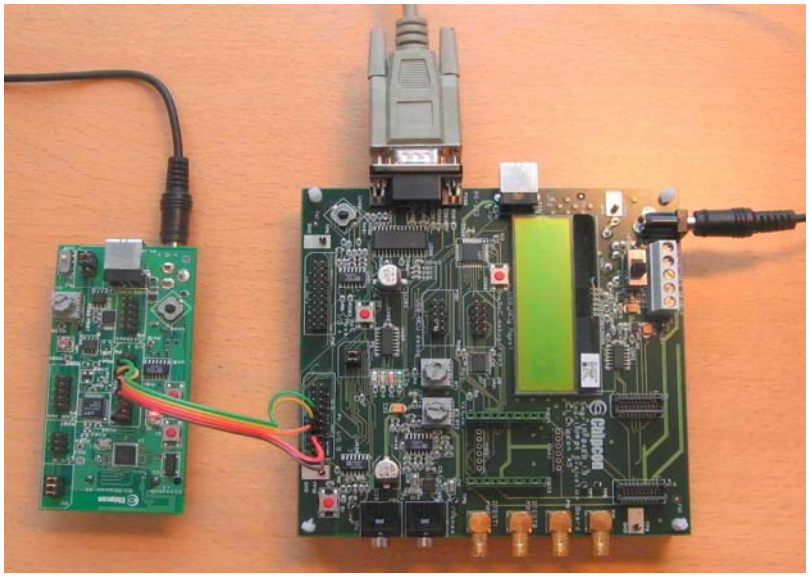

Figure 4 CC2430 connected via the SmartRF04EB board

Signal name	SmartRF04EB	CC2430DB
UART RD	P10.9	P6.6
UART TD	P10.11	P6.8
UART RTS	P10.13	P6.10
UART CTS	P10.15	P6.12
GND	P10.20	P6.20

Table 1 Pin connection between SmartRF04EB and CC2430DB

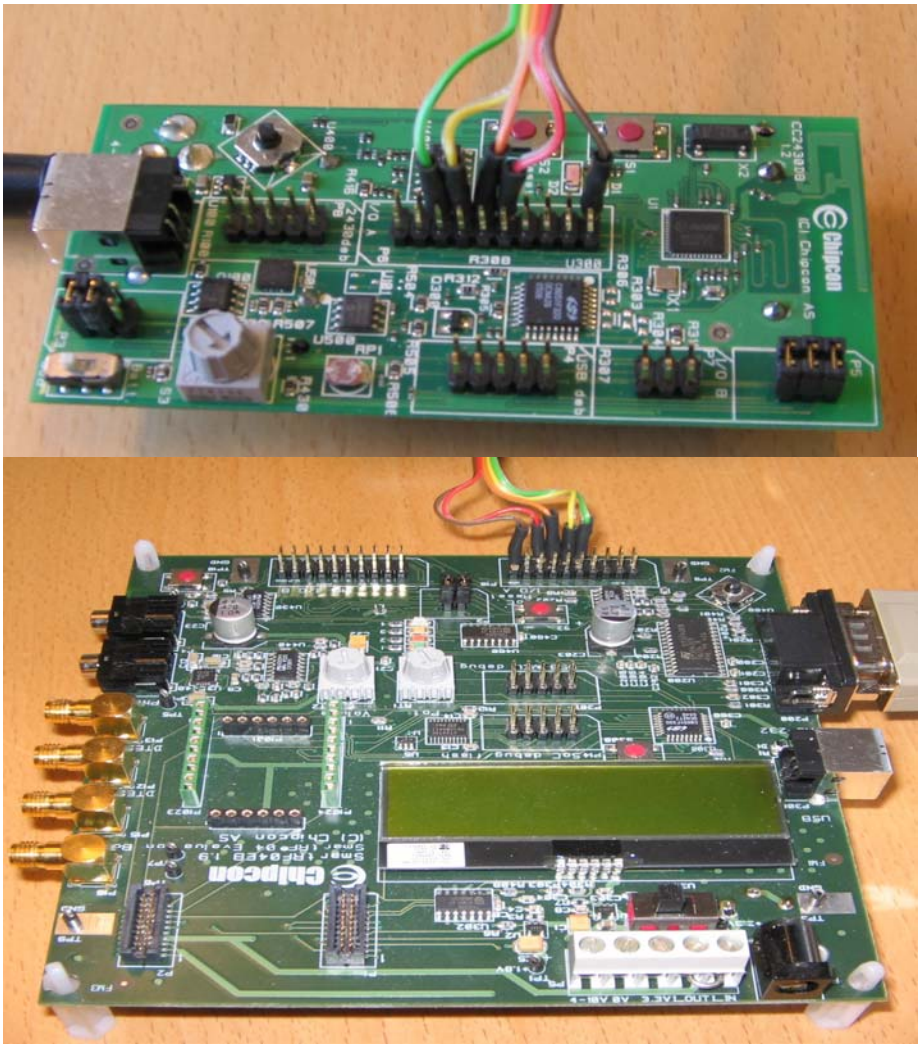

Figure 4 Pin connections

3.3 Z-Tool with CC2430EM

1. Connect the CC2430EM board to the SmartRF04EB board.
2. Connect a serial cable between SmartRF04EB and the PC.
3. Z-Tool should now be able to successfully detect the CC2430EM board.

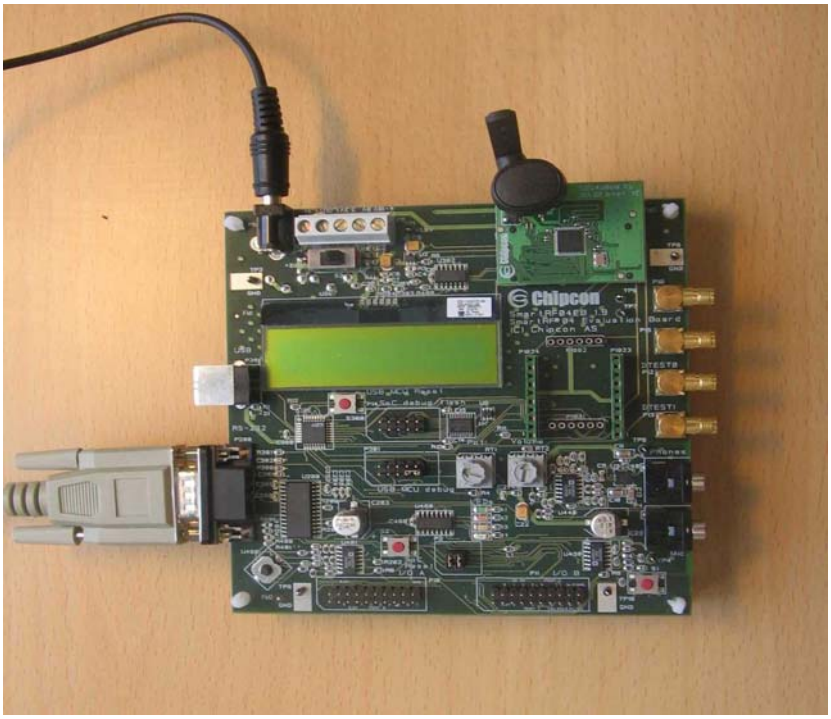

Figure 5 CC2430EM mounted on a SmartRF04EB

4 Z-Tool overview

4.1 Monitor Test

The Z-Stack monitor and test functionality enables the user application to send debug-messages from the code, which can be seen in the Z-Tool window. The debug message functionality is available in the DebugTrace.h file. In order for this functionality to be available the MT_TASK compile options have to be set in the downloaded code. See section 3 for how to set the compile options with IAR embedded workbench.

Use the *debug_str*("display this") to send a null-terminated string from within your application. This string will appear in the Z-Tool window. This functionality can be useful for watching real-time program flow.

The function _ltoa() (defined in osal.c) can be used to send values with debug_str(). This function can be used as follows in the application code:

```
unsigned char buf[8]
_ltoa((unsigned long)ValueToConvert, &buf[0],10);
debug_str(buf);
```

Refer to DebugTrace.h for definition of the available debug functions.

4.1.1 LCD support

If the target has a LCD display, which is the case when using the CC2430EM board mounted on to a SmartRF04EB, you can use the LCD functions to write to the LCD display. The downloaded code then has to be compiled with the LCD_SUPPORTED compile option. Note that if the code is compiled with LCD_SUPPORTED=DEBUG the debug text will be written to the LCD display only.

4.2 Z-Tool Commands

There are several categories of commands to be issued from Z-Tool:

- System commands: RAM read/write, Debug, Trace etc.
- MAC Interface commands
- NWK Interface Commands
- PHY Interface Commands
- SPI Interface Commands
- Sequence Interface Commands
- APS Interface Commands
- AF Interface Commands
- ZDO Interface Commands
- Device Interface Commands

Each command has a specific command number and command type specified in Serial Port Interface_F8W-2003-0001.pdf document [1] (Note: This document is integrated with the Z-Stack distribution). See also this document for a description of each of the commands.

4.2.1 Get/Set IEEE extended address

The command SYS_SET_EXTENDED_ADDRESS is used to set the 64 bits IEEE address in the target. SYS_GET_EXTENDED_ADDRESS reads this address from the target.

4.2.2 Read/Write Non-Volatile Memory

The command SYS_SET_NV is used for writing a user defined value from Z-Tool to Non-Volatile memory. Non-Volatile memory can be read with the command SYS_GET_NV.

Please also refer to section 10 in the OS Abstraction Layer API document [2] for a description of the Non-Volatile Memory API in Z-Stack (Note: This document is part of the Z-Stack package).

4.2.3 System commands

SYS_PING is used to ping the target board to check the connection.
SYS_RESET resets the board.
SYS_APP_MSG: This command is used to send a user message to a specific endpoint.
SYS_KEY_EVENT: Sends a key event message to the target e.g. to emulate a key press at the target.
SYS_GET_TIME_ALIVE: Gets time in seconds since last reset.

4.3 Message structure

The Z-Tool commands contain the following fields:

- SOP (Start of Packet): This is a one byte field with the value 0x01
- CMD (Command ID): This is a two byte field with a value denoting the Command Identification (ID) for this message.
- LEN (Length): This is a one byte field with value equal to the number of bytes in the Data field.
- Data: This is a variable length field containing the actual data to be transmitted.
- FCS (Frame check sequence): This is a one byte field with the purpose of ensuring packet integrity.

Figure 6 Z-tool message format

Multi-byte fields are transmitted most significant byte first (MSB). The specific command IDs for each command type are defined in the Serial Port Interface_F8W-2003-0001.pdf document [1].

4.4 Callbacks

The tester can subscribe to or unsubscribe from specific callbacks from the target. The callbacks are asynchronous messages from the target. The command SYS_CALLBACK_SUBSCRIBE is used to specify which callbacks to subscribe to or unsubscribe from. A value of 0xFFFF indicates all callbacks. Action is a 1 byte field used to indicate whether to subscribe or unsubscribe (0 – unsubscribe, 1 – subscribe).

See the Serial Port Interface document [1] and section 3.6 for a complete list of callback command IDs. Remember to include the right compile options for the different callbacks to be used (see section 4.5).

4.4.1 Subscribe to all callbacks

Click the *SYS*_CALLBACK_SUBSCRIBE command under the *System* folder. Set *commandID* to 0xFFFF and Action to 1. Right click on SYS_CALLBACK_SUBSCRIBE again, and *Send Message*. For unsubscribing all callbacks send the same message with Action = 0. Please refer to Figure 7.

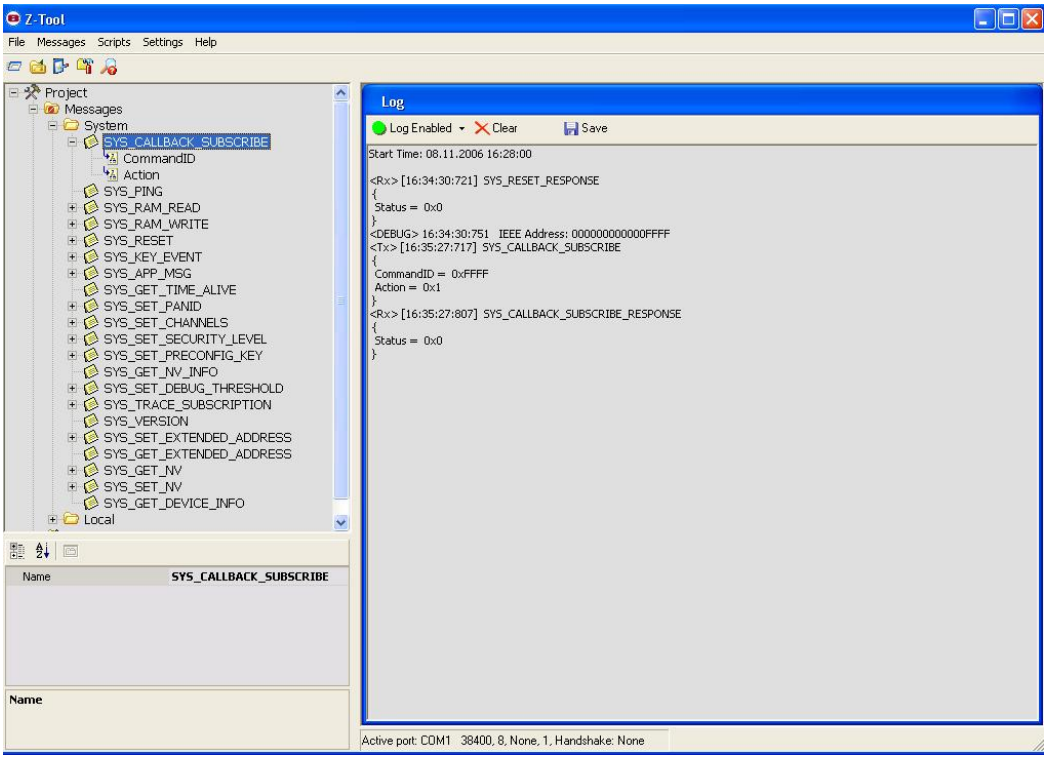

Figure 7 Subscribe to all callbacks

4.4.2 Individual callbacks, ZDO IEEE address response callback

It is also possible to subscribe to individual callbacks, for example the ZDO IEEE response callback. This callback can be used to identify the devices that are attached to each other in the PAN. Subscribe to the ZDO_IEEEADDRESS_RESPONSE_CB (*commandID* 0x0A81). Then send a ZDO_IEEEADDRESS_REQUEST with the *ShortAddress* set to 0, Type set to 1, *StartIndex* set to 0 and *SecuritySuite* set to 0. This command is found in the ZDO folder. The response (figure 8) shows that the coordinator has one device attached to it with ShortAddress of 0x0001. The ZDO_IEEEADDRESS_REQUEST command can now be sent with *ShortAddress* of 0x0001 to identify which devices are attached to the device with ShortAddress 0x0001. This method can be used to reveal the whole network structure.

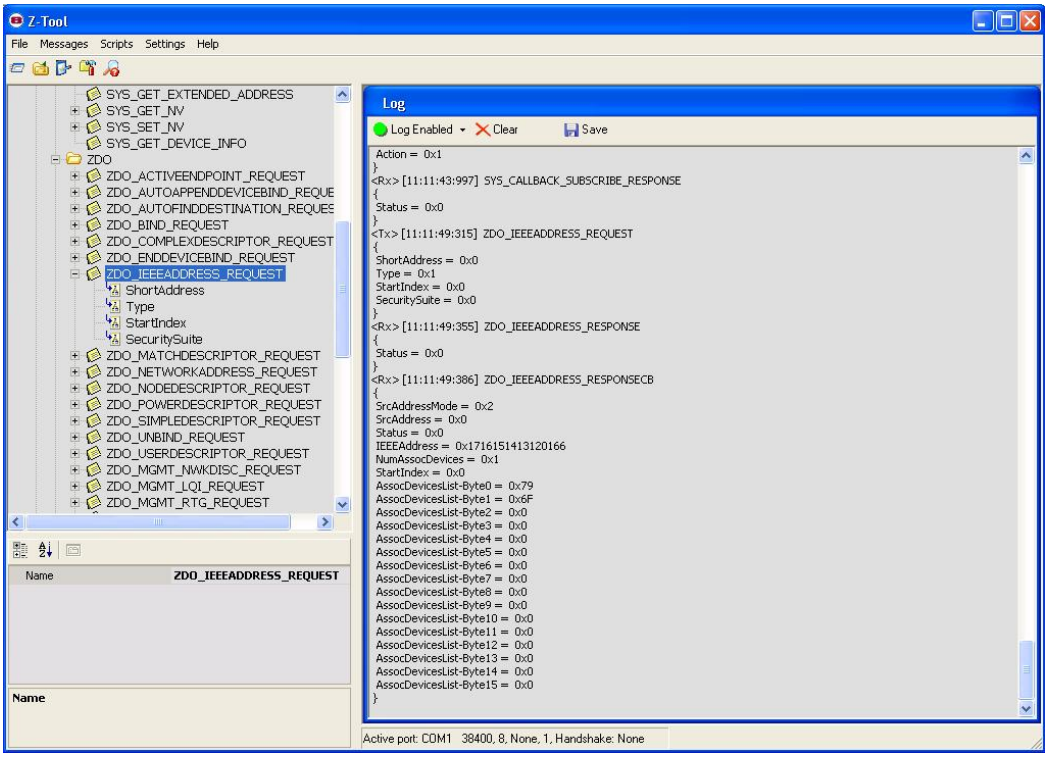

Figure 8 ZDO_IEEEADDRESS_RESPONSECB

4.5 Compile options

The different message folders in Z-Tool are enabled by compiling the target code with different compile options. See section 3 *Quick start* for how to enable compile options in IAR Embedded workbench. The MT_TASK option must be included in order to communicate with Z-Tool. Table 2 shows the other compile options that can be defined.

Table 2 Compile options

MT_TASK	Enable Monitor-Test task and debug functionality. This must be set for using Z-Tool
MT_AF_FUNC	Enable Monitor-Test processing of AF commands issued from Z-Tool.
MT_AF_CB_FUNC	Enable Monitor-Test processing of AF callbacks issued from Z-Tool.
MT_MAC_FUNC	Enable Monitor-Test processing of MAC commands issued from Z-Tool
MT_MAC_CB_FUNC	Enable Monitor-Test processing of MAC callbacks issued from Z-Tool
MT_NWK_FUNC	Enable Monitor-Test processing of NWK commands issued from Z-Tool
MT_NWK_CB_FUNC	Enable Monitor-Test processing of NWK callbacks issued from Z-Tool
MT_ZDO_FUNC	Enable Monitor-Test processing of ZDO commands issued from Z-Tool
MT_ZDO_MGMT	Enable Monitor-Test processing of ZDO MGMT commands issued from Z-Tool
MT_USER_TEST_FUNC	Enable Monitor-Test processing of User commands issued from Z-Tool
MT_SEQ	Enable Monitor-Test command sequences to be used.

4.6 CommandIDs for callbacks

Table 3 ZDO callbacks

ZDO Callback	CommandID
SPI_CB_ZDO_NWK_ADDR_RSP	0x0A80
SPI_CB_ZDO_IEEE_ADDR_RSP	0x0A81
SPI_CB_ZDO_NODE_DESC_RSP	0x0A82
SPI_CB_ZDO_POWER_DESC_RSP	0x0A83
SPI_CB_ZDO_SIMPLE_DESC_RSP	0x0A84
SPI_CB_ZDO_ACTIVE_EPINT_RSP	0x0A85
SPI_CB_ZDO_MATCH_DESC_RSP	0x0A86
SPI_CB_ZDO_END_DEVICE_BIND_RSP	0x0A87
SPI_CB_ZDO_BIND_RSP	0x0A88
SPI_CB_ZDO_UNBIND_RSP	0x0A89
SPI_CB_ZDO_MGMT_NWKDISC_RSP	0x0A8A
SPI_CB_ZDO_MGMT_LQI_RSP	0x0A8B
SPI_CB_ZDO_MGMT_RTG_RSP	0x0A8C
SPI_CB_ZDO_MGMT_BIND_RSP	0x0A8D
SPI_CB_ZDO_MGMT_DIRECT_JOIN_RSP	0x0A8E
SPI_CB_ZDO_USER_DESC_RSP	0x0A8F

Table 4 MAC callbacks

MAC Callback	CommandID
SPI_CB_NWK_SYNC_LOSS_IND	0x2080
SPI_CB_NWK_ASSOCIATE_IND	0x2081
SPI_CB_NWK_ASSOCIATE_CNF	0x2082
SPI_CB_NWK_BEACON_NOTIFY_IND	0x2083
SPI_CB_NWK_DATA_CNF	0x2084
SPI_CB_NWK_DATA_IND	0x2085
SPI_CB_NWK_DISASSOCIATE_IND	0x2086
SPI_CB_NWK_DISASSOCIATE_CNF	0x2087
SPI_CB_NWK_GTS_CNF	0x2088
SPI_CB_NWK_GTS_IND	0x2089
SPI_CB_NWK_ORPHAN_IND	0x208A
SPI_CB_NWK_POLL_CNF	0x208B
SPI_CB_NWK_SCAN_CNF	0x208C
SPI_CB_NWK_SECURITY_ERR_IND	0x208D
SPI_CB_NWK_START_CNF	0x208E

Table 5 NWK callbacks

NWK Callback	CommandID
SPI_CB_NLDE_DATA_CNF	0x0180
SPI_CB_NLDE_DATA_IND	0x0181
SPI_CB_NLME_INITCOORD_CNF	0x0182
SPI_CB_NLME_JOIN_CNF	0x0183
SPI_CB_NLME_JOIN_IND	0x0184
SPI_CB_NLME_LEAVE_CNF	0x0185
SPI_CB_NLME_LEAVE_IND	0x0186
SPI_CB_NLME_SYNC_IND	0x0189
SPI_CB_NLME_PING_CNF	0x018C
SPI_CB_NLME_NWK_DISC_CNF	0x018D
SPI_CB_NLME_START_ROUTER_CNF	0x018F

Table 6 SYS callbacks

SYS Callback	CommandID
SYS_RESET_RESPONSE	0x1005
SYS_CALLBACK_SUBSCRIBE_RESPONSE	0x1006
SYS_PING_RESPONSE	0x1007
SYS_GET_DEVICE_INFO_RESPONSE	0x1014
SYS_KEY_EVENT_RESPONSE	0x1016
SYS_APP_MESSAGE_RESPONSE	0x1018
SYS_LED_CONTROL_RESPONSE	0x1019

5 Z-Script

Z-Tool supports automated testing by use of scripting. The scripting engine called Z-Script are based on Jscript .NET.

To load a script press *Scripts* -> *Load* in the Z-Tool window:

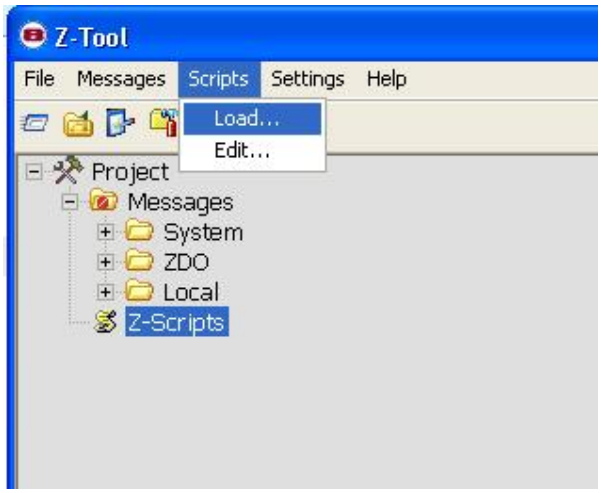

Figure 9 Load script

This window will appear when the script is loaded. Press *Compile* and then *Run*:

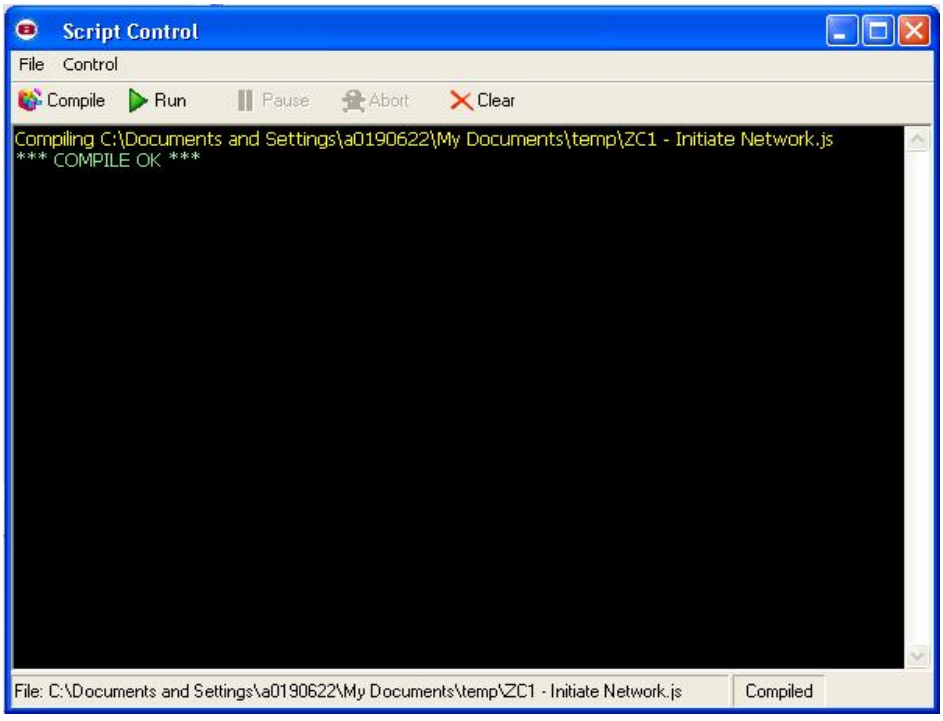

Figure 10 Compile and run Z-Script

Please see the document “Z-script API Guide” for more information how to use Z-script and to how to write scripts to use with Z-Tool [3].

6 References

[1] Serial Port Interface_F8W-2003-0001.pdf. This document is found in this folder in the default installation: C:\Texas Instruments\ CC-1.0-1.4.0\Documents\Serial Port Interface.

[2] OS Abstraction Layer Application Programming Interface, OSAL API_F8W-2003-0002_.pdf. This document is found in this folder in the default Z-Stack installation: C:\Texas Instruments\ CC-1.0-1.4.0\Documents\OS Abstraction Layer

[3] Z-Script API Guide. This document is found in C:\Texas Instruments\CC-1.4.0-Beta-2\Tools\Z-Tool\Documentation

7 Document History

Revision	Date	Description/Changes
1.0	2006-12-07	Initial release.

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