Instruction

Z-Wave 500 Series Appl. Programmers Guide v6.51.03

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3	20131010	PSH JFR	4.7 4.1	Added note to ZW_Store** functions about reset. Updated details about external NVM
3	20131104	JSI	4.3.2.3	Updated ZW_GetRandomWord description.
3	20131111	PSH	4.3.2.20 & 4.3.2.21	Added ZW_GetTxTimer() and ZW_ClearTxTimers() API calls
3	20131202	JSI	4.4.10 4.4.11	Updated ZW_GetLastWorkingRoute description with added parameter Added ZW_SetLastWorkingRoute description
3	20131209	MVO	4.3.11.15, 4.3.11.19, 4.3.11.36, 4.3.11.40, 4.3.13.26, and 4.3.13.30 4.3.13.32 4.3.15.4 , 4.3.15.6, 4.3.15.7, 4.3.15.8, and 4.3.15.9 4.3.13.22 and 4.3.13.23 All 4.3.6.3	Changed type of pointers from BYTE to XBYTE Added section describing ZW_UARTx_rx_dma_byte_count_enable() Added missing AES functions Added missing UART functions Renamed "Single Chip" to "SoC" Added missing IOS function
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4	20131217	JFR JSI	4.3.3.7 & 4.3.3.8	Added ZW_LockRoute
4	20140107	JFR	4.3.8	Offset clarified wrt. using far variables.
4	20140120	JFR	-	Application note regarding inclusion/exclusion implementation removed. Refer to [4] regarding details about this subject.
4	20140121	PSH	4.4.28	Added serialAPI interface to ZW_SetRoutingMAX()
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4	20140225	JSI	4.8.2 4.9.5	Added NOTE regarding asynchronous include complete callbacks Updated ZW_RequestNodeInfo description
4	20140228	JBU	4.8.2	OK to process broadcasts during inclusion, but do not transmit.
4	20140228	JBU	4.3.3.1.4 and 4.9.3	Fixed TRANSMIT_OPTION_EXPLORE spelling.
5	20140423	JSI	4.3.8.8, 4.3.8.10, 4.3.8.11, 4.3.8.12 and 4.3.8.13	Added NVM_get_id() and added SerialAPI usage descriptions.
5	20140514	PSH	4.3.8.9	Added description of the ZW_NVRGetValue() API call
6	20140605	JFR	4.3.1.6	Clarified SerialAPI_ApplicationNodeInformation usage.
6	20140714	JSI SSE JFR	4.3.4 4.3.10.1	Added ZW_firmwareUpdate_NVM API descriptions Clarified description when using EXT1 I/O as external wake up source for a FLiRS node.

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1 ABBREVIATIONS

Abbreviation	Explanation
ACK	Acknowledge
AES	The Advanced Encryption Standard is a symmetric block cipher algorithm. The AES is a NIST-standard cryptographic cipher that uses a block length of 128 bits and key lengths of 128, 192 or 256 bits. Officially replacing the Triple DES method in 2001, AES uses the Rijndael algorithm developed by Joan Daemen and Vincent Rijmen of Belgium.
ANZ	Australia/New Zealand
AODV	Ad hoc On-Demand Distance Vector (AODV) Routing.
API	Application Programming Interface
ASIC	Application Specific Integrated Circuit
CR	Carriage Return, move the position of the cursor to the first position on the same line.
DLL	Dynamic Link Library
DUT	Device Under Test
ECB	Electronic CookBook (block cipher mode)
ERTT	Enhanced Reliability Test tool
EU	Europe
FET	Field-Effect Transistor
FLiRS	Frequently Listening Routing Slave. Communication to a FLiRS node can be established by a wakeup beam.
GNU	An organization devoted to the creation and support of Open Source software
HK	Hong Kong
HW	Hardware
IGBT	Insulated Gate Bipolar Transistor
IL	Israel
IN	India
IR	InfraRed
ISR	Interrupt Service Routines
JP	Japan
KR	South Korea
LF	Line Feed, Move cursor to the next line
LRC	Longitudinal Redundancy Check
LS	Less significant
LWR	Last Working Route
MS	Most significant
MTP	Many Times Programmable memory
MY	Malaysia
NAK	Not Acknowledged
NVM	Non-Volatile Memory
NVR	Non-Volatile Read memory (cannot write)
NWI	Network Wide Inclusion
OTA	Over The Air
OTP	One Time Programmable memory
PA	Power Amplifier
POR	Power On Reset
PRBS	Pseudo-Random Binary Sequence
PRNG	Pseudo-Random Number Generator
PWM	Pulse Width Modulator
RF	Radio Frequency
RFRNG	Radio Frequency Random Number Generator
RU	Russian Federation

Abbreviation	Explanation
SDK	Software Developer's Kit
SFR	Special Function Registers
SIS	SUC ID Server
SoC	System-on-Chip
SOF	Start Of Frame
SPI	Serial Peripheral Interface
SUC	Static Update Controller
UPnP	Universal Plug and Play
US	United States
WUT	Wake Up Timer
XML	eXtensible Markup Language

2 INTRODUCTION

2.1 Purpose

The Application Programming Guide gives guidance for developing Z-Wave application programs, which use the Z-Wave application programming interface (API) to access the Z-Wave Protocol services and 500 Series SoC resources. For host processor application development using the serial API refer also to [2].

For details about working in the 500 Series environment, refer to [9].

The document is also an API reference guide for programmers.

2.2 Audience and Prerequisites

The audience is Z-Wave partners and Sigma Designs involved in application development. The application programmer should be familiar with the PK51 Keil Development Tool Kit for 8051 micro controllers.

2.3 Backward compatibility

The latest SDK's contain new features to improve installation flexibility and network topology distribution of a Z-Wave network. Therefore is it important to understand these features in detail to ensure backward compatibility with Z-Wave enabled products built on older Developer's Kit releases.

From SDK v6.5x the 500 series chip is supported as the only hardware platform. The SDK 6.5x has the same features as version 6.02.00 but includes also functionality from 6.11.01, 5.03.00 and 4.55.00. All 6.5x based nodes are compatible with nodes based on older kits.

From SDK v6.0x the 400 series chip is supported as the only hardware platform and 100kbps baud rate is introduced. The SDK 6.0x has all the same functionality as the 4.5x kit and all node types now supports FLiRS. All 6.0x based nodes are compatible with nodes based on older kits.

From SDK v4.5x (v4.50 came after v5.02) explorer frames were introduced to improve network resilience and inclusion flexibility. FLiRS and Zensor nodes are not supported but all kind of v4.50 slaves are able to beam when acting as repeater.

From SDK v5.0x, Beaming wake-up technology was introduced. This enables the creation of FLiRS nodes.

From SDK Kit v4.2x the silent acknowledge mechanism was introduced to reduce routing latency.

From SDK v3.4x the SUC can in addition also function as a node ID server (SIS) to allow other controllers to include/exclude nodes to/from the network. Furthermore, the unique node ID 0xEF for primary controllers was discontinued.

From SDK v3.3x the Static Update Controller (SUC) was introduced to allow slave and controller nodes to request network topology updates.

2.4 Key words to Indicate Requirement Levels

The guidelines outlined in IETF RFC 2119 “Key words for use in RFCs to Indicate Requirement Levels” [12] apply:
The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119.

3 Z-WAVE SOFTWARE ARCHITECTURE

Z-Wave software relies on polling of functions, command complete callback function calls, and delayed function calls.

The software is split into two groups of program modules: Z-Wave basis software and Application software. The Z-Wave basis software includes system startup code, low-level poll function, main poll loop, Z-Wave protocol layers, and memory and timer service functions. From the Z-Wave basis point of view the Application software include application hardware and software initialization functions, application state machine (called from the Z-Wave main poll loop), command complete callback functions, and a received command handler function. In addition to that, the application software can include hardware drivers.

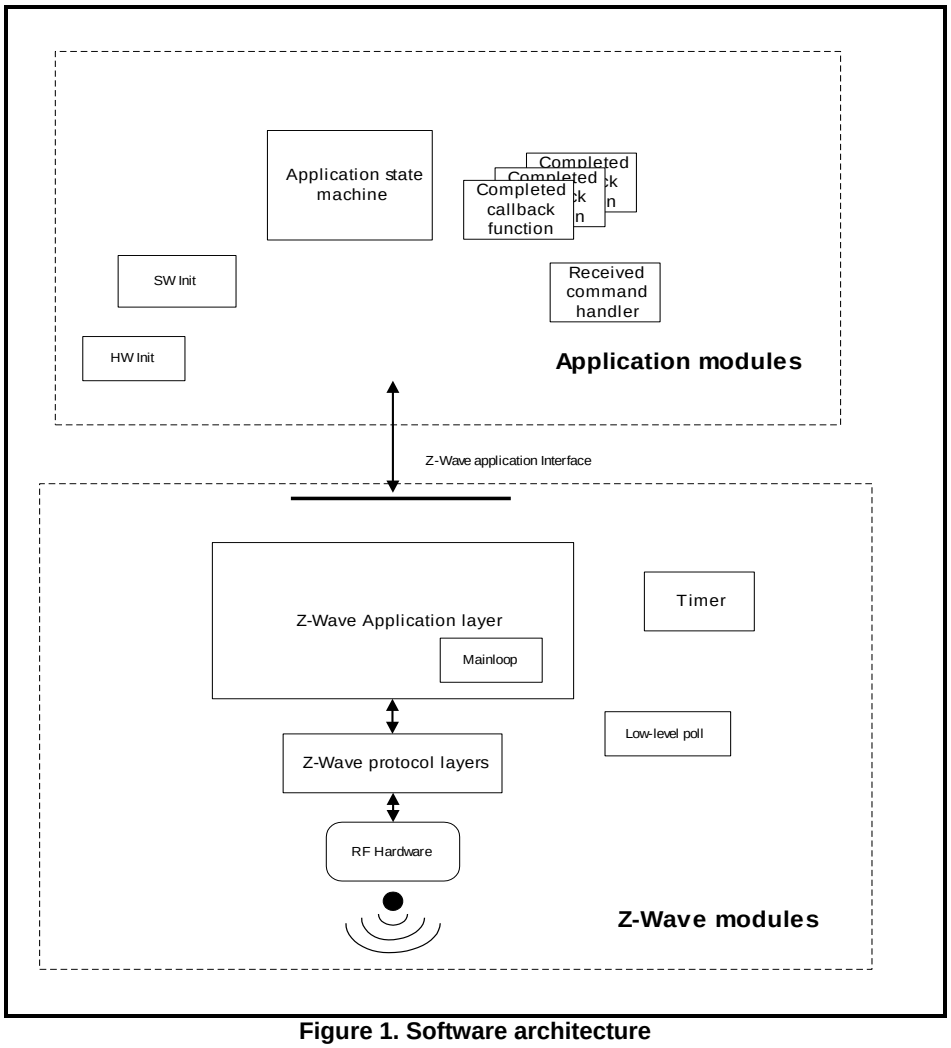


Figure 1. Software architecture

3.1 Z-Wave System Startup Code

The Z-Wave modules include the system startup function (main). The Z-Wave system startup function first initializes the Z-Wave hardware and then calls the application hardware initialization function **ApplicationInitHW**. Then initializing the Z-Wave software (including the software timer used by the timer module), initializes the NVM if necessary and finally calling the application software initialization function **ApplicationInitSW**. Execution then proceeds in the Z-Wave main loop.

Notice: Initialization of the external NVM is now handled internally by the Z-Wave protocol library. The protocol will now delete and initialize the NVM on bootup if a 16 bit validation field in the NVM is not correct Therefore the NVM initialization file extern_epp.hex is now obsoleted.

3.2 Z-Wave Main Loop

The Z-Wave main loop will call the list of Z-Wave protocol functions, including the **ApplicationPoll** function and the **ApplicationCommandHandler** function (if a frame was received) in round robin order. The functions must therefore be designed to return to the caller as fast as possible to allow the MCU to do other tasks. Busy loops are not allowed. This will make it possible to receive Z-Wave data, transfer data via the UART and check user-activated buttons, etc. “simultaneously”. In order not to disrupt the radio communication and the protocol, no application function must execute code for more than 5ms without returning.

For production testing the application can be forced into the **ApplicationTestPoll** function instead of the **ApplicationPoll** function.

3.3 Z-Wave Protocol Layers

When transmission of data to another node is requested, the Z-Wave protocol layer adds a frame header and a checksum to the data before transmission. The protocol layer also handles frame retransmissions, as well as routing of frames through “repeater” nodes to Z-Wave nodes that are not within direct RF communication reach. When the frame transmission is completed, an application-specified transmit complete callback function is called. The transmission complete callback function includes a parameter that indicates the transmission result. The transmission complete callback function indicate also when the next frame can be send to avoid overwriting the transmit queue.

The Z-Wave frame receiver module (within the MAC layer) can include more than one frame receive buffer, so the upper layers can interpret one frame while the next frame is received.

3.1 Z-Wave Routing Principles

The Z-Wave protocol use source routing, which is a technique whereby the sender of a frame specifies the exact route the frame must take to reach the destination node. Source routing assumes that the sender knows the topology of the network, and can therefore determine a route having a minimum number of hops. The Z-Wave protocol supports up to four repeaters between sender and destination node. Routing can also be used to reach FLiRS destination nodes. Source routing allows implementation of a leightweight protocol by avoiding distributed topologies in all repeaters. Nodes containing the topology can also assign routes to a topology-less node enabling it to communicate with a number of destination nodes using routes.

In case sender fails to reach destination node using routes an explorer mechanism can be launched on demand to discover a working route to the destination node in question. The explorer mechanism builds

on AODV routing with adjustments for source routing and memory footprint. Explorer frames implement managed multi-hop broadcast forwarding and returns a working route to sender as result. The application payload piggybacks on explorer frame to reduce latency.

The routing algorithm in controllers store information about successful attempts to reach a destination node avoiding repetition of previously failed attempts. The last successful route used between sender and destination node are stored in NVM and is called Last Working Route (LWR). The LWR list comprises of 232 destination nodes having up to one route/direct each. The LWR can also contain direct attempts. Updating LWR happens in the following situations:

- When receiving a successful explorer frame route.
- When receiving a successful routed/direct request from another node.
- When receiving a successful acknowledge for a transmitted explorer frame.
- When receiving a successful acknowledge for a transmitted routed/direct frame.

The LWR is removed from the LWR list in case it fails.

The routing algorithm in slaves store information about successful attempts to reach a destination node in response routes after the same priciples as LWR handling in controllers. However, the response routes contains up to two routes to different destination nodes. A response route for a new destination node overwrites the oldest buffered response route.

The routing attempts depend on the Z-Wave library and transmit options used in the node, for details refer to section 3.7.

The source routing algorithm does not alter the topology due to failed attempts or store any statistics regarding link quality.

3.2 Z-Wave Application Layer

The application layer provides the interface to the communications environment which is used by the application process. The application software is located in the hardware initialization function **ApplicationInitHW**, software initialization function **ApplicationInitSW**, application state machine (called from the Z-Wave main poll loop) **ApplicationPoll**, command complete callback functions, and a receive command handler function **ApplicationCommandHandler**.

The application implements communication on application level with other nodes in the network. On application level, a framework is defined of Device and Command Classes to obtain interoperability between Z-Wave enabled products from different vendors. For details of the Z-Wave+ framework refer to [4], [5], [6] and [7]. For details of the old Z-Wave framework but still interoperable refer to [1], [6] and [7]. The basic structure of these commands provides the capability to set parameters in a node and to request parameters from a node responding with a report containing the requested parameters. The Device and Command Classes are defined in the header file ZW_classcmd.h.

Wireless communication is by nature unreliable because a well-defined coverage area simply does not exist since propagation characteristics are dynamic and unpredictable. The Z-Wave protocol minimizes these "noise and distortion" problems by using a transmission mechanisms of the frame there include two re-transmissions to ensure reliable communication. In addition are single casts acknowledged by the receiving node so the application is notified about how the transmission went. No precautions can unfortunately prevent that multiple copies of the same frame are passed to the application. Therefore is it very important to implement a robust state machine on application level there can handle multiple copies of the same frame. Below are shown a couple of examples how this can happen:

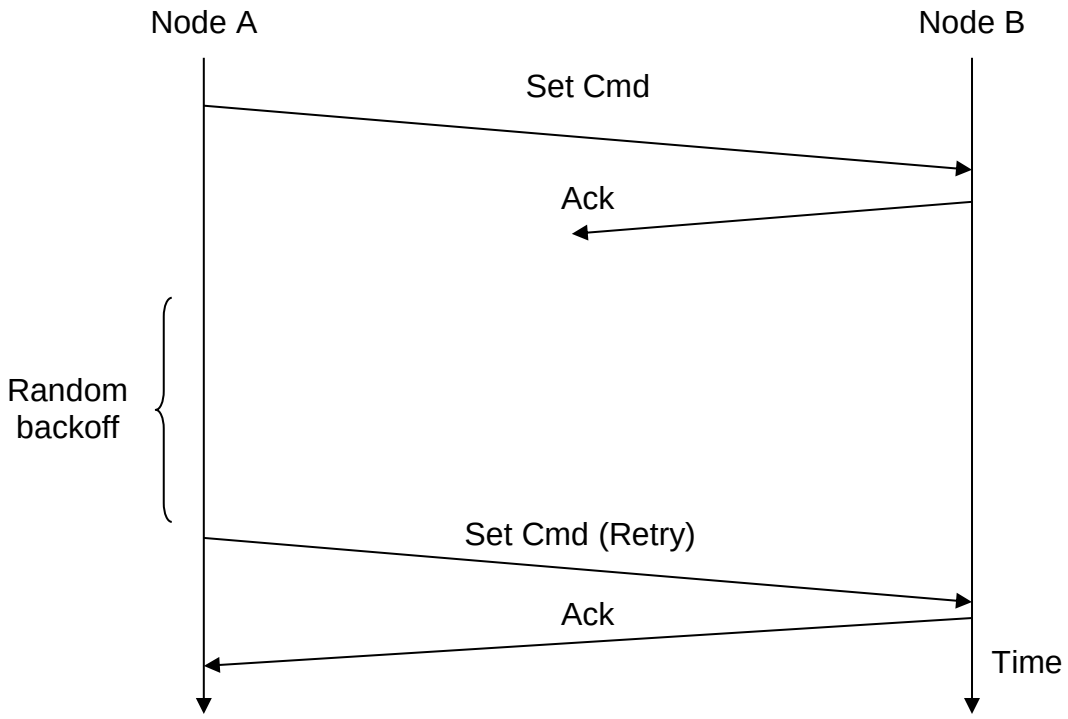


Figure 2. Multiple copies of the same Set frame

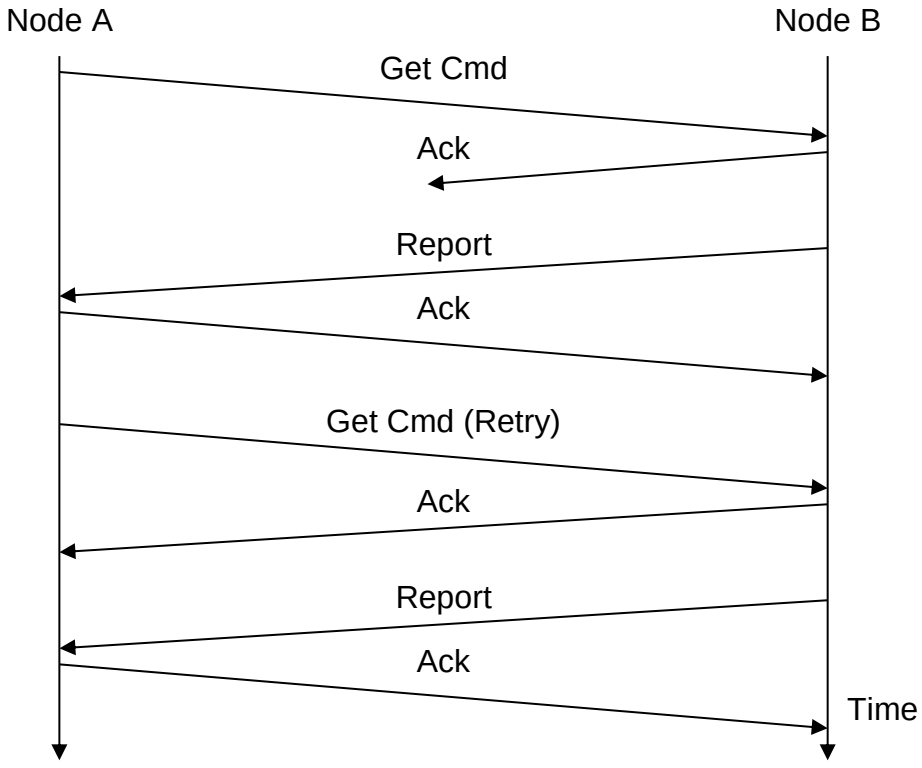


Figure 3. Multiple copies of the same Get/Report frame

The Z-Wave protocol is designed to have low latency on the expense of handling simultaneously communication to a number of nodes in the Z-Wave network. To obtain this is the number of random

backoff values limited to 4 (0, 1, 2, and 3). The figure below shows how simultaneous communication to even a small number of nodes easily can block the communication completely.

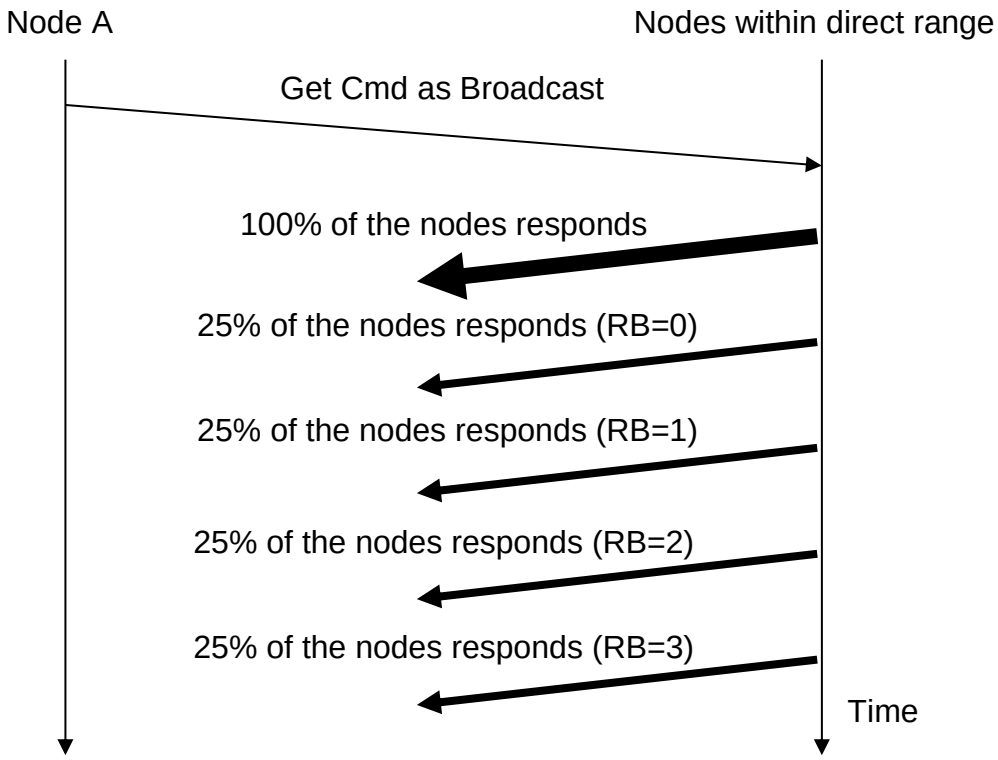


Figure 4. Simultaneous communication to a number of nodes

Avoid simultaneous request to a number of nodes in a Z-Wave network in case the nodes in question respond on the application level.

3.3 Z-Wave Software Timers

The Z-Wave timer module is designed to handle a limited number of simultaneous active software timers. The Z-Wave basis software reserves some of these timers for protocol timeouts.

A delayed function call is initiated by a **TimerStart** API call to the timer module, which saves the function address, sets up the timeout value and returns a timer-handle. The timer-handle can be used to cancel the timeout action e.g. an action completed before the time runs out.

The timer can also be used for frequent inspection of special hardware e.g. a keypad. Specifying the time settings to 50 ms and repeating forever will call the timer call-back function every 50 msec.

3.4 Z-Wave Hardware Timers

The 200/300/400/500 Series Z-Wave SoCs have a number of hardware timers/counters. Some are reserved by the protocol and others are free to be used by the application as shown in the table below:

Table 1. 200/300/400/500 Series Z-Wave SoCs hardware timer allocation

	200 Series	300 Series	400 Series	500 Series
TIMER0	Protocol system clock	Protocol system clock	Available for the application	Available for the application
TIMER1	Available for the application	Available for the application	Used by the protocol	Available for the application
GPTIMER	Available for the application	Available for the application	Available for the application	Available for the application

The TIMER0 and TIMER1 are standard 8051 timers/counters.

3.5 Z-Wave Hardware Interrupts

Application interrupt service routines (ISR) must use 8051 register bank 0. However, do not use USING 0 attribute when declaring ISR's. The Z-Wave protocol uses 8051 register bank 1 for protocol ISR's, see table below regarding application ISR availability:

Table 2. 200/300/400/500 Series Z-Wave SoC Application ISR availability

200 Series	300 Series	400 Series	500 Series
INUM_INT1	INUM_INT1	INUM_INT0	INUM_INT0
INUM_TIMER1	INUM_TIMER1	INUM_TIMER0	INUM_INT1
INUM_SERIAL	INUM_SERIAL	INUM_SERIAL0	INUM_TIMER0
INUM_SPI	INUM_SPI	INUM_SPI0	INUM_SERIAL0
INUM_TRIAC	INUM_TRIAC	INUM_TRIAC	INUM_SPI0
INUM_GP_TIMER	INUM_GP_TIMER	INUM_GP_TIMER	INUM_TRIAC
INUM_ADC	INUM_ADC	INUM_ADC	INUM_GP_TIMER
		INUM_USB	INUM_ADC
		INUM_IR	INUM_USB
			INUM_IR

The duration of an application interrupt routine must be below 80us.

Refer to ZW020x.h, ZW030x.h, ZW040x.h and ZW050x.h header files with respect to ISR definitions. For an example, refer to UART ISR in serial API sample application.

3.6 Interrupt service routines.

When using interrupt service routines from one of the hardware interfaces such as ADC, GP timer or UART, one should be aware of certain issues as described in the following sections.

3.6.1 SFR pages

The 500 Series Z-Wave SoC uses multiple pages of 8051 SFR registers. The page selection is set using SFRPAGE. Consequently the SFRPAGE must be preserved when calling an Interrupt Service Routine (ISR) in your code. In order to do this the intrinsic functions _push_() and _pop_() must be called. Function _push_() must be called when the ISR starts, and _pop_() just before returning from the ISR.

For example, the ISR of the ADC should be look as follow:

#include <INTRINS.H>

```
void ADC_int(void) interrupt INUM_ADC
{
  _push_(SFRPAGE)[1];

  call api's
 _pop_(SFRPAGE);
}
```

3.6.2 Calling functions from ISR

The 8051 core of the 500 Series Z-Wave SoC has no register-to-register move. Therefore, the compiler generates register to memory moves instead. Since the compiler knows the register bank, the physical address of a register in a register bank can be calculated. For example, when the compiler calculates the address of register R2 in register bank 0, the address is 0x02. If the register bank selected is not really 0, then the function overwrites this register. This might result in unpredictable behavior of the program. This technique of accessing a register using its absolute address is called absolute register addressing.

In the Z-Wave system the system timer and RF interrupt use register bank 1. The default register bank used for non-interrupt code is register bank 0. Therefore, if a function is called from an ISR it might be looking in the wrong place for its register values.

To solve this problem, one of these solutions can be used:

1. Use the C51's REGISTERBANK directive to specify that a certain function uses the same register bank as the ISR that calls the function. Hence, no code is generated in the function to switch the register bank. For example:
   ```
   #pragma registerbank(1)
   void foo (void)
   {
   }
   ```
2. Use the NOAREGS directive to specify that the compiler should not use absolute register addressing. This make the function register bank independent so that it may be called from any function that uses a different register bank than the default.

[1] The _push_ and _pop_ functions are intrinsic functions and the header file INTRINS.H. Therefore, INTRINS.H should be included in order to be able to use them.

3.7 Z-Wave Nodes

From a protocol point of view, there are seven types of Z-Wave nodes: Portable Controller nodes, Static Controller nodes, Bridge Controller nodes, Routing Slave nodes, and Enhanced 232 Slave nodes. All controller based nodes stores information about other nodes in the Z-Wave network. The node information includes the nodes each of the nodes can communicate with (routing information). The Installation node will present itself as a Controller node, which includes extra functionality to help a professional installer setup, configure, and troubleshoot a Z-Wave network. The bridge controller node stores information about the nodes in the Z-Wave network and in addition is it possible to generate up to 128 Virtual Slave nodes.

3.7.1 Z-Wave Portable Controller Node

The software components of a Z-Wave portable controller are split into the controller application and the Z-Wave-Controller basis software, which includes the Z-Wave protocol layers and control of the various data stored into the NVM.

Portable controller nodes include an external NVM in which the non-volatile application data area can be placed. The Z-Wave basis software has reserved the first area of the external NVM.

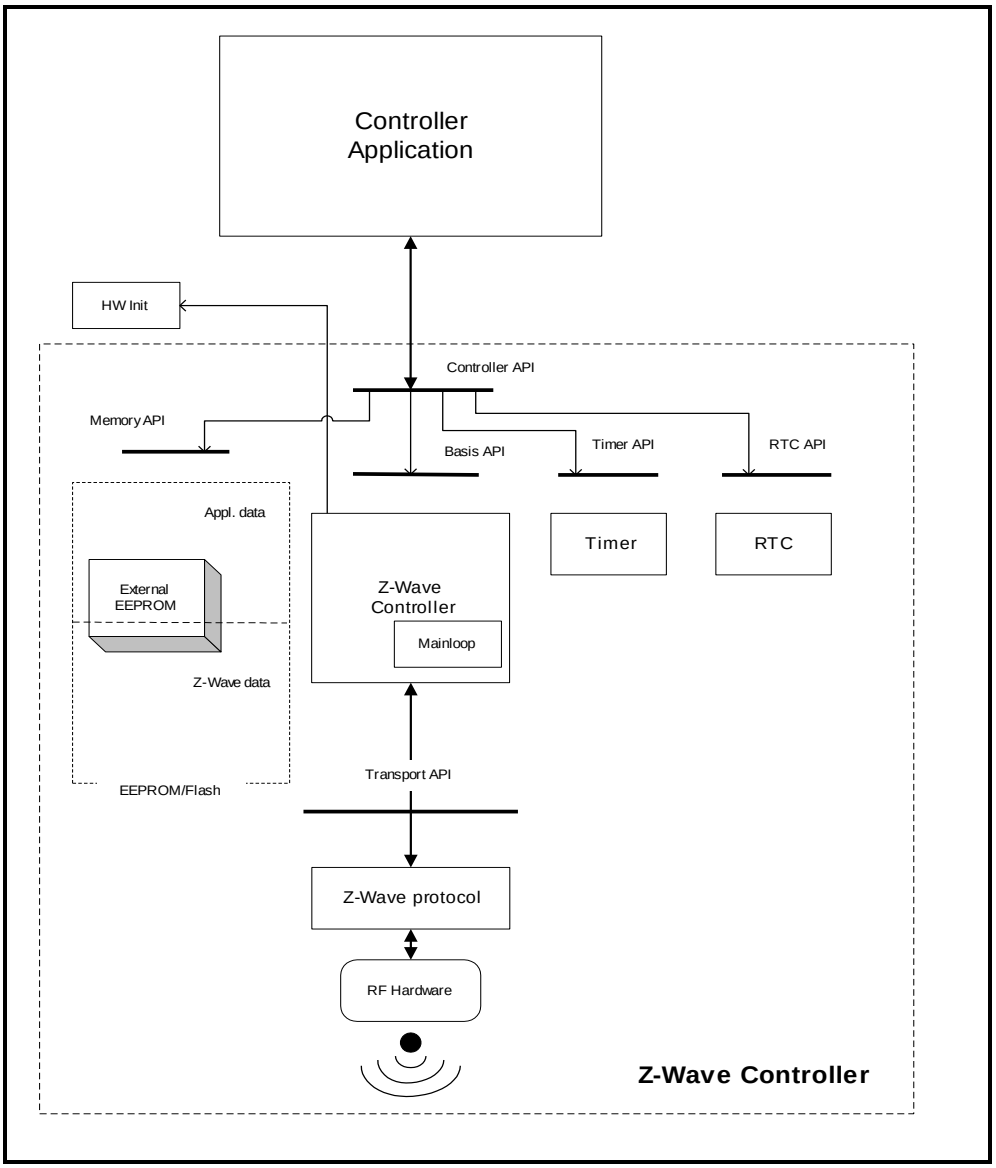


Figure 5. Portable controller node architecture

The Portable Controller node has a unique home ID number assigned, which is stored in the Z-Wave basis area of the external NVM. Care must be taken, when reprogramming the external NVM, that different controller nodes do not get the same home ID number.

When new Slave nodes are registered to the Z-Wave network, the Controller node assigns the home ID and a unique node ID to the Slave node. The Slave node stores the home ID and node ID.

When a controller is primary, it will send any networks changes to the SUC node in the network. Controllers can request network topology updates from the SUC node.

The routing attempts done by a portable controller to reach the destination node are as follows:

- If LWR does not exist and TRANSMIT_OPTION_ACK set. Try direct with retries.
- If LWR exist and TRANSMIT_OPTION_ACK set. Try direct without retries. In case it fails, try the LWR. In case the LWR also fails, purge it.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then calculate up to two routing attempts per entry/repeater node. In case TRANSMIT_OPTION_EXPLORE set, a maximum number limits number of tries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set, then direct with retries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set then issue an explore frame as last resort.

When developing application software the header file “ZW_controller_api.h” also include the other Z-Wave API header files e.g. ZW_timer_api.h.

The following define must be set when compiling the application: ZW_CONTROLLER.

The application must be linked with ZW_CONTROLLER_PORTABLE_ZW∗S.LIB
(∗ = 050X for 500 Series Z-Wave modules, etc).

3.7.2 Z-Wave Static Controller Node

The software components of a Z-Wave static controller node are split into a Static Controller application and the Z-Wave Static Controller basis software, which includes the Z-Wave protocol layers and control of the various data stored into the NVM.

The difference between the static controller and the controller described in chapter 3.7.1 is that the static controller cannot be powered down, that is it cannot be used for battery-operated devices. The static controller has the ability to look for neighbors when requested by a controller. This ability makes it possible for a primary controller to assign static routes from a routing slave to a static controller.

The Static Controller can be set as a SUC node, so it can sends network topology updates to any requesting secondary controller. A secondary static controller not functioning as SUC can also request network Topology updates.

The routing attempts done by a static controller to reach the destination node are as follows:

- If LWR does not exist and TRANSMIT_OPTION_ACK set. Try direct when neighbors.
- If LWR exist and TRANSMIT_OPTION_ACK set. Try the LWR. In case the LWR fails, purge it and try direct if neighbor.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then calculate up to two routing attempts per entry/repeater node. In case TRANSMIT_OPTION_EXPLORE set, a maximum number limits number of tries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set, then direct with retries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set then issue an explore frame as last resort.

When developing application software the header file “ZW_controller_static_api.h” also include the other Z-Wave API header files e.g. ZW_timer_api.h.

The following define is being included compiling the application: ZW_CONTROLLER_STATIC.

The application must be linked with ZW_CONTROLLER_STATIC_ZW∗S.LIB
(∗ = 050X for 500 Series Z-Wave modules, etc).

3.7.3 Z-Wave Bridge Controller Node

The software components of a Z-Wave Bridge Controller node are split into a Bridge Controller application and the Z-Wave Bridge Controller basis software, which includes the Z-Wave protocol layer.

The Bridge Controller is essential a Z-Wave Static Controller node, which incorporates extra functionality that can be used to implement controllers, targeted for bridging between the Z-Wave network and others network (ex. UPnP).

The Bridge application interface is an extended Static Controller application interface, which besides the Static Controller application interface functionality gives the application the possibility to manage Virtual Slave nodes. Virtual Slave nodes is a routing slave node without repeater and assign return route functionality, which physically resides in the Bridge Controller. This makes it possible for other Z-Wave nodes to address up to 128 Slave nodes that can be bridged to some functionality or to devices, which resides on a foreign Network type.

The routing attempts done by a bridge controller to reach the destination node are as follows:

- If LWR does not exist and TRANSMIT_OPTION_ACK set. Try direct when neighbors.
- If LWR exist and TRANSMIT_OPTION_ACK set. Try the LWR. In case the LWR fails, purge it and try direct if neighbor.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then calculate up to two routing attempts per entry/repeater node. In case TRANSMIT_OPTION_EXPLORE set, a maximum number limits number of tries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set, then direct with retries.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set then issue an explore frame as last resort.

When developing application software the header file “ZW_controller_bridge_api.h” also include the other Z-Wave API header files.

The following define is being included compiling the application: ZW_CONTROLLER_BRIDGE.

The application must be linked with ZW_CONTROLLER_BRIDGE_ZW∗S.LIB
(∗ = 050X for 500 Series Z-Wave modules, etc).

3.7.4 Z-Wave Routing Slave Node

The software components of a Z-Wave routing slave node are split into a Slave application and the Z-Wave-Slave basis software, which includes the Z-Wave protocol layers.

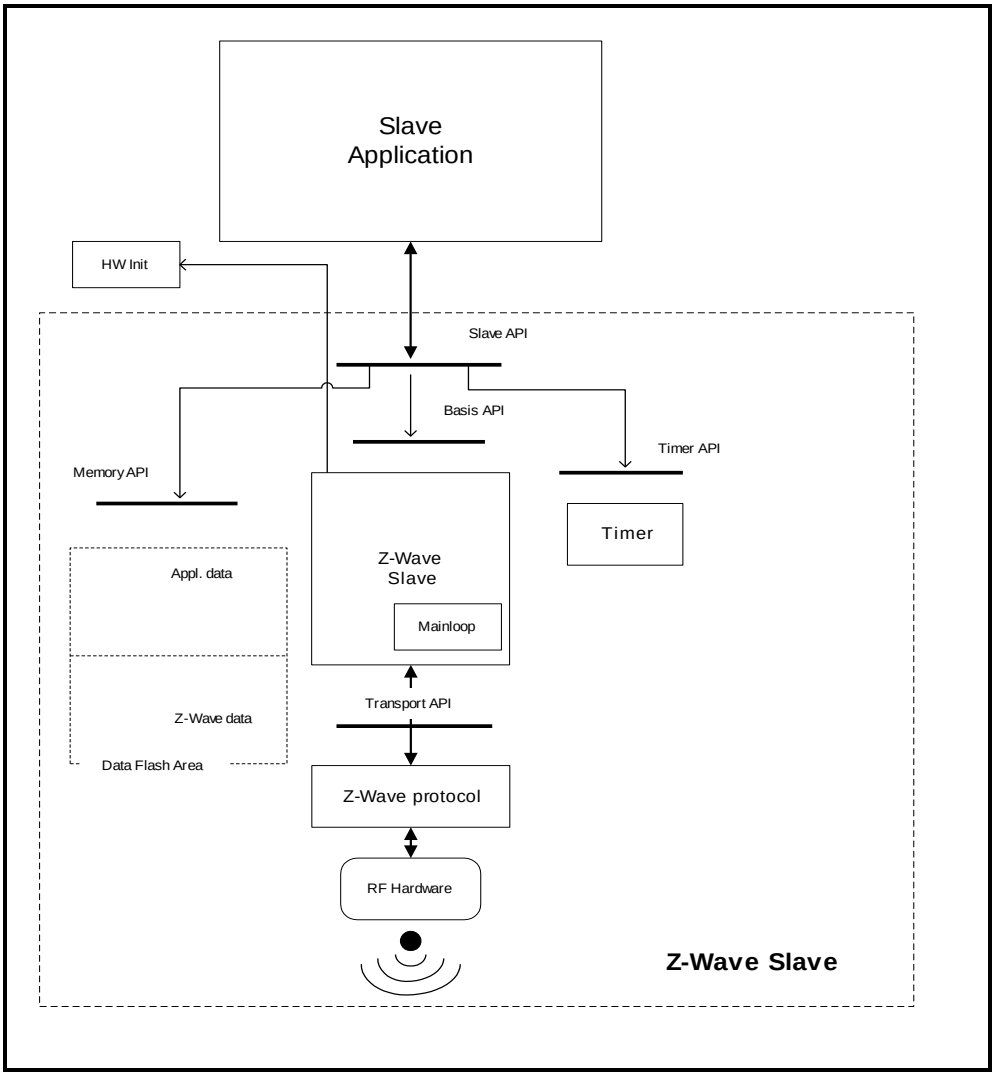


Figure 6. Routing slave node architecture

The routing slave is capable of initiating communication. Examples of a routing slave could be a wall control or temperature sensor. If a user activates the wall control, the routing slave sends an “on” command to a lamp (slave).
The routing slave does not have a complete routing table. Frames are sent to destinations configured during association. The association is performed via a controller. If routing is needed for reaching the destinations, it is also up to the controller to calculate the routes.

Routing slave nodes have an area of 64 bytes MTP (Many Times Programmable memory) for storing data. The Z-Wave basis software reserves the first part of this area, and application data uses the remaning part.

The home ID is set to a randomly generated value and node ID is zero. When registering a slave node to a Z-Wave network the slave node receive home and node ID from the networks primary controller node. These ID’s are stored in the Z-Wave basis data area in the flash.

The routing slave can send unsolicited and non-routed broadcasts, singlecasts, and multicasts. Singlecasts can also be routed. Further, it can respond with a routed singlecast (response route) in case another node has requested this by sending a routed singlecast to it. A received multicast or broadcast results in a response route without routing.

A temperature sensor based on a routing slave may be battery operated. To improve battery lifetime, the application may bring the node into sleep mode most of the time. Using the wake-up timer (WUT), the application may wake up once per second, measure the temperature and go back to sleep. In case the measurement exceeded some threshold, a command (e.g. “start heating”) may be sent to a heating device before going back to sleep.

The routing attempts done by a routing slave to reach the destination node are as follows:

- If TRANSMIT_OPTION_ACK is set and destination is available in response routes, try response route.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try return routes.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try direct.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set, issue an explore frame as last resort.

The return route comprises of five destinations having one route each. Return routes can also contain direct attempts beside a full route.

New routes/direct are qualified for return route insertion by checking if the destination exist and route/direct do not exist. In that event the new route/direct entry will be placed either in a free route or the one having lowest priority.

When developing application software the header file “ZW_slave_routing_api.h” also include the other Z-Wave API header files e.g. ZW_timer_api.h.

The following define will be generated by the headerfile, if it does not already exist when when compiling the application: ZW_SLAVE.

The application must be linked with ZW_SLAVE_ROUTING_ZW∗S.LIB
(∗ = 040X for 500 Series Z-Wave modules, etc).

3.7.5 Z-Wave Enhanced 232 Slave Node

The Z-Wave enhanced 232 slave has the same basic functionality as a Z-Wave routing slave node, but offers return route assignment of up to 232 destination nodes instead of 5.

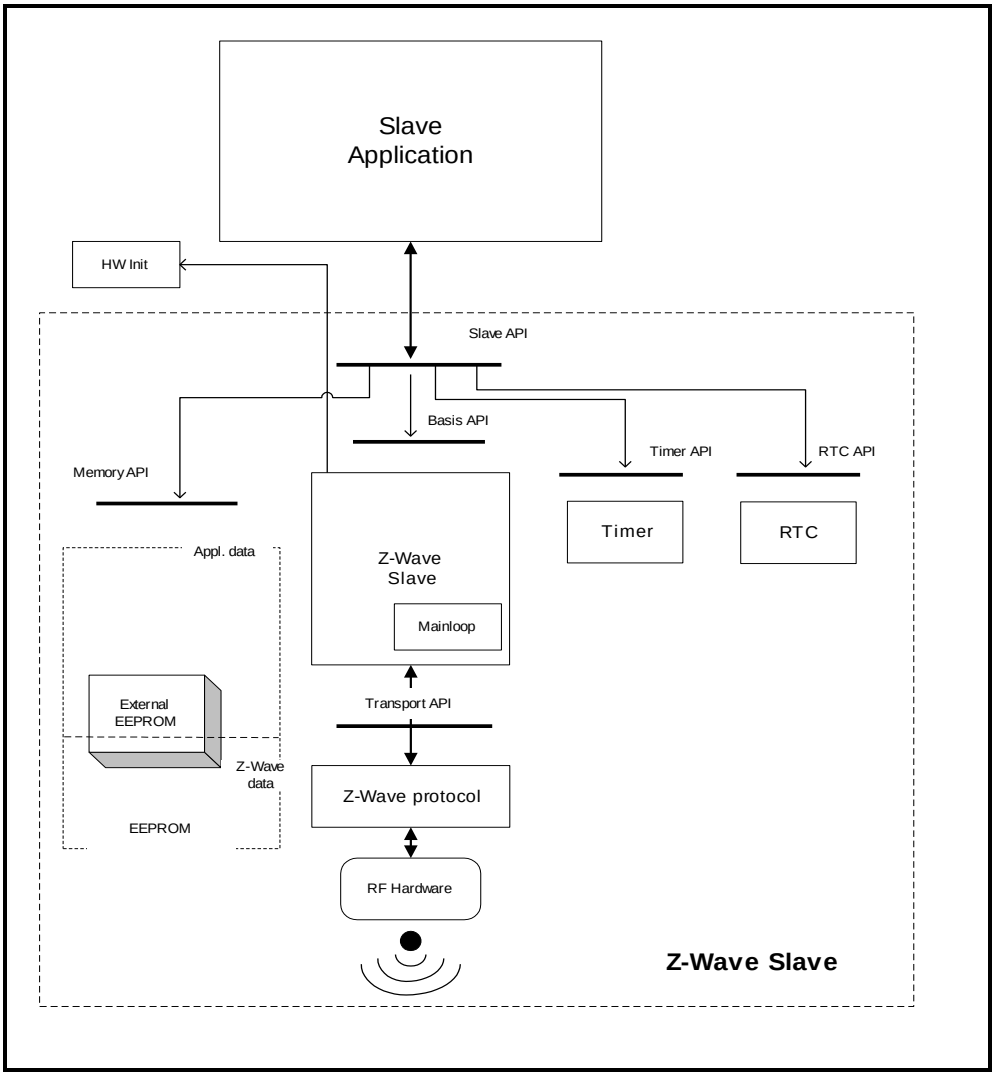


Figure 7. Enhanced 232 slave node architecture

Enhanced 232 slave nodes have an external NVM and a WUT. The Z-Wave basis software reserves the first area of the external NVM: The last area of the NVM is reserved for the application data.

The routing attempts done by an enhanced 232 slave to reach the destination node are as follows:

- If TRANSMIT_OPTION_ACK is set and destination is available in response routes, try response route.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try return routes.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_AUTO_ROUTE are set then try direct.
- If TRANSMIT_OPTION_ACK and TRANSMIT_OPTION_EXPLORE are set, issue an explore frame as last resort.

The return route comprises of 232 destinations having up to four routes each. Return routes can also contain direct attempts. Return routes can also contain direct attempts.

New routes/direct are qualified for return route insertion by checking if the destination exist and route/direct do not exist. In that event the new route/direct entry will be placed either in a free route or the one having lowest priority.

When developing application software the header file “ZW_slave_32_api.h” also include the other Z-Wave API header files e.g. ZW_timer_api.h.

The following define will be generated by the headerfile, if it does not already exist when compiling the application: ZW_SLAVE and ZW_SLAVE_32.

The application must be linked with ZW_SLAVE_ENHANCED_232_ZW∗S.LIB
(∗ = 040X for 500 Series Z-Wave modules, etc).

3.7.6 Adding and Removing Nodes to/from the network

Its only controllers that can add new nodes to the Z-Wave network, and reset them again is the primary or inclusion controller. The home ID of the Primary Z-Wave Controller identifies a Z-Wave network.

Information about the result of a learn process is passed to the callback function in a variable with the following structure:

```
typedef struct _LEARN_INFO_
{
  BYTE  bStatus;      /* Status of learn mode                    */
  BYTE  bSource;      /* Node id of the node that send node info */
  BYTE  *pCmd;        /* Pointer to Application Node information */
  BYTE  bLen;         /* Node info length                        */
} LEARN_INFO;
```

When adding nodes to the network the controller have a number of choices of how to add, and what nodes to add to the network.

3.7.6.1 Adding a node normally.

The normal way to add a node to the network is to use ZW_AddNodeToNetwork() function on the primary controller, and use the function ZW_SetLearnMode() on the node that should be included into the network.

3.7.6.2 Adding a new controller and make it the primary controller

A primary controller can add a controller to the network and in the same process give the role as primary controller to the new controller. This is done by using the ZW_ControllerChange() on the primary controller, and use the function ZW_SetLearnMode() on the controller that should be included into the network.. Note that the original primary controller will become a secondary controller when the inclusion is finished.

3.7.6.3 SUC ID Server (SIS)

Previously Z-Wave offered a Static Update Controller (SUC) functionality that could be enabled in a static controller. This functionality can no longer be enabled alone but is now an intregrated part of the SUC ID Server (SIS). The SIS becomes the primary controller in the network because it always has the latest update of the network topology and capability to include/exclude nodes in the network. When including a controller to the network it becomes an inclusion controller because it has the capability to include/exclude nodes in the network via the SIS. The inclusion controller’s network topology is dated

from last time a node was included or it requested a network update from the SIS. The SUC and the SIS functionality can not be spilt and will always be avalible on the same controller

3.7.7 The Automatic Network Update

A Z-Wave network consists of slaves, a primary controller and secondary controllers. New nodes can only be added and removed to/from the network by using the primary controller. This could cause secondary controllers and routing slaves to misbehave, if for instance a preferred repeater node is removed. Without automatic network updating a new replication has to be made from the primary controller to all secondary controllers and routing slaves should also be manually updated with the changes. In networks with several controller and routing slave nodes, this process will be cumbersome.

To automate this process, an automatic network update scheme has been introduced to the Z-Wave protocol. To use this scheme a static controller must be available in the network. This static controller is dedicated to hold a copy of the network topology and the latest changes that have occurred to the network. The static controller used in the Automatic update scheme is called the SUC ID Server (SIS).

Each time a node is added, deleted or a routing change occurs, the inclusion controller will send the node information to the SIS. Other controllers can then ask the SIS if any updates are pending. The SIS will then in turn respond with any changes since last time this controller asked for updates. In the controller requesting an update, **ApplicationControllerUpdate** will be called to notify the application that a new node has been added or removed in the network.

The SIS holds up to 64 changes of the network. If a node requests an update after more than 64 changes occurred, then it will get a complete copy (see **ZW_RequestNetWorkUpdate**).

Routing slaves have the ability to request updates for its known destination nodes. If any changes have occurred to the network, the SIS will send updated route information for the destination nodes to the Routing slave that requested the update. The Routing slave application will be notified when the process is done, but will not get information about any changes to its routes.

If an inclusion controller sends a new node’s node information and its routes to the SIS while it is updating another controller, the updating process will be aborted to process the new nodes information.

4 Z-WAVE APPLICATION INTERFACES

The Z-Wave basis software consists of a number of different modules. Time critical functions are written in assembler while the other Z-Wave modules are written in C. The Z-Wave API consists of a number of C functions which give the application programmer direct access to the Z-Wave functionality.

4.1 API usage guidelines

The following guidelines should be followed when making a Z-Wave application.

4.1.1 Code space, data space and internal/external NVM

One code bank of 32KB memory in flash is allocated for application development. The data SRAM avalible for the application is 4KB. The internal NVM is only used in the routing slave library and here 64 bytes are avalible for the application.

The external NVM avalible depends on the NVM chip used. To allow full utilization of the 500 series internal memory during OTA and future protocol feature roadmap results in the following recommendations for external NVM memory:

Selecting EEPROM as external NVM:

- 16KB – Will not be upgradeable to future protocol versions requiring additional NVM (Not recommended)
- 32KB (new) – Will be upgradeable to future protocol versions requiring additional NVM (Recommended for devices without OTA support)

Selecting FLASH as external NVM:

- 128KB – Required for OTA enabled slave devices
- 256KB (new) – Required for OTA enabled controller devices

Initialization of the external NVM is completely handled by the Z-Wave protocol and thereby obsoleting NVM initialization file extern_epp.hex. Application data offset has also changed in external NVM as follows:

- For controllers the protocol reserved area in a 16KB EEPROM has changed moving the application start address from NVM_APPL_OFFSET = 0x2C00 (used in 300 Series) to NVM_APPL_OFFSET = 0x3000.
- For slaves the protocol reserved area in a 16KB EEPROM has changed moving the application start address from NVM_APPL_OFFSET = 0x1200 (used in 300 Series) to NVM_APPL_OFFSET = 0x3000.
- For controllers/slaves using 32KB EEPROM, 128KB and 256KB FLASH the application start address NVM_APPL_OFFSET = 0x6000. The protocol will only initialize the first 16KB and the application is responsible for initializing the remaining part (only done once).
- For OTA firmware update support the firmware is stored from address FIRMWARE_NVM_IMAGE_NEW = 0x77FF in a 128KB FLASH.
- For OTA firmware update support the firmware is stored from address FIRMWARE_NVM_IMAGE_NEW = 0xFFFF in a 256KB FLASH.

4.1.2 Buffer protection

Some API calls has one parameter that is a pointer to a buffer in the application SRAM area and another parameter that is a pointer to a callback function. When using these API functions in Z-Wave, it is important that the application does not change the contents of the buffer before the last callback from the API function has been issued. If the content of the buffer is changed before that callback, the Z-Wave protocol might perform the function on invalid data.

4.1.3 Overlapping API calls

In general, it should be avoided to call an API function before the previously started API function is finished and has called the callback function for the last time. Due to the limited resources available for the API not all combinations of API calls will work, some API calls will use the same state machine or the same buffers so if multiple functions is started one or both of the functions might fail.

4.1.4 Error handling.

For purpose of robustness, an application implementation may choose to guard callback API calls whith a timer. In this guide, a timeout value for each API call, which uses a callback, is given. In some functions it is necessarry to to execute some commands in order to recover from a timeout exception. Recovery handling is described for each operation.

4.2 Z-Wave Libraries

4.2.1 Library Functionality

Each of the API's provided in the Developer's Kit contains a subset of the full Z-Wave functionality; the table below shows what kind of functionality the API's support independent of the network configuration:

Table 3. Library functionality

	Routing Slave	Enhanced 232 Slave	Portable Controller	Static Controller	Bridge Controller
Basic Functionality					
Singlecast	X	X	X	X	X
Multicast	X	X	X	X	X
Broadcast	X	X	X	X	X
UART support	X	X	X	X	X
SPI support	-	-	-	-	-
ADC support	X	X	X	X	X
TRIAC control	X	X	X	X	X
PWM/HW timer support	X	X	X	X	X
Power management	X	X	X	-	-
SW timer support	X	X	X	X	X
Controller replication	-	-	X	X	X
Promiscuous mode	-	-	X	-	-
Random number generator	X	X	X	X	X
Able to act as NWI center	-	-	X	X	X
Able to be included via the NWI mechanism	X	X	X	X	X
Able to issue an explorer frame	X	X	X	X	X
Able to forward an explorer frame	X	X	-	X	-
Memory Location					
Non-volatile RAM in MTP	X	-	-	-	-
Non-volatile RAM in FLASH/EEPROM	-	X	X	X	X
Network Management					
Network router (repeater)	X	X	-	X	-
Assign routes to routing slave	-	-	X	X	X
Routing slave functionality	X	X	-	-	-
Access to routing table	-	-	X	-	-
Maintain virtual slave nodes	-	-	-	-	X[1]
Able to be a FLiRS node	X	X	-	-	-
Able to beam when repeater	X	X	-	-	-
Able to create route containing beam	X[2]	X[2]	X	X	-

[1] Only when secondary controller

[2] Only when return routes are assigned by a controller capable of creating routes containing beam

4.2.1.1 Library Functionality without a SIS

Some of the API's functionality provided on the Developer's Kit depends on the network configuration. The table below shows what kind of functionality the API's support without a SIS in the Z-Wave network:

Table 4. Library functionality without a SIS

	Routing Slave	Enhanced 232 Slave	Portable Controller	Static Controller	Bridge Controller
Network Management					
Controller replication	-	-	X	X	X
Controller shift	-	-	X[1]	X[1]	X[1]
Create new primary controller	-	-	-	-	-
Request network updates	-	-	-	-	-
Request rediscovery of a node	-	-	X[1]	X[1]	X[1]
Remove failing nodes	-	-	X[1]	X[1]	X[1]
Replace failing nodes	-	-	X[1]	X[1]	X[1]
Provide routing table info	-	-	X	X	X

[1] Only when primary controller

4.2.1.2 Library Functionality with a SIS

Some of the API's functionality provided on the Developer's Kit depends on the network configuration. The table below shows what kind of functionality the API's support with a SUC ID Server (SIS) in the Z-Wave network:

Table 5. Library functionality with a SIS

	Routing Slave	Enhanced 232 Slave	Portable Controller	Static Controller	Bridge Controller
Network Management					
Controller replication	-	-	X	X	X
Controller shift	-	-	-	-	-
Create new primary controller	-	-	-	-	-
Request network updates	X	X	X	X	X
Request rediscovery of a node	-	-	X[1]	X[1]	X[1]
Remove failing nodes	-	-	X[1]	X[1]	X[1]
Replace failing nodes	-	-	X[1]	X[1]	X[1]
Set static ctrl. to SIS	-	-	X[2]	X[2]	X[2]
Work as SIS	-	-	-	X	X
Work as inclusion controller			X	X	X
"I'm lost" – cry for help	X	X	-	-	-
"I'm lost" – provide help	X[3]	X[3]	X[3]	X[4]	X
Provide routing table info	-	-	X	X	X

Note that the ability to provide help for "I'm lost" requests is limited to forwarding the request to the SIS. Only the portable controller configured as SIS can actually do the updating of the device.

[1] Only when primary/inclusion controller
[2] Only when primary controller
[3] Only if "always listening"
[4] The library without repeater functionality cannot provide help or forward help requests.

4.3 Z-Wave Common API

This section describes interface functions that are implemented within all Z-Wave nodes. The first subsection defines functions that must be implemented within the application modules, while the second subsection defines the functions that are implemented within the Z-Wave basis library.

Functions that does not complete the requested action before returning to the application (e.g. ZW_SEND_DATA) have a callback function pointer as one of the entry parameters. Unless explicitly specified this function pointer can be set to NULL (no action to take on completion).

A serial API implementation provide an interface to the major part of interface functions via a serial port. The SDK contains a serial API application [13], which enables a host processor to control the interface functions via a serial port.

4.3.1 Required Application Functions

The Z-Wave library requires the functions mentioned here implemented within the Application layer.

4.3.1.1 ApplicationInitHW

BYTE ApplicationInitHW(BYTE bWakeupReason)

ApplicationInitHW is used to initialize hardware used by the application. The Z-Wave hardware initialization function set all application IO pins to input mode. The **ApplicationInitHW** function MUST be called by the Z-Wave main function during system startup. At this point of time the Z-Wave timer system is not started so waiting on hardware to get ready SHOULD be done by MCU busy loops.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	Application hardware initialized
	FALSE	Application hardware initialization failed. Protocol enters test mode and Calls **ApplicationTestPoll**

Parameters:

bWakeupReason IN	Wakeup flags:	
	ZW_WAKEUP_RESET	Woken up by reset or external interrupt
	ZW_WAKEUP_WUT	Woken up by the WUT timer
	ZW_WAKEUP_SENSOR	Woken up by a wakeup beam
	ZW_WAKEUP_WATCHDOG	Reset because of a watchdog timeout
	ZW_WAKEUP_EXT_INT	Woken up by external interrupt
	ZW_WAKEUP_POR	Reset by Power on reset circuit

Serial API (Not supported)

4.3.1.2 ApplicationInitSW

BYTE ApplicationInitSW(void)

ApplicationInitSW is used to initialize memory used by the application and driver software. **ApplicationInitSW** MUST be called from the Z-Wave main function during system startup. Notice that watchdog is enabled by default and MUST be kicked by the application to avoid resetting the system (See ZW_WatchDogKick).

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	Application software initialized
	FALSE	Application software initialization failed. (No Z-Wave basis action implemented yet)

Serial API (Not supported)

4.3.1.3 ApplicationTestPoll

void ApplicationTestPoll(void)

The **ApplicationTestPoll** function is the entry point from the Z-Wave basis software to the application software when the production test mode is enabled in the protocol. This will happen when **ApplicationInitHW** returns FALSE. The **ApplicationTestPoll** function will be called indefinitely until the device is reset. The device must be reset and **ApplicationInitHW** must return TRUE in order to exit this mode. When **ApplicationTestPoll** is called the protocol will acknowledge frames sent to home ID equal to 0x00000000 and node ID as follows.

Device	Node ID
Slave	0x00
Controllers before Dev. Kit v3.40	0xEF
Controllers from Dev. Kit v3.40 or later	0x01

The following API calls are only available in production test mode:

1. **ZW_EepromInit** is used to initialize the external NVM. Remember to initialize controllers with a unique home ID that typically can be transferred via the UART on the production line.
2. **ZW_SendConst** is used to validate RF communication. Remember to enable RF communication when testing products based on a portable controller, routing slave or enhanced 232 slave.

Defined in: ZW_basis_api.h

Serial API (Not supported)

4.3.1.4 ApplicationPoll

void ApplicationPoll(void)

The **ApplicationPoll** function is the entry point from the Z-Wave basis software to the application software modules. The **ApplicationPoll** function is called from the Z-Wave main loop when no low-level time critical actions are active. In order not to disrupt the radio communication and the protocol, the application code MUST return within 2ms measured from the call of **ApplicationPoll**.

To determine the ApplicationPoll frequency (see table below) is a LED Dimmer application modified to be able to measure how often ApplicationPoll is called via an output pin. The minimum value is measured when the module is idle, i.e. no RF communication, no push button activation etc. The maximum value is measured when the ERTT application at the same time sends Basic Set Commands (value equal 0) as fast as possible to the LED Dimmer (DUT).

Table 6. ApplicationPoll frequency

	ZW0201 LED Dimmer	ZW0301 LED Dimm,er	400 Series LED Dimmer	500 Series LED Dimmer
Minimum	7.2 us	7.2 us	80 us	80 us
Maximum	2.4 ms	2.4 ms	180 us	180 us

The abovementioned output pin mapped to the ApplicationPoll SHOULD also be used during application testing to ensure that the application code never runs for more than 2ms even in worst-case scenarios; setting the pin high when entering and low when leaving the ApplicationPoll function.

Defined in: ZW_basis_api.h

Serial API (Not supported)

4.3.1.5 ApplicationCommandHandler (Not Bridge Controller library)

In libraries not supporting promiscuous mode (see Table 3):

```
void ApplicationCommandHandler( BYTE  rxStatus,
                                BYTE  sourceNode,
                                ZW_APPLICATION_TX_BUFFER  *pCmd,
                                BYTE  cmdLength)
```

In libraries supporting promiscuous mode:

```
void ApplicationCommandHandler( BYTE  rxStatus,
                                BYTE  destNode,
                                BYTE sourceNode,
                                ZW_APPLICATION_TX_BUFFER  *pCmd,
                                BYTE  cmdLength)
```

The Z-Wave protocol will call the **ApplicationCommandHandler** function when an application command or request has been received from another node. The receive buffer is released when returning from this function. The type of frame used by the request can be determined (single cast, mulitcast or broadcast frame). This is used to avoid flooding the network by responding on a multicast or broadcast. In order not to disrupt the radio communication and the protocol, no application function must execute code for more than 5ms without returning.

Except for the Bridge Controller library, this function MUST be implemented by the Application layer.

Defined in: ZW_basis_api.h

Parameters:

rxStatus IN	Received frame status flags	Refer to ZW_transport_API.h header file
	RECEIVE_STATUS_ROUTED_BUSY xxxxxxx1	A response route is locked by the application
	RECEIVE_STATUS_LOW_POWER xxxxxx1x	Received at low output power level
	RECEIVE_STATUS_TYPE_SINGLE xxxx00xx	Received a single cast frame
	RECEIVE_STATUS_TYPE_BROAD xxxx01xx	Received a broadcast frame
	RECEIVE_STATUS_TYPE_MULTI xxxx10xx	Received a multicast frame
	RECEIVE_STATUS_FOREIGN_FRAME	The received frame is not addressed to this node (Only valid in promiscuous mode)
destNode IN	Command destination Node ID	Only valid in promiscuous mode and for singlecast frames.
sourceNode IN	Command sender Node ID	
pCmd IN	Payload from the received frame.	The command class is the very first byte.
cmdLength IN	Number of Command class bytes.	

Serial API:

ZW->HOST: REQ | 0x04 | rxStatus | sourceNode | cmdLength | pCmd[ ]

When a foreign frame is received in promiscuous mode:
ZW->HOST: REQ | 0xD1 | rxStatus | sourceNode | cmdLength | pCmd[ ] | destNode

The destNode parameter is only valid for singlecast frames.

4.3.1.6 ApplicationNodeInformation

void ApplicationNodeInformation(BYTE *deviceOptionsMask,
APPL_NODE_TYPE *nodeType,
BYTE **nodeParm,
BYTE *parmLength)

The Z-Wave Application Layer MUST use the **ApplicationNodeInformation** function to generate the Node Information frame and to save information about node capabilities. All Z-Wave application related fields of the Node Information structure MUST be initialized by this function. For a description of the Generic Device Classes, Specific Device Classes, and Command Classes refer to [4], [5], [6] and [7]. The deviceOptionsMask is a Bit mask where Listening and Optional functionality flags MUST be set or cleared accordingly to the nodes capabilities.

The listening option in the deviceOptionsMask (APPLICATION_NODEINFO_LISTENING) indicates a continuously powered node ready to receive frames. A listening node assists as repeater in the network.

The non-listening option in the deviceOptionsMask (APPLICATION_NODEINFO_NOT_LISTENING) indicates a battery-operated node that power off RF reception when idle (prolongs battery lifetime)..

The optional functionality option in the deviceOptionsMask (APPLICATION_NODEINFO_OPTIONAL_FUNCTIONALITY) indicates that this node supports other command classes than the mandatory classes for the selected generic and specific device class.

Examples:

To set a device as Listening with Optional Functionality:

```
*deviceOptionsMask = APPLICATION_NODEINFO_LISTENING |
                     APPLICATION_NODEINFO_OPTIONAL_FUNCTIONALITY;
```

To set a device as not listening and with no Optional functionality support:

```
*deviceOptionsMask = APPLICATION_NODEINFO_NOT_LISTENING;
```

Note for Controllers: Because controller libraries store some basic information about themselves from **ApplicationNodeInformation** in nonvolatile memory. **ApplicationNodeInformation** should be set to the correct values before Application return from **ApplicationInitHW()**, for applications where this cannot be done. The Application must call **ZW_SetDefault()** after updating **ApplicationNodeInformation** in order to force the Z-Wave library to store the correct values.

A way to verify if **ApplicationNodeInformation** is stored by the protocol is to call **ZW_GetNodeProtocolInfo** to verify that Generic and specific nodetype are correct. If they differ from what is expected, the Application should Set the **ApplicationNodeInformation** to the correct values and call **ZW_SetDefault()** to force the protocol to update its information.

Defined in: ZW_basis_api.h

Parameters:

deviceOptionsMask OUT		Bitmask with options
	APPLICATION_NODEINFO_LISTENING	In case this node is always listening (typically AC powered nodes) and stationary.
	APPLICATION_NODEINFO_NOT_LISTENING	In case this node is non-listening (typically battery powered nodes).
	APPLICATION_NODEINFO_ OPTIONAL_FUNCTIONALITY	If the node supports other command classes than the ones mandatory for this nodes Generic and Specific Device Class
	APPLICATION_FREQ_LISTENING_MODE_250ms	This option bit should be set if the node should act as a Frequently Listening Routing Slave with a wakeup interval of 250ms. This option is only available on Routing Slaves. This option is not available on 3-channel systems (the JP frequency).
	APPLICATION_FREQ_LISTENING_MODE_1000ms	This option bit should be set if the node should act as a Frequently Listening Routing Slave with a wakeup interval of 250ms. This option is only available on Routing Slaves.
nodeType OUT	Pointer to structure with the Device Class:	
	(*nodeType).generic	The Generic Device Class [5]. Do not enter zero in this field.
	(*nodeType).specific	The Specific Device Class [5].

nodeParm OUT	Command Class buffer pointer.	Command Classes [6] and [7] supported by the device itself and optional Command Classes the device can control in other devices.
parmLength OUT	Number of Command Class bytes.	

Serial API:

HOST->ZW: REQ | 0x03 | deviceOptionsMask | generic | specific | parmLength | nodeParm[ ]

The **ApplicationNodeInformation** is replaced by **SerialAPI_ApplicationNodeInformation**. Used to set information that will be used in subsequent calls to ZW_SendNodeInformation. Replaces the functionality provided by the ApplicationNodeInformation() callback function.

```
void SerialAPI_ApplicationNodeInformation(BYTE  deviceOptionsMask,
                                          APPL_NODE_TYPE *nodeType,
                                          BYTE  *nodeParm,
                                          BYTE  parmLength)
```

The define APPL_NODEPARM_MAX in serialappl.h must be modified accordingly to the number of command classes to be notified. Prior to either start or join a Z-Wave network the HOST needs to initially setup the Node Information Frame (NIF) which should define the type of Z-Wave node the SerialAPI module is supposed to be. For the NIF to be stored in the protocol NVM area as well as in the application NVM area the HOST need to perform the following steps:

1. HOST->ZW: send **SerialAPI_ApplicationNodeInformation()** with NIF information

2. HOST->ZW: send **ZW_SetDefault()**

The figure below lists the Node Information Frame structure on application level. The Z-Wave Protocol creates this frame via ApplicationNodeInformation. The Node Information Frame structure when transmitted by RF does not include the Basic byte descriptor field. The Basic byte descriptor field on application level is deducted from the Capability and Security byte descriptor fields.

Byte descriptor \ bit number	7	6	5	4	3	2	1	0
Capability	Liste-ning	Z-Wave Protocol Specific Part						
Security	Opt. Func.	Z-Wave Protocol Specific Part						
Reserved	Z-Wave Protocol Specific Part							
Basic	Basic Device Class (Z-Wave Protocol Specific Part)							
Generic	Generic Device Class							
Specific	Specific Device Class							
NodeInfo[0]	Command Class 1							
…	…							
NodeInfo[n-1]	Command Class n							

Figure 8. Node Information Frame structure on application level

WARNING: Must use deviceOptionsMask parameter and associated defines to initialize Node Information Frame with respect to listening, non-listening and optional functionality options.

4.3.1.7 ApplicationSlaveUpdate (All slave libraries)

void ApplicationSlaveUpdate (BYTE bStatus,
BYTE bNodeID,
BYTE *pCmd,
BYTE bLen)

The Z-Wave protocol MAY notify a slave application by calling **ApplicationSlaveUpdate** when a Node Information Frame has been received. The Z-Wave protocol MAY refrain from calling the function if the protocol is currently expecting node information.

All slave libraries requires this function implemented by the application.

Defined in: ZW_slave_api.h

Parameters:

bStatus IN	The status, value could be one of the following:	
	UPDATE_STATE_NODE_INFO_RECEIVED	A node has sent its Node Info while the Z-Wave protocol is idle.
bNodeID IN	The updated node's node ID (1..232).	
pCmd IN	Pointer of the updated node's node info.	
bLen IN	The length of the pCmd parameter.	

Serial API:

ZW->HOST: REQ | 0x49 | bStatus | bNodeID | bLen | basic | generic | specific | commandclasses[ ]

4.3.1.8 ApplicationControllerUpdate (All controller libraries)

void ApplicationControllerUpdate (BYTE bStatus,
BYTE bNodeID,
BYTE *pCmd,
BYTE bLen)

A controller application MAY use the information provided by **ApplicationControllerUpdate** to update local data structures.

The Z-Wave protocol MUST notify a controller application by calling **ApplicationControllerUpdate** when a new node has been added or deleted from the controller through the network management features.

The Z-Wave protocol MUST call **ApplicationControllerUpdate** in response to **ZW_RequestNodeInfo** being called by the controller application. The Z-Wave protocol MAY notify a controller application by calling **ApplicationControllerUpdate** when a Node Information Frame has been received. The Z-Wave protocol MAY refrain from calling the function if the protocol is currently expecting a Node Information frame.

ApplicationControllerUpdate MUST be called in a controller node operating as SIS each time a node is added or deleted by the primary controller. **ApplicationControllerUpdate** MUST be called in a controller node operating as SIS each time a node is added/deleted by an inclusion controller.

The Z-Wave protocol MAY notify a controller application by calling **ApplicationControllerUpdate** when a Node Information Frame has been received. The Z-Wave protocol MAY refrain from calling the function if the protocol is currently expecting node information.

A controller application MAY send a **ZW_RequestNetWorkUpdate** command to a SIS or SIS node. In response, the SIS MUST return update information for each node change since the last update handled by the requesting controller node. The application of the requesting controller node MAY receive multiple calls to **ApplicationControllerUpdate** in response to **ZW_RequestNetWorkUpdate**.

The Z-Wave protocol MUST NOT call **ApplicationControllerUpdate** in a controller node acting as primary controller or inclusion controller when a node is added or deleted.

Any controller application MUST implement this function.

Defined in: ZW_controller_api.h

Parameters:

bStatus	IN	The status of the update process, value could be one of the following:	
		UPDATE_STATE_NEW_ID_ASSIGNED	A new node has been added to the network
		UPDATE_STATE_DELETE_DONE	A node has been deleted from the network
		UPDATE_STATE_NODE_INFO_RECEIVED	A node has sent its node info either unsolicited or as a response to a ZW_RequestNodeInfo call
		UPDATE_STATE_SUC_ID	The SIS node Id was updated

bNodeID IN The updated node's node ID (1..232).

pCmd IN Pointer of the updated node's node info.

bLen IN The length of the pCmd parameter.

Serial API:

ZW->HOST: REQ | 0x49 | bStatus | bNodeID | bLen | basic | generic | specific | commandclasses[ ]

ApplicationControllerUpdate via the Serial API also have the possibility for receiving the status UPDATE_STATE_NODE_INFO_REQ_FAILED, which means that a node did not acknowledge a ZW_RequestNodeInfo call.

4.3.1.9 ApplicationCommandHandler_Bridge (Bridge Controller library only)

void ApplicationCommandHandler_Bridge(BYTE rxStatus,
BYTE destNode,
BYTE sourceNode,
ZW_MULTI_DEST multi,
ZW_APPLICATION_TX_BUFFER *pCmd,
BYTE cmdLength)

The Z-Wave protocol MUST call the **ApplicationCommandHandler_Bridge** function when an application command has been received from another node to the Bridge Controller or an existing virtual slave node. The Z-Wave protocol MUST NOT reuse the receive buffer until the application has exited this function.

A bridge controller application MUST implement this function.

Defined in: ZW_controller_bridge_api.h

Parameters:

rxStatus IN	Frame header info:	
	RECEIVE_STATUS_ROUTED_BUSY xxxxxxx1	A response route is locked by the application
	RECEIVE_STATUS_LOW_POWER xxxxxx1x	Received at low output power level
	RECEIVE_STATUS_TYPE_SINGLE xxxx00xx	Received a single cast frame
	RECEIVE_STATUS_TYPE_BROAD xxxx01xx	Received a broadcast frame
	RECEIVE_STATUS_TYPE_MULTI xxxx10xx	Received a multicast frame
destNode IN	Command receiving Node ID. Either Bridge Controller Node ID or virtual slave Node ID. If received frame is a multicast frame then destNode is not valid and multi points to a multicast structure containing the destination nodes.	
sourceNode IN	Command sender Node ID.	
multi IN	If received frame is, a multicast frame then multi points at the multicast Structure containing the destination Node IDs.	
pCmd IN	Payload from the received frame. The command class is the very first byte.	

cmdLength IN Number of Command class bytes.

Serial API:

ZW->HOST: REQ | 0xA8 | rxStatus | destNodeID | srcNodeID | cmdLength | pCmd[ ] | multiDestsOffset_NodeMaskLen | multiDestsNodeMask

4.3.1.10 ApplicationSlaveNodeInformation (Bridge Controller library only)

void ApplicationSlaveNodeInformation(BYTE destNode,
BYTE *listening,
APPL_NODE_TYPE *nodeType,
BYTE **nodeParm,
BYTE *parmLength)

Request Application Virtual Slave Node information. The Z-Wave protocol layer calls **ApplicationSlaveNodeInformation** just before transmitting a "Node Information" frame.

The Z-Wave Bridge Controller library requires this function implemented by the application.

Defined in: ZW_controller_bridge_api.h

Parameters:

destNode IN	Which Virtual Node do we want the node information from.	
listening OUT	TRUE if this node is always listening and not moving.	
nodeType OUT	Pointer to structure with the Device Class:	
	(*nodeType).generic	The Generic Device Class [5]. Do not enter zero in this field.
	(*nodeType).specific	The Specific Device Class [5].
nodeParm OUT	Command Class buffer pointer.	Command Classes [6] and [7] supported by the device itself and optional Command Classes the device can control in other devices.
parmLength OUT	Number of Command Class bytes.	

Serial API:

The **ApplicationSlaveNodeInformation** is replaced by **SerialAPI_ApplicationSlaveNodeInformation**. Used to set node information for the Virtual Slave Node in the embedded module this node information will then be used in subsequent calls to ZW_SendSlaveNodeInformation. Replaces the functionality provided by the ApplicationSlaveNodeInformation() callback function.

void SerialAPI_ApplicationSlaveNodeInformation(BYTE destNode,
BYTE listening,
APPL_NODE_TYPE * nodeType,
BYTE *nodeParm,
BYTE parmLength)

HOST->ZW:
REQ | 0xA0 | destNode | listening | genericType | specificType | parmLength | nodeParm[]

4.3.1.11 ApplicationRfNotify

void ApplicationRfNotify (BYTE rfState)

This function is used to inform the application about the current state of the radio enabling control of an external power amplifier (PA). The Z-Wave protocol will call the **ApplicationRfNotify** function when the radio changes state as follows:

- From Tx to Rx
- From Rx to Tx
- From powere down to Rx
- From power down to Tx
- When PA is powered up
- When PA is powered down

This enables the application to control an external PA using the appropriate number of I/O pins. For details, refer to [14].

A device incorporating an external PA, MUST set the parameter FLASH_APPL_PLL_STEPUP_OFFS in App_RFSetup.a51 to 0 (zero) for adjustment of the signal quality. This is necessary to be able to pass a FCC compliance test.

The **ApplicationRfNotify** function MUST be defined in the application regardless not used for controlling an external PA.

Defined in: ZW_basis_api.h

Parameters:

rfState IN	The current state of the radio.	Refer to ZW_transport_API.h header file
	ZW_RF_TX_MODE	The radio is in Tx state. Previous state is either Rx or power down
	ZW_RF_RX_MODE	The radio in Rx or power down state. Previous state is ether Tx or power down
	ZW_RF_PA_ON	The radio in Tx moode and the PA is powered on
	ZW_RF_PA_OFF	The radio in Tx mode and the PA is powered off

Serial API:

Not implemented

4.3.2 Z-Wave Basis API

This section defines functions that are implemented in all Z-Wave nodes.

4.3.2.1 ZW_ExploreRequestInclusion

BYTE ZW_ExploreRequestInclusion()

An application MAY use this function to initiate a Network-Wide Inclusion process. In response to the call, the Z-Wave protocol MUST send out an explorer frame requesting inclusion into a network.

The application MUST enable Learn Mode (refer to 4.4.26) before calling this function.

A controller in Network-Wide Inclusion mode MAY accept the inclusion request. In that case, the application requesting inclusion MUST get notified through the callback function specified when calling the ZW_SetLearnMode() function. Once a callback is received from ZW_SetLearnMode() saying that the inclusion process has started, the application MUST NOT make further calls to this function.

NOTE: An application SHOULD NOT call this function more than once every 4 seconds.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	Inclusion request queued for transmission
	FALSE	Node is not in learn mode

Serial API

HOST->ZW: REQ | 0x5E

ZW->HOST: RES | 0x5E | retVal

4.3.2.2 ZW_GetProtocolStatus

BYTE ZW_GetProtocolStatus(void)

Macro: ZW_GET_PROTOCOL_STATUS()

The application MAY request the status of the protocol by calling this function.
In response to this function, the Z-Wave protocol MUST return a bitmask reporting the current status of the protocol.

Defined in: ZW_basis_api.h

Return value:

BYTE	Returns the protocol status as one of the following:	
	Zero	Protocol is idle.
	ZW_PROTOCOL_STATUS_ROUTING	Protocol is analyzing the routing table.
	ZW_PROTOCOL_STATUS_SUC	SIS sends pending updates.

Serial API

HOST->ZW: REQ | 0xBF

ZW->HOST: RES | 0xBF | retVal

4.3.2.3 ZW_GetRandomWord

BYTE ZW_GetRandomWord(BYTE *randomWord)

Macro: ZW_GET_RANDOM_WORD(randomWord)

An application SHOULD NOT use this function during normal operation as the radio communication is disabled during function execution. The function MAY however be used for algorithms depending on true randomness, e.g. as a seed generator for Pseudo-Random Number Generator (PRNG) functions used for security encryption. Instead, the function ZW_Random SHOULD be used (refer to 4.3.2.4).

This function returns a random word using the 500 series built-in hardware random number generator based on (internal) RF noise (RFRNG).

Defined in: ZW_basis_api.h

Return value:

BOOL	TRUE	If possible to generate random number.
	FALSE	If not possible – will happen if RF is busy at the time of the function call.

Parameters:

randomWord OUT	Pointer to word variable, which should receive the random word.

Serial API

The Serial API function 0x1C makes use of the ZW_GetRandomWord to generate a specified number of random bytes:

- Call ZW_GetRandomWord until enough random bytes generated or ZW_GetRandomWord returns FALSE.
- Return result to HOST.

HOST -> ZW: REQ | 0x1C | [noRandomBytes]

noRandomBytes	Number of random bytes needed. Optional if not present or equal ZERO then 2 random bytes are returned Range 1...32 random bytes are supported.

ZW -> HOST: RES | 0x1C | randomGenerationSuccess | noRandomBytesGenerated | noRandomGenerated[noRandomBytesGenerated]

randomGenerationSuccess	TRUE if random bytes could be generated FALSE if no random bytes could be generated
noRandomBytesGenerated	Number of random numbers generated
noRandomBytesGenerated[]	Array of generated random bytes

4.3.2.4 ZW_Random

BYTE ZW_Random(void)

Macro: ZW_RANDOM()

This function implements a simple pseudo-random number generator that generates a sequence of numbers, the elements of which are approximately independent of each other. The same sequence of pseudo-random numbers will be repeated in case the module is power cycled.

An application MAY use this function for implementing random behavior, e.g. when multiple nodes respond to a multicast message. The Z-Wave protocol MAY also use this function for random backoff, etc.
Due to its simple nature, an application MUST NOT use this function for obtaining random values for security key calculation and encryption.

Defined in: ZW_basis_api.h

Return value:

BYTE Random number (0 – 0xFF)

Serial API

HOST->ZW: REQ | 0x1D

ZW->HOST: RES | 0x1D | rndNo

4.3.2.5 ZW_RFPowerLevelSet

BYTE ZW_RFPowerLevelSet(BYTE powerLevel)

Macro: ZW_RF_POWERLEVEL_SET(POWERLEVEL)

An application MAY use this function to set the power level used for RF transmission. The actual RF power is dependent on the settings for transmit power level in App_RFSetup.a51. If this value is changed from the default library value the resulting power levels might differ from the intended values. The returned value is however always the actual one used.

NOTE: This function should only be used in an install/test link situation and the power level should always be set back to normal Power when the testing is done.

Defined in: ZW_basis_api.h

Parameters:

powerLevel IN	Powerlevel to use in RF transmission, valid values:	
	normalPower	Max power possible
	minus1dB	Normal power - 1dB (mapped to minus2dB[1])
	minus2dB	Normal power - 2dB
	minus3dB	Normal power - 3dB (mapped to minus4dB)
	minus4dB	Normal power - 4dB
	minus5dB	Normal power - 5dB (mapped to minus6dB)
	minus6dB	Normal power - 6dB
	minus7dB	Normal power - 7dB (mapped to minus8dB)
	minus8dB	Normal power - 8dB
	minus9dB	Normal power - 9dB (mapped to minus10dB)

Return value:

BYTE	The powerlevel set.

Serial API (Serial API protocol version 4):

HOST->ZW: REQ | 0x17 | powerLevel

ZW->HOST: RES | 0x17 | retVal

[1] 500 Series support only -2dB power level steps

4.3.2.6 ZW_RFPowerLevelGet

BYTE ZW_RFPowerLevelGet(void)

Macro: ZW_RF_POWERLEVEL_GET()

Get the current power level used in RF transmitting.

NOTE: This function should only be used in an install/test link situation.

Defined in: ZW_basis_api.h

Return value:

BYTE	The power level currently in effect during RF transmissions.

Serial API

HOST->ZW: REQ | 0xBA

ZW->HOST: RES | 0xBA | powerlevel

4.3.2.7 ZW_RequestNetWorkUpdate

BYTE ZW_RequestNetWorkUpdate (VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus))

Macro: ZW_REQUEST_NETWORK_UPDATE (func)

This API call is used to request a network update from a SUC/SIS controller. Any changes are reported to the application by calling the **ApplicationControllerUpdate**).

All controllers MAY use this call if there is a SUC/SIS in the network. Secondary controllers MUST NOT use this call if there is a SUC in the network.

All types of routing slaves MAY use this call if there is a SUC/SIS in the network. Routing Slaves MUST NOT use this call if there is no SUC in the network. In case the Routing Slave has called ZW_RequestNewRouteDestinations prior to ZW_RequestNetWorkUpdate, then Return Routes for the destinations specified by the application in ZW_RequestNewRouteDestinations will be updated along with the SUC Return Route.

Checking if a SUC/SIS is known by the node is done using the API call **ZW_GetSUCNodeID**.

NOTE: The SUC/SIS can only handle one network update process at a time. If another request is made during a network update process then the latest requesting node receives a ZW_SUC_UPDATE_WAIT status.

WARNING: This API call will generate a lot of network activity that will use bandwidth and stress the SUC/SIS in the network. Therefore, network updates SHOULD be requested as seldom as possible and never more often that once every hour from a controller.

Defined in: ZW_controller_api.h and ZW_slave_routing_api.h

Return value:

BYTE	TRUE	If the updating process is started.
	FALSE	If the requesting controller is the SUC node or the SUC node is unknown.

Parameters:

completedFunc IN	Transmit complete call back.

Callback function Parameters:

txStatus IN	Status of command:	
	ZW_SUC_UPDATE_DONE	The update process succeeded.
	ZW_SUC_UPDATE_ABORT	The update process aborted because of an error.
	ZW_SUC_UPDATE_WAIT	The SUC node is busy.
	ZW_SUC_UPDATE_DISABLED	The SUC functionality is disabled.
	ZW_SUC_UPDATE_OVERFLOW	The controller requested an update after more than 64 changes have occurred in the network. The update information is then out of date in respect to that controller. In this situation the controller have to make a replication before trying to request any new network updates.

Serial API:

HOST->ZW: REQ | 0x53 | funcID

Notice: funcID is used to correlate callback with original request. Callback is disabled by setting funcID equal to zero in original request.

ZW->HOST: RES | 0x53 | retVal

ZW->HOST: REQ | 0x53 | funcID | txStatus

4.3.2.8 ZW_RFPowerlevelRediscoverySet

void ZW_RFPowerlevelRediscoverySet(BYTE bNewPower)

Macro: ZW_RF_POWERLEVEL_REDISCOVERY_SET(bNewPower)

This function MAY be used to set the power level locally in the node when finding neighbors.

The default power level used for rediscovery is normal power minus 6dB. The default power level SHOULD be used. The call to ZW_RFPowerlevelRediscoverySet MAY be omitted if the default power level is to be used.

It is NOT RECOMMENDED to use other power levels. Increased power levels may cause weak RF links to be included in the routing table. Weak RF links can increase latency in the network due to retries to get through. Further reduced power levels may cause nodes with good link properties to not be discovered. This may lead to increased latency due to additional hops to the destination.

A call to this function affects the power level used for all future neighbor discovery operations. The function can be called from ApplicationInit or during runtime from ApplicationPoll or Application-CommandHandler.

Defined in: ZW_basis_api.h

Parameters:

bNewPower IN	Powerlevel to use when doing neighbor discovery, valid values:	
	normalPower	Max power possible
	minus1dB	Normal power - 1dB (mapped to minus2dB[1])
	minus2dB	Normal power - 2dB
	minus3dB	Normal power - 3dB (mapped to minus4dB)
	minus4dB	Normal power - 4dB
	minus5dB	Normal power - 5dB (mapped to minus6dB)
	minus6dB	Normal power - 6dB
	minus7dB	Normal power - 7dB (mapped to minus8dB)
	minus8dB	Normal power - 8dB
	minus9dB	Normal power - 9dB (mapped to minus10dB)

Serial API:

[1] 400 Series support only -2dB power level steps

HOST->ZW: REQ | 0x1E | powerLevel

4.3.2.9 ZW_SendNodeInformation

BYTE ZW_SendNodeInformation(BYTE destNode,
BYTE txOptions,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_SEND_NODE_INFO(node,option,func)

Create and transmit a “Node Information” frame. The Z-Wave transport layer builds a frame, request application node information (see **ApplicationNodeInformation**) and queue the “Node Information” frame for transmission. The completed call back function (**completedFunc**) is called when the transmission is complete.

The Node Information Frame is a protocol frame and will therefore not be directly available to the application on the receiver. The API call ZW_SetLearnMode() can be used to instruct the protocol to pass the Node Information Frame to the application.

When ZW_SendNodeInformation() is used in learn mode for adding or removing the node from the network the transmit option TRANSMIT_OPTION_LOW_POWER should NOT be used.

NOTE: ZW_SendNodeInformation uses the transmit queue in the API, so using other transmit functions before the complete callback has been called by the API is not recommended.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	If frame was put in the transmit queue
	FALSE	If it was not (callback will not be called)

Parameters:

destNode IN	Destination Node ID (NODE_BROADCAST == all nodes)
txOptions IN	Transmit option flags. (see **ZW_SendData**)
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x12 | destNode | txOptions | funcID

ZW->HOST: RES | 0x12 | retVal

ZW->HOST: REQ | 0x12 | funcID | txStatus

4.3.2.10 ZW_SendTestFrame

BYTE ZW_SendTestFrame(BYTE nodeID,
BYTE powerlevel,
VOID_CALLBACKFUNC(func)(BYTE txStatus))

Macro: ZW_SEND_TEST_FRAME(nodeID, power, func)

Send a test frame directly to nodeID without any routing, RF transmission power is previously set to powerlevel by calling ZW_RF_POWERLEVEL_SET. The test frame is acknowledged at the RF transmission powerlevel indicated by the parameter powerlevel by nodeID (if the test frame got through). This test will be done using 9600 kbit/s transmission rate.

NOTE: This function should only be used in an install/test link situation.

Defined in: ZW_basis_api.h

Parameters:

nodeID IN	Node ID on the node ID (1..232) the test frame should be transmitted to.	
powerLevel IN	Powerlevel to use in RF transmission, valid values:	
	normalPower	Max power possible
	minus1dB	Normal power - 1dB (mapped to minus2dB[1])
	minus2dB	Normal power - 2dB
	minus3dB	Normal power - 3dB (mapped to minus4dB)
	minus4dB	Normal power - 4dB
	minus5dB	Normal power - 5dB (mapped to minus6dB)
	minus6dB	Normal power - 6dB
	minus7dB	Normal power - 7dB (mapped to minus8dB)
	minus8dB	Normal power - 8dB
	minus9dB	Normal power - 9dB (mapped to minus10dB)
func IN	Call back function called when done.	

Callback function Parameters:

[1] 200/300 Series support only -2dB power level steps

txStatus IN	(see **ZW_SendData**)	

Return value:

BYTE	FALSE	If transmit queue overflow.

Serial API

HOST->ZW: REQ | 0xBE | nodeID| powerlevel | funcID

ZW->HOST: REQ | 0xBE | retVal

ZW->HOST: REQ | 0xBE | funcID | txStatus

4.3.2.11 ZW_SetExtIntLevel

void ZW_SetExtIntLevel(BYTE intSrc,
BYTE triggerLevel)

Macro: ZW_SET_EXT_INT_LEVEL(SRC, TRIGGER_LEVEL)

This function MAY be used to set the trigger level for external interrupts. Level triggered interrupt MUST be selected as follows:

	Level Triggered
External interrupt 0	IT0 = 0;
External interrupt 1	IT1 = 0;

Defined in: ZW_basis_api.h

Parameters:

intSrc IN	The external interrupt valid values:	
	ZW_INT0	External interrupt 0 (Pin P1.0)
	ZW_INT1	External interrupt 1 (Pin P1.1)
triggerLevel IN	The external interrupt trigger level:	
	TRUE	Set the interrupt trigger to high level
	FALSE	Set the interrupt trigger to low level

Serial API

HOST->ZW: REQ | 0xB9 | intSrc | triggerLevel

4.3.2.12 ZW_SetPromiscuousMode (Not Bridge Controller library)

void ZW_SetPromiscuousMode(BOOL state)

Macro: ZW_SET_PROMISCUOUS_MODE(state)

ZW_SetPromiscuousMode Enable / disable the promiscuous mode.

This function MAY be used to enable promiscuous mode. If enabled, all frames will be passed to the application even if the frames are addressed to another node. When promiscuous mode is disabled, only frames addressed to the node will be passed to the application.

Promiscuously received frames are delivered to the application via the ApplicationCommandHandler callback function (see section 4.3.1.5).

Defined in: ZW_basis_api.h

Parameters:

state IN TRUE to enable the promiscuous mode,
FALSE to disable it.

Serial API:

HOST->ZW: REQ | 0xD0 | state

See section 4.3.1.5 for callback syntax when a frame has been promiscuously received.

4.3.2.13 ZW_SetRFReceiveMode

BYTE ZW_SetRFReceiveMode(BYTE mode)

Macro: ZW_SET_RX_MODE(mode)

ZW_SetRFReceiveMode is used to power down the RF when not in use e.g. expects nothing to be received. **ZW_SetRFReceiveMode** can also be used to set the RF into receive mode. This functionality is useful in battery powered Z-Wave nodes e.g. the Z-Wave Remote Controller. The RF is automatic powered up when transmitting data.

Defined in: ZW_basis_api.h

Return value:

BYTE	TRUE	If operation was successful
	FALSE	If operation was none successful

Parameters:

mode IN	TRUE	On: Set the RF in receive mode and starts the receive data sampling
	FALSE	Off: Set the RF in power down mode (for battery power save).

Serial API

HOST->ZW: REQ | 0x10 | mode

ZW->HOST: RES | 0x10 | retVal

4.3.2.14 ZW_Type_Library

BYTE ZW_Type_Library(void)

Macro: ZW_TYPE_LIBRARY()

Get the Z-Wave library type.

Defined in: ZW_basis_api.h

Return value:

BYTE	Returns the library type as one of the following:	
	ZW_LIB_CONTROLLER_STATIC	Static controller library
	ZW_LIB_CONTROLLER_BRIDGE	Bridge controller library
	ZW_LIB_CONTROLLER	Portable controller library
	ZW_LIB_SLAVE_ENHANCED	Enhanced 232 slave library
	ZW_LIB_SLAVE_ROUTING	Routing slave library
	ZW_LIB_SLAVE	Slave library
	ZW_LIB_INSTALLER	Installer library

Serial API

HOST->ZW: REQ | 0xBD

ZW->HOST: RES | 0xBD | retVal

4.3.2.15 ZW_Version

BYTE ZW_Version(BYTE *buffer)

Macro: ZW_VERSION(buffer)

Get the Z-Wave basis API library version.

Defined in: ZW_basis_api.h

Parameters:

buffer OUT	Returns the API library version in text using the format: Z-Wave x.yy where x.yy is the library version.	

Return value:

BYTE	Returns the library type as one of the following:	
	ZW_LIB_CONTROLLER_STATIC	Static controller library
	ZW_LIB_CONTROLLER_BRIDGE	Bridge controller library
	ZW_LIB_CONTROLLER	Portable controller library
	ZW_LIB_SLAVE_ENHANCED	Enhanced 232 slave library
	ZW_LIB_SLAVE_ROUTING	Routing slave library
	ZW_LIB_SLAVE	Slave library
	ZW_LIB_INSTALLER	Installer library

Serial API:

HOST->ZW: REQ | 0x15

ZW->HOST: RES | 0x15 | buffer (12 bytes) | library type

4.3.2.16 ZW_VERSION_MAJOR / ZW_VERSION_MINOR / ZW_VERSION_BETA

Macro: ZW_VERSION_MAJOR/ZW_VERSION_MINOR/ ZW_VERSION_BETA

These #defines can be used to get a decimal value of the used Z-Wave library. ZW_VERSION_MINOR should be 0 padded when displayed to users EG: ZW_VERSION_MAJOR = 1 ZW_VERSION_MINOR =2 should be shown as: 1.02 to the user where as ZW_VERSION_MAJOR = 1 ZW_VERSION_MINOR =20 should be shown as 1.20.

ZW_VERSION_BETA is only defined for beta releases of the Z-Wave Library. In which case it is defined as a single char for instance: 'b'

Defined in: ZW_basis_api.h

Serial API (Not supported)

4.3.2.17 ZW_WatchDogEnable

void ZW_WatchDogEnable(void)

Macro: ZW_WATCHDOG_ENABLE()

This function may be used to enable the 500 Series Z-Wave SoC built-in watchdog.

It is possible to implement a reliable safety system with a hardware watchdog; resetting the entire hardware if a part of the system stops operating correctly. Properly designed, the watchdog handler monitors a critical chain of conditions that must be met before the watchdog is kicked again. Please refer to 4.3.2.19.

By default, the watchdog is disabled. The watchdog SHOULD be enabled in released product firmware. It is however RECOMMENDED that the watchdog is not enabled during development and testing prior to final release testing. An enabled watchdog may prevent firmware crashes and stalls from being discovered during development and initial testing. As a side note, debugging a system with an enabled watchdog can be a challenge.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0xB6

4.3.2.18 ZW_WatchDogDisable

void ZW_WatchDogDisable(void)

Macro: ZW_WATCHDOG_DISABLE ()

This function may be used to disable the 500 Series Z-Wave SoC built in watchdog.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0xB7

4.3.2.19 ZW_WatchDogKick

void ZW_WatchDogKick(void)

Macro: ZW_WATCHDOG_KICK ()

This function SHOULD be used to keep the watchdog timer from resetting the 500 Series Z-Wave SoC. The watchdog timeout interval is 1 second. If enabled, the watchdog MUST be kicked at least one time per interval. Failing to do so will cause the 500 Series Z-Wave SoC to be reset.

It is possible to implement a reliable safety system with a hardware watchdog; resetting the entire hardware if a part of the system stops operating correctly. Properly designed, the watchdog handler monitors a critical chain of conditions that must be met before the watchdog is kicked again.

It is RECOMMENDED that the designer seeks inspiration in the literature for the design of a reliable watchdog handler.

The resulting executable code does not necessarily require much code space. As a minimum, one SHOULD call **ZW_WatchDogKick** from the function **ApplicationPoll**.
An unconditional call of **ZW_WatchDogKick** from **ApplicationPoll** will however only catch Z-Wave protocol exceptions. Without the abovementioned critical chain of conditions, an application may hang infinitely in an unforeseen state without getting reset by the hardware watchdog.

The watchdog SHOULD be kicked one or more times from the function **ApplicationInitSW** to avoid unintentional reset of the application during initialization.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0xB8

4.3.2.20 ZW_GetTxTimer

void ZW_GetTxTimer(BYTE bChannel,
DWORD *dwTxTime)

This function gets the protocols internal tx timer for the specified channel. The returned value is in milli seconds from the last call to ZW_ClearTxTimers(). The tx timers are updated by the protocol exery time a frame is send.

Defined in: ZW_basis_api.h

Parameters:

bChannel IN	The channel to get the tx timer from. Valid channels are 0, 1 and 2
dwTxTime OUT	The time the transmitter has been active since the last reset or call to ZW_ClearTxTimers()

Serial API:

HOST->ZW: REQ | 0x38

ZW->HOST: RES | 0x38 | TxTimeChannel0 | TxTimeChannel1 | TxTimeChannel2

4.3.2.21 ZW_ClearTxTimers

void ZW_ClearTxTimers(void)

This function clears the protocols internal tx timers. The tx timers are updated by the protocol exery time a frame is send.

Defined in: ZW_basis_api.h

Serial API

HOST->ZW: REQ | 0x37

4.3.3 Z-Wave Transport API

The Z-Wave transport layer controls transfer of data between Z-Wave nodes including retransmission, frame check and acknowledgement. The Z-Wave transport interface includes functions for transfer of data to other Z-Wave nodes. Application data received from other nodes is handed over to the application via the **ApplicationCommandHandler** function. The ZW_MAX_NODES define defines the maximum of nodes possible in a Z-Wave network.

4.3.3.1 ZW_SendData

BYTE ZW_SendData(BYTE nodeID,
BYTE *pData,
BYTE dataLength,
BYTE txOptions,
Void (*completedFunc)(BYTE txStatus))

Macro: ZW_SEND_DATA(node,data,length,options,func)

This function MAY be used to transmit contents of a data buffer to a single node or all nodes (broadcast). The data buffer contents are encapsulated in a Z-Wave transport frame by adding a protocol header and a checksum trailer. The frame is appended to the end of the transmit queue (first in; first out) and transmitted whenever possible.

The protocol layer automatically handles the necessary signaling when the ZW_SendData function is used to initiate a transmission to a FliRS node.

A bridge controller library MUST NOT send to a virtual node belonging to the bridge itself.

The following parameters MUST be specified for the SendData function.

4.3.3.1.1 nodeID parameter

The nodeID parameter MUST specify the destination nodeID.

The nodeID parameter MAY specify the broadcast nodeID (0xFF).

4.3.3.1.2 *pData parameter

The *pData parameter MUST specify a pointer to a data buffer containing a valid Z-Wave command.
The data buffer referenced by the *pData parameter MUST contain the number of bytes indicated by the dataLength parameter.

4.3.3.1.3 dataLength parameter

The data buffer referenced by the *pData parameter is used to hold a valid Z-Wave command.
The dataLength parameter MUST specify the length of the Z-Wave command.

4.3.3.1.4 txOptions parameter

The calling application MUST compose the txOptions parameter value by combining relevant options chosen from the table below.

One or more callbacks to the completedFunc pointer indicate the status of the operation.

The TRANSMIT_OPTION_ACK option SHOULD be used to request that an acknowledgement is returned by the destination node. If the TRANSMIT_OPTION_ACK transmit option is specified, the protocol layer monitors the arrival of the acknowledgement frame. Up to two retransmissions may be attempted if no acknowledgement frame is received.

The application SHOULD specify the TRANSMIT_OPTION_AUTO_ROUTE option. This will enable mesh routing to destinations which are out of direct range.

The TRANSMIT_OPTION_NO_ROUTE option MAY be specified to limit the transmission to direct range for special application purposes.

Table 7. SendData :: txOptions

TRANSMIT_OPTION_	Description	Priority
ACK	Request acknowledged transmission.	If ACK is disabled (0), all other options are ignored by the SendData function
NO_ROUTE	Request acknowledged transmission and explicitly disable routing.	ACK MUST be enabled (1)
AUTO_ROUTE	Request acknowledged transmission and allow routing. If TRANSMIT_OPTION_AUTO_ROUTE == 0, only the Last Working Route is used for routing if direct range transmission fails. If TRANSMIT_OPTION_AUTO_ROUTE == 1, routed transmission uses the Last Working Route and routing table if direct range transmission fails	ACK MUST be enabled (1) NO_ROUTE MUST be disabled (0)
EXPLORE	Request acknowledged transmission and allow routing. Allow dynamic route resolution if Last Working Route, routing table and direct range transmission fails.	ACK MUST be enabled (1) NO_ROUTE MUST be disabled (0) AUTO_ROUTE SHOULD be enabled (1)

If the broadcast nodeID (0xFF) is specified, the txOptions parameter SHOULD carry the following option values

- TRANSMIT_OPTION_ACK = 0
- TRANSMIT_OPTION_NO_ROUTE = 1
- TRANSMIT_OPTION_AUTO_ROUTE = 0
- TRANSMIT_OPTION_EXPLORE = 0

Table 8. Use of transmit options for controller libraries

TRANSMIT_OPTION_			Protocol behaviour
NO_ROUTE	ACK	AUTO_ROUTE	
1	0	(ignore)	Transmit frame with no routing, nor retransmission; just as if it was a broadcast frame.
1	1	(ignore)	Frame will be transmitted with direct communication i.e. no routing regardless whether a LWR exist or not.
0	1	0	In case direct transmission fails, the frame will be transmitted using LWR if one exists to the destination in question.
0	1	1	If direct communication fails, then attempt with LWR. If LWR also fails or simply do not exist to the destination, then routes from the routing table will be used.

4.3.3.1.4.1 TRANSMIT_OPTION_ACK

The transmit option TRANSMIT_OPTION_ACK MAY be used to request the destination node to return a transfer acknowledgement. The Z-Wave protocol layer will retry the transmission if no acknowledgement is received.

The transmit option TRANSMIT_OPTION_ACK SHOULD be specified for all normal application communication.

If the nodeID parameter specifies the broadcast nodeID (0xFF), the Z-Wave protocol layer ignores the transmit option TRANSMIT_OPTION_ACK.

4.3.3.1.4.2 TRANSMIT_OPTION_NO_ROUTE

The transmit option TRANSMIT_OPTION_NO_ROUTE MAY be used to force the protocol to send the frame without routing. All available routing information is ignored.

The transmit option TRANSMIT_OPTION_NO_ROUTE SHOULD NOT be specified for normal application communication.

If the nodeID parameter specifies the broadcast nodeID (0xFF), the Z-Wave protocol layer ignores the transmit option TRANSMIT_OPTION_NO_ROUTE.

4.3.3.1.4.3 TRANSMIT_OPTION_AUTO_ROUTE

The transmit option TRANSMIT_OPTION_AUTO_ROUTE MAY be used to enable routing.

The Z-Wave protocol layer will then try transmitting the frame via repeater nodes in case destination node is out of direct range.

Controller nodes MAY use the TRANSMIT_OPTION_AUTO_ROUTE to enable routing via Last Working Routes, calculated routes and routes discovered via dynamic route resolution.

Routing Slave and Enhanced 232 Slave nodes MAY use the TRANSMIT_OPTION_AUTO_ROUTE to enable routing via return routes for the actual destination nodeID (if any exist).

If the nodeID parameter specifies the broadcast nodeID (0xFF), the Z-Wave protocol layer ignores the transmit option TRANSMIT_OPTION_AUTO_ROUTE.

4.3.3.1.4.4 TRANSMIT_OPTION_EXPLORE

The transmit option TRANSMIT_OPTION_EXPLORE MAY be used to enable dynamic route resolution. Dynamic route resolution allows a node to discover new routes if all known routes are failing.
An explorer frame cannot wake up FLiRS nodes.

An explorer frame uses normal RF power level minus 6dB. This is also the power level used by a node finding its neighbors.

The API function ZW_SetRoutingMAX MAY be used to specify the maximum number of routing attempts based on routing table lookups to use before the Z-Wave protocol layer resorts to dynamic route resolution.
A default value of five routing attempts SHOULD be used.

For backwards compatibility reasons, transmissions to nodes which do not support dynamic route resolution will ignore the transmit option flag TRANSMIT_OPTION_EXPLORE.

4.3.3.1.4.5 TRANSMIT_OPTION_LOW_POWER

The TRANSMIT_OPTION_LOW_POWER option should only be used when the two nodes that are communicating are close to each other (<2 meter). In all other cases, this option SHOULD NOT be used.

4.3.3.1.4.6 completedFunc

The **completedFunc** parameter MUST specify the calling address of a function that can be called when the SendData frame transmission completes. Completion includes a range of possible situations:

- Direct range frame was successfully transmitted (as requested) without acknowledgement
- Direct range frame was successfully acknowledged
- Routed frame was successfully acknowledged

The transmit status txStatus indicates how the transmission operation was completed.

Table 9. txStatus values

txStatus	Description
TRANSMIT_COMPLETE_OK	The operation was successful.
TRANSMIT_COMPLETE_NO_ACK	No acknowledgement was received from the destination node.
TRANSMIT_COMPLETE_FAIL	Indicates that the network is busy (jammed).

WARNING: Allways use the completeFunc callback to determine when the next frame can be send. Calling the ZW_SendData or ZW_SendDataMulti in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail. The data buffer in the application must not be changed before completeFunc callback is received because it is only the pointer there is passed to the transmit queue.

4.3.3.1.5 Payload size

The maximum size of a frame is 64 bytes. The protocol header and checksum takes 10 bytes in a single cast or broadcast frame leaving 54 bytes for the payload. A S0 security enabled single cast takes 20 bytes as overhead. The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used.

Table 10. Maximum payload size

Transmit option	Maximum dataLength	
Notice: Always use lowest maximum dataLength depending on options used.	**Non-secure**	**Secure**
TRANSMIT_OPTION_EXPLORE	46 bytes	26 bytes
TRANSMIT_OPTION_AUTO_ROUTE	48 bytes	28 bytes
TRANSMIT_OPTION_NO_ROUTE	54 bytes	34 bytes

4.3.3.1.6 Embedded API function prototypes

Defined in: ZW_transport_api.h

Return value:

BYTE	FALSE	If transmit queue overflow

Parameters:

nodeID IN	Destination node ID (NODE_BROADCAST == all nodes)	The frame will also be transmitted in case the source node ID is equal destination node ID
pData IN	Data buffer pointer	
dataLength IN	Data buffer length	The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. For details, see section 3.1. The payload must be minimum one byte.

txOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_NO_ROUTE	Only send this frame directly, even if a response route exist
	TRANSMIT_OPTION_ACK	Request acknowledge from destination node.
	TRANSMIT_OPTION_AUTO_ROUTE	Controllers: Request retransmission via repeater nodes (at normal output power level). Number of max routes can be set using **ZW_SetRoutingMax** Routing and Enhanced 232 Slaves: Send the frame to nodeID using the return routes assigned for nodeID to the routing/enhanced 232 slave, if no routes are valid then transmit directly to nodeID (if nodeID = NODE_BROADCAST then the frame will be a BROADCAST). If return routes exists and the nodeID = NODE_BROADCAST then the frame will be transmitted to all assigned return route destinations. If nodeID != NODE_BROADCAST then the frame will be transmitted via the assigned return routes for nodeID.
	TRANSMIT_OPTION_EXPLORE	Transmit frame as an explore frame if everything else fails.
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus	Transmit completion status:	
	TRANSMIT_COMPLETE_OK	Successfully
	TRANSMIT_COMPLETE_NO_ACK	No acknowledge is received before timeout from the destination node. Acknowledge is discarded in case it is received after the timeout.
	TRANSMIT_COMPLETE_FAIL	Not possible to transmit data because the Z-Wave network is busy (jammed).

Timeout: 65s

Exception recovery: If a timeout occurs, it is important to call ZW_SendDataAbort to stop the sending of the frame.

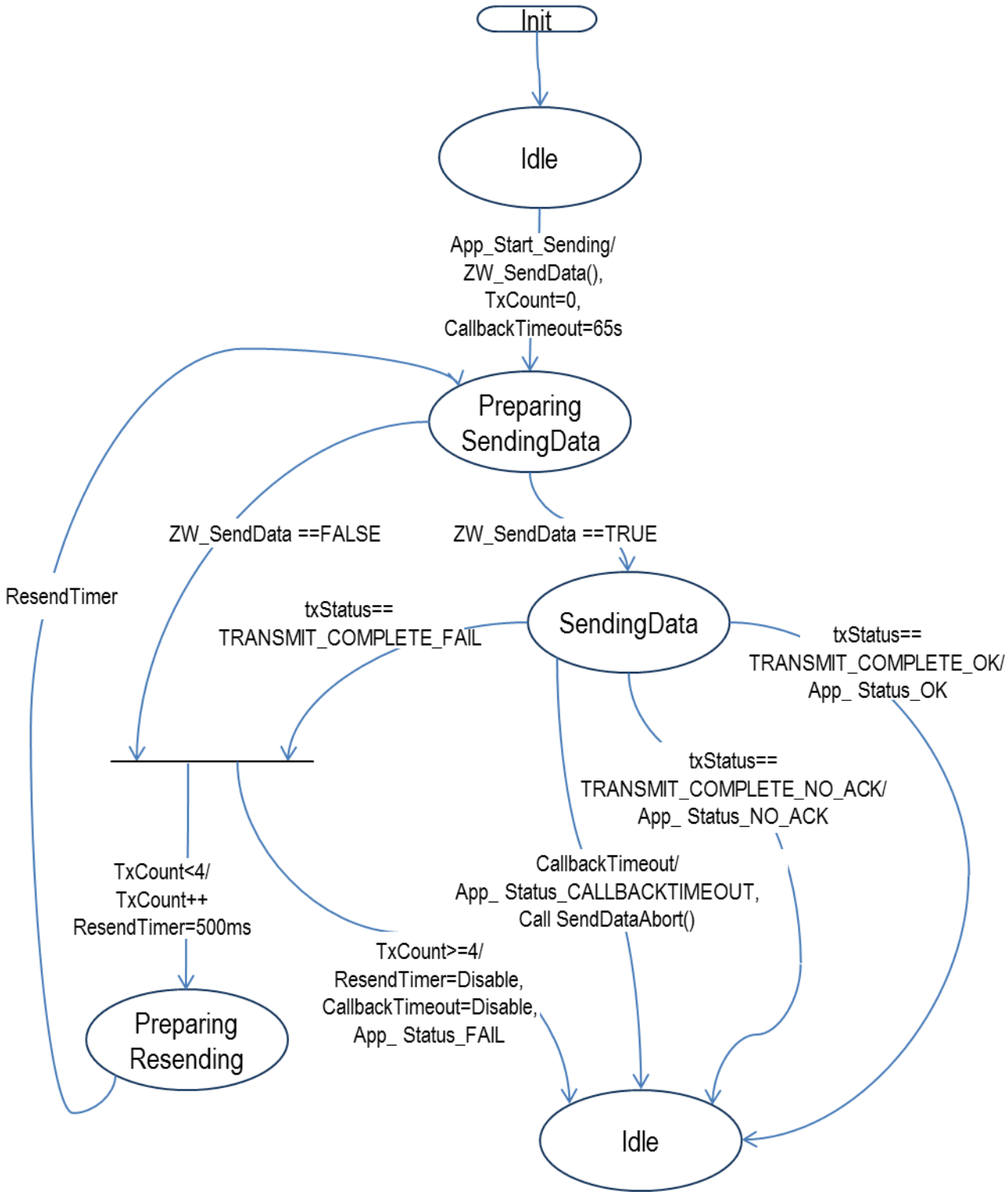


Figure 9. Application state machine for ZW_SendData

Table 11. ZW_SendData : State/Event processing

Idle	Waiting for events Event: (Init) => // Initialize timers, etc. Event: App_Start_Sending => // Higher layer application event calls for data to be sent New state: <PreparingSendingData> Actions: Call ZW_SendData() Reset retransmission counter TxCount=0 Set CallbackTimeout=65s

PreparingSendingData	Waiting for events
	
	Event: ZW_SendData()==FALSE => // Transmitter queue is full. Transmission is not attempted
	New state: <PreparingResending>
	Actions: IF (TxCount<4) THEN
	Increment TxCount retransmission counter
	Preset retransmission delay timer ResendTimer to 500ms
	ELSE
	Disable retransmission delay timer ResendTimer
	Disable callback timeout timer CallbackTimeout
	Generate App_Status_FAIL event for application
	ENDIF
	// App_Status_FAIL SHOULD cause application to report to user that
	// that transmission was not possible, RF media may be jammed
	
	Event: ZW_SendData()==TRUE => // Transmitter is starting; await callback events
	New state: <SendingData>
	Actions: (none)

SendingData	Waiting for events
	
	Event: txStatus==TRANSMIT_COMPLETE_OK => // Callback
	New state: <Idle>
	Actions: Generate App_Status_OK event for application
	
	Event: txStatus==TRANSMIT_COMPLETE_NO_ACK => // Callback
	New state: <Idle>
	Actions: Generate App_Status_NO_ACK event for application
	// App_Status_NO_ACK SHOULD cause application to report to user that
	// that transmission failed, Destination may be unreachable.
	
	Event: CALLBACKTIMEOUT => // Timer event
	// This is an exception that should never happen.
	New state: <Idle>
	Actions: Generate App_Status_CALLBACKTIMEOUT event for application
	Call ZW_SendDataAbort()
	// Recommended application response is hard reset target via watchdog timeout.
	// The state machine may receive one or more SendDataAbort callback events
	// after entering the <Idle> state. These events must be ignored.

PreparingResending	Waiting for events Event: ResendTimer => // Timer event New state: <PreparingSendingData> Actions: (none)

4.3.3.1.7 Serial API function prototypes

HOST->ZW: REQ | 0x13 | nodeID | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0x13 | RetVal

ZW->HOST: REQ | 0x13 | funcID | txStatus

SerialAPI based Static Controller supporting IMA

The ZW_SendData() implementation in the serialAPI based Static Controller supporting IMA has been enhanced with a transmit time measurement. The serialAPI returns the time txTime the whole transmission took. The time is measured from the ZW_SendData() call is made to the protocol and until the protocol returns the callback. The returned time is a 16 bit value in steps of 10ms where MSB is send first.

HOST->ZW: REQ | 0x13 | nodeID | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0x13 | RetVal

ZW->HOST: REQ | 0x13 | funcID | txStatus | txTimeMSB | txTimeLSB

Notice: Serial API version is unchanged despite changed format in ZW-SendData for this particular application.

4.3.3.2 ZW_SendData_Bridge

BYTE ZW_SendData_Bridge(BYTE srcNodeID,
BYTE destNodeID,
BYTE *pData,
BYTE dataLength,
BYTE txOptions,
Void (*completedFunc)(BYTE txStatus))

NOTE: Only supported by the Bridge Controller library. For backward compatibility macros for the Bridge Controller library has been made for ZW_SendData(node,data,length,options,func) and ZW_SEND_DATA(node,data,length,options,func)

Macro: ZW_SEND_DATA_BRIDGE(srcnodeid, destnodeid, data, length, options, func)

Transmit the data buffer to a single Z-Wave Node or all Z-Wave Nodes (broadcast). The data buffer is queued to the end of the transmit queue (first in; first out) and when ready for transmission the Z-Wave protocol layer frames the data with a protocol header in front and a checksum at the end.

The transmit option TRANSMIT_OPTION_ACK requests the destination node to return a transfer acknowledge to ensure proper transmission. The transmitting node will retry the transmission if no acknowledge received. The Controller nodes can add the TRANSMIT_OPTION_AUTO_ROUTE flag to the transmit option parameter. The Controller will then try transmitting the frame via repeater nodes if the direct transmission failed.

The transmit option TRANSMIT_OPTION_NO_ROUTE force the protocol to send the frame without routing, even if a response route exist.

To enable dynamic route resolution a new transmit option TRANSMIT_OPTION_EXPLORE must be appended to the well known send API calls. This instruct the protocol to transmit the frame as an explore frame to the destination node if source routing fails. An explore frame uses normal RF power level minus 6dB similar to a node finding neighbors. It is also possible to specify the maximum number of source routing attempts before the explorer frame kicks in using the API call ZW_SetRoutingMAX. Default value is five with respect to maximum number of source routing attempts. When communicating with nodes, which do not support dynamic route resolution the transmit option flag TRANSMIT_OPTION_EXPLORE is ignored. Notice that an explorer frame cannot wake up FLiRS nodes.

The **completedFunc** is called when the frame transmission completes, that is when transmitted if ACK is not requested; when acknowledge received from the destination node, or when routed acknowledge completed if the frame was transmitted via one or more repeater nodes. The transmit status TRANSMIT_COMPLETE_NO_ACK indicate that no acknowledge is received from the destination node. The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed).

The TRANSMIT_OPTION_LOW_POWER option should only be used when the two nodes that are communicating are close to each other (<2 meter). In all other cases this option should **not** be used.

NOTE: Always use the completeFunc callback to determine when the transmit is done. The completeFunc should flag the application state machine that the transmit has been done and next state/action can be started. A frame transmit should always be started through the application state machine in order to be sure that the transmit buffer is ready for sending next frame. Calling the ZW_SendData_Bridge in a loop without using the completeFunc callback will overflow the transmit queue and eventually fail. The payload data buffer in the application must not be changed before completeFunc callback is received because it is only the pointer that is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE	FALSE	If transmit queue overflow

Parameters:

srcNodeID IN	Source node ID. Valid values:	
	NODE_BROADCAST = Bridge Controller NodeID.	
	Bridge Controller NodeID.	
	Virtual Slave NodeID (only existing Virtual Slave NodeIDs).	
destNodeID IN	Destination node ID (NODE_BROADCAST == all nodes)	The frame will also be transmitted in case the source node ID is equal destination node ID
pData IN	Data buffer pointer	
dataLength IN	Data buffer length	The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. The payload must be minimum one byte.
txOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_NO_ROUTE	Only send this frame directly, even if a response route exist
	TRANSMIT_OPTION_EXPLORE	Transmit frame as an Explore frame if all else fails
	TRANSMIT_OPTION_ACK	Request acknowledge from destination node.
	TRANSMIT_OPTION_AUTO_ROUTE	Request retransmission via repeater nodes (at normal output power level).
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus	Transmit completion status:	
	TRANSMIT_COMPLETE_OK	Successfully
	TRANSMIT_COMPLETE_NO_ACK	No acknowledge is received before timeout from the destination node. Acknowledge is discarded in case it is received after the timeout.
	TRANSMIT_COMPLETE_FAIL	Not possible to transmit data because the Z-Wave network is busy (jammed).
	TRANSMIT_COMPLETE_HOP_0_FAIL	Transmission between Source node and hop 1 failed.
	TRANSMIT_COMPLETE_HOP_1_FAIL	Transmission between hop 1 and hop 2 failed. Only detected in case a Routed Error is returned to source node.
	TRANSMIT_COMPLETE_HOP_2_FAIL	Transmission between hop 2 and hop 3 failed. Only detected in case a Routed Error is returned to source node.
	TRANSMIT_COMPLETE_HOP_3_FAIL	Transmission between hop 3 and hop 4 failed. Only detected in case a Routed Error is returned to source node.
	TRANSMIT_COMPLETE_HOP_4_FAIL	Transmission between hop 4 and destination node failed. Only detected in case a Routed Error is returned to source node.

Serial API:

HOST->ZW: REQ | 0xA9 | srcNodeID | destNodeID | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0xA9 | RetVal

ZW->HOST: REQ | 0xA9 | funcID | txStatus

4.3.3.3 ZW_SendDataMeta_Bridge

BYTE ZW_SendDataMeta_Bridge(BYTE srcNodeID,
BYTE destNodeID,
BYTE *pData,
BYTE dataLength,
BYTE txOptions,
Void (*completedFunc)(BYTE txStatus))

Macro: ZW_SEND_DATA_META_BRIDGE(srcnodeid, nodeid, data, length, options, func)

NOTE: This function is only available in the Bridge Controller library.

Transmit streaming or bulk data in the Z-Wave network. The application must implement a delay of minimum 35ms after each ZW_SendDataMeta_Bridge call to ensure that streaming data traffic does not prevent control data from getting through in the network. Both virtual slaves and the bridge controller id can use the API call ZW_SendDataMeta_Bridge. The call checks that the destination supports 40kbps and denies transmission if destination is 9.6kbps only. Both 40kbps and 9.6kbps hops are allowed in case routing is necessary.

NOTE: The **completedFunc** is called when the frame transmission completes in the case that ACK is not requested; When TRANSMIT_OPTION_ACK is requested the callback function is called when frame has been acknowledged or all transmission attempts are exausted.

The transmit status TRANSMIT_COMPLETE_NO_ACK indicate that no acknowledge is received from the destination node. The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed).

NOTE: Allways use the completeFunc callback to determine when the transmit is done. The completeFunc should flag the application state machine that the transmit has been done and next state/action can be started. A frame transmit should always be started through the application state machine in order to be sure that the transmit buffer is ready for sending next frame. Calling the ZW_SendDataMeta_Bridge in a loop without using the completeFunc callback will overflow the transmit queue and eventually fail. The payload data buffer in the application must not be changed before completeFunc callback is received because it is only the pointer that is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE	FALSE	If transmit queue overflow or if destination node is not 40kbit/s compatible

Parameters:

srcNodeID IN	Source node ID. Valid values: NODE_BROADCAST = Bridge Controller NodeID. Bridge Controller NodeID. Virtual Slave NodeID (only existing Virtual Slave NodeIDs).	
destNodeID IN	Destination node ID	Node to send Meta data to. Should be 40kbit/s capable
pData IN	Data buffer pointer	Pointer to data buffer.
dataLength IN	Data buffer length	Length of buffer
txOptions IN	Transmit option flags:	The maximum dataLength field depends on the transmit options and whether a non-secure/secure frame is used. The payload must be minimum one byte.
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_EXPLORE	Transmit frame as an Explore frame if all else fails
	TRANSMIT_OPTION_ACK	Request the destination node to acknowledge the frame
	TRANSMIT_OPTION_AUTO_ROUTE	Request retransmission on single cast frames via repeater nodes (at normal output power level)
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API (Serial API protocol version 4):

HOST->ZW: REQ | 0xAA | srcNodeID | destNodeID | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0xAA | RetVal

ZW->HOST: REQ | 0xAA | funcID | txStatus

4.3.3.4 ZW_SendDataMulti

BYTE ZW_SendDataMulti(BYTE *pNodeIDList,
BYTE *pData,
BYTE dataLength,
BYTE txOptions,
Void (*completedFunc)(BYTE txStatus))

Macro: ZW_SEND_DATA_MULTI(nodelist,data,length,options,func)

NOTE: This function is not available in the Bridge Controller library (See ZW_SendDataMulti_Bridge).

Transmit the data buffer to a list of Z-Wave Nodes (multicast frame). If the transmit optionflag TRANSMIT_OPTION_ACK is set the data buffer is also sent as a singlecast frame to each of the Z-Wave Nodes in the node list.

The **completedFunc** is called when the frame transmission completes in the case that ACK is not requested; When TRANSMIT_OPTION_ACK is requested the callback function is called when all single casts have been transmitted and acknowledged.

The transmit status TRANSMIT_COMPLETE_NO_ACK indicate that no acknowledge is received from the destination node. The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed). The data pointed to by pNodeIDList should not be changed before the callback is called.

NOTE: Allways use the completeFunc callback to determine when the next frame can be send. Calling the ZW_SendData or ZW_SendDataMulti in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail. The data buffer in the application must not be changed before completeFunc callback is received because it is only the pointer there is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE	FALSE	If transmit queue overflow

Parameters:

pNodeIDList IN	List of destination node ID's	This is a fixed length bit-mask.
Pdata IN	Data buffer pointer	
DataLength IN	Data buffer length	The maximum size of a packet is 64 bytes. The protocol header, multicast addresses and checksum takes 39 bytes in a multicast frame leaving 25 bytes for the payload. In case routed single casts follow multicast the source routing info takes up to 6 bytes depending on the number of hops leaving minimum 19 bytes for the payload. In case it is a singlecast, which piggyback on an explorer frame overhead is 8 bytes leaving minimum 17 bytes for the payload. The payload must be minimum one byte.
TxOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_EXPLORE	If TRANSMIT_OPTION_ACK is set the will make the node try sending as an Explore frame if all else fails when doing the single cast transmits
	TRANSMIT_OPTION_ACK	The multicast frame will be followed by a number of single cast frames to each of the destination nodes and request acknowledge from each destination node.
	TRANSMIT_OPTION_AUTO_ROUTE **(Controller API only)**	Request retransmission on single cast frames via repeater nodes (at normal output power level)
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x14 | numberNodes | pNodeIDList[ ] | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0x14 | RetVal

ZW->HOST: REQ | 0x14 | funcID | txStatus

4.3.3.5 ZW_SendDataMulti_Bridge

BYTE ZW_SendDataMulti_Bridge(BYTE srcNodeID,
BYTE *pNodeIDList,
BYTE *pData,
BYTE dataLength,
BYTE txOptions,
Void (*completedFunc)(BYTE txStatus))

Macro: ZW_SEND_DATA_MULTI_BRIDGE(srcnodid,nodelist,data,length,options,func)

NOTE: This function is only available in the Bridge Controller library.

Transmit the data buffer to a list of Z-Wave Nodes (multicast frame). If the transmit optionflag TRANSMIT_OPTION_ACK is set the data buffer is also sent as a singlecast frame to each of the Z-Wave Nodes in the node list.

The **completedFunc** is called when the frame transmission completes in the case that ACK is not requested; When TRANSMIT_OPTION_ACK is requested the callback function is called when all single casts have been transmitted and acknowledged.

The transmit status TRANSMIT_COMPLETE_NO_ACK indicate that no acknowledge is received from the destination node. The transmit status TRANSMIT_COMPLETE_FAIL indicate that the Z-Wave network is busy (jammed). The data pointed to by pNodeIDList should not be changed before the callback is called.

NOTE: Allways use the completeFunc callback to determine when the next frame can be send. Calling the ZW_SendData_Bridge or ZW_SendDataMulti_Bridge in a loop without checking the completeFunc callback will overflow the transmit queue and eventually fail. The data buffer in the application must not be changed before completeFunc callback is received because it's only the pointer there is passed to the transmit queue.

Defined in: ZW_transport_api.h

Return value:

BYTE	FALSE	If transmit queue overflow

Parameters:

srcNodeID IN	Source node ID. Valid values: NODE_BROADCAST = Bridge Controller NodeID. Bridge Controller NodeID. Virtual Slave NodeID (only existing Virtual Slave NodeIDs).	
pNodeIDList IN	List of destination node ID's	This is a fixed length bit-mask.
Pdata IN	Data buffer pointer	
DataLength IN	Data buffer length	The maximum size of a packet is 64 bytes. The protocol header, multicast addresses and checksum takes 39 bytes in a multicast frame leaving 25 bytes for the payload. In case routed single casts follow multicast the source routing info takes up to 6 bytes depending on the number of hops leaving minimum 19 bytes for the payload. In case it is a singlecast, which piggyback on an explorer frame overhead is 8 bytes leaving minimum 17 bytes for the payload. The payload must be minimum one byte.
TxOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range).
	TRANSMIT_OPTION_EXPLORE	If TRANSMIT_OPTION_ACK is set the will make the node try sending as an Explore frame if all else fails when doing the single cast transmits
	TRANSMIT_OPTION_ACK	The multicast frame will be followed by a number of single cast frames to each of the destination nodes and request acknowledge from each destination node.
	TRANSMIT_OPTION_AUTO_ROUTE	Request retransmission on single cast frames via repeater nodes (at normal output power level)
completedFunc	Transmit completed call back function	

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0xAB | srcNodeID | numberNodes | pNodeIDList[ ] | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0xAB | RetVal

ZW->HOST: REQ | 0xAB | funcID | txStatus

4.3.3.6 ZW_SendDataAbort

void ZW_SendDataAbort(void)

Macro: ZW_SEND_DATA_ABORT

Abort the ongoing transmit started with **ZW_SendData()** or **ZW_SendDataMulti()**. If an ongoing transmission is aborted, the callback function from the send call will return with the status TRANSMIT_COMPLETE_NO_ACK.

Defined in: ZW_transport_api.h

Serial API:

HOST->ZW: REQ | 0x16

4.3.3.7 ZW_LockRoute (Only controllers)

void ZW_LockRoute(bLockRoute)

Macro: ZW_LOCK_ROUTE

This function locks and unlocks all last working routes (LWR) for purging.

Defined in: ZW_transport_api.h

Parameters:

bLockRoute IN	Lock and unlocks all LWR	TRUE lock all LWR – no purging allowed. FALSE unlock purging of LWR

Serial API

HOST->ZW: REQ | 0x90 | bLockRoute

4.3.3.8 ZW_LockRoute (Only slaves)

void ZW_LockRoute(node)

Macro: ZW_LOCK_ROUTE

This function locks and unlocks response route for a given node ID.

Defined in: ZW_transport_api.h

Parameters:

node IN	Lock and unlocks response route for a given node ID	node = 1..232 lock response route for the specified node ID. node = 0 unlock response route.

Serial API

HOST->ZW: REQ | 0x90 | node

4.3.3.9 ZW_SendConst

void ZW_SendConst(BYTE bStart, BYTE bChNo, BYTE bSignalType)

This function start/stop generating RF test signal.
The test signal can be on of the following:

- Test signal with only the carrier frequency.
- Test signal with a modulated carrier frequency; the signal will switch between sending logical 1 frequency and logical zero frequency

The function also selects which channel to send the test signal on.

This API call can only be called in production test mode from **ApplicationTestPoll**.

The API should only be called when starting\stopping a test.

Defined in: ZW_transport_api.h

Parameters:

bStart IN	Start/Stop generating RF test signal	TRUE start sending RF test signal. FALSE stop sending RF test signal
bChNot IN	The number of channel to send the test signal on.	0..1 for 2 channels targets 0..2 for 3 channels targets
bSignalType IN	type of the RF test signal to generater	ZW_RF_TEST_SIGNAL_CARRIER ZW_RF_TEST_SIGNAL_CARRIER_MODULATED

Serial API (Not supported)

4.3.3.10 ZW_SetListenBeforeTalkThreshold

void ZW_SetListenBeforeTalkThreshold(BYTE bChannel, BYTE bThreshold)

This function sets the “Listen Before Talk” threshold used in the Japanese frequency band. The default threshold value is set to “49(dec)” and corresponds to a chip input power of -75dBm. The appropriate value range goes from 34(dec) to 78(dec) and each threshold step corresponds to a 1.5dB input power step.

For instance, if a SAW filter with an insertion loss of 3dB is inserted between the antenna feed-point and the chip, the threshold value should be set to 47(dec).

NOTICE: This function is only available when using JP and KR frequency.

Parameters:

bChannel	IN	Channel number the Threshold should be set for. Valid channel numbers are 0,1 and 2
bThreshold	IN	The threshold the RSSI should use. Valid threshold range is from 34(dec) to 78(dec).

Defined in: ZW_transport_api.h

Serial API (Not supported)

4.3.4 ZWave Firmware Update API

The Firmware Update API provides functionality which together with the SDK supplied ZW_Bootloader module and a big enough external NVM makes it possible to implement firmware update. Currently the external NVM needs to be minimum 1Mbit(128KB) in size to allow for Firmware Updates, but this minimum requirement indicates that the firmware image must have a maximum size for it to be possible to fit in the 1 Mbit NVM together with protocol and application NVM data. The Max firmware using 1Mbit NVM introduces effectively a maximum on the possible usage of BANK3: 0x20000 – 0x7800 – (3 * 0x8000) = 0x2000, which equals 8KB. If a NVM bigger or equal to 2Mbit a full 128KB firmware image can be updated.

Serial API The Firmware Update functionality contains several functions and are all controlled through the FUNC_ID_ZW_FIRMWARE_UPDATE_NVM serialAPI funcID:

HOST->ZW: REQ | 0x78 | FIRMWARE_UPDATE_NVM_functionality | functionalityParameters[]

Defined FIRMWARE_UPDATE_NVM_functionality:

FIRMWARE_UPDATE_NVM_INIT = 0
FIRMWARE_UPDATE_NVM_SET_NEW_IMAGE = 1
FIRMWARE_UPDATE_NVM_GET_NEW_IMAGE = 2
FIRMWARE_UPDATE_NVM_UPDATE_CRC16 = 3
FIRMWARE_UPDATE_NVM_IS_VALID_CRC16 = 4
FIRMWARE_UPDATE_NVM_WRITE = 5

4.3.4.1 ZW_FirmwareUpdate_NVM_Init

BYTE ZW_FirmwareUpdate_NVM_Init()

Initialize the Firmware Update functionality. The initialization includes determining if attached NVM can be used for Firmware Update. If it is determined the the attached NVM do not support (or if ZW_Firmware_Update_NVM_Init has not been called) following calls to any other FirmwareUpdate_NVM_xyz functionality will fail and do nothing.

defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	TRUE	If specified sourceBuffer has been written to NVM
	FALSE	If either NVM is not firmware update capable of the sourceBuffer contents already are present at specified firmware offset in NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x00
ZW->HOST: RES | 0x78 | 0x00 | retVal

4.3.4.2 ZW_FirmwareUpdate_NVM_Set_NEWIMAGE

BYTE ZW_FirmwareUpdate_NVM_Set_NEWIMAGE(BYTE bValue)

Set the NEWIMAGE marker in NVM. Used to signal to ZW_Bootloader if a new Firmware Image are present in NVM or not.

Return value:

BYTE	TRUE	If specified bValue has been written to NVM
	FALSE	If either NVM is not firmware update capable or the Firmware NEWIMAGE value is already set to bValue

Defined in: ZW_firmware_update_nvm_api.h

Parameters:

bValue IN	Value to set “NEWIMAGE” mark to in NVM, which ZW_Bootloader uses to determine if a possible new Firmware exist in external NVM. FIRMWARE_UPDATE_NVM_NEWIMAGE_NEW informs the Bootloader that a possible NEW firmware image exist in external NVM. FIRMWARE_UPDATE_NVM_NEWIMAGE_NOT_NEW informs the ZW_Bootloader that NO NEW firmware image exists in external NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x01 | value
ZW->HOST: RES | 0x78 | 0x01 | retVal

4.3.4.3 ZW_FirmwareUpdate_NVM_Get_NEWIMAGE

BYTE ZW_FirmwareUpdate_NVM_Get_NEWIMAGE()

Get New Firmware Image available indicator in NVM. The New Firmware Image indicator is used to signal the ZW_Bootloader if a possible new Firmware Image is present in NVM.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	FIRMWARE_UPDATE_NVM_NEWIMAGE_NOT_NEW	If either NVM is not Firmware Update capable or Indicator indicates NO NEW Firmware Image present
	FIRMWARE_UPDATE_NVM_NEWIMAGE_NEW	If Indicator indicates NEW Firmware Image is present in NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x02
ZW->HOST: RES | 0x78 | 0x02 | retVal

4.3.4.4 ZW_FirmwareUpdate_NVM_UpdateCRC16

WORD ZW_FirmwareUpdate_NVM_UpdateCRC16(WORD crc,
DWORD nvmOffset,
WORD blockSize)

Calculate CRC16 for specified NVM block of data.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

WORD	0x0000-0xFFFF	Resulting CRC16 value after CRC16 calculation on specified block of data in external NVM

Parameters:

crc IN	Seed CRC16 value to start CRC16 calculation with
nvmOffset IN	Offset into NVM (full address space) where block of data are placed
blockSize IN	Size of block of data in NVM to calculate CRC16 on

Serial API

HOST->ZW: REQ | 0x78 | 0x03 | offset3byte(MSB) | offset3byte | offset2byte(LSB) | length2byte(MSB) | length2byte(LSB) | seedCRC16_high | seedCRC16_low
ZW->HOST: RES | 0x78 | 0x03 | resCRC16_high | resCRC16_low

4.3.4.5 ZW_FirmwareUpdate_NVM_isValidCRC16

BYTE ZW_FirmwareUpdate_NVM_isValidCRC16()

Check if Firmware present in NVM is valid using Firmware Descriptor information regarding BANK sizes and the corresponding firmware CRC16 calculated and placed in the Firmware Descriptor structure at compile/link time (fixbootcrc tool). Uses variables initialized by ZW_FirmwareUpdate_NVM_Init to determine where in NVM to find the stored firmware, if present.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	TRUE	If NVM contains a valid ZW_Bootloader upgradeable Firmware and resCRC16_high/resCRC16_low contains the resulting CRC16 value after the CRC16 calculations on the possible present firmware in external NVM
	FALSE	If NVM do NOT contain a valid ZW_Bootlader upgradable Firmware

Serial API

HOST->ZW: REQ | 0x78 | 0x04
ZW->HOST: RES | 0x78 | 0x04 | retVal | resCRC16_high | resCRC16_low

4.3.4.6 ZW_FirmwareUpdate_NVM_Write

BYTE ZW_FirmwareUpdate_NVM_Write(BYTE *sourceBuffer,
WORD fw_bufsize,
DWORD firmwareOffset)

Write Firmware.Image block to NVM if applicable.

Uses variables initialized by the FirmwareUpdate_NVM_Init together with the specified firmware offset (where the sourceBuffer belongs) to determine if and where in the external NVM space the sourceBuffer should be written, so that the Bootloader can later do the actual Firmware Update if update was successful.

Defined in: ZW_firmware_update_nvm_api.h

Return value:

BYTE	TRUE	If specified sourceBuffer has been written to NVM
	FALSE	If either NVM is not firmware update capable of the sourceBuffer contents already are present at specified firmware offset in NVM

Parameters:

sourceBuffer IN	Buffer containing data to write to NVM
fw_bufsize IN	Size of block to write the NVM
firmwareOffset IN	Offset in firmware where sourceBuffer should be written in NVM

Serial API

HOST->ZW: REQ | 0x78 | 0x05 |offset3byte(MSB) | offset3byte | offset2byte(LSB) | length2byte(MSB) | length2byte(LSB) | buffer[]
ZW->HOST: RES | 0x78 | 0x05 | retVal

4.3.5 Z-Wave Node Mask API

The Node Mask API contains a set of functions to manipulate bit masks. This API is not necessary when writing a Z-Wave application, but is provided as an easy way to work with node ID lists as bit masks.

4.3.5.1 ZW_NodeMaskSetBit

void ZW_NodeMaskSetBit(BYTE_P pMask,
BYTE bNodeID)

Macro: ZW_NODE_MASK_SET_BIT(pMask, bNodeID)

Set the node bit in a node bit mask.

Defined in: ZW_nodemask_api.h

Parameters:

pMask IN Pointer to node mask

bnodeID IN Node id (1..232) to set in node mask

Serial API (Not supported)

4.3.5.2 ZW_NodeMaskClearBit

void ZW_NodeMaskClearBit(BYTE_P pMask,
BYTE bNodeID)

Macro: ZW_NODE_MASK_CLEAR_BIT(pMask, bNodeID)

Clear the node bit in a node bit mask.

Defined in: ZW_nodemask_api.h

Parameters:

PMask IN Pointer to node mask

bNodeID IN Node ID (1..232) to clear in node mask

Serial API (Not supported)

4.3.5.3 ZW_NodeMaskClear

void ZW_NodeMaskClear(BYTE_P pMask,
BYTE bLength)

Macro: ZW_NODE_MASK_CLEAR(pMask, bLength)

Clear all bits in a node mask.

Defined in: ZW_nodemask_api.h

Parameters:

pMask IN Pointer to node mask

bLength IN Length of node mask

Serial API (Not supported)

4.3.5.4 ZW_NodeMaskBitsIn

BYTE ZW_NodeMaskBitsIn(BYTE_P pMask,
BYTE bLength)

Macro: ZW_NODE_MASK_BITS_IN (pMask, bLength)

Number of bits set in node mask.

Defined in: ZW_nodemask_api.h

Return value:

BYTE Number of bits set in node mask

Parameters:

pMask IN Pointer to node mask

bLength IN Length of node mask

Serial API (Not supported)

4.3.5.5 ZW_NodeMaskNodeIn

BYTE ZW_NodeMaskNodeIn (BYTE_P pMask,
BYTE bNode)

Macro: ZW_NODE_MASK_NODE_IN (pMask, bNode)

Check if a node is in a node mask.

Defined in: ZW_nodemask_api.h

Return value:

BYTE	ZERO	If not in node mask
	NONEZERO	If in node mask

Parameters:

pMask IN	Pointer to node mask
bNode IN	Node to clear in node mask

Serial API (Not supported)

4.3.6 IO API

The 500 Series Z-Wave SoC has four ports: P0, P1, P2, and P3. All IO's can be set as either input or output. The initial state of IO's are input mode with the internal pull-up enabled. The IO cells are push/pull cells. When an IO is set as input, a pull-up can be enabled optionally on the input pin of that IO.

Port	ZM4101
P0	P0.0-P0.7
P1	P1.0-P1.7
P2	P2.0
P3	P3.0,P3.1,P3.4-P3.5

The IO's can be used either as a general purpose IO (GPIO) or for some of the IO's, it can be used by one or more of the built-in HW peripherals. The IO's are default set as GPIO's. This means that they are directly controlled by the MCU. If a built-in HW peripheral is enabled it can take over control of the IO, this means the direction of the IO, the pull-up state or the output state. In the case where several HW peripherals that it takes control over can use a particular IO, the control is prioritized as depicted in Table 12.

Table 12. IO functions (Some of the functions are not yet available)

IO	**Functions** (Listed with lowest priority first)
P0.4	GPIO, Key scanner Column 4 output, LED0 output
P0.5	GPIO, Key scanner Column 5 output, LED1 output
P0.6	GPIO, Key scanner Column 6 output, LED2 output
P0.7	GPIO, Key scanner Column 7 output, LED3 output
P1.0	GPIO, External Interrupt 0, Key scanner Row 0 input
P1.1	GPIO, External Interrupt 1, Key scanner Row 1 input
P1.2	GPIO, Key scanner Row 2 input
P1.3	GPIO, Key scanner Row 3 input
P1.4	GPIO, Key scanner Row 4 input
P1.5	GPIO, Key scanner Row 5 input
P1.6	GPIO, Key scanner Row 6 input
P1.7	GPIO, Key scanner Row 7 input
P2.0	GPIO, Key scanner Column 15 output, UART0 Rx input
P2.1	GPIO, Key scanner Column 14 output, UART0 Tx output
P2.2	GPIO, SPI1 master output
P2.3	GPIO, SPI1 master Input
P2.4	GPIO, SPI1 serial clock output
P2.5	GPIO
P2.6	GPIO
P3.1	GPIO, Key scanner Column 12 output, IR Rx input
P3.4	GPIO, ADC0 input, Key scanner Column 11 output, IR Tx0 output
P3.5	GPIO, ADC1 input, Key scanner Column 10 output, IR Tx1 output
P3.6	GPIO, ADC2 input, Key scanner Column 9 output, IR Tx2 output, Triac output
P3.7	GPIO, ADC3 input, Key scanner Column 8 output, Triac Zero-cross input, PWM output

The state of the IO's must be fixed before the 500 Series Z-Wave SoC is put into powerdown mode and must be enabled after the 500 Series Z-Wave SoC is powered-up. This is done to avoid unwanted glitches on the IO's when the 500 Series Z-Wave SoC is powered up.

4.3.6.1 ZW_IOS_enable

void ZW_IOS_enable(BYTE bStatus)

This function is used to unlock or lock the state of the GPIO

Defined in: ZW_basis_api.h

Parameters:

bStatus IN	Lock or Unlock the state of the IO pins	TRUE	The state of the IO pins can now be changed. If the state of a IO pin was changed before the IO's are enabled then the change will be made when the IO's are enabled
		FALSE	The state of the IO pins are now locked and any changes made to the state will not be made until the IO's are enable again

Serial API (Not supported)

4.3.6.2 ZW_IOS_set

void ZW_IOS_set(BYTE bPort,
BYTE bDirection,
BYTE bValue)

This function is used to set the state of the GPIO's In **ApplicationInitHW()**.

Defined in: ZW_basis_api.h

Parameters:

bPort IN	0-3	Port number 0 => P0, 1 => P1, 2 => P2, 3 => P3
bDirection IN	bit pattern	Direction. 0b=output, 1b=input. E.g. 0xF0=> upper 4 IO's are inputs and the lower 4 IO's are outputs
bValue IN	bit pattern	Output setting / Pull-up state When an IO is set as output the corresponding bit in bValue will determine the output setting: 1b=high 0b=low When an IO is set as input the corresponding bit in bValue will determine the state of the pull-up resistor in the IO cell: 1b=pull-up disabled 0b=pull-up enabled

Serial API (Not supported)

4.3.6.3 ZW_IOS_get

void ZW_IOS_get(BYTE *bPort,
BYTE *bDirection,
BYTE *bValue)

This function is used to read the state of the GPIO's In **ApplicationInitHW()**.

Defined in: ZW_basis_api.h

Parameters:

bPort IN	0-3	Port number 0 => P0, 1 => P1, 2 => P2, 3 => P3
bDirection OUT	bit pattern	Direction. 0b=output, 1b=input. E.g. 0xF0=> upper 4 IO's are inputs and the lower 4 IO's are outputs
bValue OUT	bit pattern	Output setting / Pull-up state When an IO is set as output the corresponding bit in bValue will determine the output setting: 1b=high 0b=low When an IO is set as input the corresponding bit in bValue will determine the state of the pull-up resistor in the IO cell: 1b=pull-up disabled 0b=pull-up enabled

Serial API (Not supported)

4.3.7 GPIO macros

The GPIOs MAY be controlled individually via a set of helper macros. These macros can set a GPIO as input/output, set the state of the output GPIO or read the value of an input GPIO.

The GPIO name MUST be specified as a parameter in all the macros. The format of the pin name is as follow:

P(port number)(IO number)

thus IO pin 3 in port 1 name will be P13.

WARNING: Be aware of limitations when using GPIO macros in **ApplicationInitHW()**. Refer to the individual GPIO macros for details.

4.3.7.1 PIN_OUT

PIN_OUT(pin)

This macro sets a GPIO as an output IO.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIOr x = port number; y = IO number

Example:

```
PIN_OUT(P12);
```

4.3.7.2 PIN_IN

PIN_IN(pin, pullup)

This macro sets a GPIO as an input and determines whether the internal pullup is enabled or disabled.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIO x = port number; y = IO number
pullup IN	Boolean	Pull-up state. 0b=disabled, 1b=enabled.

Example:

```
PIN_IN(P30,TRUE);
```

4.3.7.3 PIN_LOW

PIN_LOW(pin)

This macro sets the state of an output GPIO to low.

WARNING: This macro can be called in **ApplicationInitHW()** but GPIO output level will first change immediately after exit of **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIOr x = port number; y = IO number

Example:

```
PIN_LOW(P12);
```

4.3.7.4 PIN_HIGH

PIN_HIGH(pin)

This macro sets the state of an output GPIO to HIGH.

WARNING: This macro can be called in **ApplicationInitHW()** but GPIO output level will first change immediately after exit of **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIOr x = port number; y = IO number

Example:

```
PIN_HIGH(P12);
```

4.3.7.5 PIN_TOGGLE

PIN_TOGGLE(pin)

This macro toggle the state of an output GPIO from high to low or low to high.

WARNING: This macro can be called in **ApplicationInitHW()** but GPIO output level will first change immediately after exit of **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIOr x = port number; y = IO number

Example:

```
PIN_TOGGLE(P12);
```

4.3.7.6 PIN_GET

PIN_GET(pin)

This macro gets the state of the pin of a GPIO.

WARNING: The API call **ZW_IOS_enable** MUST be called before calling **PIN_GET** in **ApplicationInitHW()**. It is not necessary to call **ZW_IOS_enable** in case **PIN_GET** is not called in **ApplicationInitHW()**.

Defined in: ZW_pindefs.h

Parameters:

pin IN	Pxy	Name of a GPIOr x = port number; y = IO number

Return value

BOOL	TRUE	The pin is high
	FALSE	The pin is low

Example:

```
a=PIN_GET(P12);
```

4.3.8 Z-Wave NVM Memory API

The memory application interface handles accesses to the application data area in NVM.

Routing slave nodes use MTP for storing application data. Enhanced 232 slave and all controller nodes use an external NVM for storing application data. The Z-Wave protocol uses the first part of the external NVM for home ID, node ID, routing table etc. The external NVM is accessed via the SPI1 interface and using P2.5 as chip select. Alternative chip select pins, refer to [13].

NVM variables are declared and defined just like any other variables, apart from the needed use of the "far" keyword: However, when declaring NVM variables use the #pragma ORDER at the top of the file to keep the variables in order. When adding a new variable then append it at the end of the defined far variables. Obsoleting a variable remember to keep a dummy far variable to maintain the variables offset.

```
BYTE far EEOFFSET_SENSOR_LEVEL_far; /* Just an example */
```

NVM variables declared like this will be located in a virtual XDATA class called HDATA ranging from address 0x10000 and upwards. The application NVM variables are located at offset 0x16000 (0x13000 for 16K NVM). The NVM variables can only be accessed through the NVM Memory API, and not directly. The way you should access the NVM variables are like this:

```
ZW_MEM_PUT_BYTE((WORD)&EEOFFSET_SENSOR_LEVEL_far, toggleBasicSet); /* An example */
```

The map file from the linker tells you where your variable are located like this:

```
02016006H   HDATA    BYTE      EEOFFSET_SENSOR_LEVEL_far  /* An example */
```

where the first two digits means external data. The last 6 digits are the address of the variable, which is offset by 0x10000 from the physical NVM chip address.

The NVM variables will not be initialized at reset or power on. Only the first time the device is started, the pre-initialized variables will be initialized, because we have a sanity check of the contents. Example of a pre-initialized far variable:

```
BYTE far EEOFFSET_SENSOR_LEVEL_far = 0xff; /* Just an example */
```

You can force an initialization of the pre-initialized NVM contents by calling ZW_SetDefault();

NOTE: The MCU halts while the API is writing to flash memory, so care should be taken not to write to

4.3.8.1 MemoryGetID

void MemoryGetID(BYTE *pHomeID, BYTE *pNodeID)

Macro: ZW_MEMORY_GET_ID(homeID, nodeID)

The **MemoryGetID** function copy the Home-ID and Node-ID from the NVM to the specified RAM addresses.

NOTE: A NULL pointer can be given as the pHomeID parameter if the application is only interested in reading the Node ID.

Defined in: ZW_mem_api.h

Parameters:

pHomeID OUT Home-ID pointer

pNodeID OUT Node-ID pointer

Serial API:

HOST->ZW: REQ | 0x20

ZW->HOST: RES | 0x20 | HomeId(4 bytes) | NodeId

4.3.8.2 MemoryGetByte

BYTE MemoryGetByte(WORD offset)

Macro: ZW_MEM_GET_BYTE(offset)

Read one byte from the NVM allocated for the application.

If a write operation is in progress, the write queue will be checked for the actual data.

Defined in: ZW_mem_api.h

Return value:

BYTE	Data from the application area of the external NVM

Parameters:

offset IN	Address of declared far variable (see section 4.3.8).

Serial API:

HOST->ZW: REQ | 0x21 | offset (2 bytes)

ZW->HOST: RES | 0x21 | RetVal

4.3.8.3 MemoryPutByte

BYTE MemoryPutByte(WORD offset, BYTE data)

Macro: ZW_MEM_PUT_BYTE(offset,data)

Write one byte to the application area of the NVM.

On controllers and enhanced 232 slaves this function is based on external NVM and a long write time (2-5 msec.) must be taken into consideration when implementing the application.

The data to be written to FLASH are not written immediately to the FLASH. Instead it is saved in a RAM buffer and then written when the RF is not active and it is more than 200ms ago the buffer was accessed.

Defined in: ZW_mem_api.h

Return value:

BYTE	FALSE	If write buffer full.

Parameters:

offset IN	Address of declared far variable (see section 4.3.8).
data IN	Data to store

Serial API:

HOST->ZW: REQ | 0x22 | offset(2bytes) | data

ZW->HOST: RES | 0x22 | RetVal

4.3.8.4 MemoryGetBuffer

void MemoryGetBuffer(WORD offset,
BYTE *buffer,
BYTE length)

Macro: ZW_MEM_GET_BUFFER(offset,buffer,length)

Read a number of bytes from the NVM allocated for the application.

If a write operation is in progress, the write queue will be checked for the actual data.

Defined in: ZW_mem_api.h

Parameters:

offset IN	Address of declared far variable (see section 4.3.8).
buffer IN	Buffer pointer
length IN	Number of bytes to read

Serial API:

HOST->ZW: REQ | 0x23 | offset(2 bytes) | length

ZW->HOST: RES | 0x23 | buffer[ ]

4.3.8.5 MemoryPutBuffer

BYTE MemoryPutBuffer(WORD offset,
BYTE *buffer,
WORD length,
VOID_CALLBACKFUNC(func)(void))

Macro: ZW_MEM_PUT_BUFFER(offset,buffer,length, func)

Copy a number of bytes from a RAM buffer to the application area of the NVM.

If an area is to be set to zero there is no need to specify a buffer, just specify a NULL pointer.

Defined in: ZW_mem_api.h

Return value:

BYTE	FALSE	If the buffer put queue is full.

Parameters:

offset IN	Address of declared far variable (see section 4.3.8).	
buffer IN	Buffer pointer	If NULL all of the area will be set to 0x00
length IN	Number of bytes to read	
func IN	Buffer write completed function pointer	

Serial API:

HOST->ZW: REQ | 0x24 | offset(2bytes) | length(2bytes) | buffer[ ] | funcID

ZW->HOST: RES | 0x24 | RetVal

ZW->HOST: REQ | 0x24 | funcID

4.3.8.6 ZW_EepromInit

BOOL ZW_EepromInit(BYTE *homeID)

Macro: ZW_EEPROM_INIT(HOMEID)

Initialize the external NVM by writing zeros to the entire NVM. The API then writes the content of homeID if not zero to the home ID address in the external NVM.

This API call can only be called in production test mode from **ApplicationTestPoll**.

NOTE: This function is not implemented in Routing Slave API Library due to lack of external NVM.

Defined in: ZW_mem_api.h

Return value:

BOOL	TRUE	If the external NVM initialized successfully
	FALSE	Initialization failed

Parameters:

homeID IN	The home ID to be written to the external NVM.

Serial API (Not supported)

4.3.8.7 ZW_MemoryFlush

void ZW_MemoryFlush(void)

Macro: ZW_MEM_FLUSH()

This call writes data immediately to the application area of the NVM.

The data to be written to FLASH are not written immediately to the FLASH. Instead it is saved in a SRAM buffer and then written when the RF is not active and it is more than 200ms ago the buffer was accessed. This function can be used to write data immediately to FLASH without waiting for the RF to be idle.

NOTE: This function is only implemented in Routing Slave API libraries because they are the only libaries that use a temporary SRAM buffer. The other libraries use an external NVM. Data is written directly to the external NVM.

Defined in: ZW_mem_api.h

Serial API (Not supported)

4.3.8.8 NVM_get_id

void NVM_get_id(NVM_TYPE_T *pNVMid**)**

Macro: None

Get NVM ID from external NVM. The NVM ID is collected using a NVM “read ID” command, but not all supported NVMs support this command, so the memoryCapacity is set according to the NVM information in the NVR.

NOTE: This function is only available in libraries that has an external NVM.

Defined in: ZW_firmware_bootloader_defs.h

Return value:

pNVMid OUT NVM ID structure.

pNVMid->manufacturerID

Valid values for manufacturerID:
0x00-0xFE,
NVM_MANUFACTURER_UNKNOWN

pNVMid->memoryType

Valid values for memoryType:
NVM_TYPE_FLASH,
NVM_TYPE_EEPROM (all NVMs not supporting NVM read ID command)

pNVMid->memoryCapacity

Valid values for memoryCapacity:
NVM_SIZE_16KB, NVM_SIZE_32KB,
NVM_SIZE_128KB, NVM_SIZE_256KB,
NVM_SIZE_512KB,
NVM_SIZE_UNKNOWN

Serial API:

HOST->Z: REQ | 0x29

ZW->HOST: RES | 0x29 | length | NVMid

4.3.8.9 ZW_NVRGetValue

void NVRGetValue(BYTE bOffset, BYTE bLength, BYTE *pNVRValue)

Macro: None

Read a value from the NVR Flash memory area. The function will check the checksum of the NVR page and if the checksum is correct the function will read the value in NVR. If the checksum is incorrect the default unitialized value 0xFF will be read from all fields. The valid offset goes from 0x00 to 0xEF and to hide the lock bits from the application it is offset with 0x10 compared to the addresses that can be seen in the Z-Wave programmer when doing a raw read of the NVR.

The offset of a specific value can be found using the NVR_FLASH_STRUCT. An example of reading the NVM Type could be:

ZW_NVRGetValue(offsetof(NVR_FLASH_STRUCT, bNVMType) , 1, &bMyNVMType);

Defined in: ZW_nvr_api.h

Return value:

pNVRValue OUT	NVR Value. Valid values are 0x00-0xFF where a values of 0xFF indicates that the field in the NVR is not valid

Parameters:

bOffset IN	Offset of the NVR value as given by the NVR_FLASH_STRUCT
bLength IN	Length of the NVR value that should be read

Serial API:

HOST->ZW: REQ | 0x28 | offset | length

ZW->HOST: RES | 0x28 | length | NVRValue

4.3.8.10 NVM_ext_read_long_byte

BYTE NVM_ext_read_long_byte(DWORD offset)

Macro: None

Read a byte from external NVM at address offset.

NOTE: This function is used when doing OTA, and it is only avalible in libraries that has an external NVM.

Defined in: ZW_firmware_bootloader_defs.h

Return value:

BYTE	Data read from the external NVM

Parameters:

offset IN	Offset where to data is to be read. Currently only the 3 least significant bytes are used when addressing the NVM

Serial API:

HOST->ZW: REQ | 0x2C | offset3byte(MSB) | offset3byte | offset3byte(LSB)

ZW->HOST: RES | 0x2C | retval

4.3.8.11 NVM_ext_write_long_byte

BYTE NVM_ext_write_long_byte(DWORD offset, BYTE data)

Macro: None

Write a byte to external NVM at address offset.

NOTE: This function is used when doing OTA, and it is only avalible in libraries that has an external NVM.

WARNING: This function can write in the full NVM address space and is not offset to start at the application area. So care should be taken when using this function to avoid writing in the protocol NVM area.

Defined in: ZW_firmware_bootloader_defs.h

Return value:

BYTE	FALSE	If no write was needed.
	TRUE	If write was done

Parameters:

offset IN	Offset where to data is to be written. Currently only the 3 least significant bytes are used when addressing the NVM.
data IN	Data to write to external NVM

Serial API:

HOST->ZW: RES | 0x2D | offset3byte(MSB) | offset3byte | offset3byte(LSB) | data

ZW->HOST: REQ | 0x2D | retval

4.3.8.12 NVM_ext_read_long_buffer

void NVM_ext_read_long_buffer(DWORD offset,
BYTE *buffer,
WORD length)

Macro: None

Read a number of bytes from external NVM starting from address offset.

NOTE: This function is used when doing OTA, and it is only avalible in libraries that has an external NVM.

Defined in: ZW_firmware_bootloader_defs.h

Parameters:

offset IN	Offset from where data is to be read. Currently only the 3 least significant bytes are used when addressing the NVM
buffer OUT	Buffer pointer
length IN	Number of bytes to read

Serial API:

ZW->HOST: RES | 0x2A | offset3byte(MSB) | offset3byte | offset3byte(LSB) | length(MSB) | length(LSB)

ZW->HOST: REQ | 0x2A | buffer[]

4.3.8.13 NVM_ext_write_long_buffer

byte NVM_ext_write_long_buffer(DWORD offset,
BYTE *buffer,
WORD length)

Macro: None

Write a number of bytes to external NVM starting from address offset.

NOTE: This function is used when doing OTA, and it is only avalible in libraries that has an external NVM.

WARNING: This function can write in the full NVM address space and is not offset to start at the application area. So care should be taken when using this function to avoid writing in the protocol NVM area.

Defined in: ZW_firmware_bootloader_defs.h

Return Value:

BYTE	FALSE	If no write was needed.
	TRUE	If write was done

Parameters:

offset IN	Offset where to data is to be written. Currently only the 3 least significant bytes are used when addressing the NVM.
buffer IN	Buffer pointer
length IN	Number of bytes to write

Serial API:

HOST->ZW: REQ | 0x2B | offset3byte(MSB) | offset3byte | offset3byte(LSB) | length(MSB) | length(LSB) | buffer[]

ZW->HOST: RES | 0x2B | retval

4.3.9 Z-Wave Timer API

The Z-Wave Timer API provides a set a functions which MAY be used by an application to control the timing of events. Applications SHOULD use the Z-Wave Timer API functions. The Z-Wave Timer API supports a high number of concurrent software timer instances.
In addition to the software timers, the application MAY use one or two hardware timers provided by the 8051 architecture. Before using a hardware timer, the application designer MUST make sure that the actual hardware timer is not already allocated for use by the Z-Wave protocol library. Refer to section 3.4.

Software timers are based on a “tick-function” every 10 ms. The “tick-function” triggers a global tick counter and a number of active timers. The global tick counter is incremented on each “tick”. Active software timers are decremented on each “tick”. When an active timer value reaches 0, the registered timer function is called. The timer function is called from the Z-Wave main loop (non-interrupt environment).

Software timers provide limited accuracy. They are stopped while changing RF transmission direction and during sleep mode. The global tick counter and software timers will continue from their current state when resuming operation after sleep mode.

Software timers are targeted for a limited time duration. Longer timers may implemented by the application designer by multiple software timer periods combined with referring to the global tick counter. The global tick counter is stored in the global variable:

```
WORD  tickTime
```

4.3.9.1 TimerStart

BYTE TimerStart(VOID_CALLBACKFUNC(func)(),
BYTE bTimerTicks,
BYTE bRepeats)

Macro: ZW_TIMER_START(func, bTimerTicks, bRepeats)

Register a function that is called when the specified time has elapsed. Remember to check if the timer is allocated by testing the return value. The call back function is called "bRepeats" times before the timer is stopped. It's possible to have up to 5 timers running simultaneously.

Defined in: ZW_timer_api.h

Return value:

BYTE	Timer handle (timer table index). 0xFF is returned if the timer start operation failed. The timer handle is used when calling other timer functions such as TimerRestart, etc.

Parameters:

pFunc IN	Timeout function address (not NULL).
bTimerTicks IN	Timeout value (value * 10 ms). Predefined values: TIMER_ONE_SECOND
bRepeats IN	Number of function calls. Maximum value is 253. Predefined values: TIMER_ONE_TIME TIMER_FOREVER

Serial API (Not supported)

4.3.9.2 TimerRestart

BYTE TimerRestart(BYTE bTimerHandle)

Macro: ZW_TIMER_RESTART(BYTE bTimerHandle)

Set the specified timer's tick count to the initial value (extend timeout value).

NOTE: There is no protection in the API against calling this function with a wrong handler, so care should be taken not to use a handler of a timer that has already expired or been canceled.

Defined in: ZW_timer_api.h

Return value:

BYTE	TRUE	Timer restarted

Parameters:

bTimerHandle IN	Timer to restart

Serial API (Not supported)

4.3.9.3 TimerCancel

BYTE TimerCancel(BYTE bTimerHandle)

Macro: ZW_TIMER_CANCEL(bTimerHandle)

Stop and unregister the specified timer.

NOTE: There is no protection in the API against calling this function with a wrong handler, so care should be taken not to use a handler of a timer that has already expired.

Defined in: ZW_timer_api.h

Return value:

BYTE	TRUE	Timer cancelled

Parameters:

bTimerHandle IN	Timer number to stop

Serial API (Not supported)

4.3.10 Power Control API

The 500 Series Z-Wave SoC has two types of power down modes: WUT mode and Stop mode.

Stopped mode is the lowest power mode of the SoC where all circuitry is shut down except for a small basic block that keeps the IO states.

WUT mode is identical to Stopped mode except for enabling of a low power ring oscillator that ticks every second or 1/128 second. The WUT timer can wake up the chip after a programmable period of time.

Wake up of the two modes can also be accomplished by an external source (EXT1 pin).

During power down mode is a small part of the RAM powered called Critical Memory.

4.3.10.1 ZW_SetSleepMode

BOOL ZW_SetSleepMode(BYTE mode,
BYTE intEnable,
BYTE beamCount)

Macro: ZW_SET_SLEEP_MODE(MODE,MASK_INT)

This function MAY be used to set the SoC in a specified power down mode. Battery-operated devices may use this functionality in order to save power when idle.

If the Z-Wave protocol is currently busy, the node may stay awake for some time after the application issues a call to ZW_SetSleepMode(). When the protocol is idle, (stopped RF transmission etc.) the MCU will power down.

The RF transceiver is turned off so nothing can be received while in WUT or Stop mode. The ADC is also disabled when in WUT or Stop mode. The Z-Wave main loop is stopped until the MCU is awake again. Refer to the mode parameter description regarding how the MCU can be wakened up from sleep mode. In STOP and WUT modes interrupt(s) may be masked out so they cannot wake up the chip.

Any external hardware controlled by the application should be turned off before returning from the application poll function. The Z-Wave main loop is stopped until the MCU is wakened.
The chip resumes from sleep mode via a reset event. Thus, all temporary state must be re-established after the sleep mode.

It is RECOMMENDED that applications implementing FLiRS node functionality stays awake for two seconds after receiving a frame; either singlecast or multicast. This allows a transmitting node to send additional frames to the FLiRS node without prepending a beam to each frame. A two second stay-awake period after each received frame allows a FLiRS to quickly initiate secure communication and to transfer long payloads such as security certificates and firmware images.

When the ASIC is in power-down mode the EXT1 pin can get the SoC out of the power-down state by asserting it. This mode of operation can be activated by setting the IntEnable parameter in ZW_SetSleepMode to ZW_INT_MASK_EXT1. If the EXT1 pin is asserted when the SoC is in power-down mode, the ASIC will wake up from reset. If we are in FLIRS mode and the EXT1 pin is asserted and the unasserted during beam search then it will not wakeup the SoC. If we are in FLIRS mode and WUT timeout occur and an event on EXT1 happens simultaneously, the Z-Wave protocol will search for a beam, and if no beam is detected, then it will power down again. So to make sure that an event in EXT1 is detected when in FLiRS mode we should ensure that it is asserted longer than the beam search time (2.5ms for 2 channels and 4ms for 3 channels).

Warning: Using EXT1 pin as both an external interrupt source by setting EX1 = 1 and as wake up source for a FLiRS node requires that the EXT1 Interrupt Service Routine (ISR) can handle wake up events in an appropriate manner.

NOTE: This function is only implemented in Routing Slave, Enhanced 232 Slave and Portable Controller API libraries.

Defined in: ZW_power_api.h

Return values

BOOL	TRUE	The chip will power down when the protocol is ready
	FALSE	The protocol can not power down because a wakeup beam is being received, try again later.

Parameters:

mode IN	Specify the type of power save mode:	
	ZW_STOP_MODE	The whole chip is turned down. The chip can be wakened up again by Hardware reset or by the external interrupt INT1.
	ZW_WUT_MODE	The chip is powered down, and it can only be waked by the timer timeout or by the external interrupt INT1. The timeout interval of the WUT timer is controlled by the API call **ZW_SetWutTimeout**.
	ZW_WUT_FAST_MODE	This mode has the same functionality as ZW_WUT_MODE, except that the timer resolution is 1/128 s. The maximum timeout value is 2 s.
	ZW_FREQUENTLY_LISTENING_MODE	This mode make the module enter a Frequently Listening mode where the module will wakeup for a few milliseconds every 1000 ms or 250 ms and check for radio transmissions to the module (See 4.3.1.6 for details about selecting wakeup speed). The application will only wakeup if there is incoming RF traffic or if the intEnable or beamCount parameters are used.

intEnable IN	Interrupt enable bit mask. If a bit mask is 1, the corresponding interrupt is enabled and this interrupt will wakeup the chip from power down. Valid bit masks are:	
	ZW_INT_MASK_EXT1	External interrupt 1 (PIN P1_1) is enabled as interrupt source
	0x00	No external Interrupts will wakeup. Useful in WUT mode
beamCount IN	Frequently listening WUT wakeups	
	0x00	No WUT wakeups in Frequently listening mode. Both macro and serial API call use this value when called.
	0x01-0xFF	Number of frequently listening wakeup interval between the module does a normal WUT wakeup. This parameter is only used if mode is set to ZW_FREQUENTLY_LISTENING_MODE.

Serial API

HOST->ZW: REQ | 0x11 | mode | intEnable

4.3.10.2 ZW_SetWutTimeout

void ZW_SetWutTimeout (BYTE wutTimeout)

Macro: ZW_SET_WUT_TIMEOUT(TIME)

ZW_SetWutTimeout is speficially intended to set the WUT timer interval.

The chip resumes from sleep mode via a reset event. Thus, **ZW_SetWutTimeout** SHOULD be called before every call to **ZW_SetSleepMode** when enabling ZW_WUT_MODE. If not calling **ZW_SetWutTimeout**, a default value of 0 (zero) will be used (corresponding to 1 second).

The timer resolution of the WUT timer is one second. The maximum timeout value is 256 secs.

NOTE: This function is only implemented in Routing Slave, Enhanced 232 Slave and Portable Controller API libraries.

Defined in: ZW_power_api.h

Parameters:

wutTimeout IN	The Wakeup Timer timeout value.	The unit is the second. The resolution is 8 bit. [0..255] => [1 sec .. 256 sec]

Serial API

HOST->ZW: REQ | 0xB4 | wutTimeout

4.3.11 SPI interface API

The 500 Series Z-Wave SoC offers up to two SPI interfaces:

SPI0: operate as a SPI master or as a SPI slave
SPI1: operates as a SPI master

The SPI master, SPI1, is reserved by the Z-Wave protocol, if the 500 Series Z-Wave SoC is programmed as one of the following Z-Wave nodes types: Portable Controller, Static Controller, Bridge Controller, or Enhanced 232 Slave.

The state of the IO's used for SCK, MOSI, MISO and SS_N automatically setup by the SPI once it is enabled.

The SS_N input is used as SPI Slave Select for an SPI setup as a slave. If the SPI controller is master and it needs to select the slave(s), this has to be controlled by the application SW and an extra IO pin(s) has to be used for that purpose.

The SPI controllers can as an option be equipped with a DMA handler which enables buffered Rx and/or Tx operations. This can offload the built-in MCU when transceiving several bytes at a time.

4.3.11.1 Operation without DMA

Data to be transmitted is written to a SPI data register, one byte at the time and data received is read from a SPI data register one byte at the time.

A SPI interrupt is set when the SPI interface has transferred a byte on the SPI interface. T

4.3.11.2 Operation with Rx DMA

The following describes the functionality of each of the Rx DMA's for the SPI0 and the SPI1. Refer to the function descriptions further down in the document.

4.3.11.2.1 Buffer Configuration

The Receiver DMA is able to write to two RX buffers located in the lower 4kB XRAM. The first buffer (buffer 0) at a 12 bit byte-address that is set using the **ZW_SPI0_rx_dma_init()/ZW_SPI1_rx_dma_init()** function. The second buffer (buffer 1) is located right after the last byte of buffer 0. The buffers have the same length. This length is also set in the **ZW_SPI0_rx_dma_init()/ZW_SPI1_rx_dma_init()** function. See Figure 10.

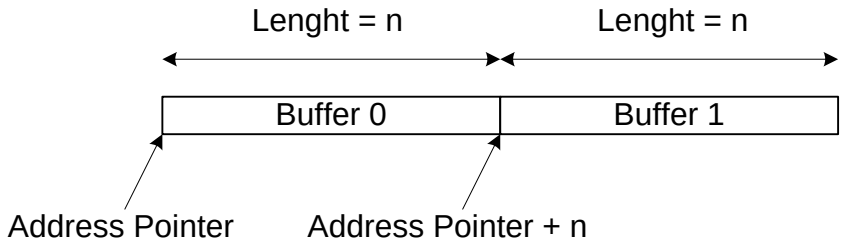


Figure 10 SPI Rx DMA buffers

4.3.11.2.2 Status/interrupts

When the Rx DMA has filled a buffer it can be setup to switch to the other and start transferring the following data bytes to the beginning of this other buffer. If it is not setup to switch to the other buffer on full it will stop the DMA function. The status bit SPI_RX_DMA_STATUS_BUFFULL will in both cases be

set and this bit can be read by the means of the **ZW_SPI0_rx_dma_status()** / **ZW_SPI0_rx_dma_status()** function.

An “interrupt byte count” can be set to instruct the SPI Rx DMA to issue an interrupt when it has received a certain number of bytes (or more) to the XRAM buffer.

> Example:
> The MCU sets the "interrupt byte count"to 4. The Rx DMA is enabled. When Rx DMA has transferred 4 bytes to the XRAM it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count"to 8. When Rx DMA has transferred 8 bytes (in total) to the XRAM it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count"to 10. In the meanwhile the Rx DMA already had transferred 12 bytes to the XRAM and therefore it issues an interrupt right away. Then MCU sets the "interrupt byte count"to 11 and this makes the Rx DMA to issues yet another interrupt right away.

When the Rx DMA reaches the “interrupt byte count” it can be instructed to switch to the other buffer and start transferring the following data bytes from the beginning of this buffer.

If the Rx DMA isn’t setup to switch to the other buffer at an “byte count” and it reaches the end of a buffer it can be configured either to stop or to switch to the other buffer.

The SPI Rx DMA can be setup to switch buffer when a user defined character has been received. When such an event occurs the ststus bit SPI_RX_DMA_STATUS_EOR will be set.

Any time the MCU can get the if status on whether the SPI Rx DMA is active. Likewise it can read which buffer (0 or 1) that the Rx DMA currently is using for the received data and how many data bytes that have been transferred to this buffer.

The Rx DMA will set a “loss of data” status bit, SPI_RX_DMA_STATUS_LOD, if a received data byte had to be discarded because the access to the XRAM was too slow. As an option the Rx DMA can issue an interrupt when the “loss of data” status bit is set.

The SPI Rx DMA function can be disabled anytime, in with case it will return to normal single byte operation.

4.3.11.3 Operation with Tx DMA

The following describes the functionality of each of the Tx DMA’s for the SPI0 and the SPI1.

4.3.11.3.1 Buffer Configuration

The transmitter DMA utilizes one TX buffer at a time. A buffer must be located in the 4kB XRAM at a 12 bit byte-address, which together with the buffer length is set by the means of the **ZW_SPI0_tx_dma_data()** / **ZW_SPI1_tx_dma_data()** function.

4.3.11.3.2 Status/interrupts

The “interrupt byte count” is used to instruct the Tx DMA to issue an interrupt when it has transmitted a certain number of bytes (or more) from the XRAM buffer.

> Example:
> The MCU sets the "interrupt byte count" to 4. The SPI Tx DMA is enabled. When Tx DMA has transferred 4 bytes from the XRAM to the SPI controller it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count" to 8. When Tx DMA has transferred 8 bytes (in total) to the XRAM it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count" to 10. In the meanwhile the Tx DMA already had transferred 12 bytes from the

XRAM and therefore it issues an interrupt right away. Then MCU sets the "interrupt byte count" to 11 and this makes the Tx DMA to issues yet another interrupt right away.

When the Tx DMA reaches the end of the buffer it will stop and clear the running status bit SPI_TX_DMA_STATUS_RUNNING. Note that this status bit does not inidicate whether the last byte has actually been transmitted on the SPI interface.

If the SPI is operating as a SPI master the SPI Tx DMA can be configured to insert a delay between each byte transmission (0-60 system clock periods).

Any time the MCU can read how many data bytes that have been transferred from the XRAM buffer.

The Rx DMA will set a status bit SPI_TX_DMA_STATUS_SLOW_XRAM if the SPI controller is ready to transfer a new data byte, but the Tx DMA wasn't able to read the new byte because the access to the XRAM was too slow.

The SPI Tx DMA function can be disabled anytime, in with case it will return to normal single byte operation.

4.3.11.4 ZW_SPI0_init

void ZW_SPI0_init(BYTE bSpiInit)

Initializes the 500 Series Z-Wave SoC built-in SPI0 master/slave controller. Notice that not all 500 Series Z-Wave SoC/modules has this SPI available on the pin-out and for some Z-Wave device types this SPI is reserved for the Z-Wave protocol.

This function sets the SPI clock speed, the signaling mode and the data order. E.g.:

```
ZW_SPI0_init(SPI_SPEED_8_MHZ|SPI_MODE_0|SPI_MSB_FIRST)
```

Sets clock speed to 8MHz, SPI clock idle to low, data sampled at rising edge and clocked at falling edge, and sends most significant bit first.

Defined in: ZW_spi_api.h

Parameters:

bSpiInit IN bit mask:

Speed of the SPI clock (master mode only)

SPI_SPEED_8_MHZ	SPI clock runs at @8MHz
SPI_SPEED_4_MHZ	SPI clock runs at @4MHz
SPI_SPEED_2_MHZ	SPI clock runs at @2MHz
SPI_SPEED_1_MHZ	SPI clock runs at @1MHz

SPI signaling modes[1]

SPI_MODE_0	SPI clock idle low, data sampled at rising edge and clocked at falling edge
SPI_MODE_1	SPI clock idle low, data sampled at falling edge and clocked at rising edge
SPI_ MODE_2	SPI clock idle high, data sampled at falling edge and clocked at rising edge
SPI_ MODE_3	SPI clock idle high, data sampled at rising edge and clocked at falling edge

Data order

SPI_MSB_FIRST	send MSB bit first
SPI_LSB_FIRST	send LSB bit first

Master/Slave

SPI_MASTER	enable SPI master mode
SPI_SLAVE	enable SPI slave mdoe

[1] In the 400 series API SPI_MODE_0 was called SPI_SIG_MODE_1, SPI_MODE_1 was called SPI_SIG_MODE_2, etc. The 400 names can still be used ina 500 Series application, but beware of the numbering.

Slave Select (Slave mode only)

SPI_SS_N_SS	use io SS_N IO as the slave select signal input when the 500 Series Z-Wave SoC is in SPI slave mode
SPI_SS_N_GPIO	slave controller is always enabled when the 500 Series Z-Wave SoC is in SPI slave mode. The IO, SS_N, can freely be used as a GPIO or for another HW function.

Serial API (Not supported)

4.3.11.5 ZW_SPI0_enable

void ZW_SPI0_enable(BYTE bState)

Function enables the SPI0 master and allocates the pins MISO0, MOSI0, and SCK0. If SPI_SS_N_SS is set in **ZW_SPI0_init()** then also SS_N0 is allocated.

Defined in: ZW_spi_api.h

Parameters:

bState IN	TRUE	enable the SPI0 controller
	FALSE	disable the SPI0 controller

Serial API (Not supported)

4.3.11.6 ZW_SPI0_rx_get

BYTE ZW_SPI0_rx_get(void)

Function returns a previously received byte from SPI0.

This function does not wait until data has been received.

Defined in: ZW_spi_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.11.7 ZW_SPI0_tx_set

void ZW_SPI0_tx_set(BYTE data)

For SPI master:

Function starts transmission over the SPI0. Waits until SPI0 transmitter is idle before it sends the new data and will then immediately return before the serial transmission has taken place.

For SPI slave:

Function transfers a data byte to the SPI0 register. Waits until SPI0 transmitter is idle before it transfers the new data, but it will not ensure that the transfer of data to the SPI0 register didn't happen without colliding with the next byte transfer. Use the function **ZW_SPI0_rx_coll_get()** to check whether a collition has occurred. The function will then immediately return possibly before the serial transmission is started (initiated by the SPI master).

Defined in: ZW_spi_api.h

Parameters:

data IN Data to be send.

Serial API (Not supported)

4.3.11.8 ZW_SPI0_active_get

BYTE ZW_SPI0_active_get(void)

Read the SPI0 send data status.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI0 Transmitter is busy
	zero (0x00)	SPI0 Transmitter is idle

Serial API (Not supported)

4.3.11.9 ZW_SPI0_coll_get

BYTE ZW_SPI0_coll_get(void)

This function returns the state of the SPI0 collision flag and then clears the collision flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI0 data collided
	zero (0x00)	SPI0 no collisions

Serial API (Not supported)

4.3.11.10 ZW_SPI0_int_enable

void ZW_SPI0_int_enable(BYTE boEnable)

Call will enable or disable the SPI0 interrupt. If enabled an interrupt routine must be defined. Default is the SPI0 interrupt is disabled.
NOTE: If the SPI0 interrupt is used, then the SPI0 interrupt flag should be reset before returning from the interrupt routine by calling **ZW_SPI0_int_clear**.
.

Defined in: ZW_spi_api.h

Parameters:

boEnable IN	TRUE	Enables the SPI0 interrupt.
	FALSE	Disables the SPI0 interrupt.

Serial API (Not supported)

4.3.11.11 ZW_SPI0_int_get

BYTE ZW_SPI0_int_get(void)

This function returns the state of the SPI0 interrupt/transmission done flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI0 interrupt/transmission flag is set
	zero (0x00)	SPI0 interrupt/transmission flag is cleared

Serial API (Not supported)

4.3.11.12 ZW_SPI0_int_clear

void ZW_SPI0_int_clear(void)

Function clears the SPI0 interrupt/transmission done flag

Defined in: ZW_spi_api.h

Serial API (Not supported)

4.3.11.13 ZW_SPI0_tx_dma_int_byte_count

void ZW_SPI0_tx_dma_int_byte_count(BYTE bByteCount)

Interrupt is issued when a certain number of bytes has been DMA'ed to the SPI. Only applicable when SPI0 Tx DMA is enabled.

Defined in: ZW_spi_api.h

Parameters:

bByteCount IN	Interrupt is issued when this number of bytes has been DMA'ed to SPI0	Disabled when set to 0x00

Serial API (Not supported)

4.3.11.14 ZW_SPI0_tx_dma_inter_byte_delay

void ZW_SPI0_tx_dma_inter_byte_delay(BYTE bDelay)

Sets the delay between the transmitted bytes. Only applicable when SPI0 is configured as SPI master and the SPI0 Tx DMA is enabled.

Defined in: ZW_spi_api.h

Parameters:

bDelay IN	Inter byte delay	0x00: no delay (default after reset) 0x01: 125ns delay 0x02: 250ns delay : : 0x0F: 1875ns delay

Serial API (Not supported)

4.3.11.15 ZW_SPI0_tx_dma_data

Void ZW_SPI0_tx_dma_data(XBYTE *pbAddress,
BYTE bBufferLen)

Sets buffer address and length and then starts SPI0 DMA. Discards any ongoing SPI Tx DMA process.

Defined in: ZW_spi_api.h

Parameters:

pbAddress IN Pointer to Tx buffer in lower 4kB XRAM

bBufferLen IN Buffer byte length (0-255)

Serial API (Not supported)

4.3.11.16 ZW_SPI0_tx_dma_status

BYTE ZW_SPI0_tx_dma_status(void)

If the SPI0 DMA process is ongoing this function Returns the status of this ongoing process. Returns the status of the latest SPI0 DMA process if the DMA has stopped

Defined in: ZW_spi_api.h

Return value:

BYTE	Returns the SPI0 Tx DMA status as bit mask byte	
	Zero	The DMA has stopped
	SPI_TX_DMA_STATUS_SLOW_XRAM	The DMA process can not keep up with configured inter byte because of congestion in XRAM access
	SPI_TX_DMA_STATUS_RUNNING	The DMA is transferring data to SPI0.

Serial API

Not implemented

4.3.11.17 ZW_SPI0_tx_dma_bytes_transferred

BYTE ZW_SPI0_tx_dma_bytes_transferred(void)

Returns the number of bytes that has been transferred to SPI0 from XRAM for the ongoing DMA process. If no transfer is ongoing it returns the number of bytes that has been transferred to SPI0 from XRAM during the latest SPI Tx DMA process.

Defined in: ZW_spi_api.h

Return value:

BYTE	Number of bytes that has been transferred to SPI0 from XRAM (0-255)

Serial API

Not implemented

4.3.11.18 ZW_SPI0_tx_dma_cancel

void ZW_SPI0_tx_dma_cancel(void)

Cancels any ongoing DMA process and brings SPI0 Tx DMA to idle state.

Defined in: ZW_spi_api.h

Parameters:

None

Serial API (Not supported)

4.3.11.19 ZW_SPI0_rx_dma_init

void ZW_SPI0_rx_dma_init(XBYTE *pbAddress
BYTE bBufLength
BYTE bBitMask)

Initialize the buffers, setup and start the SPI0 Rx DMA. Will discard any ongoing SPI0 Rx DMA process and clears status information before the DMA is started.

Defined in: ZW_spi_api.h

Parameters:

pbAddress IN	Pointer to the base address of the two Rx buffers in lower 4KB XRAM	
bBufLength IN	Length of SPI0 RX Buffer – (1-255)	Must be greater than 0
bBitMask IN	Bit mask contains the setting of the Rx DMA	
	SPI_RX_DMA_LOD_INT_EN	Enable Loss Of Data interrupt
	SPI_RX_DMA_SWITCH_COUNT	Switch buffer when byte count is reached. Refer to ??
	SPI_RX_DMA_SWITCH_FULL	Switch buffer when buffer full
	SPI_RX_DMA_SWITCH_EOR	Switch buffer when End-Of_Record char has been received. Refer to ??

Serial API (Not supported)

4.3.11.20 ZW_SPI0_rx_dma_int_byte_count

void ZW_SPI0_rx_dma_int_byte_count(BYTE bByteCount)

Set interrupt SPI0 Rx DMA byte count. A value of 0x00 means disabled.

Defined in: ZW_spi_api.h

Parameters:

bByteCount IN	An interrupt is issued when this number of bytes has been DMA'ed from SPI0 (0-255)	Disabled when set to 0x00

Serial API (Not supported)

4.3.11.21 ZW_SPI0_rx_dma_status

BYTE ZW_SPI0_rx_dma_status(void)

If the SPI0 Rx DMA process is ongoing this function returns the status of this ongoing process. Returns the status of the latest SPI0 Rx DMA process if the DMA has stopped.

Defined in: ZW_spi_api.h

Return value:

BYTE	Bit mask	
	SPI_RX_DMA_STATUS_EOR	The DMA switched RX buffer because it has recieved an End of Record char
	SPI_RX_DMA_STATUS_LOD	DMA can not keep up with the speed of the incomming data
	SPI_RX_DMA_STATUS_CURBUF1	Set when the SPI0 Rx DMA currently is transferring data to buffer 1. When cleared the SPI0 Rx DMA currently is transferring data to buffer 0
	SPI_RX_DMA_STATUS_BUFFULL	Set when the SPI0 DMA has filled a buffer to the limit
	SPI_RX_DMA_STATUS_RUNNING	The DMA is enabled

Serial API

Not implemented

4.3.11.22 ZW_SPI0_rx_dma_bytes_transferred

BYTE ZW_SPI0_rx_dma_bytes_transferred(void)

Returns the number of bytes that has been transferred from SPI0 to XRAM for the ongoing DMA process.

Defined in: ZW_spi_api.h

Return value:

BYTE	number of bytes that has been transferred to SPI0 to XRAM (0-255)

Serial API

Not implemented

4.3.11.23 ZW_SPI0_rx_dma_cancel

void ZW_SPI0_rx_dma_cancel(void)

Cancels any ongoing SPI0 Rx DMA process and brings SPI0 Rx DMA to idle state

Defined in: ZW_spi_api.h

Parameters:

None

Serial API (Not supported)

4.3.11.24 ZW_SPI0_rx_dma_eor_set

void ZW_SPI0_rx_dma_eor_set(BYTE bEorChar)

Sets SPI0 Rx DMA End-Of-Record character.

Defined in: ZW_spi_api.h

Return value:

bEorChar	End of Record chararter for the SPI0 Rx DMA

Serial API

Not implemented

4.3.11.25 ZW_SPI1_init

void ZW_SPI1_init(BYTE bSpiInit)

Initializes the 500 Series Z-Wave SoC built-in SPI master controller, SPI1. Notice that not all 500 Series Z-Wave SoC/modules has this SPI available on the pin-out and for some Z-Wave device types this SPI is reserved for the Z-Wave protocol.

The function sets the SPI clock speed, the signaling mode and the data order. E.g.:

```
ZW_SPI1_init(SPI_SPEED_8_MHZ|SPI_MODE_0|SPI_MSB_FIRST)
```

Sets clock speed to 8MHz, SPI clock idle to low, data sampled at rising edge and clocked at falling edge, and sends most significant bit first.

Defined in: ZW_spi_api.h

Parameters:

bSpiInit IN bit mask:

Speed of the SPI clock

SPI_SPEED_8_MHZ	SPI clock runs at @8MHz
SPI_SPEED_4_MHZ	SPI clock runs at @4MHz
SPI_SPEED_2_MHZ	SPI clock runs at @2MHz
SPI_SPEED_1_MHZ	SPI clock runs at @1MHz

SPI signaling modes[1]

SPI_MODE_0	SPI clock idle low, data sampled at rising edge and clocked at falling edge
SPI_MODE_1	SPI clock idle low, data sampled at falling edge and clocked at rising edge
SPI_ MODE_2	SPI clock idle high, data sampled at falling edge and clocked at rising edge
SPI_ MODE_3	SPI clock idle high, data sampled at rising edge and clocked at falling edge

Data order

SPI_MSB_FIRST	send MSB bit first
SPI_LSB_FIRST	send LSB bit first

Serial API (Not supported)

[1] In the 400 series API SPI_MODE_0 was called SPI_SIG_MODE_1, SPI_MODE_1 was called SPI_SIG_MODE_2, etc. The 400 names can still be used ina 500 Series application, but beware of the numbering.

4.3.11.26 ZW_SPI1_enable

void ZW_SPI1_enable(BYTE bState)

Function enables the SPI1 master and allocates the pins MISO1, MOSI1, and SCK1.

Defined in: ZW_spi_api.h

Parameters:

bState IN	TRUE	enable the SPI1 controller
	FALSE	disable the SPI1 controller

Serial API (Not supported)

4.3.11.27 ZW_SPI1_rx_get

BYTE ZW_SPI1_rx_get(void)

This function returns a previously received byte from SPI1.

This function does not wait until data has been received.

Defined in: ZW_spi_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.11.28 ZW_SPI1_tx_set

void ZW_SPI1_tx_set(BYTE data)

Function starts transmission over the SPI1. Waits until SPI1 transmitter is idle before it sends the new data and will then immediately return before the serial transmission has taken place.

Defined in: ZW_spi_api.h

Parameters:

data IN Data to be send.

Serial API (Not supported)

4.3.11.29 ZW_SPI1_active_get

BYTE ZW_SPI1_active_get(void)

Read the SPI1 send data status.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI1 Transmitter is busy
	zero (0x00)	SPI1 Transmitter is idle

Serial API (Not supported)

4.3.11.30 ZW_SPI1_coll_get

BYTE ZW_SPI1_coll_get(void)

This function returns the state of the SPI1 collision flag and then clears the collision flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI1 data collided
	zero (0x00)	SPI1 no collisions

Serial API (Not supported)

4.3.11.31 ZW_SPI1_int_enable

void ZW_SPI1_int_enable(BYTE boEnable)

Call will enable or disable the SPI1 interrupt. If enabled an interrupt routine must be defined. Default is the SPI1 interrupt is disabled.
NOTE: If the SPI1 interrupt is used, then the SPI1 interrupt flag should be reset before returning from the interrupt routine by calling **ZW_SPI1_int_clear**.
.

Defined in: ZW_spi_api.h

Parameters:

boEnable IN	TRUE	Enables the SPI1 interrupt.
	FALSE	Disables the SPI1 interrupt.

Serial API (Not supported)

4.3.11.32 ZW_SPI1_int_get

BYTE ZW_SPI1_int_get(void)

This function returns the state of the SPI1 interrupt/transmission done flag.

Defined in: ZW_spi_api.h

Return value:

BYTE	non-zero	SPI1 interrupt/transmission flag is set
	zero (0x00)	SPI1 interrupt/transmission flag is cleared

Serial API (Not supported)

4.3.11.33 ZW_SPI1_int_clear

void ZW_SPI1_int_clear(void)

Function clears the SPI1 interrupt/transmission done flag

Defined in: ZW_spi_api.h

Serial API (Not supported)

4.3.11.34 ZW_SPI1_tx_dma_int_byte_count

void ZW_SPI1_tx_dma_int_byte_count(BYTE bByteCount)

Set interrupt tx byte count. Only applicable when SPI1 Rx DMA is enabled.

Defined in: ZW_spi_api.h

Parameters:

bByteCount IN	Interrupt is issued when this number of bytes has been DMA'ed to SPI1	Disabled when set to 0x00

Serial API (Not supported)

4.3.11.35 ZW_SPI1_tx_dma_inter_byte_delay

void ZW_SPI1_tx_dma_inter_byte_delay(BYTE bDelay)

Sets the delay between the transmitted bytes. Only applicable when the SPI0 Tx DMA is enabled.

Defined in: ZW_spi_api.h

Parameters:

bDelay IN	Inter byte delay	0x00: no delay (default after reset) 0x01: 125ns delay 0x02: 250ns delay : : 0x0F: 1875ns delay

Serial API (Not supported)

4.3.11.36 ZW_SPI1_tx_dma_data

Void ZW_SPI1_tx_dma_data(XBYTE pbAddress,
BYTE bBufferLen)

Sets buffer address and length and then starts SPI1 DMA. Discards any ongoing SPI Tx DMA process.

Defined in: ZW_spi_api.h

Parameters:

pbAddress IN Pointer to Tx buffer in lower 4kB XRAM

bBufferLen IN Buffer byte length (0-255)

Serial API (Not supported)

4.3.11.37 ZW_SPI1_tx_dma_status

BYTE ZW_SPI1_tx_dma_status(void)

If the SPI1 DMA process is ongoing this function Returns the status of this ongoing process. Returns the status of the latest SPI1 DMA process if the DMA has stopped.

Defined in: ZW_spi_api.h

Return value:

BYTE	Returns the SPI1 Tx DMA status as bit mask byte	
	Zero	The DMA has stopped
	SPI_TX_DMA_STATUS_SLOW_XRAM	The DMA process can not keep up with configured inter byte because of congestion in XRAM access
	SPI_TX_DMA_STATUS_RUNNING	The DMA is transferring data to SPI1

Serial API

Not implemented

Defined in: ZW_spi_api.h

4.3.11.38 ZW_SPI1_tx_dma_bytes_transferred

BYTE ZW_SPI1_tx_dma_bytes_transferred(void)

Returns the number of bytes that has been transferred to SPI1 from XRAM for the ongoing DMA process. If no transfer is ongoing the number of bytes that has been transferred to SPI1 from XRAM from the latest process is returned.

Defined in: ZW_spi_api.h

Return value:

BYTE	Number of bytes that has been transferred to SPI1 from XRAM (0-255)

Serial API

Not implemented

4.3.11.39 ZW_SPI1_tx_dma_cancel

void ZW_SPI1_tx_dma_cancel(void)

Cancels any ongoing SPI1 Tx DMA process and brings SPI1 Tx DMA to idle state

Defined in: ZW_spi_api.h

Parameters:

None

Serial API (Not supported)

4.3.11.40 ZW_SPI1_rx_dma_init

void ZW_SPI1_rx_dma_init(XBYTE *pbAddress
BYTE bBufLength
BYTE bBitMask)

Initialize the buffers, setup and start the SPI1 Rx DMA. Will discard any ongoing SPI1 Rx DMA process and clears status information before the DMA is started.

Defined in: ZW_spi_api.h

Parameters:

pbAddress IN	Pointer to the base address of the two Rx buffers in lower 4KB XRAM	
bBufLength IN	Length of SPI1 RX Buffer – (1-255)	Must be greater than 0
bBitMask IN	Bit mask contains the setting of the Rx DMA	
	SPI_RX_DMA_LOD_INT_EN	Enable Loss Of Data interrupt
	SPI_RX_DMA_SWITCH_COUNT	Switch buffer when byte count is reached. Refer to ??
	SPI_RX_DMA_SWITCH_FULL	Switch buffer when buffer full
	SPI_RX_DMA_SWITCH_EOR	Switch buffer when End-Of_Record char has been received. Refer to ??

Serial API (Not supported)

4.3.11.41 ZW_SPI1_rx_dma_int_byte_count

void ZW_SPI1_rx_dma_int_byte_count(BYTE bByteCount)

Set interrupt SPI1 Rx DMA byte count. A value of 0x00 means disabled.

Defined in: ZW_spi_api.h

Parameters:

bByteCount IN	An interrupt is issued when this number of bytes has been DMA'ed from SPI1 (0-255)	Disabled when set to 0x00

Serial API (Not supported)

4.3.11.42 ZW_SPI1_rx_dma_status

BYTE ZW_SPI1_rx_dma_status(void)

If a SPI1 Rx DMA process is ongoing this function returns the status of this ongoing process. Returns the status of the latest SPI1 Rx DMA process if the DMA has stopped.

Defined in: ZW_spi_api.h

Return value:

BYTE	Bit mask	
	SPI_RX_DMA_STATUS_EOR	The DMA switched RX buffer because it has recieved an End of Record char
	SPI_RX_DMA_STATUS_LOD	DMA can not keep up with the speed of the incomming data
	SPI_RX_DMA_STATUS_CURBUF1	Set when the SPI1 Rx DMA currently is transferring data to buffer 1. When cleared the SPI1 Rx DMA currently is transferring data to buffer 0
	SPI_RX_DMA_STATUS_BUFFULL	Set when the SPI1 DMA has filled a buffer to the limit
	SPI_RX_DMA_STATUS_RUNNING	The DMA is enabled

Serial API

Not implemented

4.3.11.43 ZW_SPI1_rx_dma_bytes_transferred

BYTE ZW_SPI1_rx_dma_bytes_transferred(void)

Returns the number of bytes that has been transferred from SPI1 to XRAM for the ongoing DMA process.

Defined in: ZW_spi_api.h

Return value:

BYTE	number of bytes that has been transferred to SPI1 to XRAM (0-255)

Serial API

Not implemented

4.3.11.44 ZW_SPI1_rx_dma_cancel

void ZW_SPI1_rx_dma_cancel(void)

Cancels any ongoing SPI1 Rx DMA process and brings SPI1 Rx DMA to idle state

Defined in: ZW_spi_api.h

Parameters:

None

Serial API (Not supported)

4.3.11.45 ZW_SPI1_rx_dma_eor_set

void ZW_SPI1_rx_dma_eor_set(BYTE bEorChar)

Sets SPI1 Rx DMA End-Of-Record character

Defined in: ZW_spi_api.h

Return value:

bEorChar	End of Record chararter for the SPI1 Rx DMA

Serial API

Not implemented

4.3.12 ADC interface API

The ADC interface API provides access to an 8/12-bit ADC with input multiplexer [11].

The ADC MAY be used for monitoring battery levels [10], voltages across various sensors etc. The ADC MAY be configured to generate an interrupt request if the measured voltage is above, below or equal to a threshold depending on the configuration settings. The ADC MAY use up to 4 GPIO as inputs depending on its configuration. Input pins that are not enabled MAY be used as GPIO

Three sources can work as voltage-references for the ADC, namely either the power-supply for the chip, an internal 1.2V voltage-reference or the P3.7 pin. The sample rate when in continuous conversion mode is 21k sample/s for 8 bit conversions and 9k sample/s for 12 bit conversions.

The figures below show when the ADC interrupt is released dependent on, how the ADC threshold gradient is set:

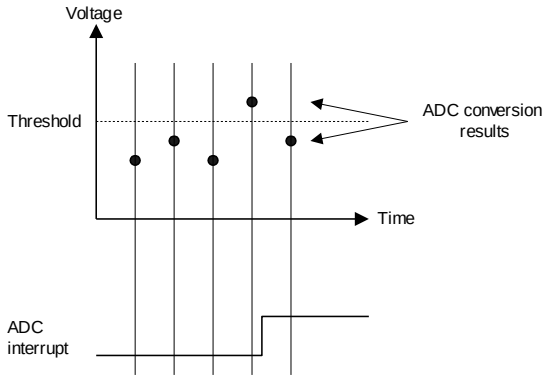


Figure 11. Threshold functionality when threshold gradient set to high

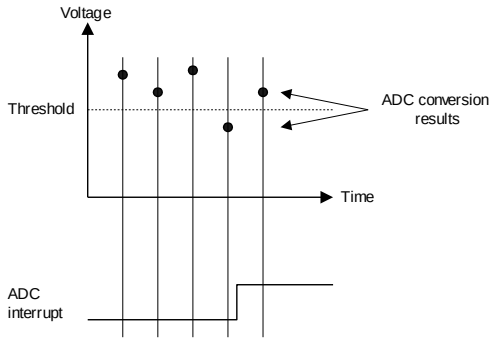


Figure 12. Threshold functionality when threshold gradient set to low

The figure below shows how the connections to the ADC can be configured:

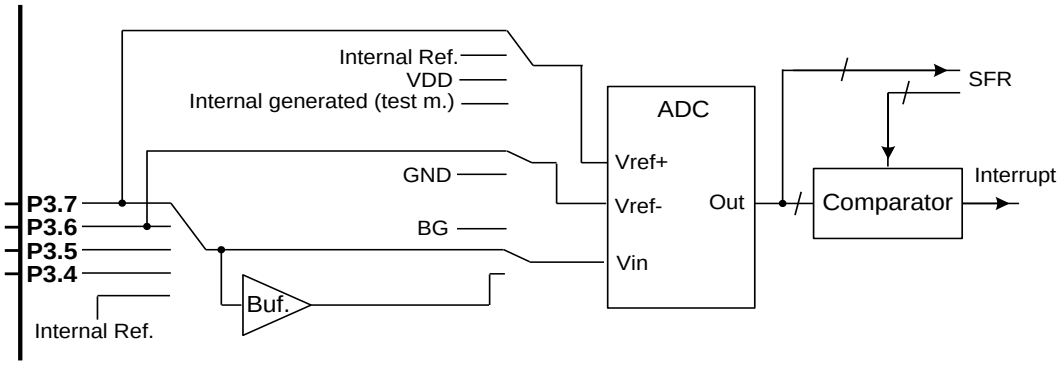


Figure 13. Configuration of input pins

The below are description of the API available to use the ADC.

4.3.12.1 ZW_ADC_init

void ZW_ADC_init (BYTE bMode,
BYTE bUpper_ref,
BYTE bLower_ref,
BYTE bPin_en)

This function MAY be used to initialize the ADC unit. The ADC unit may be operated in two different modes.

The ADC unit can sample four hardware inputs as well as the battery voltage. The Upper reference voltage can be set to be VCC, internal bandgab or external voltage on ADC_PIN_1. Lower reference voltage can be set to be either GND or external voltage on pin ADC_PIN_2.

If called, this function MUST be used to enable one or more of the I/O pins (ADC_PIN_1 .. ADC_PIN_4) as ADC inputs pins. No I/O pin will be selected as the active ADC input by this function. To select the active ADC input, **ZW_ADC_pin_select** MUST be called. To select battery measurement, **ZW_ADC_batt_monitor_enable** MUST be called

Defined in: ZW_adcdriv_api.h

Parameters

bMode IN	ADC_MULTI_CON_MODE	Set the ADC in multi conversion mode The ADC will continue converting until it is stopped.
	ADC_SINGLE_CON_MODE	Set the ADC in single conversion mode The ADC will convert one time then stops.
	ADC_BATT_MON_MODE	Set the ADC in battery monitoring mode. The chip supply voltage (VDD) is automatically selected as upper reference. GND will be selected as lower reference voltage. The ADC input will be the band gap circuit.
bUpper_ref	ADC_REF_U_VDD	Select the chip power supply (VDD) as the upper reference voltage. Ignored when ADC in battery monitor mode.
	ADC_REF_U_EXT	Select IO P3.7 as the upper reference voltage. Ignored when ADC in battery monitor mode.
	ADC_REF_U_BGAB	Select the band gab circuit as the upper reference voltage. Ignored when ADC in battery monitor mode.
bLower_ref	ADC_REF_L_VSS	Select the ground (VSS) as the lower reference voltage. Ignored when ADC in battery monitor mode.
	ADC_REF_L_EXT	Select IO P3.6 as lower reference voltage. Ignored when ADC in battery monitor mode.

bPin_en	Bitmask	Select which IO to enable as ADC inputs. Selected pins MUST NOT be used as GPIOs
	ADC_PIN_1	Select I/O P3.4 as an ADC input
	ADC_PIN_2	Select I/O P3.5 as an ADC input
	ADC_PIN_3	Select I/O P3.6 as an ADC input
	ADC_PIN_4	Select I/O P3.7 as an ADC input

Serial API (Not supported)

4.3.12.2 ZW_ADC_power_enable

void ZW_ADC_power_enable(BYTE boEnable)

This function SHOULD be used to control when the ADC unit is powered.

Battery powered devices not depending on an operational ADC during sleep (e.g. for keyboard decoding) may extend the battery lifetime by turning off the ADC unit before entering sleep mode.

Defined in: ZW_adcdriv_api.h

Parameters:

boEnable IN	TRUE	Turn the ADC power on
	FALSE	Turn the ADC power off. The ADC will cancel any activity immediately.

Serial API (Not supported)

4.3.12.3 ZW_ADC_enable

void ZW_ADC_enable(BYTE boStart)

This function MAY be used to start / stop the ADC unit.

If the ADC unit is currently performing a voltage conversion, the conversion process will continue running until pending conversions are finished.

Defined in: ZW_adcdriv_api.h

Parameters:

boStart IN	TRUE	Start the ADC and begin converting
	FALSE	Stop the ADC.

Serial API (Not supported)

4.3.12.4 ZW_ADC_pin_select

void ZW_ADC_pin_select(BYTE bAdcPin)

This function MAY be used to select the IO pin to use as active ADC input.

The IO pin MUST be enabled as an ADC input.

Defined in: ZW_adcdriv_api.h

Parameters:

bAdcPin IN	ADC_PIN_1	Select I/O P3.4 as an ADC input
	ADC_PIN_2	Select I/O P3.5 as an ADC input
	ADC_PIN_3	Select I/O P3.6 as an ADC input
	ADC_PIN_4	Select I/O P3.7 as an ADC input

Serial API (Not supported)

4.3.12.5 ZW_ADC_threshold_mode_set

void ZW_ADC_threshold_mode_set(BYTE bThresMode)

This function MAY be used to set the threshold mode of the ADC unit.
The threshold mode controls when the ADC generates an interrupt request.

Defined in: ZW_adcdriv_api.h

Parameters:

bThresMode	ADC_THRES_UPPER	Generate an interrupt request when input is above/equal to the threshold value
	ADC_THRES_LOWER	Generate an interrupt request when input is below/equal to the threshold value

Serial API (Not supported)

4.3.12.6 ZW_ADC_threshold_set

void ZW_ADC_threshold_set(WORD wThreshold)

This function MAY be used to set the ADC threshold value.
Depending on the threshold mode (set by **ZW_ADC_threshold_mode_set**) , the threshold value is used to trigger an interrupt when the sampled value is above/equal or below/equal the threshold value.

The API **ZW_ADC_resolution_set** MUST be called before calling this function.

Defined in: ZW_adcdriv_api.h

Parameters:

wThreshold IN	8-bit resolution	Threshold value range is 0 .. 255
	12-bit resolution	Threshold value range is 0 .. 4095

Serial API (Not supported)

4.3.12.7 ZW_ADC_int_enable

void ZW_ADC_int_enable(BYTE boEnable)

Thus function MAY be used to enable or disable ADC interrupt requests. If enabled an interrupt routine MUST be defined. The ADC interrupt is disabled by default.

If ADC interrupts are enabled, the ADC interrupt flag MUST be reset by calling **ZW_ADC_int_clear** before returning from the interrupt routine**.**

Defined in: ZW_adcdriv_api.h

Parameters:

boEnable IN	TRUE	Enable the ADC interrupt
	FALSE	Disable the ADC interrupt

Serial API (Not supported)

4.3.12.8 ZW_ADC_int_clear

void ZW_ADC_int_clear(void)

If ADC interrupts are enabled, this function MUST be called before returning from the interrupt routine**.**

Defined in: ZW_adcdriv_api.h

Serial API (Not supported)

4.3.12.9 ZW_ADC_is_fired

BOOL ZW_ADC_is_fired(void)

This function MAY be used to check if the most recent ADC conversion result meets the threshold criterion.

Defined in: ZW_adcdriv_api.h

Retrun value:

BOOL	TRUE	The most recent conversion result meets the threshold criterion
	FALSE	ADC conversion is not finished or the most recent conversion result does not meet the threshold criterion

Serial API (Not supported)

4.3.12.10 ZW_ADC_result_get

WORD ZW_ADC_result_get(void)

This function MAY be used to read back the result of the most recent ADC conversion. The return value is an 8-bit or 12-bit integer depending on the ADC resolution mode. The value ADC_NOT_FINISHED may be returned in case the ADC conversion process is still running.

Defined in: ZW_adcdriv_api.h

Return value:

WORD	8-bit resolution	Return value range is 0 .. 255 in bits 0..7 The 8 MS bits of the return value MUST be ignored
	12-bit resolution	Return value range is 0 .. 4095 in bits 0..11 The 4 MS bits of the return value MUST be ignored.

Serial API (Not supported)

4.3.12.11 ZW_ADC_buffer_enable

void ZW_ADC_buffer_enable(BYTE boEnable)

This function MAY be used to enable or disable an input buffer between the analog input and the ADC converter. The input buffer is disabled by default.

The input buffer SHOULD be enabled when interfacing to a high impedance analog input. A high impedance analog input connected directly to the ADC converter may cause increased ADC settling time.

Defined in: ZW_adcdriv_api.h

Parameters:

boEnable	TRUE	Enable the input buffer
	FALSE	Disable the input buffer

Serial API (Not supported)

4.3.12.12 ZW_ADC_auto_zero_set

void ZW_ADC_auto_zero_set(BYTE bAzpl)

This function MAY be used to define the ADC sampling period. Default value is ADC_AZPL_128.
It is RECOMMENDED to use longer sampling periods for high impedance analog inputs.

Defined in: ZW_adcdriv_api.h

Parameters:

bAzpl	ADC_AZPL_1024	Set the autozero period to 1024 clocks. RECOMMENDED for high impedance analog inputs
	ADC_AZPL_512	Set the autozero period to 512 clocks. RECOMMENDED for medium to high impedance analog inputs.
	ADC_ZPL_256	Set the autozero period to 256 clocks. RECOMMENDED for medium to low impedance analog inputs.
	ADC_ZPL_128	Set the autozero period to 128 clocks. RECOMMENDED for low impedance analog inputs.

Serial API (Not supported)

4.3.12.13 ZW_ADC_resolution_set

void ZW_ADC_resolution_set(BYTE bReso)

Thus function SHOULD be used to set the resolution of the ADC.
The threshold value SHOULD also be updated when changing the ADC resolution.

Defined in: ZW_adcdriv_api.h

Parameters:

bReso	ADC_12_BIT	Set the ADC resolution to 12 bits
	ADC_8_BIT	Set the ADC resolution to 8 bits

Serial API (Not supported)

4.3.12.14 ZW_ADC_batt_monitor_enable

void ZW_ADC_batt_monitor_enable(BYTE boEnable)

This function MAY be used to enable or disable the battery monitor mode.

When in battery monitor mode, the ADC will automatically be configured to have the VDD as upper reference voltage, VSS as lower reference voltage and the band gap as the ADC input.

If the ADC is running in 8-bit mode, the supply voltage can be calculated as follows:
Vsupply = (Vref * 256)/(ADC conversion result).

If the ADC is running in 12-bit mode, the supply voltage can be calculated as follows:
Vsupply = (Vref * 4096)/(ADC conversion result)
.

Defined in: ZW_adcdriv_api.h

Parameters:

bEnable	TRUE	Select battery monitor mode
	FALSE	Select normal conversion mode

Serial API (Not supported)

4.3.13 UART interface API

The UART (Universal Asynchronous Receiver Transmitter) interface is for serial communication with external devices such as PC's, host controllers etc. The two UART interfaces transmits data in an asynchronous way, and is a two-way communication protocol, using 2 pins each as a communications means: TxD and RxD. The two pins can be enabled and disabled individually. If only using RX mode the TxD pin can be used as general IO pins and vice versa. The UART's use dedicated timers and do not take up any 8051 timer resources.

Since the two UART's are identical the description of each function is collapsed using the notation UARTx, where x is either 0 or 1.

The UARTx supports full duplex and can operate with the baud rates between 9.6kbaud and 230.4 kbaud. (See under **ZW_UARTx_init**)

The interface operates with 8 bit words, one start bit (low), one stop bit (high) and no parity. This setup is hardwired and can not be changed.

The UARTx shifts data in/out in the following order: start bit, data bits (LSB first) and stop bit. The figure below gives the waveform of a serial byte.

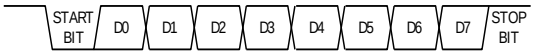


Figure 14. Serial Waveform

4.3.13.1 Transmission

An interrupt is released when D7 has been sent on the TxD pin. A new byte can be written to the buffer when the interrupt has been released.

4.3.13.2 Reception

The reception is activated by a falling edge on RxD. If the falling edge is not verified by the majority voting on the start bit, then the serial port stops reception and waits for another falling edge on RxD. When the MSB of the byte has been received a stop bit is expected. The first 2/3 of the stop bit is sampled and a majority decision is made on these samples. The interrupt will be released if the stop bit is recognized as high.

When 2/3 of the stop bit has been received the serial port waits for another high-to-low transition (start bit) on the RxD pin.

4.3.13.3 RS232

Connecting a RS232 level converter to the 2 pins of a UART interface makes the 500 Series Z-Wave SoC able to communicate according to the RS232 standard.

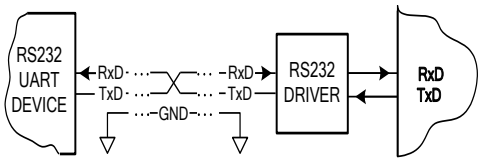


Figure 15. RS232 Setup

4.3.13.4 Integration

Before using the UARTx the UART should be initialized and mapped to the IO pins. This initialization should be performed in the initialization function **ApplicationInitHW**. The initialization and IO mapping is performed using the **ZW_UARTx_init** functions and if needed the **ZW_UART0_zm5202_mode_enable** function. There are no requirements to the order of calling these functions.

The use of the UART is typically performed in the **ApplicationPoll**. The UART is then polled and characters are received / transmitted. Alternatively, the UART can be serviced in an ISR, but this approach is often to slow for higher baudrates.

A UART application typically writes a character or string to a teminal. This can be performed by initializing the modem as described above in **ApplicationInitHW** and then calling **ZW_UARTx_tx_send_str(BYTE *str)** for an entire string. The function wait until the UART is ready before sending each character. However in some cases it is not desirable to wait until the UART is ready before continuing code execution. In this case it is better to poll to see if the UART is ready and then transmit characters when the UART is ready. In this case a different set of functions are needed as given below.

```
if (!ZW_UART0_tx_active_get())
{
    ZW_UART0_tx_send_str();
}
```

Another possibility is to use the interrupt flags:

```
if (ZW_UART0_tx_int_get())
{
    ZW_UART0_tx_int_clear();
    ZW_UART0_tx_send_str();
}
```

However the latter method has the disadvantage that it requires an initial write to the UART or else the first interrupt flag will not go high and the writing will never start.

Another typical UART application is to receive a character to the 500-series Z-Wave SoC. Similarly as for the TX setup, it is possible to poll for a new character before reading it.

An example of the preferred solution to receive characters is given below:

```
if (ZW_UART0_rx_int_get())
{
    ZW_UART0_rx_int_clear(); // Clear flag right after detection
    ch = ZW_UART0_rx_data_get(); // Where ch is of the type BYTE
    ...
}
```

Note: It is important to clear the interrupt flag as fast as possible after detecting the interrupt flag (even before reading data). Omitting to do this may lead to loss of data as the interrupt flag may trigger again before the flag is cleared. This is especially a concern at high baudrates.

The serial interface API handles transfer of data via the serial interfaces using the 500 Series Z-Wave SoC built-in UART0 and UART1.

The UART controllers can as an option be equipped with a DMA handler which enables buffered Rx and/or Tx operations. This can offload the built-in MCU when transceiving several bytes at a time.

4.3.13.5 Operation without DMA

Data to be transmitted is written to a UART data register, one byte at the time and data received is read from a SPI data register one byte at the time. A UART interrupt can be issued when the UART controller has transferred a byte on the UART interface. This non-DMA API supports transmissions of either a single byte, or a data string. The received characters are read by the application one-by-one.

4.3.13.6 Operation with Rx DMA

The following describes the functionality of each of the Rx DMA's for the UART0 and the UART1. Refer to the function descriptions further down in the document.

4.3.13.6.1 Buffer Configuration

The Receiver DMA is able to write to two RX buffers located in the lower 4kB XRAM. The first buffer (buffer 0) at a 12 bit byte-address that is set using the **ZW_UARTx_rx_dma_init()** function. The second buffer (buffer 1) is located right after the last byte of buffer 0. The buffers have the same length. This length is also set in the **ZW_UARTx_rx_dma_init** function. See Figure 16.

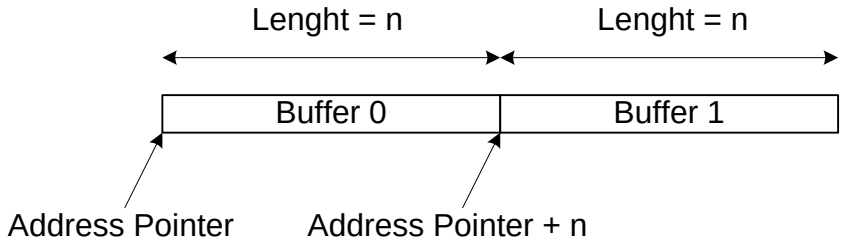


Figure 16 UART Rx DMA buffers

4.3.13.6.2 Status/interrupts/Switch buffer

When the Rx DMA has filled a buffer it can be setup to switch to the other and start transferring the following data bytes to the beginning of this other buffer. If it is not setup to switch to the other buffer on full it will stop the DMA function. The status bit UART_RX_DMA_STATUS_BUFFULL will in both cases be set and this bit can be read by the means of the **ZW_UARTx_rx_dma_status()** function.

An "interrupt byte count" can be set to instruct the UART Rx DMA to issue an interrupt when it has received a certain number of bytes (or more) to the XRAM buffer.

> Example:
> The MCU sets the "interrupt byte count"to 4. The Rx DMA is enabled. When Rx DMA has transferred 4 bytes to the XRAM it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count"to 8. When Rx DMA has transferred 8 bytes (in total) to the XRAM it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count"to 10. In the meanwhile the Rx DMA already had transferred 12 bytes to the XRAM and therefore it issues an interrupt right away. Then MCU sets the "interrupt byte count"to 11 and this makes the Rx DMA to issues yet another interrupt right away.

When the Rx DMA reaches the “interrupt byte count” it can be instructed to switch to the other buffer and start transferring the following data bytes from the beginning of this other buffer. This option is set initially using ZW_UARTx_rx_dma_init() or runtime using ZW_UARTx_rx_byte_count_enable().

If the Rx DMA isn’t setup to switch to the other buffer at an “byte count” and it reaches the end of a buffer it can be configured either to stop or to switch to the other buffer.

The UART Rx DMA can be setup to switch buffer when a user defined character has been received. When such an event occurs the status bit UART_RX_DMA_STATUS_EOR will be set.

Any time the MCU can get the status telling if the UART Rx DMA is active. Likewise it can read which buffer (0 or 1) that the Rx DMA currently is using for the received data and how many data bytes that have been transferred to this buffer.

The Rx DMA will set a “loss of data” status bit, UART_RX_DMA_STATUS_LOD, if a received data byte had to be discarded because the access to the XRAM was too slow. As an option the Rx DMA can issue an interrupt when the “loss of data” status bit is set.

The UART Rx DMA function can be disabled anytime, in with case it will return to normal single byte operation.

4.3.13.7 Operation with Tx DMA

The following describes the functionality of each of the Tx DMA’s for the UART0 and the UART1.

4.3.13.7.1 Buffer Configuration

The transmitter DMA utilizes one TX buffer at a time. A buffer must be located in the 4kB XRAM at a 12 bit byte-address, which together with the buffer length is set by the means of the ZW_UARTx_tx_dma_data() function.

4.3.13.7.2 Status/interrupts

The “interrupt byte count” is used to instruct the Tx DMA to issue an interrupt when it has transmitted a certain number of bytes (or more) from the XRAM buffer.

> Example:
> The MCU sets the "interrupt byte count" to 4. The UART Tx DMA is enabled. When Tx DMA has transferred 4 bytes from the XRAM to the UART controller it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count" to 8. When Tx DMA has transferred 8 bytes (in total) to the XRAM it issues an interrupt. The MCU handles the interrupt and sets the "interrupt byte count" to 10. In the meanwhile the Tx DMA already had transferred 12 bytes from the XRAM and therefore it issues an interrupt right away. Then MCU sets the "interrupt byte count" to 11 and this makes the Tx DMA to issues yet another interrupt right away.

When the Tx DMA reaches the end of the buffer it will stop and clear the running status bit UART_TX_DMA_STATUS_RUNNING. Note that this status bit does not inidicate whether the last byte has actually been transmitted on the UART interface.

If the UART is operating as a UART master the UART Tx DMA can be configured to insert a delay between each byte transmission (0-60 system clock periods).

Any time the MCU can read how many data bytes that have been transferred from the XRAM buffer.

The Rx DMA will set a status bit UART_TX_DMA_STATUS_SLOW_XRAM if the UART controller is ready to transfer a new data byte, but the Tx DMA wasn’t able to read the new byte because the access to the XRAM was too slow.

The UART Tx DMA function can be disabled anytime, in with case it will return to normal single byte operation.

4.3.13.8 ZW_UART0_init / ZW_UART1_init

void ZW_UART0_init(WORD bBaudRate, BYTE bEnableTx, BYTE bEnableRx) /
void ZW_UART1_init(WORD bBaudRate, BYTE bEnableTx, BYTE bEnableRx)

Initializes the 500 Series Z-Wave SoC built-in UARTx to support ZM5101 and SD3502. Using ZM5202 requires an additional call **ZW_UART0_zm5202_mode_enable** to map to correct pin configuration. The order of calling these functions are optional but the functions should be called in the **ApplicationInitHW()** so the ports are mapped correctly when the chip starts up.

The init functions optionally enable/disable UARTx transmit and/or receive, clears the rx and tx interrupt flags and sets the specified baud rate.

Defined in: ZW_uart_api.h

Parameters:

bBaudRate IN	Baud Rate / 100	Valid values: 96 ⇒ 9.6kbaud, 144 ⇒ 14.4kbaud, 192 ⇒ 19.2kbaud, 384 ⇒ 38.4kbaud, 576 ⇒ 57.6kbaud, 1152 ⇒ 115.2kbaud, 2304 ⇒ 230.4kbaud
bEnableTx IN	TRUE	Enable UARTx transmitter and allocate TxD pin as follows: UART0 TxD is allocated on P2.1 UART1 TxD is allocated on P3.1
	FALSE	Disable UARTx Transmitter and de-allocate TxD pin
bEnableRx IN	TRUE	Enable UARTx receiver and allocate RxD pin as follows: UART0 RxD is allocated on P2.0 UART1 RxD is allocated on P3.0
	FALSE	Disable UARTx receiver and de-allocate RxD pin

Serial API (Not supported)

4.3.13.9 ZW_UART0_zm5202_mode_enable

void ZW_UART0_zm5202_mode_enable(BOOL bState)

Map pins of the 500 Series Z-Wave SoC built-in UART0 to support ZM5202. Only available on UART0. Refer also to **ZW_UART0_init / ZW_UART1_init**

Defined in: ZW_uart_api.h

Parameters:

bState IN	TRUE	Support ZM5202 built-in UART0 by mapping TxD to IO P3.5 and RxD to IO P3.4. In addition, PWM is moved to P1.0.
	FALSE	Support ZM5101/SD3502 built-in UART0 by mapping TxD to IO P2.1 and RxD to IO P2.0. In addition, PWM is moved to P3.7.

Serial API (Not supported)

4.3.13.10 ZW_UART0_rx_data_get / ZW_UART1_rx_data_get

BYTE ZW_UART0_rx_data_get(void) / BYTE ZW_UART1_rx_data_get(void)

This function returns the last received byte from UARTx. The UART should be polled using the **ZW_UART0_rx_int_get / ZW_UART1_rx_int_get** to see whether a new byte is ready before calling this function.

The function does not wait for a byte to be received but returns immediately. The alternative functions **ZW_UART0_rx_data_wait_get / ZW_UART1_rx_data_wait_get** waits until a byte is received before returning.

Defined in: ZW_uart_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.13.11 ZW_UART0_rx_data_wait_get / ZW_UART1_rx_data_wait_get

BYTE ZW_UART0_rx_data_wait_get(void) / BYTE ZW_UART1_rx_data_wait_get(void)

Returns a byte from the UARTx receiver. If no byte is available the function waits until data has been received. This function should be used with *extreme caution* as it may freeze the system if no character is received. In normal cases it is better to use polling, **ZW_UART0_rx_int_get / ZW_UART1_rx_int_get**, to check if a new byte is received and then **ZW_UART0_rx_data_get / ZW_UART1_rx_data_get** to get the byte.

Defined in: ZW_uart_api.h

Return value:

BYTE Received data.

Serial API (Not supported)

4.3.13.12 ZW_UART0_tx_active_get / ZW_UART1_tx_active_get

BYTE ZW_UART0_tx_active_get(void) / BYTE ZW_UART1_tx_active_get(void)

Read the UARTx send data status. The function returns TRUE if the UART is currently busy transmitting data. The function is typically used in a polled TX setup to check whether the UART is ready before sending the next character using **ZW_UART0_tx_data_set / ZW_UART1_tx_data_set**.

Defined in: ZW_uart_api.h

Return value:

BYTE	non-zero	UARTx Transmitter is busy
	zero (0x00)	UARTx Transmitter is idle

Serial API (Not supported)

4.3.13.13 ZW_UART0_tx_data_set / ZW_UART1_tx_data_set

void ZW_UART0_tx_data_set(BYTE data) / void ZW_UART1_tx_data_set(BYTE data)

Function sets the transmit data register

This function does not wait until UARTx transmitter is idle before it sends the new data. The function should not be called unless the UART is ready. To check if the UART is ready is done using the **ZW_UART0_tx_active_get / ZW_UART1_tx_active_get**. Data send to the UART when it is not ready will be ignored.

Defined in: ZW_uart_api.h

Parameters:

data IN Data to send.

Serial API (Not supported)

4.3.13.14 ZW_UART0_tx_send_num / ZW_UART1_tx_send_num

void ZW_UART0_tx_send_num(BYTE data) / void ZW_UART1_tx_send_num(BYTE data)

Converts a byte to a two-byte hexadecimal ASCII representation, and transmits it over the UART. This function waits until UARTx transmitter is idle before it sends the new data. The function does not wait until the last data byte has been sent.

See also: **ZW_UART0_tx_send_str / ZW_UART1_tx_send_str** and ZW_UART0_tx_send_str / ZW_UART1_tx_send_str

void ZW_UART0_send_str(BYTE *str) / void ZW_UART1_send_str(BYTE *str)

Transmit a null terminated string over UARTx. The null data is not transmitted. This function waits until UARTx transmitter is idle before it sends the first data byte data. The function does not wait until the last data byte has been sent.

See also: **ZW_UART0_tx_send_num** / ZW_UART1_tx_send_num and

4.3.13.15 ZW_UART0_INT_ENABLE / ZW_UART1_INT_ENABLE

ZW_UART0_INT_ENABLE / ZW_UART1_INT_ENABLE

This macros enables UARTx interrupts

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.16 ZW_UART0_INT_DISABLE / ZW_UART1_INT_DISABLE

ZW_UART0_INT_DISABLE / ZW_UART1_INT_DISABLE

This macros disables UARTx interrupts

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.17 ZW_UART0_tx_send_nl / ZW_UART1_tx_send_nl

void ZW_UART0_tx_send_nl(void) / void ZW_UART1_tx_send_nl(void)

Transmit “new line” sequence (CR + LF) over UARTx .

See also: **ZW_UART0_tx_send_num** / ZW_UART1_tx_send_num and **ZW_UART0_tx_send_str / ZW_UART1_tx_send_str**

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.18 ZW_UART0_tx_int_clear / ZW_UART1_tx_int_clear

void ZW_UART0_tx_int_clear(void) / void ZW_UART1_tx_int_clear(void)

Clear the UARTx transmit interrupt/done flag.

See also: **ZW_UART0_tx_int_get / ZW_UART1_tx_int_get**

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.19 ZW_UART0_rx_int_clear / ZW_UART1_rx_int_clear

void ZW_UART0_rx_int_clear(void) / void ZW_UART1_rx_int_clear(void)

Clear the UARTx receiver interrupt/ready flag.

See also: **ZW_UART0_rx_int_get** / ZW_UART1_rx_int_get

Defined in: ZW_uart_api.h

Serial API (Not supported)

4.3.13.20 ZW_UART0_tx_int_get / ZW_UART1_tx_int_get

BYTE ZW_UART0_tx_int_get(void) / BYTE ZW_UART1_tx_int_get(void)

Returns the state of the Transmitter done/interrupt flag. This function has limited used and in practice it is preferred to check if the UART is ready using **the ZW_UART0_tx_active_get / ZW_UART1_tx_active_get** function in a polled configuration. The **ZW_UART0_tx_active_get / ZW_UART1_tx_active_get** does not require the interrupt flag to be cleared.

See also : **ZW_UART0_tx_int_clear / ZW_UART1_tx_int_clear**

Defined in: ZW_uart_api.h

Return value:

BYTE	non-zero	UARTx Transmitter done/interrupt flag is set
	zero (0x00)	UARTx Transmitter done/interrupt flag is cleared

Serial API (Not supported)

4.3.13.21 ZW_UART0_rx_int_get / ZW_UART1_rx_int_get

BYTE ZW_UART0_rx_int_get(void) / BYTE ZW_UART1_rx_int_get(void)

Returns the state of the receiver data ready/interrupt flag. The flag goes high when a new byte has been received. The flag should be cleared as soon as possible after detection in order to minimize risk of data loss (especially at high baud rates). Clearing the interrupt flag is done using the function **ZW_UART0_rx_int_clear / ZW_UART1_rx_int_clear**. When a new byte is detected the byte can be read using the **ZW_UART0_rx_data_get / ZW_UART1_rx_data_get** function.

See also: **ZW_UART0_rx_int_clear / ZW_UART1_rx_int_clear** and **ZW_UART0_rx_data_get** / ZW_UART1_rx_data_get

Defined in: ZW_uart_api.h

Return value:

BYTE	non-zero	UARTx Receiver data ready/interrupt flag is set
	zero (0x00)	UARTx receiver data ready/interrupt flag is cleared

Serial API (Not supported)

4.3.13.22 ZW_UART0_rx_enable / ZW_UART1_rx_enable

void ZW_UART0_rx_enable(BYTE bState) /
void ZW_UART1_rx_enable(BYTE bState)

This function is used to enable or disable the UARTx Rx function in runtime. Use the function **ZW_UARTx_init** to set the initial state of the Rx function. When enabling the UARTx Rx function the UARTx Rx pin will become an intput.

Defined in: ZW_uart_api.h

Parameters:

bState IN	TRUE	UARTx Rx enabled
	FALSE	UARTx Rx disabled

Serial API (Not supported)

4.3.13.23 ZW_UART0_tx_enable / ZW_UART1_tx_enable

void ZW_UART0_tx_enable(BYTE bState) /
void ZW_UART1_tx_enable(BYTE bState)

This function is used to enable or disable the UARTx TX function in runtime. Use the function **ZW_UARTx_init** to set the initial state of the Rx function. When enabling the UARTx Tx function the UARTx Tx pin will become an output.

Defined in: ZW_uart_api.h

Parameters:

bState IN	TRUE	UARTx Tx enabled
	FALSE	UARTx Tx disabled

Serial API (Not supported)

4.3.13.24 ZW_UART0_tx_dma_int_byte_count / ZW_UART1_tx_dma_int_byte_count

void ZW_UART0_tx_dma_int_byte_count(BYTE bByteCount) /
void ZW_UART1_tx_dma_int_byte_count(BYTE bByteCount)

Interrupt is issued when a certain number of bytes has been DMA'ed to the UART. Only applicable when the UART Tx DMA is enabled.

Defined in: ZW_uart_api.h

Parameters:

bByteCount IN	Interrupt is issued when this number of bytes has been DMA'ed to UARTx	Disabled when set to 0x00

Serial API (Not supported)

4.3.13.25 ZW_UART0_tx_dma_inter_byte_delay / ZW_UART1_tx_dma_inter_byte_delay

void ZW_UART0_tx_dma_inter_byte_delay(BYTE bDelay) /
void ZW_UART1_tx_dma_inter_byte_delay(BYTE bDelay)

Sets the delay between the transmitted bytes. Only applicable when UART0 is enabled.

Defined in: ZW_uart_api.h

Parameters:

bDelay IN	Inter byte delay	0x00: no delay (default after reset) 0x01: 125ns delay 0x02: 250ns delay : : 0x0F: 1875ns delay

Serial API (Not supported)

4.3.13.26 ZW_UART0_tx_dma_data / ZW_UART1_tx_dma_data

Void ZW_UART0_tx_dma_data(XBYTE *pbAddress,
BYTE bBufferLen) /
Void ZW_UART0_tx_dma_data(XBYTE *pbAddress,
BYTE bBufferLen)

Sets buffer address and length and then starts UART0 Tx DMA. Discards any ongoing UART Tx DMA process.

Defined in: ZW_uart_api.h

Parameters:

pbAddress IN Pointer to Tx buffer in lower 4kB XRAM

bBufferLen IN Buffer byte length (0-255)

Serial API (Not supported)

4.3.13.27 ZW_UART0_tx_dma_status / ZW_UART1_tx_dma_status

BYTE ZW_UART0_tx_dma_status(void) /
BYTE ZW_UART1_tx_dma_status(void)

If the UARTx Tx DMA process is ongoing this function returns the status of this ongoing process. Returns the status of the latest UARTx DMA process if the DMA has stopped

Defined in: ZW_uart_api.h

Return value:

BYTE	Returns the UARTx Tx DMA status as bit mask byte	
	Zero	The DMA has stopped
	UART_TX_DMA_STATUS_SLOW_XRAM	The DMA process can not keep up with configured inter byte because of congestion in XRAM access
	UART_TX_DMA_STATUS_RUNNING	The DMA is transferring data to UARTx.

Serial API

Not implemented

4.3.13.28 ZW_UART0_tx_dma_bytes_transferred / ZW_UART1_tx_dma_bytes_transferred

BYTE ZW_UART0_tx_dma_bytes_transferred(void) /
BYTE ZW_UART1_tx_dma_bytes_transferred(void)

Returns the number of bytes that has been transferred to UARTx from XRAM for the ongoing DMA process. If no transfer is ongoing it returns the number of bytes that has been transferred to UARTx from XRAM during the latest UARTx Tx DMA process.

Defined in: ZW_uart_api.h

Return value:

BYTE	Number of bytes that has been transferred to UARTx from XRAM (0-255)

Serial API

Not implemented

4.3.13.29 ZW_UART0_tx_dma_cancel / ZW_UART1_tx_dma_cancel

void ZW_UART0_tx_dma_cancel(void) /
void ZW_UART1_tx_dma_cancel(void)

Cancels any ongoing DMA process and brings UARTx Tx DMA to idle state.

Defined in: ZW_uart_api.h

Parameters:

None

Serial API (Not supported)

4.3.13.30 ZW_UART0_rx_dma_init / ZW_UART1_rx_dma_init

```
void ZW_UART0_rx_dma_init(  XBYTE *pbAddress,
                            BYTE bBufLength,
                            BYTE bBitMask) /
void ZW_UART1_rx_dma_init(  XBYTE *pbAddress,
                            BYTE bBufLength,
                            BYTE bBitMask)
```

Initialize the buffers, setup and start the UARTx Rx DMA. Will discard any ongoing UARTx Rx DMA process and clears status information before the DMA is started.

Defined in: ZW_uart_api.h

Parameters:

pbAddress IN	Pointer to the base address of the two Rx buffers in lower 4KB XRAM	
bBufLength IN	Length of UARTx RX Buffer – (1-255)	Must be greater than 0
bBitMask IN	Bit mask contains the setting of the Rx DMA	
	UART_RX_DMA_LOD_INT_EN	Enable Loss Of Data interrupt
	UART_RX_DMA_SWITCH_COUNT	Switch buffer when byte count is reached. Refer to 4.3.13.31 and 4.3.13.32 sections
	UART_RX_DMA_SWITCH_FULL	Switch buffer when buffer full
	UART_RX_DMA_SWITCH_EOR	Switch buffer when End-Of_Record char has been received. Refer to section 4.3.13.36

Serial API (Not supported)

4.3.13.31 ZW_UART0_rx_dma_int_byte_count / ZW_UART1_rx_dma_int_byte_count

void ZW_UART0_rx_dma_int_byte_count(BYTE bByteCount) /
void ZW_UART1_rx_dma_int_byte_count(BYTE bByteCount)

Set interrupt UARTx Rx DMA byte count. A value of 0x00 means disabled. The DMA can be configured to switch Rx buffer when the numbers of bytes set by this function have been received. See section 4.3.13.32

Defined in: ZW_uart_api.h

Parameters:

bByteCount IN	An interrupt is issued when this number of bytes has been DMA'ed from UARTx (0-255)	Disabled when set to 0x00

Serial API (Not supported)

4.3.13.32 ZW_UART0_rx_dma_byte_count_enable / ZW_UART1_rx_dma_ byte_count_enable

void ZW_UART0_rx_dma_byte_count_enable(BYTE bEnable) /
void ZW_UART1_rx_dma_byte_count_enable(BYTE bEnable)

Enables or disables the option to switch Rx buffer when a certain byte count is reached. The byte count is set using the function ZW_UARTx_rx_dma_int_byte_count()

Defined in: ZW_uart_api.h

Parameters:

bEnable IN	TRUE	The UARTx DMA will switch Rx buffer when the number of bytes specified by ZW_UARTx_rx_dma_int_byte_count have been received.
	FALSE	The UARTx DMA will not switch Rx buffer when the number of bytes specified by ZW_UARTx_rx_dma_int_byte_count have been received.

Serial API (Not supported)

4.3.13.33 ZW_UART0_rx_dma_status / ZW_UART1_rx_dma_status

BYTE ZW_UART0_rx_dma_status(void) /
BYTE ZW_UART1_rx_dma_status(void)

If the UARTx Rx DMA process is ongoing this function returns the status of this ongoing process. Returns the status of the latest UARTx Rx DMA process if the DMA has stopped.

Defined in: ZW_uart_api.h

Return value:

BYTE	Bit mask	
	UART_RX_DMA_STATUS_EOR	The DMA switched RX buffer because it has recieved an End of Record char
	UART_RX_DMA_STATUS_LOD	DMA can not keep up with the speed of the incomming data
	UART_RX_DMA_STATUS_CURBUF1	Set when the UARTx Rx DMA currently is transferring data to buffer 1. When cleared the UARTx Rx DMA currently is transferring data to buffer 0
	UART_RX_DMA_STATUS_BUFFULL	Set when the UARTx DMA has filled a buffer to the limit
	UART_RX_DMA_STATUS_RUNNING	The DMA is enabled

Serial API

Not implemented

4.3.13.34 ZW_UART0_rx_dma_bytes_transferred / ZW_UART1_rx_dma_bytes_transferred

BYTE ZW_UART0_rx_dma_bytes_transferred(void) /
BYTE ZW_UART1_rx_dma_bytes_transferred(void)

Returns the number of bytes that has been transferred from UARTx to XRAM for the ongoing DMA process.

Defined in: ZW_uart_api.h

Return value:

BYTE	Number of bytes that has been transferred to UARTx to XRAM (0-255)

Serial API

Not implemented

4.3.13.35 ZW_UART0_rx_dma_cancel / ZW_UART1_rx_dma_cancel

void ZW_UART0_rx_dma_cancel(void) /
void ZW_UART1_rx_dma_cancel(void)

Cancels any ongoing UARTx Rx DMA process and brings UARTx Rx DMA to idle state

Defined in: ZW_uart_api.h

Parameters:

None

Serial API (Not supported)

4.3.13.36 ZW_UART0_rx_dma_eor_set/ ZW_UART1_rx_dma_eor_set

void ZW_UART0_rx_dma_eor_set(BYTE bEorChar) /
void ZW_UART1_rx_dma_eor_set(BYTE bEorChar)

Sets UARTx Rx DMA End-Of-Record character.

Defined in: ZW_uart_api.h

Return value:

bEorChar	End of Record chararter for the UARTx Rx DMA

Serial API

Not implemented

4.3.14 Application HW Timers/PWM interface API

The 500 Series Z-Wave SoC has three built-in HW timers available for the application:

1. Timer0
2. Timer1
3. GPTimer or PWM generator.

Timer	bits	Clocked by	Count up/down
Timer0	8/13/16	32MHz / 2 or P3.4	Counts up
Timer1	8/13/16	32MHz / 2 or P3.5	Counts up
GPTimer	16	32MHz / 8 or 32MHz / 1024	Counts down

Timer0 and Timer1 are standard 8051 timers that can be configured to:

- be enabled/disabled
- use the system clock divided by 2 (16MHz) or use a pin as clock source
- generate an interrupt at overflow

Refer to figure below for principle diagrams of how the clock control works for Timer0.

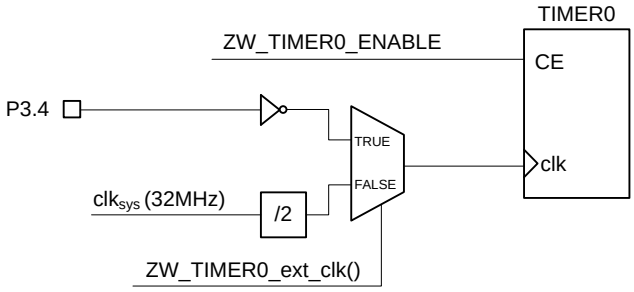


Figure 17. Principle of clock control for Timer0

Refer to figure below for principle diagrams of how the clock control works for Timer0.

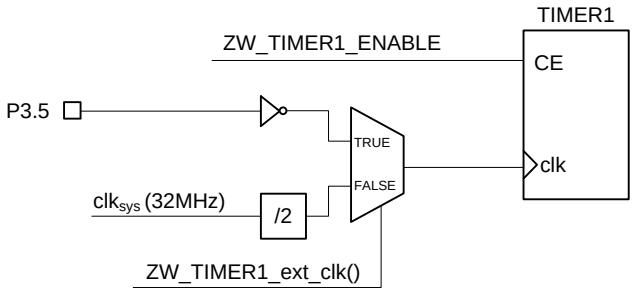


Figure 18. Principle of clock control (mode 0-2) for Timer1

Timer0 and Timer1 can operate in four different modes. Refer to the description of **ZW_TIMER1_init**

4.3.14.1 ZW_TIMER0_init

void ZW_TIMER0_init(BYTE bValue)

This function SHOULD be used to initialize Timer0.

Defined in: ZW_appltimer_api.h

Parameters:

bValue	Timer0 Mode:	
	TIMER_MODE_0	13 bit mode. The 5 lower bits of the low register acts as a 5 bit prescaler for the high byte
	TIMER_MODE_1	16 bit mode
	TIMER_MODE_2	8bit - auto reload mode. The 8bit timer runs in the high byte register. After an overflow the low byte register value is loaded into the high byte register
	TIMER_MODE_3	Timer 0 division mode. Timer 0 is divided into two 8 bit timers, one controlled by the Timer 0 control bits and the other controlled by the Timer 1 control bits. **Warning:** Enabling this will stop Timer 1

Serial API (Not supported)

4.3.14.2 ZW_TIMER1_init

void ZW_TIMER1_init(BYTE bValue)

This function SHOULD be used to initialize Timer1.

Defined in: ZW_appltimer_api.h

Parameters:

bValue	Timer1 Mode:	
	TIMER_MODE_0	13 bit mode. The 5 lower bits of the low register acts as a 5 bit prescaler for the high byte
	TIMER_MODE_1	16 bit mode (no reload)
	TIMER_MODE_2	8bit - auto reload mode. The 8bit timer runs in the high byte register. After an overflow the low byte register value is loaded into the high byte register
	TIMER_MODE_3	Disabled. **Warning:** If Timer0 uses mode 3 then Timer1 is stopped.

Serial API (Not supported)

4.3.14.3 ZW_TIMER0_INT_CLEAR / ZW_TIMER1_INT_CLEAR

ZW_TIMERx_INT_CLEAR

This macro SHOULD be used to clear timer interrupt/overflow flags.

Mode0-2: This macro clears the TIMER0/TIMER1 interrupt/overflow flag.
Mode3: This macro clears the TIMER0/TIMER1 high counter interrupt/overflow flag.

Defined in: ZW_appltimer_api.h

Serial API (Not supported)

4.3.14.4 ZW_TIMER0_INT_ENABLE / ZW_TIMER1_INT_ENABLE

ZW_TIMERx_INT_ENABLE(BYTE bState)

This macro SHOULD be used to enable or disable the Tiimer0/Timer1 interrupt.

Defined in: ZW_ appltimer _api.h

Parameters:

bState IN	TRUE	Mode0-2: TIMER0/TIMER1 interrupt is enabled Mode 3: TIMER0/TIMER1 high counter interrupt is enabled
	FALSE	Mode0-2: TIMER0/TIMER1 interrupt is enabled Mode 3: TIMER0/TIMER1 high counter interrupt is enabled

Serial API (Not supported)

4.3.14.5 ZW_TIMER0_ENABLE / ZW_TIMER1_ENABLE

ZW_TIMERx_ENABLE(BYTE bState)

This macro SHOULD be used to enable or halt Timer0/Timer1.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	Mode0-2: TIMER0/TIMER1 runs Mode 3: Timer0/Timer1 high counter runs
	FALSE	Mode0-2: TIMER0/TIMER1 is halted Mode 3: Timer0/timer1 high counter is halted

Serial API (Not supported)

4.3.14.6 ZW_TIMER0_ext_clk / ZW_TIMER1_ext_clk

ZW_TIMERx_ext_clk(BYTE bState)

This function SHOULD be used to set the clock source for timer0/timer1

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	Timer0 runs on external clock (falling edge) of P3.4. Timer1 runs on external clock (falling edge) of P3.5. (synchronized to the system clock)
	FALSE	Timer0/Timer1 runs on system clock (divided by 2) - default value after reset

Serial API (Not supported)

4.3.14.7 ZW_TIMER0_LOWBYTE_SET / ZW_TIMER1_LOWBYTE_SET

ZW_TIMERx_LOWBYTE_SET (BYTE bValue)

This macro SHOULD be used to set the timer0/timer1 low byte value, see below.

Defined in: ZW_appltimer_api.h

Parameters:

bValue IN The input value depends on the chosen mode:

Mode0: Lower 5 bits sets the prescaler value for the 13 bit timer
Mode1: Sets the lower 8 bits of the 16 bit timer
Mode2: N.A.
Mode3: N.A.

Serial API (Not supported)

4.3.14.8 ZW_TIMER0_HIGHBYTE_SET / ZW_TIMER1_HIGHBYTE_SET

ZW_TIMERx_HIGHBYTE_SET (BYTE bValue)

This macro SHOULD be used to set the timer0/timer1 high byte value, see below.

Defined in: ZW_appltimer_api.h

Parameters:

bValue IN The input value depends on the chosen mode:

Mode0: Sets the 8 bit timer value
Mode1: Sets the upper 8 bits of the 16 bit timer
Mode2: Sets the 8 bit reload value of the 8 bit timer0
Mode3: N.A.

Serial API (Not supported)

4.3.14.9 ZW_TIMER0_HIGHBYTE_GET / ZW_TIMER1_HIGHBYTE_GET

BYTE ZW_TIMERx_HIGHBYTE_GET

This macro MAY be used to query the timer0/timer1 high register value

Defined in: ZW_appltimer_api.h

Return value:

BYTE The return value depends on the chosen mode:

Mode0: 8 bit timer value
Mode1: upper 8 bits of the 16 bit timer
Mode2: 8 bit timer value
Mode3: N.A.

Serial API (Not supported)

4.3.14.10 ZW_TIMER0_LOWBYTE_GET / ZW_TIMER1_LOWBYTE_GET

BYTE ZW_TIMERx_LOWBYTE_GET

This macro MAY be used to query the timer0/timer1 timer low register value

Defined in: ZW_appltimer_api.h

Return value:

BYTE The return value depends on the chosen mode:

Mode0: 5 bit prescaler value for the 13 bit timer. (lower 5 bits)
Mode1: lower 8 bits of the 16 bit timer
Mode2: 8 bit timer value
Mode3: N.A.

Serial API (Not supported)

4.3.14.11 ZW_TIMER0_word_get / ZW_TIMER1_word_get

WORD ZW ZW_TIMERx_word_get (void)

This function MAY be used to query the two 8 bit timer0/timer1 register values as one 16 bit value. Used when timer0/timer1 is set in mode 1.

Defined in: ZW_appltimer_api.h

Return value:

WORD 16bit timer value

Serial API (Not supported)

4.3.14.12 ZW_GPTIMER_init

void ZW_GPTIMER_init(BYTE bValue)

This function SHOULD be used to initialize the GPTimer. Calling **ZW_GPTIMER_init()** will disable the PWM, since the GP Timer and the PWM share the same hardware resources. The GPTimer is hardcoded to count down.

Defined in: ZW_appltimer_api.h

Parameters:

bValue IN	Bit mask:	
	Prescaler setting	
	PRESCALER_BIT	When set: Timer counter runs @ 32MHz / 1024 = 31.25kHz When nor set: Timer counter runs @ 32MHz / 8 = 4MHz
	Reload Timer	
	RELOAD_BIT	When set: The GPTimer counter registers are reloaded with the reload register value upon underrun. When not set: The GPTimer stops upon underrun.
	Immediate write	
	IMWR_BIT	When set: The GP Timer counters will be loaded with the value of the reload register when it is disabled or immediately when the reload values are set. When not set: The GP Timer counters will be loaded with the value of the reload register when it is disabled or when it times out (underrun).

Serial API (Not supported)

4.3.14.13 ZW_GPTIMER_int_clear

void ZW_GPTIMER_int_clear (void)

This function SHOULD be used to clear the GP Timer interrupt flag.

Defined in: ZW_appltimer_api.h

Serial API (Not supported)

4.3.14.14 ZW_GPTIMER_int_get

BYTE ZW_GPTIMER_int_get (void)

This function MAY be used to query the state of the GP Timer interrupt flag.

Defined in: ZW_appltimer_api.h

Return value:

BYTE	0x00: interrupt flag is not set mom-0x00: Interrupt is set

Serial API (Not supported)

4.3.14.15 ZW_GPTIMER_int_enable

void ZW_GPTIMER_int_enable(BYTE bState)

This function SHOULD be used to enable or disable the GPTimer interrupt.

The application designer MUST declare an Interrupt Service Routine (ISR) to handle the GP Timer interrupt. The ISR MUST use the ISR number INUM_GP_TIMER as declared in section 3.6.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	enable GPTimer interrupt
	FALSE	disable GPTimer interrupt

Serial API (Not supported)

4.3.14.16 ZW_GPTIMER_enable

void ZW_GPTIMER_enable(BYTE bState)

This function SHOULD be used to enable or disable the GPTimer.
Disabling the GPTimer also clears the interrupt flag and resets the GPTimer counters.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	enable GPTimer.
	FALSE	disable GPTimer.

Serial API (Not supported)

4.3.14.17 ZW_GPTIMER_pause

void ZW_GPTIMER_pause(BYTE bState)

This function MAY be used to control the GPTimer pause state.
When entering the pause state, the GPTimer counters stops counting.
When leaving the pause state, the counters will start counting from the state they were in when the pause state was entered.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	Enter GPTimer pause state.
	FALSE	Leave GPTimer pause state.

Serial API (Not supported)

4.3.14.18 ZW_GPTIMER_reload_set

void ZW_GPTIMER_reload_set(WORD wReloadValue)

This function SHOULD be used to set the 16 bit GPTimer reload register. This value sets the time from where the GPTimer is enabled or is reloaded until it reaches zero (issues an interrupt).
As an example, if the GPtimer reload value is set to 0x0137 and the prescaler is set to 1024, the timer will reach zero after $0x137 * 1024 * (32MHz)^{-1} = 9.95ms$.

The value 0x0000 equals a timer reload value of 0x10000. E.g. if the GPtimers reload value is set to 0x0000 and the prescaler is set to 8, the timer will reach zero after $0x10000 * 8 * (32MHz)^{-1} = 16.38ms$.

Defined in: ZW_appltimer_api.h

Parameters:

wReloadValue IN 16 bit reload value

Serial API (Not supported)

4.3.14.19 ZW_GPTIMER_reload_get

WORD ZW_GPTIMER_reload_get(void)

This function MAY be used to query the 16 bit GPTimer reload register value.

Defined in: ZW_appltimer_api.h

Return value:

WORD 16 bit reload value

Serial API (Not supported)

4.3.14.20 ZW_GPTIMER_get

WORD ZW_GPTIMER_get(void)

This function MAY be used to query the 16 bit GPTimer counter register value.
The returned value is in the range [reload_value-1;0]. As an example, if the reload value is set to 0x2A40, **ZW_GPTIMER_get()** will return a value in the range [0x2A3F;0].

An application SHOULD be designed to be robust if a higher value is returned, e.g. because the reload value was not correctly stored in the chip.

Defined in: ZW_appltimer_api.h

Return value:

WORD	16 bit counter value

Serial API (Not supported)

4.3.14.21 ZW_PWM_init

void ZW_PWM_init(BYTE bValue)

This function SHOULD be used to initialize the pulse width modulator. Calling **ZW_PWM_init()** will disable the GPTimer function, since the PWM and the GP Timer share the same hardware.

It is NOT RECOMMENDED that Immediate write mode is enabled as it introduces a risk of unintended waveforms.

Defined in: ZW_appltimer_api.h

Parameters:

bValue IN	Bit mask:	
	Prescaler setting	
	PRESCALER_BIT	When set: PWM counter runs @ 32MHz / 1024 = 31.25kHz When nor set: PWM counter runs @ 32MHz / 8 = 4MHz
	Invert signal	
	PWMINV_BIT	When set: PWM signal is inverted. When not set: The signal is not inverted
	Immediate write	
	IMWR_BIT	When set: The PWM counters will be loaded with the value of the waveform registers when it is disabled or immediately when the waveform values are set. When not set: The PWM counters will be loaded with the value of the waveform registers when it is disabled or at the end of a PWM signal period.

Serial API (Not supported)

4.3.14.22 ZW_PWM_enable

void ZW_PWM_enable(BYTE bState)

This function SHOULD be used to enable or disable the PWM.
Disabling the PWM also clears the interrupt flag and resets the PWM counter.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	enable PWM.
	FALSE	disable PWM.

Serial API (Not supported)

4.3.14.23 ZW_PWM_int_clear

void ZW_PWM_int_clear (void)

This function SHOULD be used to clear the PWM interrupt flag.

Defined in: ZW_appltimer_api.h

Serial API (Not supported)

4.3.14.24 ZW_PWM_int_get

BYTE ZW_PWM_int_get (void)

This function MAY be used to query the state of the PWM interrupt flag.

Defined in: ZW_appltimer_api.h

Return value:

BYTE	0x00: interrupt flag is not set non-0x00: Interrupt is set

Serial API (Not supported)

4.3.14.25 ZW_PWM_int_enable

void ZW_PWM_int_enable(BYTE bState)

This function SHOULD be used to enable or disable the PWM interrupt.
The PWM interrupt is triggered on the rising edge of the PWM signals (or at the falling edge of the PWM signal if PWMINV_BIT is set in ZW_PWM_init()).

The application designer MUST declare an Interrupt Service Routine (ISR) to handle the PWM controller interrupt. The ISR MUST use the ISR number INUM_GP_TIMER as declared in section 3.6.

Section 4.3.14.25 recommends that Immediate write is not enabled. With Immediate write disabled, the application may unintentionaly inhibit the flow of IRQs from the PWM controller. This may happen if the application calls ZW_PWM_waveform_set with the parameter value (0,0). Refer to 4.3.14.26 on how to recover from this situation.

Defined in: ZW_appltimer_api.h

Parameters:

bState IN	TRUE	enable PWM interrupt
	FALSE	disable PWM interrupt

Serial API (Not supported)

4.3.14.26 ZW_PWM_waveform_set

void ZW_PWM_waveform_set (BYTE bHigh,
BYTE bLow)

This function SHOULD be used to set the high and low time of the PWM signal. Refer to figure below.

High time of PWM signal: $t_{hPWM} = (bHigh * PRESCALER)/f_{sys}$
Low time of PWM signal $t_{lPWM} = (bLow * PRESCALER) /f_{sys}$
Total period of PWM signal: $T_{PWM} = t_{hPWM} + t_{lPWM}$

where f_{sys} is 32MHz and
PRESCALER is 1024 when PRESCALER_BIT is set by ZW_PWM_init() and
PRESCALER is 8 when PRESCALER_BIT is not set.

NOTE: If PWMINV_BIT was set by ZW_PWM_init(), bHigh defines the duration of the low period and bLow defines the duration of the high period..

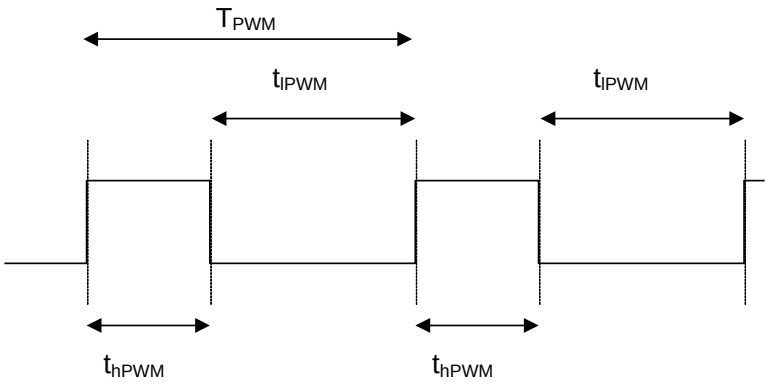


Figure 19. PWM waveform

Section 4.3.14.25 recommends that Immediate write is not enabled. With Immediate write disabled, the application SHOULD NOT call ZW_PWM_waveform_set with the parameter value (0,0). In case the parameter value (0,0) has been used, the application MUST call ZW_PWM_waveform_set with one or two non-zero values and subsequently disable and re-enable the PWM controller by calling ZW_PWM_enable.
While NOT RECOMMENDED, Immediate write MAY be enabled. In that case, the application MAY call ZW_PWM_waveform_set with any parameter value.

Defined in: ZW_appltimer_api.h

Parameters:

bHigh IN high time

bLow IN low time

Serial API (Not supported)

4.3.14.27 ZW_PWM_waveform_get

void ZW_waveform_get(BYTE *bHigh,
BYTE *bLow)

This function MAY be used to query the values of the waveform registers.

Defined in: ZW_appltimer_api.h

Parameters:

bHigh OUT high time

bLow OUT low time

Serial API (Not supported)

4.3.15 AES API (Only available in a secure SDK)

The built-in AES-128 hardware engine is a NIST standardized AES 128 block cipher. The cipher engine is used by the Z-Wave Protocol to encrypt/decrypt Z Wave frame payload and to authenticate Z Wave frames. In addition this AES-128 encryption engine can also be used to encrypt a 128bit data block (Using ECB - Electronic CookBook mode) by the application.

The input and output data and key for the AES API's are 16 bytes long char arrays. **ZW_AES_ecb_set** is used to set the input data (plaintext and key) and the function **ZW_AES_ecb_get** is used to return the cipher data from the AES engine. The ECB process is started using the function **ZW_AES_ecb_enable(TRUE)** and it lasts about 24µs. The process can be canceled by calling **ZW_AES_ecb_enable(FALSE).** The AES engine must be polled, using the function **ZW_AES_ecb_active** to check when a ECB process is done. Figure below gives an example of how the AES engine functions are called.

```
/* Example of ECB ciphering. Vectors are from FIPS-197 */

void ApplicationPoll()
{
    :
   switch (mainState)
   {
     :
   case START_AES_TEST:
      keybuffer[15] =  0x00;
      keybuffer[14] =  0x01;
      keybuffer[13] =  0x02;
      keybuffer[12] =  0x03;
      keybuffer[11] =  0x04;
      keybuffer[10] =  0x05;
      keybuffer[9]  =  0x06;
      keybuffer[8]  =  0x07;
      keybuffer[7]  =  0x08;
      keybuffer[6]  =  0x09;
      keybuffer[5]  =  0x0A;
      keybuffer[4]  =  0x0B;
      keybuffer[3]  =  0x0C;
      keybuffer[2]  =  0x0D;
      keybuffer[1]  =  0x0E;
      keybuffer[0]  =  0x0F;

      plainbuffer[15] = 0x00;
      plainbuffer[14] = 0x11;
      plainbuffer[13] = 0x22;
      plainbuffer[12] = 0x33;
      plainbuffer[11] = 0x44;
      plainbuffer[10] = 0x55;
      plainbuffer[9]  = 0x66;
      plainbuffer[8]  = 0x77;
      plainbuffer[7]  = 0x88;
      plainbuffer[6]  = 0x99;
      plainbuffer[5]  = 0xAA;
      plainbuffer[4]  = 0xBB;
      plainbuffer[3]  = 0xCC;
      plainbuffer[2]  = 0xDD;
      plainbuffer[1]  = 0xEE;
      plainbuffer[0]  = 0xFF;

      cipherbuffer[15] = 0x69;
      cipherbuffer[14] = 0xC4;
      cipherbuffer[13] = 0xE0;
      cipherbuffer[12] = 0xD8;
```

```
      cipherbuffer[11] = 0x6A;
      cipherbuffer[10] = 0x7B;
      cipherbuffer[9]  = 0x04;
      cipherbuffer[8]  = 0x30;
      cipherbuffer[7]  = 0xD8;
      cipherbuffer[6]  = 0xCD;
      cipherbuffer[5]  = 0xB7;
      cipherbuffer[4]  = 0x80;
      cipherbuffer[3]  = 0x70;
      cipherbuffer[2]  = 0xB4;
      cipherbuffer[1]  = 0xC5;
      cipherbuffer[0]  = 0x5A;
      /* Set AES ECB input data pointers */
      ZW_AES_ecb_set(plainbuffer,keybuffer);
      /* Start AES ECB function */
      ZW_AES_enable(TRUE);
      mainState= WAIT_AES_ECB;
      break;
   case WAIT_AES_ECB:
      /* Check to se if AES ECB procedure is done */
      if (ZW_AES_active_get()==FALSE)
      {
         ZW_AES_ecb_get(plainbuffer);
         /* check against proven data */
         fail=FALSE;
         for (i=0;i<16;i++)
         {
            if (plainbuffer[i]!=chipherbuffer[i])
            {
               fail=TRUE;
               break;
            }
         }
         if (fail) report();

         mainState= IDLE;
      }
        :
      break;
   }
}
```

Figure 20. Example of ECB ciphering. Vectors are from FIPS-197.

4.3.15.1 ZW_AES_ecb_set

void ZW_AES_ecb_set (BYTE *bData,
BYTE *bKey)

Call this function to setup the input data for the AES in ECB mode (Electronic Cookbook mode). Use the function ZW_AES_swap_byte to swap the order of which the data from the array is read into the AES engine.

Defined in: ZW_aes_api.h

Parameters:

bData	Array of 16 bytes	Pointer to byte array containing the data to be encrypted.
bKey	Array of 16 bytes	Pointer to byte array containing the encryption key

Serial API (Not supported)

4.3.15.2 ZW_AES_ecb_get

void ZW_AES_ecb_get(BYTE *bData)

After calling **ZW_AES_ecb_set** , use **ZW_AES_active_get** to see if the AES process is done. When this is the case, call **ZW_AES_ecb_get** to transfer the result of a AES ECB process to the array bData. Use the function **ZW_AES_swap_byte** to swap the order of which the data from the array is read from the AES engine.

Defined in: ZW_aes_api.h

Parameters:

bData	Array of 16 bytes	Pointer to byte array buffer containing encrypted data

Serial API (Not supported)

4.3.15.3 ZW_AES_enable

void ZW_AES_enable(BOOL bState)

Call **ZW_AES_enable(TRUE)** to enable the AES engine and start the ECB process. The AES engine will automatically be disabled when a ECB process is done. Call **ZW_AES_enable(FALSE)** if a ECB process is to be canceled.

Defined in: ZW_aes_api.h

Parameters:

bState	TRUE	Enable the AES and start the ECB mode.
	FALSE	Disable the AES.

Serial API (Not supported)

4.3.15.4 ZW_AES_swap_data

void ZW_AES_swap_data(BOOL bState)

The function is used to enable the option to swap the byte order of the data read into and read from the the AES engine.

Defined in: ZW_aes_api.h

Parameters:

bState	TRUE	Swap data bytes.
	FALSE	Do not swap data bytes

Serial API (Not supported)

4.3.15.5 ZW_AES_active_get

BYTE ZW_AES_active_get (void)

Returns the active/idle state of the AES engine. Use this function to see when a ECB process is done.

Defined in: ZW_aes_api.h

Return value:

BOOL	TRUE	The AES is busy.
	FALSE	The AES is idle.

Serial API (Not supported)

4.3.15.6 ZW_AES_int_enable_get

void ZW_AES_int_enable (BYTE bState)

Call this function to enable or disable AES interrupts.

Defined in: ZW_aes_api.h

Parameters:

bState IN	TRUE	The AES interrupt is enabled.
	FALSE	The AES interrupt is disabled

Serial API (Not supported)

4.3.15.7 ZW_AES_int_get

BYTE ZW_AES_int_get (void)

The function return the state of the AES interrupt flag.

Defined in: ZW_aes_api.h

Return value:

BYTE	0x00	The AES interrupt flag is set
	non-0x00	The AES interrupt flag is cleared

Serial API (Not supported)

4.3.15.8 ZW_AES_int_clear

void ZW_AES_int_clear (void)

Call this function to clearthe AES interrupt flag.

Defined in: ZW_aes_api.h

Serial API (Not supported)

4.3.15.9 ZW_AES_ecb/ZW_AES_ecb_dma

```
BYTE ZW_AES_ecb (  BYTE *bKey
                   BYTE *bInput
                   BYTE *bOutput)
BYTE ZW_AES_ecb_dma (BYTE *bKey
                     BYTE *bInput
                     BYTE *bOutput)
```

These functions execute a AES-128 ECB task and return the encrypted data. Once started the functions will be blocking until the task is done.The function **ZW_AES_ecb_dma** will use the built-in DMA function to transfer data between the AES engine and the XRAM, whereas the data handling will be done purely by the 8051 using the function **ZW_AES_ecb** . Use the function **ZW_AES_swap_byte** to swap the order of which the data bytes from the array are written to and read from the AES engine.

Defined in: ZW_aes_api.h

Parameters:

*bKey IN	pointer to byte array in lower 4kB XRAM containing the input data (16 bytes)	
*bInput IN	pointer to byte array in lower 4kB XRAM containing the key (16 bytes)	The AES is idle.
*bOutput OUT	pointer to byte array in lower 4kB XRAM containing the output data (16 bytes)	The AES is idle.

Serial API (Not supported)

4.3.16 TRIAC Controller API

The built-in TRIAC Controller is targeted at controlled light / power dimming applications. The Triac Controller is able to drive both TRIAC's and FET's/IGBT's. The Triac Controller can dim the load with a precision of 1000 steps in each half-period.

When controlling TRIAC's the Triac Controller will generate one or more fire pulses in each half period of the mains to turn on the Triac. The fire angle if set by the specified dim level. The Triac will turn off when the current is close to zero at the end of the half period. The Triac Controller will generate multiple pulses if the fire angle is less than 90º. The multiple pulses ensure that at least one pulse is located after the middle of a half-period, thereby ensuring that the Triac will be fired even with fully inductive loads, and still limiting the current consumption.

When controlling a FET/IGBT the Triac Controller will turn on the FET/IGBT at a Zero-X of the mains and turn off the FET/IGBT later in the half-period according to the specified dim level.

The Triac Controller can operate in both 50Hz and 60Hz environments.

The application software can use the following TRIAC API calls to control the 500 Series Z-Wave SoC TRIAC Controller.

4.3.16.1 ZW_TRIAC_init

BYTE ZW_TRIAC_init(BYTE bMode,
WORD wPulseLength,
BYTE bPulseRepLength,
BYTE bZeroXMode,
BYTE bInitMask,
BYTE bInvZerox,
BYTE bMainsFreq,
WORD wCorrection,
BYTE bCorPrescale,
BYTE bKeepOff)

ZW_TRIAC_init initializes the 500 Series Z-Wave SoC's integrated TRIAC controller. Refer to the section after the function parameter list for a description of the setup of the different zero-cross modes (page 273). Place this function call in **ApplicationInitHW.**

Defined in: ZW_triac_api.h

Parameters:

bMode IN	Mode of operation: FALSE: Triac Mode TRUE: FET/IGBT Mode	
wPulseLength IN	Triac Fire pulse length Legal values: 1-1023 Each step equals $\frac{n}{32MHz}$, where n is 265 in 60Hz systems 318 in 50Hz systems i.e. setting this parameter to 40 in a 50Hz system gives a Triac pulse length of $40 \cdot \frac{318}{32MHz} = 397.5us$	Not applicable in FET Mode (set this value to 0) Set this parameter so that is equals the minimum Triac gate high time according to the datasheet of the specific Triac in use.

bPulseRepLength IN	Triac fire pulse repetition period	Not applicable in FET Mode (Set this value to 0)
	Legal values: 18-255 and bPulseRepLength **must** be larger than wPulseLength/4:	This parameter sets the period from the rising edge of one fire pulse to the rising edge of the next fire pulse.
	Each step equals $\frac{4 \cdot n}{32MHz}$, where n is 265 in 60Hz systems 318 in 50Hz systems i.e. setting this parameter to 20 in a 50Hz system gives a Triac pulse length of $20 \cdot \frac{4 \cdot 318}{32MHz} = 795us$	The Triac Controller will generate multiple fire pulses when the fire angle is less than 90°
bZeroXMode IN	Bridge types:	
	TRIAC_FULLBRIDGE	The TRIAC signal is triggered only on the rising edges of the ZEROX signal or in the falling edges if bInvZerox is TRUE.
	TRIAC_HALFBRIDGE_A	The TRIAC signal is triggered on the rising and the falling edge of the ZEROX signal.
	TRIAC_HALFBRIDGE_B	The TRIAC signal is triggered on the rising[1] edge of the ZEROX signal in every second halfperiod or on the rising[2] edge of the ZEROX signal in every second halfperiod edges if bInvZerox is TRUE
bInitMask IN	Initial zero-cross mask:	
	TRUE	Mask out noise impulses on the mains from the point of a detected zero-cross to the start of the Triac fire pulse
	FALSE	Do not Mask out impulse noise on the mains from the point of a detected zero-cross to the start of the Triac fire pulse

[1] If bInitMask is set to TRUE, the Triac controller will trigger on a falling edge in every second half-period

[2] If bInitMask is set to TRUE, the Triac controller will trigger on a falling edge in every second half-period

bInvZerox IN	Inverse zero-cross signal:	
	TRUE	Inverse zero-cross signal
	FALSE	Do not inverse zero-cross signal
bMainsFreq IN	AC mains frequency:	
	FREQUENCY_50HZ	Using 50Hz AC mains supply
	FREQUENCY_60HZ	Using 60Hz AC mains supply
wCorrection IN	ZeroX Duty-Cycle correction Legal values: 0-1023. The Triac controller has a timer, that can compensate for a non-50/50 duty cycle of the ZeroX signal when using Half Bridge Mode A or to ajust the starting point of the second half period when using Half Bridge Mode B. The timer can run on a prescalered clock (see bCorPrescale below) I.e. setting this parameter to 300 and bCorPrescale to '1' gives a correction of $300 \cdot \frac{3}{32MHz} = 28.1\mu s$.	Half Bridge Mode A: The parameter is used to compensate from a ZeroX signal duty-cycle that is not exactly 50/50, in half bridge mode A. Typically, the high time of a ZeroX signal in half bridge mode is shorter than the low time. In this case, setting this parameter to value greater than 0, can correct this mismatch. If the high time is n ns longer than the low time, this parameter should be set so that it equals n/2 ns. Half Bridge Mode B: 60Hz systems: This value should be set to $\left\lceil 26 + 88\frac{1}{3} \cdot \text{bKeepOff} \right\rceil$ 50Hz systems: This value should be set to $31 + 106 \cdot \text{bKeepOff}$ Full Bridge Mode: N.A. (Set this value to0)

bCorPrescale	Correction prescaler Legal values: 0: Prescaler disabled 1: Prescaler enabled	When this parameter is set to 1, the clock signal that is used for the correction timer (see under wCorrection above) is prescaled by a factor of 3. That is, the timer clock will run at 32MHz/3~10.67MHz When this parameter is set to 0, the correction timer will run using the system clock (32.00MHz). Half Bridge Mode A: Set this parameter to 1 if the needed correction has to be longer than $1023*(32MHz)^{-1}$ = 31.97 µs Half Bridge Mode B: N.A. (Set this value to 0) Full Bridge Mode: N.A. (Set this value to 0)
bKeepOff	KeepOff distance Legal values: 0-9 Use this parameter to specify the minimum distance from the falling edge of the Triac pulse to the zero cross of the mains signal (ZeroX). This parameter will also specify the distance from where the Triac controller starts looking for a new ZeroX to the nominal ZeroX point. That is, use this parameter in regions where the mains frequency has large deviations.	The distance for a nominel 50Hz mains will be: $2.9\mu s + \left\lfloor \frac{bKeepOff}{4} \right\rfloor \cdot \frac{318 \cdot 4}{32MHz}$ The distance for a nominel 50Hz mains can be calculated as: $2.4\mu s + \left\lfloor \frac{bKeepOff}{4} \right\rfloor \cdot \frac{265 \cdot 4}{32MHz}$

Return values:

BYTE	0x01	bPulseRepLength is less than wPulseLength/4:
	0x02	bPulseRepLength is less than 18 (legal values 18-255)

Serial API (Not supported)

Half bridge A:

In this mode, the Triac Controller uses both edges on the zero-cross signal for each period of the mains signal. That is, the zero-cross signal is expected to go high at the beginning of the mains period and the go low at the next zero-cross, as depicted in figure below. Since this is not usually the case, because of input threshold level the duty cycle, the rising edge is delayed, and the falling edge is too early. This results in a non-50/50 duty cycle, which again will result in a DC voltage over the Triac load. Use the parameters wCorrection and bCorPrescale to correct the duty-cycle, and thereby to get rid of the DC voltage. Setting these parameters will "delay" the falling edge in the Triac controller, as depicted in figure below.

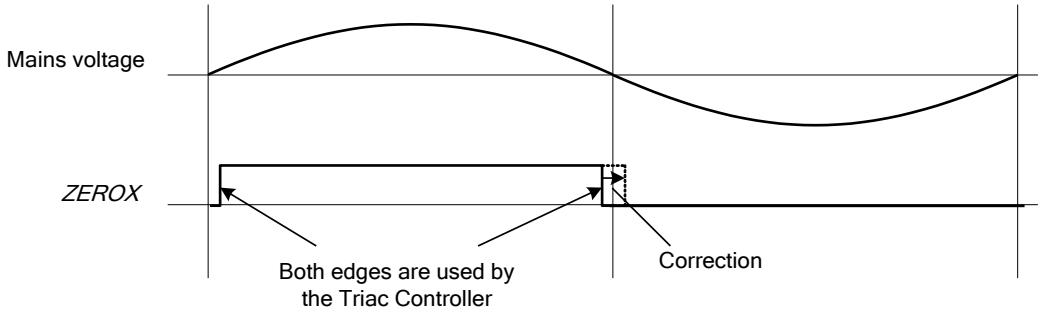


Figure 21. Half-bridge A zero-x signal

Half bridge B:

In this mode, the Triac Controller only uses one edge on the zero-x signal for each period of the mains signal. That is, the zero-x signal is expected to go high at the beginning of the mains period and the go low before the beginning of the next period, as depicted in figure below.

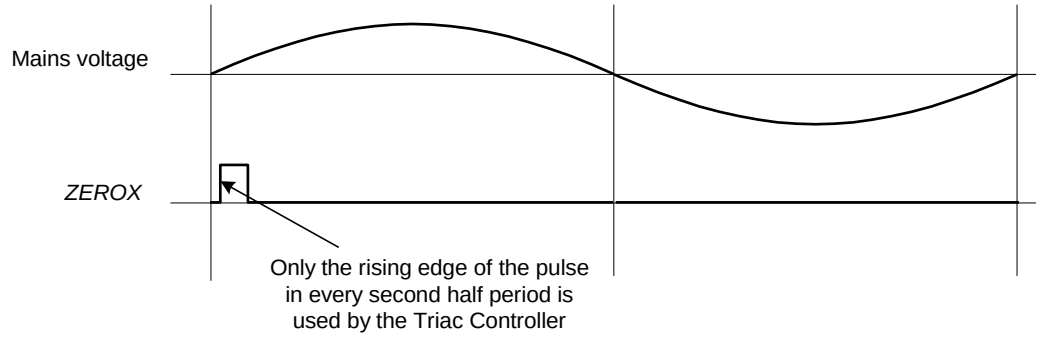


Figure 22. Example of half-bridge B zero-x signal

Full Bridge:

In this zero-x mode, the Triac Controller uses two rising edges on the zero-cross signal for each period of the mains signal. That is, the zero-cross signal is expected to go high at the beginning of the mains period and the go low before the beginning of the next half-period, then high again after the following zero-cross, and finally low again before the end of the period, as depicted in the two figures below.

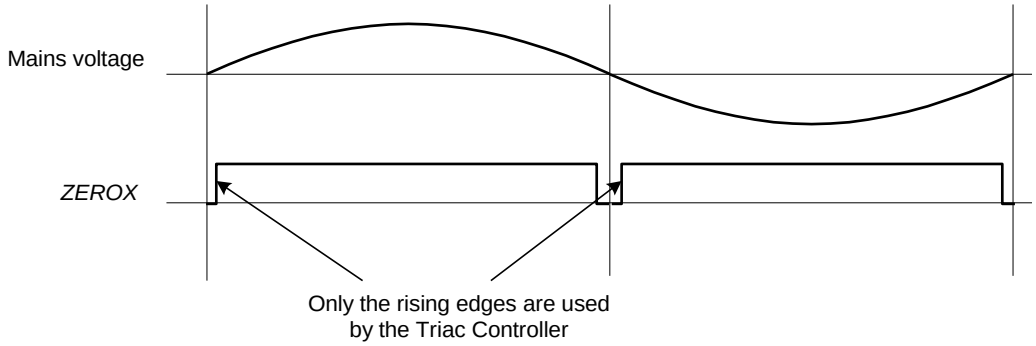


Figure 23. Example 1 of a full bridge zero-x signal

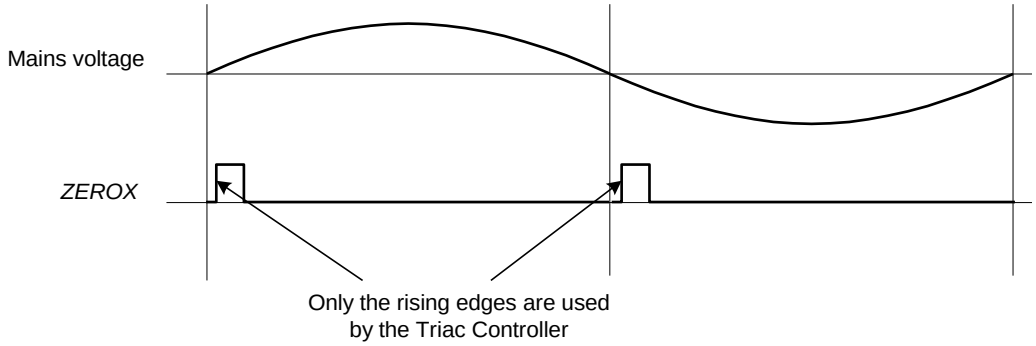


Figure 24. Example 2 of a full bridge zero-x signal

Zero-x mask

Once the Triac Controller is started, the zero-x signal is masked off the whole half period, except for a short period just before the next zero-x. This period can be adjusted using the parameter bKeepOff. See figure below

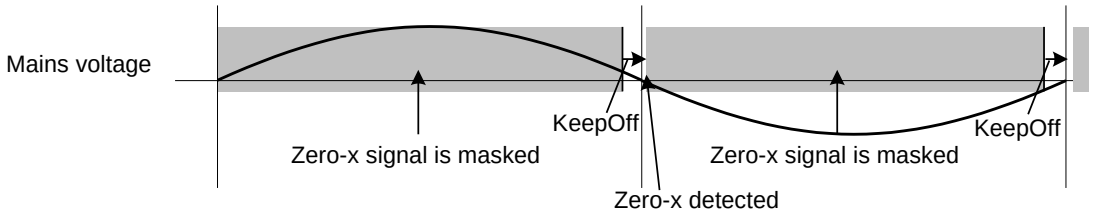


Figure 25. Masked Zero-X signal

Modes

In Triac Mode the Triac Controller will generate multiple pulses if the fire angle is less than 90º. The length of each of the pulses is set by the parameter wPulseLength and the repetition length is set by the parameter wPulseReplength. Depending on the dimming level the number of pulses will automatically be calculated so that at least one full pulse is generated in the period from 90 º to 180 º of a halfperiod. One one pulse will be generated if the dimming level is set so that the first pulse is in the period from 90 º to

180 º of a halfperiod The dimming level, i.e. position of the first pulse, is set by the function ZW_TRIAC_dimlevel_set. See figure below.

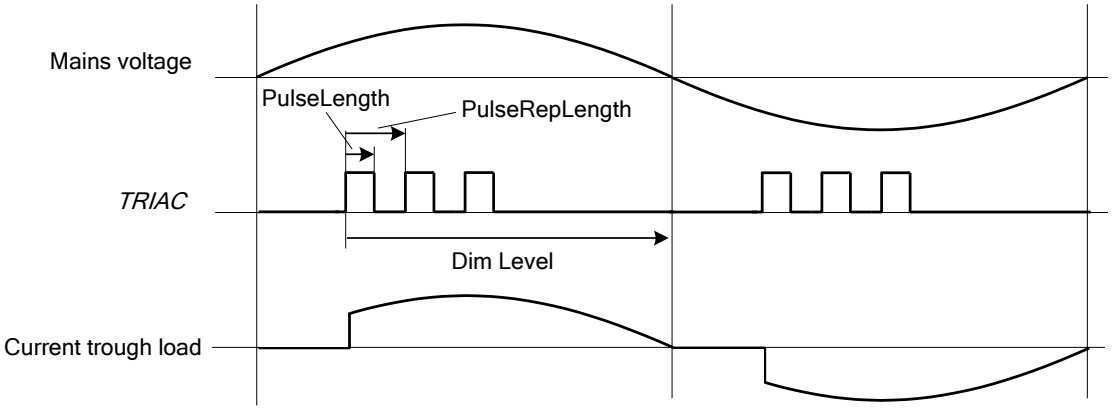


Figure 26. PulseLength and PulseRepLength used in Triac Mode (resistive load)

In FET/IGBT Mode the Triac Controller will generate one pulse per half period. The length of the pulse is set by the function ZW_TRIAC_dimlevel_set(). See figure below.

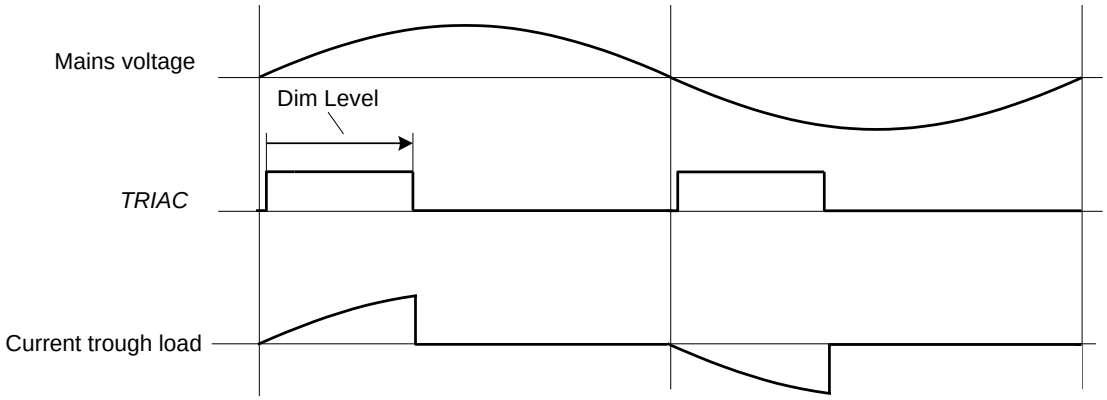


Figure 27 TRIAC output in FET/IGBT Mode (resistive load)

4.3.16.2 ZW_TRIAC_enable

void ZW_TRIAC_enable(BOOL boEnable)

ZW_TRIAC_enable enables/disables the Triac Controller. When enabled the Triac controller takes control over the TRIAC (P3.6) and the ZEROX[1] (P3.7) pins. **ZW_TRIAC_init** must have been called before the Triac Controller is enabled.

Defined in: ZW_triac_api.h

Parameters:

boEnable IN	TRUE or FALSE	TRUE: enables the Triac Controller

Serial API (Not supported)

[1] If the PWM is enabled, see ZW_PWM_enable(), then the PWM will control the P3.7 pin

4.3.16.3 ZW_TRIAC_dimlevel_set

BOOL ZW_TRIAC_dimlevel_set(WORD wLevel)

ZW_TRIAC_dimlevel_set turns the Triac controller on and sets the dimming level. **ZW_TRIAC_init** must have been called before the Triac Controller is started.

Defined in: ZW_triac_api.h

Parameters:

wLevel IN	Dimming level (0-1000), where 0 is shut off and 1000 is full on

Return values:

BOOL	TRUE	The new dim level has been accepted by the Triac Controller
	FALSE	The Triac Controller has not yet read in the previous dim level. Wait up to one half period of the mains signal (50Hz: 10ms, 60 Hz 8.33ms) and try again

Serial API (Not supported)

4.3.16.4 ZW_TRIAC_int_enable

void ZW_TRIAC_int_enable(BYTE boEnable)

ZW_TRIAC_int_enable enables/disables the zero cross (ZeroX) interrupt. The ZeroX interrupt is issued when the TRIAC controller detects a zero cross on the ZEROX signal. Hence, the Triac Controller will take control of the ZEROX pin (P3.7) when **ZW_TRIAC_int_enable(TRUE)** has been called.

The ZeroX interrupt can be used to implement a SW based TRIAC controller where the TRIAC signal is controlled by the SW. The Triac Controller will generate the ZeroX interrupt when it detects a zero cross on the ZEROX signal, even if the Triac Controller has been disabled (by calling **ZW_TRIAC_enable(FALSE)**) as long as **ZW_TRIAC_int_enable(TRUE)** has been called.

Defined in: ZW_triac_api.h

Parameters:

boEnable IN	TRUE	Enable the interrupt. The Triac controller will issue an interrupt when a zero cross is detected on the ZEROX signal.
	FALSE	Disable the Triac interrupt.

Serial API (Not supported)

The interrupt number is set by the define, INUM_TRIAC, as described in ZW050x.h

4.3.16.5 ZW_TRIAC_int_get

BOOL ZW_TRIAC_int_get(void)

ZW_TRIAC_int_get returns the state of the Triac Controller interrupt flag. Call **ZW_TRIAC_int_enable(TRUE)** to enable the interrupt.

Defined in: ZW_triac_api.h

Return values:

BOOL	TRUE	The Triac Controller interrupt flag is set.
	FALSE	The Triac Controller interrupt flag is cleared.

Serial API (Not supported)

4.3.16.6 ZW_TRIAC_int_clear

void ZW_TRIAC_int_clear(void)

ZW_TRIAC_int_get clears the Triac Controller interrupt flag. Call **ZW_TRIAC_int_enable(TRUE)** to enable the interrupt and use **ZW_TRIAC_int_get** to see whether the interrupt has been set.

Defined in: ZW_triac_api.h

Serial API (Not supported)

4.3.17 LED Controller API

The built-in LED Controller is targeted at LED light dimming applications. The controller can control up to four individual channels in 3 different modes of operation. The application can use the following LED API calls to control the 500 Series Z-Wave SoC LED Controller.

4.3.17.1 ZW_LED_init

void ZW_LED_init(BYTE bMode,
BYTE bChannelEn)

ZW_LED_init SHOULD be used to initialize the 500 Series Z-Wave SoC's integrated LED controller. The function configures the desired mode of operation and the desired number of active channels. This function SHOULD be called in **ApplicationHWInit**.

Defined in: ZW_led_api.h

Parameters:

bMode IN	Mode of operation type:	
	LED_MODE_NORMAL	In this mode, the LED controller generates a pulse width modulated signal for each active channel. The PWM signals has no phase skew. The frequency of all of the PWM signals is $32MHz/2^{16}$ = 488.28Hz. The duty-cycle of the PWM signals is set by the **ZW_LED_waveforms_set** function.
	LED_MODE_SKEW	The SKEW mode is same as the NORMAL mode except that phase of the channels are skewed. That is, the signal of channel 1 is skewed ¼ of a period compared to the signal of channel 0, the signal of channel 2 is skewed ¼ of a period compared to the signal of channel 1, etc.
	LED_MODE_PRBS	In this mode, the LED controller uses a PRBS signal generator to generate to LED signals. The total high time in this mode equals the total high time in the other modes.
bChannelEn IN	Bit mask of one of the channels to be enabled	
	LED_CHANNEL0	Enable channel 0. The LED Controller takes control of the P0.4 pin.
	LED_CHANNEL1	Enable channel 1. The LED Controller takes control of the P0.5 pin.
	LED_CHANNEL2	Enable channel 2. The LED Controller takes control of the P0.6 pin.
	LED_CHANNEL3	Enable channel 3 The LED Controller takes control of the P0.7 pin.

Serial API (Not supported)

4.3.17.2 ZW_LED_waveforms_set

void ZW_LED_waveforms_set(WORD *pwLevel)

ZW_LED_waveforms_set SHOULD be used to set the duty cycle for all LED Controller channels in one operation. The function configures the waveform for all channels even if some channels are not enabled.

The function MUST NOT be called repeatedly, as it may run for up to 2.048ms to prevent race conditions in the LED controller latch registers. This may affect frame reception and transmission in the protocol layer.

Defined in: ZW_led_api.h

Parameters:

pwLevel IN	A pointer to an array with 4 16-bits values.	
	0x0000-0xFFFF	Duty cycle times of the LED controller channels. The first 16 bit element in the array determines the value for channel 0. The next 16 bit element determines the value for channel 1, etc.

Serial API (Not supported)

4.3.17.3 ZW_LED_waveform_set

void ZW_LED_waveform_set(BYTE bChannel
WORD wLevel)

ZW_LED_waveform_set MAY be used to set the duty cycle time of one LED controller channel.

The function SHOULD NOT be called repeatedly. This may cause race conditions in the LED controller latch registers. The companion function ZW_LED_data_busy MAY be used to check if the LED controller is ready for a new value.
The application MUST NOT repeatedly call ZW_LED_data_busy from a busy waiting loop as this may affect frame reception and transmission in the protocol layer.

Defined in: ZW_led_api.h

Parameters:

bChannel IN	The channel ID LED_CHANNEL0 LED_CHANNEL1 LED_CHANNEL2 LED_CHANNEL3
wLevel	The duty cycle of the channel 0x0000-0xFFFF

Serial API (Not supported)

4.3.17.4 ZW_LED_data_busy

BOOL ZW_LED_data_busy(void)

ZW_LED_data_busy is used to check to see if the LED controller is ready for a new value.

The application MUST NOT repeatedly call ZW_LED_data_busy from a busy waiting loop as this may affect frame reception and transmission in the protocol layer.

Defined in: ZW_led_api.h

Return values:

BOOL	TRUE	The LED controller can accept new waveform values
	FALSE	The LED controller cannot accept new waveform values, since it has not yet read in the previous data set. Wait up to 2^{16}/32MHz = 2.048ms and check again.

Serial API (Not supported)

4.3.18 Infrared Controller API

The built-in Infrared (IR) Controller is targeted at IR remote control applications. The IR controller can operate either as an IR transmitter or as an IR receiver. When operating as a transmitter one or more of the three outputs (P3.4, P3.5, and P3.6) can be enabled as IR outputs that drive an IR LED, as depicted in figure below. Each output can drive 12mA. Hence, using three outputs give a drive strength of 36mA. If 36mA is insufficient you will have to implement an external driver.

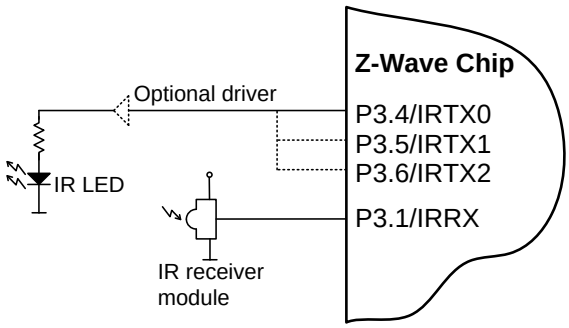


Figure 28. External IR hardware

An external IR receiver module or an IR transistor must be connected to Pin P3.1 when operating in Receive mode. An IR receiver module has a built-in photo transistor and preamplifier with automatic gain control and gives a digital TTL/CMOS output signal. The IR receivers can be found in two versions, with and without demodulator. The versions without demodulator (like Vishay TSOP 98200) generates an output signal with carrier (as depicted in the upper part of figure below), whereas the versions with demodulator (like Vishay TSOP322xx) generates an output signal without the carrier (as depicted in the lower part of figure below). Therefore, the one without demodulator is best for code learning applications, where you want to be able to detect the carrier frequency. The one with modulator has improved immunity against ambient light such as fluorescent lamps.

Using an photo transistor, where the transistor is connected directly to the 500 Series Z-Wave Chip requires that the transmitting IR LED is placed within a short range (2”-4”) of the IR transistor, since the IR transistor signal is analog and isn’t amplified. This circuit is also sensitive also to ambient light.

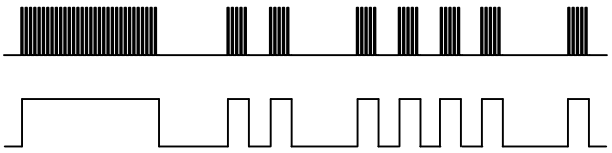


Figure 29. IR signal with and without carrier

In both cases, the IR Receiver detects widths of the marks (high/carrier on) and spaces (low) of a coded IR message, as seen in figure below. The mark/space width data is stored in SRAM using DMA. While running, the IR Controller requires very little MCU processing. The IR receiver is able to detect the waveform of the carrier[1].

The IR Transmitter generates a carrier and the marks and spaces for an IR message. The widths of the marks and the spaces are read from SRAM using DMA.

[1] Note that the IR receiver module can distort the duty cycle of the carrier.

Figure 30. IR Coded message with carrier

Both the IR Receiver and the IR Transmitter can be configured to detect/generate a wide range of IR coding formats.

4.3.18.1 Carrier Detector/Generator

The carrier detector can detect the carrier waveform (high and low periods) of a carrier modulated IR signal.

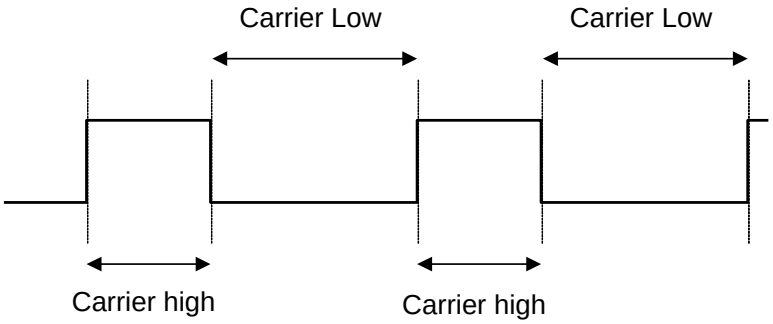


Figure 31. Carrier waveform

The following bullets provide a short feature list of the Carrier Detector/generator.

1. IR Carrier Generator frequency range: 7.8kHz - 16MHz (50/50 duty cycle) or 10.4kHz -10.7MHz (33/66 duty cycle)
2. A built-in Glitch Remover is able to remove glitches on the incoming IR signal.
3. For each detection process the IR Carrier Detector can calculate an average of the “high” duration and an average of the “low” duration over 1 (no averaging), 2, 4, or 8 periods.

4.3.18.2 Organization of Mark/Space data in Memory

Both the IR Receiver engine and the IR Transmitter engine use SRAM to store mark/space data information. The data is stored in the same format for both engines, as depicted in figure below. The width of a mark is stored in 1 to 3 bytes – likewise the width of a space is stored in 1-3 bytes.

Bit 7 in each byte is used to differentiate the mark and space bytes. That is, bit 7 of all “mark”-bytes are set to 1 and bit 7 of all “space”-bytes are set to 0.

The maximum number of bits used to describe a mark or space width is 16. The means that 3 bytes are needed to store a 16 bit value (the upper 6 bits of the 3rd byte are unused); whereas 2 bytes are needed to store a 14 bit value, and only one byte is needed to store a 7 bits value.

Refer to the example as depicted in figure below, where:

3 bytes are used for the start mark (PS0)
3 bytes are used for the start space (PS1)
2 bytes are used for each of the rest of the mark/spaces

The maximum size of the mark/space data information is 511 bytes. The data can be stored anywhere in the lower 4K XRAM in the 500 series Z-Wave SoC.

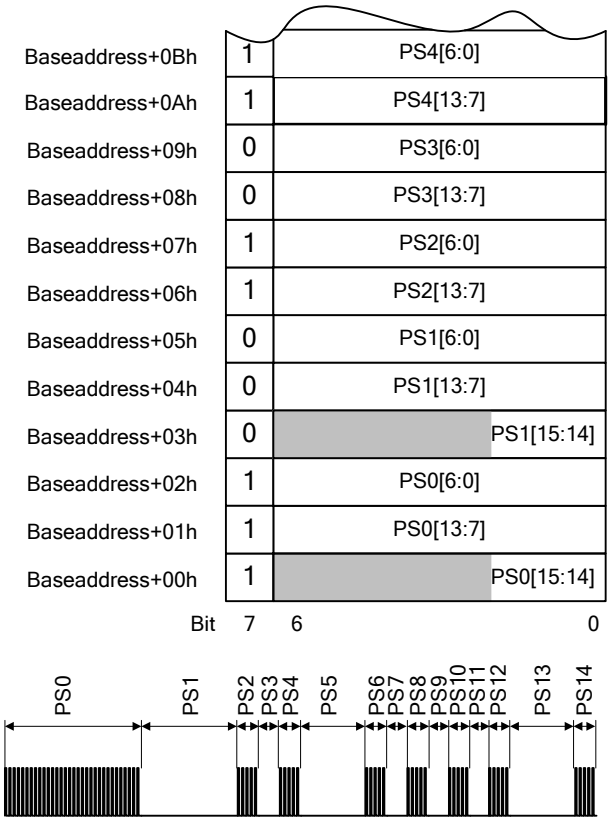


Figure 32. Mark/Space Data Memory Organization

The width is described as a certain count of prescaled clock periods. E.g if the prescaler is set to 1/16 and the width of a mark is 889us, the width will be stored as

$$\frac{period}{\frac{prescaler}{f_{sys}}} = \frac{889us}{\frac{16}{32MHz}} = 1798LSB$$

That is,

$$\frac{\ln(1798)}{\ln(2)} = 10.81$$

11 bits are needed $\Rightarrow$ 2 bytes.

Since the maximum number of bits used to store each mark or space width is 16. It results in a maximum mark or space width of:

- 262ms using clock divider of 128 or
- 1.7s using the Carrier Generator @ 36kHz

4.3.18.3 IR Transmitter

Before the IR transmitter can start generating the IR stream the IR Transmitter must have been initialized, the Mark/Space data must have been built in a buffer in the lower 4kB XRAM, and the IR interrupt is optionally enabled. The organization of the Mark/Space data is described in section 4.3.18.2. Additionally, the Carrier Generator must be initialized.

The function **ZW_IR_tx_init** must be called to initialize all the needed parameters as described below and in section 4.3.18.5:

1. The prescaler value for generating the carrier signal can be either: 1, 2, 3, 4, 5, 6, 7, or 8 resulting in a clock speed of either 32MHz, 16MHz, 32/3MHz, 8MHz, 32/5MHz, 16/3MHz, 32/7MHz, or 4MHz
2. The IR transmitter can use a prescaler that use the 32MHz clock divided by 1, 2, 4, 8, 16, 32, 64, or 128. It can also use the rising edge of the carrier generated by the Carrier Generator.
3. The output(s) can be inverted as an option
4. The Idle state of the IR signal can be either high or low
5. One, two, or three IO's can be used in parallel for driving an IR LED. Each output buffer can drive 12mA.
6. The carrier wave form is set by the carrier prescaler and two parameters that sets the low and high period of the carrier signal.

If only one IR coding style is used in a application the **ZW_IR_tx_init** function can be placed in **ApplicationInitHW,** otherwise it can be placed in other parts of the code, typically in **ApplicationPoll**

The function **ZW_IR_tx_data** must be called when a certain IR stream is to be transmitted. The parameters for this function sets is described below and in section 4.3.18.6

1. The address of the buffer in lower 4kB XRAM.
2. Size of IR data buffer in XRAM. The maximum size of the XRAM buffer is 511 bytes.

The IR Transmitter takes over control of the enabled IO's (P3.4, P3.5, and/or P3.6) when the function **ZW_IR_tx_data** is called and releases the control of the enabled IO's when the IR signal has been transmitted. Therefore, to make sure that IO's used by the IR transmitter (P3.4, P3.5, and/or P3.6) are output(s) and at the correct idle state, the GPIO must be set as outputs and the state must be set accordingly.

An IR interrupt routine is supplied with the ZW_phy_infrared_040x library. A variable `ir_tx_flag` (BOOL) is set TRUE when an IR message has been transmitted after **ZW_IR_tx_data** has been called. The `ir_tx_flag` variable is cleared when calling **ZW_IR_tx_data**.

Once the IR Transmitter is started, use the function **ZW_IR_disable** to cancel the operation.

An example of how to initialize and run the IR Transmitter is shown in Figure 33.

```
void ApplicationInitHW()
{
  EA=1;
  EIR=1;
        :
   /* Carrier freq = 8MHz/(74+148)=36kHz, Carrier duty cycle 33/66 */
   ZW_IR_tx_init(FALSE, // Use Mark/Space prescaler
               3,     // Prescaler: 32MHz/(2^3)=4MHz
               FALSE, // Output is not inverted
               FALSE, // Output state is low
               0x03,  // Enable P3.4 and P3.5
               3,     // Carrier prescaler set to 4 (32MHz/4=8MHz)
               74,    // Carrier low 74/8MHz = 9.25us
               148);  // Carrier high 148/8MHz = 18.5us
        :
}

void ApplicationPoll()
{
  BYTE bIrBuffer[16];

   switch (mainState)
   {
          :
     case SEND_PLAY:
       // This IR message send a "PLAY" command
       bIrBuffer[0]=0xA0;
       bIrBuffer[1]=0x20;
       bIrBuffer[2]=0xBF;
       bIrBuffer[3]=0x20;
       bIrBuffer[4]=0xA0;
       bIrBuffer[5]=0x20;
       bIrBuffer[6]=0xA0;
       bIrBuffer[7]=0x20;
       bIrBuffer[8]=0xA0;
       bIrBuffer[9]=0x20;
       bIrBuffer[10]=0xA0;
       bIrBuffer[11]=0x20;
       bIrBuffer[12]=0xBF;
       bIrBuffer[13]=0x20;
       bIrBuffer[14]=0xDF;
       bIrBuffer[15]=0x80;
       ZW_IR_status_clear();          // Clear all IR status flags
```

```
        /* Use IrBuffer as buffer, size 16 bytes */
        ZW_IR_tx_data((WORD)bIrBuffer, // Address of buffer
                      16);             // Size of buffer
        mainState=WAIT_IR_DONE;
        break;
      case WAIT_IR_DONE:
        if (ir_tx_flag==TRUE)      // Wait until IR TX flag is set
        {
          mainState=IDLE;
        }

        break;
    }
}
```

Figure 33. Code example on use of IR transmitter

4.3.18.4 IR Receiver

Before the IR Receiver can be used to learn an incoming IR stream the IR receiver must have been initialized, the Mark/Space data buffer must have been allocated in the lower 4kB XRAM, and the IR interrupt *must* be enabled.

The organization of the Mark/Space data is described in section 4.3.18.2.

The function **ZW_IR_learn_init** must be called to initialize all the needed parameters as described below and in section 4.3.18.5:

1. The Rx SRAM buffer size is configurable. (1-511 bytes)
2. The Mark/Space detector in the IR Receiver can use either a prescaler that use the 32MHz clock divided by 1, 2, 4, 8, 16, 32, 64, or 128.
3. If the IR Receiver requires more SRAM space for the incoming IR stream, the MCU is interrupted and an error flag is set
4. The IR Receiver can be configured to remove glitches on the incoming IR signal
5. The IR Receiver can be configured to average the detected duration of the low/high periods of the Carrier
6. The IR input signal can be inverted as an option.
7. The IR Receiver can detect that the trailing space after the last mark of a received IR message is longer that a specific size. This size must be set and this works at the same time as a timeout if the message for some reason is shorter than expected.

Call the function **ZW_IR_learn_data** to start the learn process. The function is described below and in section 4.3.18.9:

1. When the learn process starts the IR receiver will start out using the highest possible prescaler value for the Carrier detector. When it then detects a carrier, it will measure the duration of the low and high periods of the carrier and, if possible, rescale the prescaler to a lower value and rerun the carrier measurement. This is done to achieve the highest precision of the carrier measurement while preventing timer overflow.
2. The learn process will terminate when the IR Receiver has detected at least one Mark and then a Space larger than a configurable amount of time, as described above.

An IR interrupt routine is supplied with the ZW_phy_infrared_040x library. A variable `ir_rx_flag` (BOOL) is set TRUE when an IR message has been received. The `ir_rx_flag` variable is cleared when calling **ZW_IR_learn_data.**

Call the function **ZW_IR_learn_status_get** to get the size of the received mark/space data, the detected carrier characteristics and error state (status flags). The function **ZW_IR_status_clear** clears the status flag.

Once the IR Receiver is started, use the function **ZW_IR_disable** to cancel the operation.

An example of how to initialize and run the IR Receiver is shown below.

```
BYTE bIrBuffer[256];

void ApplicationInitHW()
{

  EA=1;
  EIR=1;

  ZW_IR_learn_init((WORD)bIrBuffer // Buffer address
                   256,            // Buffer Size
                   4,              // Prescaler: 32MHz/(2^4)=2MHz
                   7,              // Trailing space min 2^16/2MHz=32.8ms
                   2,              // Run average over 4 periods
                   1,              // Remove glitches below 125ns
                   FALSE);         // Do not invert input
}

void ApplicationPoll()
{
  WORD wRxDataLen;
  BYTE bRxCarrierLow;
  BYTE bRxCarrierHigh;
  BYTE bRxStatus;
       :
  switch(mainState)
  {
    case START_IR_LEARN:
      ZW_IR_status_clear();      // Clear all IR status flags
      ZW_IR_learn_data();        // Start IR Receiver
      mainState=WAIT_IR_DONE;
      break;
    case WAIT_IR_DONE:
      if (ir_rx_flag==TRUE)  // Wait until IR RX flag is set
      {
        ZW_IR_learn_status_get(  &wRxDataLen,
                                 &bCarrierPrescaler,
                                 &bRxCarrierLow,
                                 &bRxCarrierHigh,
                                 &bRxStatus);
```

```
          if (bRxStatus == 0x00 || bRxStatus == IRSTAT_CDONE)
          {
            if (bRxStatus == IRSTAT_CDONE)
            {
              /* report that carrier could not be detected */
                    :
            }
            /* decode received data */
                  :
          }
          else
          {
            /* error handling */
               :
          }
          mainState=IDLE;
        }
        else
        {
        /* Cancel the operation when boCancelIR is set
            TRUE by other part of the code */
          if (boCancelIR == TRUE) ZW_IR_disable();
          mainState=IDLE;
        }
        break;
    }
}
```

Figure 34. Code example on use of IR receiver

The application software can use the following IR API calls to control the 500 Series Z-Wave SoC IR Controller.

4.3.18.5 ZW_IR_tx_init

void ZW_IR_tx_init(BYTE boMSTimer,
BYTE bMSPrescaler,
BYTE boInvertOutput,
BYTE boHighDrive,
BYTE boIdleState,
BYTE bOutputEnable,
BYTE bCarrierPrescaler,
BYTE bCarrierLow,
BYTE bCarrierHigh)

ZW_IR_tx_init initializes the 500 Series Z-Wave SoC's integrated IR controller to Transmitter mode and sets the required TX options.

Defined in: ZW_infrared_api.h

Parameters:

boMSTimer IN	TX Mark/Space prescaler mode:	
	TRUE	Mark/space generator runs on carrier period timer. That is, the length of the Marks/Spaces is calculated as the carrier period multiplied by the value read in XRAM
	FALSE	Mark/space generator runs on a prescaled timer. That is, the length of the Marks/Spaces is calculated as the prescaled timer period multiplied by the value read in XRAM. Prescaler value is set by bMSPrescaler.
bMSPrescaler IN	Mark/Space timer prescaler	
	Valid values: 0-7 Resulting timer clock frequency: 0: 32MHz 1: 16MHz 2: 8MHz 3: 4MHz 4: 2MHz 5: 1MHz 6: 500kHz 7: 250kHz	Not applicable when boMSTimer is true
boInvertOutput IN	Invert IR output	
	TRUE	output is inverted
	FALSE	output is not inverted
boHighDrive	Invert IR output	
	TRUE	use 12mA drive strength of IR Tx IO output buffers
	FALSE	use 8mA drive strength of IR Tx IO out buffers

boIdleState IN	Idle State of IR output	
	TRUE	Idle state is high
	FALSE	Idle state is low
bOutputEnable IN	Outputs enabled	
	Valid values: 0-7 000: All outputs disabled xx1: P3.4 enabled x1x: P3.5 enabled 1xx: P3.6 enabled	Idle state is high
bCarrierPrescaler IN	Carrier generator prescaler	
	Valid values: 0-7 Resulting timer clock frequency: 0: 32MHz 1: 32MHz/2 2: 32MHz/3 3: 32MHz/4 4: 32MHz/5 5: 32MHz/6 6: 32MHz/7 7: 32MHz/8	
bCarrierLow IN	Carrier low time 0: 1 prescaled clock period 1: 2 prescaled clock periods : : 255: 256 prescaled clock periods	
bCarrierHigh IN	Carrier High time 0: 1 prescaled clock period 1: 2 prescaled clock periods : : 255: 256 prescaled clock periods	

Serial API (Not supported)

4.3.18.6 ZW_IR_tx_data

void ZW_IR_tx_data(WORD pBufferAddress,
WORD wBufferLength)

ZW_IR_tx_data sets the address and the length of the buffer containing the Mark/space data to be sent. The IR Controller will start to transmit immediately after these values have been set.

Defined in: ZW_infrared_api.h

Parameters:

pBufferAddress IN	Address of Tx buffer in lower XRAM memory
wBufferLength IN	Number of bytes in TX buffer. Valid values (1-511)

Serial API (Not supported)

4.3.18.7 ZW_IR_tx_status_get

BYTE ZW_IR_tx_status_get(void)

ZW_IR_tx_status_get is used to check to the status of the IR controller after an IR message has been transmitted.

Defined in: ZW_infrared_api.h

Return values:

IRSTAT_MSOVERFLOW	The format of the data in the IR buffer is invalid. The perceived Mark/Space value is greater than 2^{16}.
IRSTAT_PSSTARV	The IR controller's DMA engine was not able to read data from XRAM in time because the access to the XRAM was used by (an) other DMA engine(s) with higher priority. To get rid of this error, try to disable other DMA engines (USB, RF, etc.) and run the IR transmitter again.
IRSTAT_ACTIVE	The IR Controller is active

Serial API (Not supported)

4.3.18.8 ZW_IR_learn_init

```
void ZW_IR_learn_init(  WORD pBufferAddress,
                        WORD wBufferLen,
                        BYTE bMSPrescaler,
                        BYTE bTrailSpace,
                        BYTE bCAverager,
                        BYTE bCGlitchRemover,
                        BYTE boInvertInput)
```

ZW_IR_learn_init initializes the 500 Series Z-Wave SoC's integrated IR controller to receive/learn mode and sets the required RX options.

Defined in: ZW_infrared_api.h

Parameters:

pBufferAddress IN	Address of Rx buffer in lower XRAM memory	
wBufferLength IN	Size of RX buffer. Valid values (1-511)	
bMSPrescaler IN	Mark/Space timer prescaler Valid values: 0-7 Resulting timer clock frequency: 0: 32MHz 1: 16MHz 2: 8MHz 3: 4MHz 4: 2MHz 5: 1MHz 6: 500kHz 7: 250kHz	
bTrailSpace IN	Trailing space after last Mark. After the incoming IR signal has been low for this period of time the IR receiver stops. Valid values: 0-7 0: 512 prescaled clock periods 1: 1024 prescaled clock periods 2: 2048 prescaled clock periods 3: 4096 prescaled clock periods 4: 8192 prescaled clock periods 5: 16384 prescaled clock periods 6: 32768 prescaled clock periods 7: 65536 prescaled clock periods	
bCAverager IN	Average Carrier high/low length measurement over multiple carrier periods. Valid values: 0-3 0: 1 carrier period 1: 2 carrier periods 2: 4 carrier periods 3: 8 carrier periods (Recommended value)	
bCGlitchRemover IN	Remove glitches from incoming IR signal. Valid values: 0-3 0: disabled 1: < 125ns 2: < 250ns 3: < 500ns	
boInvertInput IN	TRUE FALSE	IR input is inverted IR input is not inverted

Serial API (Not supported)

4.3.18.9 ZW_IR_learn_data

void ZW_IR_learn_data(void)

ZW_IR_learn_data clears the `ir_rx_flag` variable and starts the IR Controller in Rx/learn mode. Use **ZW_IR_disable** to cancel on ongoing learn process.

Defined in: ZW_infrared_api.h

Serial API (Not supported)

Refer to section 0 for a detailed description of the learn function.

4.3.18.10 ZW_IR_learn_status_get

void ZW_IR_learn_status_get(WORD *wDataLength,
BYTE *bCarrierPrescaler,
BYTE *bCarrierLow,
BYTE *bCarrierHigh,
BYTE *bStatus)

ZW_IR_learn_status_get is used to check to the status of the IR controller, to get the length of the received data, the detected carrier characteristics, and the error state. Call this function after a learn operation is done, i.e. after the `ir_rx_flag` variable has been set.

Defined in: ZW_infrared_api.h

Parameters:

wDataLength OUT	Length of the received data	
bCarrierPrescaler OUT	Optimal Carrier prescaler value Valid values: 0-7 0: 32MHz 1: 32MHz/2 2: 32MHz/3 3: 32MHz/4 4: 32MHz/5 5: 32MHz/6 6: 32MHz/7 7: 32MHz/8	
bCarrierLow OUT	Length of the Low period of the Carrier (in prescaled system clocks)	
bCarrierHigh OUT	Length of the High period of the Carrier (in prescaled system clocks)	
bStatus OUT	IRSTAT_PSSTARV	The IR controller's DMA engine was not able to write data from XRAM in time because the access to the XRAM was used by (an) other DMA engine(s) with higher priority. To get rid of this error, try to disable other DMA engines (USB, RF, etc.) and run the IR transmitter again.
	IRSTAT_MSOVERFLOW	The duration of a mark/space exceeded 2^{16} prescaled clock periods.
	IRSTAT_COF	The Carrier detector failed because the perceived carrier low/high period was too long.
	IRSTAT_CDONE	The Carrier detector completed measuring the carrier without errors
	IRSTAT_RXBUFOVERFLOW	The RX buffer was too small to store the received IR data
	IRSTAT_ACTIVE	The IR Controller is active

Serial API (Not supported)

4.3.18.11 ZW_IR_status_clear

void ZW_IR_status_clear(void)

ZW_IR_status_clear clears the Tx and Rx IR Status flags. Call this function before rerunning the IR Controller.

Defined in: ZW_infrared_api.h

Serial API (Not supported)

4.3.18.12 ZW_IR_disable

void ZW_IR_disable(void)

This function disables any ongoing IR operation and sets the IR Controller to its idle state. Use **ZW_IR_status_clear** to clear any status bit before starting the IR Transmitter or IR Receiver.

Defined in: ZW_infrared_api.h

Serial API (Not supported)

4.3.19 Keypad Scanner Controller API

The built-in hardware keypad scanner is able to scan a key matrix of up to 8 rows x 16 columns. When the Keypad Scanner is activated, the 8 row inputs (P1.0-P1.7) must either be connected to the hardware key matrix or kept open. The number of columns can be configured to the range 1-16. The actual IO's being used as column outputs are "KSCOL0" (P0.0) when the column count is set to one, "KSCOL0, KSCOL1" (P0.0, P0.1) when the column count is set to two, "KSCOL0, KSCOL1, KSCOL2" (P0.0, P0.1, P0.2) when the column count is set to three, etc. A column output can be left open, though.

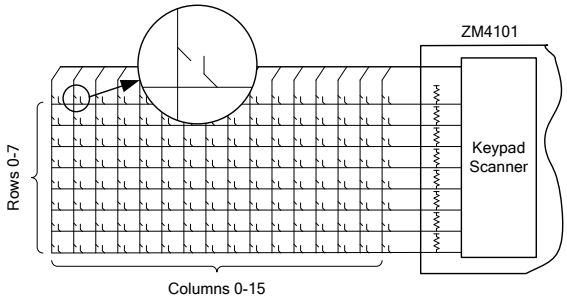


Figure 35. Keypad matix

Once the Keypad Scanner is enabled, it will scan each column for an amount of time (Scan Delay). If it, at a certain column detects a key press, it will wait for a period (Debounce delay) to get any eventual debounce noise to disappear. Then it will detect whether the input stays stable for another amount of time (Stable delay). The Keypad Scanner will issue an interrupt request to the MCU, if the row input is stable for the defined amount of "Stable delay" time. See figure below.

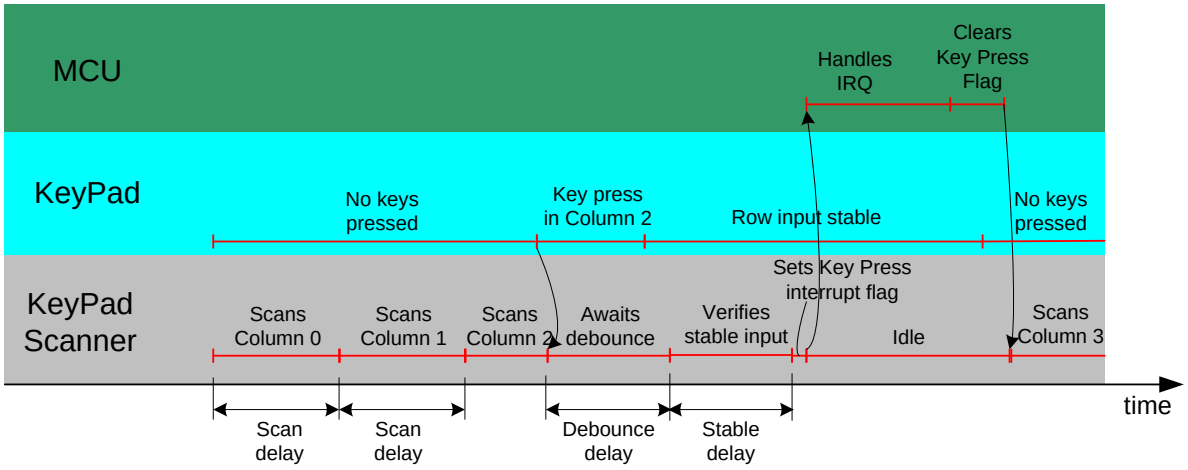


Figure 36. Scan flow

Each of these delays can be configured by using the function **ZW_KS_init,** which must be called in **ApplicationInitHW** as shown in figure below.

```
void KeyPadChanges(BYTE_P pbKeypadMatrix, BYTE bStatus)
{
   /* Call the user defined application function
      InterpretKeys with the keypad matrix as parameter */
  switch (bStatus)
  {
     case ZW_KS_KEYPRESS_VALID:
        InterpretKeys(keyPadMatrix);
        break;
     case ZW_KS_KEYPRESS_INVALID:
        beep();
        break;
     case ZW_KS_KEYPRESS_RELEASED:
        cleanup();
        break
     default:
  }
}


void ApplicationInitHW(BYTE bWakeupReason)
{
          :
     ZW_KS_init(7,     /* 8 Columns */
                4,     /* Column scan delay 10ms */
                15,    /* Debounce delay 32ms */
                5,     /* Row Stable delay 12ms */
                10,    /* Polling period of 100 ms*/
                KeyPadChanges   /* The callback function used to notify */
                                /* the application when changes occurs */
                                /* to the keypad matrix */
                )
     ZW_KS_enable(TRUE);
          :
}

void ApplicationPoll()
{
          :
     /* Go into power down mode */
     ZW_KS_pd_enable(TRUE);
     ZW_SetSleepMode(WUT_MODE,ZW_INT_MASK_EXT1,0);
          :
}
```

Figure 37. Example of the API calls for the KeyPad scanner

The Keypad ISR will detect any changes occurred to the keypad matrix. The changes to the keypad matrix array will be polled periodically. The polling period is defined by the application through **ZW_KS_init**.

Apart from setting the size of the key matrix and the delays, a callback function must be defined in **ZW_KS_init**. If any changes to the keypad matrix are detected the application will be notified by calling this user defined callback function. Figure above shows an example of how **ZW_KS_init** is used.

The parameter to the callback function is an array of the type BYTE. The array has 16 elements one for each column. It has 16 elements regardless of the number of actual configured columns in use. The element with index `n` holds the row-status for column number `n`. That is, bit 0 of an element hold the

status of row 0, bit 1 of an element hold the status of row 1, etc. The array is defined in the Keypad API library.

Note: the Keypad Scanner IRQ signal is shared with “EXT1”, external interrupt 1. Therefore, that interrupt routine must not be included in the application code, when using the Keypad Scanner.

When a key press must wake up the 500 Series Z-Wave SoC from powerdown mode, **ZW_KS_pd_enable(TRUE**) must be called just before the chip is put into powerdown mode. Doing so, will activate the external interrupt, if any key is pressed. When the 500 Series Z-Wave SoC is awake first the function **ZW_KS_init** and then **ZW_KS_enabled** must be called to initialize and enable the Key Scanner and thereby grab the actual key combination.

4.3.19.1 ZW_KS_init

void ZW_KS_init(BYTE bCols
BYTE bScanDelay
BYTE bDebounceDelay,
BYTE bStableDelay
BYTE bReportWaitTimeout,
VOID_CALLBACKFUNC(KeyPadCallBack)(BYTE_P keyMatrix, BYTE bStatus))

ZW_KS_init initializes the 500 Series Z-Wave SoC's integrated Keypad Scanner.

Defined in: ZW_keypad_scanner_api.h

Parameters:

bCols IN	Sets the number of enabled columns. Valid values 0-15. 0: 1 Column 1: 2 Columns : 15: 16 Columns E.g. setting this to 7 will enable KSCOL0-KSCOL7 (P0.0-P0.7)
bScanDelay IN	Sets column “Scan delay” 0: 2ms 1: 4ms : 15: 32ms
bDebounceDelay IN	Sets “debounce delay” 0: 2ms 1: 4ms : 15: 32ms
bStableDelay IN	Sets “stable delay” 0: 2ms 1: 4ms : 15: 32ms
bReportWaitTimeout IN	Set the timeout delay before the main loop call the KeyPadCallBack function. 0: not valid 1: 10 ms 2: 20 ms : 255: 2550 ms

KeyPadCallBack IN	The call back function that the main loop will use to notify the application about the changes in the keypad matrix. The function will only be called when changes to the keypad matrix occurs. Parameters: pbKeyMatrix OUT: Pointer to the keypad matrix BYTE array. bStatus OUT: Returns the status of the contents of the key matrix as one of the follwing:		
		ZW_KS_KEYPRESS_VALID	The contents of the key matrix array is valid
		ZW_KS_KEYPRESS_INVALID	The contents of the key matrix array is invalid, i.e. more than 3 keys are pressed in an invalid manner
		ZW_KS_KEYPRESS_RELEASED	All keys have been released

Serial API (Not supported)

4.3.19.2 ZW_KS_enable

void ZW_KS_enable(BOOL boEnable)

ZW_KS_enable enables or disables the Keypad Scanner. Must be called in **ApplicationInitHW**.

Defined in: ZW_keypad_scanner_api.h

Parameters:

boEnable IN	TRUE	Enables Keypad Scanner
	FALSE	Disables Keypad Scanner

Serial API (Not supported)

4.3.19.3 ZW_KS_pd_enable

void ZW_KS_pd_enable(BYTE boEnable)

ZW_KS_ pd_enable(TRUE) must be called before putting the 500 Series Z-Wave SoC into powerdown mode, if the chip is to be woken by a key press.

Defined in: ZW_keypad_scanner_api.h

Parameters:

boEnable IN	TRUE	Enables Keypad Scanner Powerdown mode
	FALSE	Disables Keypad Scanner Powerdown mode

Serial API (Not supported)

4.3.20 USB/UART common API

This is a simple unified API for using the UART0 or USB interfaces.

If the C-define “USBVCP” is defined, then all functions in this chapter will access the USB interface, otherwise UART0 will be used

First ZW_InitSerialIf must be called to initialize the interface, after that data can be transferred using the put and get functions described in the following sections.

For USB: On windows you need a driver included in the DevKit. On linux and Mac no driver is needed. On all platforms you will get a virtual serial port on the PC side. The certified USB interface complies to USB 2.0 full speed. However, USB driver supports only Bus-Powered USB devices and not Self-Powered.

4.3.20.1 ZW_InitSerialIf

void ZW_InitSerialIf(WORD wBaudRate)

This function initializes the controller using the baud-rate indicated by the parameter.

When using the USB-interface, this parameter does not impact the actual transmission-speed as it is dictated by the USB standard

Defined in: ZW_conbufio.h

Parameters:

bBaudRate IN	96=>9600baud/s, 1152=>115200baud/s

Serial API (Not supported)

4.3.20.2 ZW_FinishSerialIf

BOOL ZW_FinishSerialIf(void)

This function shuts down the internal USB/UART controller and transceiver, to conserve power. The interface can be restarted with ZW_InitSerialIf.

Defined in: ZW_conbufio.h

Return value

Nonzero if there is data in the input queue

Serial API (Not supported)

4.3.20.3 ZW_SerialCheck

BYTE ZW_SerialCheck(void)

This function checks if data has been received and is ready to be read

Defined in: ZW_conbufio.h

Return value

Nonzero if there is data in the input queue

Serial API (Not supported)

4.3.20.4 ZW_SerialGetByte

BYTE ZW_SerialGetByte(void)

This function reads one byte from the input buffer. First use ZW_SerialCheck to make sure that there is data available.

Defined in: ZW_conbufio.h

Return value

The byte received from the USB/UART interface

Serial API (Not supported)

4.3.20.5 ZW_SerialPutByte

BYTE ZW_SerialPutByte(BYTE b)

This function puts one byte into the USB/UART output buffer

Defined in: ZW_conbufio.h

Return value

Non-zero for success

Parameters:

Byte b	Data to be written to the USB/UART output buffer

Serial API (Not supported)

4.3.21 Flash API

The Flash API provides functions for reading the NVR area of the Flash as well as functions for earsing and programming Flash code sectors. Each sector is 2KB and there is 64 sectors in total. The code address range for sector 0 is 0x00000-0x07FF, sector 1 is 0x00800-0x00FFF, etc.

The Flash is erased sector by sector and each sector is programmed one page (256bytes) at a time. The data to be programmed into the flash sector is read from the lower 4kB XRAM.

To minimize the possibility to erase or program the flash code area by a mistake a function, **ZW_FLASH_code_prog_unlock()** that takes a "unlock string" as parameter, has to be called before an erase or program operation can be execised.

Only those sectors that not have been protected by lock bits can be erased/programming by the MCU API calls. Refer to [3] for a description of how to set the protection lock bits.

```
// Program sectors 10 to 13
for (sector=10;sector<14;sector++)
{
  // Unlock the flash erase and program funtions
  // the unlock string contains the four byte unlock string
  ZW_FLASH_code_prog_unlock(&unlock[0]);
  // Erase sector
  if(ZW_FLASH_code_sector_erase(sector))
  {
     Handle error
  }
  // Check state
  if (ZW_FLASH_prog_state())
  {
     Handle error
  }
  // lock the erase and program function
  ZW_FLASH_code_prog_lock();
  // program flash sector page by page
  for (i=0; i<8; i++)
  {
    Make data ready in buffer in memory
    // unlock programming
    if(ZW_FLASH_code_prog_unlock(&unlock[0]))
    {
       Handle error
    }
    // program page 'i' in sector 'sector' with contents from
    // XRAM starting from the address set by '&buffer'
    if(ZW_FLASH_code_page_prog(&buffer,
                               sector,
                               i))   // page
    {
       Handle error
    }
    // lock the erase and program function
    ZW_FLASH_code_prog_lock();
    Handle error
  }
}
// clear unlock to prevent undecired earse or prog operations
unlock={0x00,0x00,0x00,0x00};
```

4.3.21.1 ZW_FLASH_code_prog_unlock

BYTE ZW_Flash_code_prog_unlock(BYTE *pbUnlockString)

This function enables erase and program operations on non-protected Flash code sectors.

Defined in: ZW_flash_api.h

Parameters:

***pbUnlockString** IN	Pointer to a 4 byte string.	The string: 0xDE, 0xAD, 0xBE, 0xEF

Return value:

BYTE	Bit mask:	
	FLASH_STATE_LOCK:	Flash erase and programming is locked
	Zero:	Flash erase and programming is unlocked

Serial API (Not supported)

4.3.21.2 ZW_FLASH_code_prog_lock

BYTE ZW_Flash_code_prog_lock(void)

This function disables erase and program operations on Flash code sectors.

Defined in: ZW_flash_api.h

Return value:

BYTE	Bit mask	
	FLASH_STATE_LOCK:	Flash erase and programming is locked
	Zero:	Flash erase and programming is unlocked

Serial API (Not supported)

4.3.21.3 ZW_FLASH_code_sector_erase

BYTE ZW_Flash_code_sector_erase(BYTE bSector)

This function erases a non-protected Flash code sector. The erase operation has to be unlocked before this function will work, refer to **ZW_FLASH_code_prog_unlock()**. To check which sectors that have been prptected use the function **ZW_FLASH_nvr0_get()** to read the protection bits in the bytes located at the NVR0 addresses 0-7.

The MCU code execution will be halted for 5ms while the program operation is running.

Defined in: ZW_flash_api.h

Parameters:

bSector IN Sector number (0-63).

Return value:

BYTE Bit mask

FLASH_STATE_ERR:	The Flash erase process failed
FLASH_STATE_DONE:	The Flash erase process passed

Serial API (Not supported)

4.3.21.4 ZW_FLASH_code_page_prog

BYTE ZW_Flash_code_page_prog(BYTE pbRamAddress,
BYTE bSector,
BYTE bPage

This function programs a non-protected Flash code sector page with data from XRAM. The program operation has to be unlocked before this function will work, refer to **ZW_FLASH_code_prog_unlock()**. To check which sectors that have been prptected use the function **ZW_FLASH_nvr0_get()** to read the protection bits in the bytes located in NVR0 at the addresses 0-7.

The MCU code execution will be halted for up to 1.6ms while the program operation is running.

Defined in: ZW_flash_api.h

Parameters:

pbRamAddress IN	Pointer to data buffer in lower 4KB XRAM
bSector IN	Sector number (0-63).
bPage IN	Page number (0-7).

Return value:

BYTE	Bit mask	
	FLASH_STATE_LOCK:	Flash erase and programming is locked
	FLASH_STATE_ERR:	The Flash programming process failed
	FLASH_STATE_DONE:	The Flash programming process passed

Serial API (Not supported)

4.3.21.5 ZW_FLASH_auto_prog_set

void ZW_FLASH_auto_prog_set(void)

This function enables the Auto Program Mode and resets the 500 Series Z-Wave SOC after 7.8ms..

Defined in: ZW_flash_api.h

Parameters:

none

Serial API:

HOST->ZW: REQ | 0x27

4.4 Z-Wave Controller API

The Z-Wave Controller API makes it possible for different controllers to control the Z-Wave nodes and get information about each node's capabilities and current state. The node control commands can be sent to a single node, all nodes or to a list of nodes (group, scene…).

4.4.1 ZW_AddNodeToNetwork

void ZW_AddNodeToNetwork(BYTE bMode,
VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))

Macro: ZW_ADD_NODE_TO_NETWORK(bMode, func)
Defined in: ZW_controller_api.h

Serial API: Func_ID = 0x4A
HOST->ZW: REQ | 0x4A | mode | funcID
ZW->HOST: REQ | 0x4A | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[ ]

ZW_AddNodeToNetwork is used to add a node to a Z-Wave network.

The AddNodeToNetwork function MAY be called by a primary controller application to invoke the inclusion of new nodes in a Z-Wave network. Slave and secondary controller applications MUST NOT call this function.
A controller application MUST implement support for the AddNodeToNetwork function. The controller application MUST provide a user interface for activation of the AddNodeToNetwork function.

The bMode and completedFunc parameters MUST be specified for the AddNodeToNetwork function.

Refer to Figure 38 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.1.1 bMode parameter

The bMode parameter MUST be composed of commands and flags found in Table 13. The bMode parameter MUST NOT be assigned more than one command. The bMode parameter MAY be assigned one or more option flags. One command and multiple options are combined by logically OR'ing the bMode flags of Table 13.

Table 13. AddNode :: bMode

bMode flag	Description	Usage
ADD_NODE_ANY	Command to initiate inclusion of new node of any type.	MUST be included when initiating inclusion.
ADD_NODE_SLAVE	-	DEPRECATED. Use ADD_NODE_ANY
ADD_NODE_CONTROLLER	-	DEPRECATED. Use ADD_NODE_ANY
ADD_NODE_EXISTING	-	DEPRECATED. Use ADD_NODE_ANY
ADD_NODE_STOP	Command to abort the inclusion process. May only be used in	MAY be used to abort an active inclusion process.

	certain states.	MUST be used to terminate the inclusion process when completed.
ADD_NODE_STOP_FAILED	Command to notify the remote end when a controller replication is aborted.	SHOULD be used if aborting a controller replication.
ADD_NODE_OPTION_ NORMAL_POWER	Option flag to enable normal inclusion range.	SHOULD be included with ADD_NODE_ ANY to achieve normal inclusion range. MAY be ommitted for ADD_NODE_ANY to achieve reduced inclusion range.
ADD_NODE_OPTION_ NETWORK_WIDE	Option flag to enable Network-Wide Inclusion (NWI).	MUST be used.

Using an illegal value as bMode parameter then ADD_NODE_ANY are used instead.

4.4.1.1.1 ADD_NODE_ANY command

To invoke inclusion of a new node, a primary controller MUST call the AddNodeToNetwork function with a bMode value including the ADD_NODE_ANY command. Slave and secondary controller nodes MUST NOT call the AddNodeToNetwork function.

The RECOMMENDED call of the AddNodeToNetwork function () when adding nodes is as follows:

```
ZW_ADD_NODE_TO_NETWORK((ADD_NODE_ANY |
                        ADD_NODE_OPTION_NORMAL_POWER |
                        ADD_NODE_OPTION_NETWORK_WIDE),
                        completedFunc);
```

While defined in Z-Wave protocol libraries, it is NOT RECOMMENDED to use the ADD_NODE_SLAVE, ADD_NODE_CONTROLLER or ADD_NODE_EXISTING command codes.

4.4.1.1.2 ADD_NODE_STOP command

A controller MAY use the ADD_NODE_STOP command to abort an ongoing inclusion process.

After receiving an ADD_NODE_STATUS_DONE status callback, the application MUST terminate the inclusion process by calling the AddNodeToNetwork function one more time. This time, the completedFunc parameter MUST be the NULL pointer.

Due to the inherent risk of creating ghost nodes with duplicate NodeIDs, a controller SHOULD NOT call the AddNodeToNetwork function in the time window starting with the reception of an ADD_NODE_STATUS_NODE_FOUND status callback and ending with the reception of an ADD_NODE_STATUS_PROTOCOL_DONE status callback. An application may time out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status callback or the application may receive an ADD_NODE_STATUS_ FAILED status callback. In all three cases, the application MUST terminate the inclusion process by calling AddNodeToNetwork(ADD_NODE_STOP) with a valid completedFunc callback pointer. The API MUST return an ADD_NODE_STATUS_DONE status callback in response.

After receiving an ADD_NODE_STATUS_DONE status callback, the application MUST terminate the inclusion process by calling the AddNodeToNetwork function one more time. This time, the completedFunc parameter MUST be the NULL pointer.

4.4.1.1.3 ADD_NODE_STOP_FAILED command

When a new controller node is included in a Z-Wave network, the primary controller replicates protocol-specific databases to the new controller. An optional application-specific phase may follow after protocol-specific replication.
A primary controller SHOULD use the ADD_NODE_STOP_FAILED command during the application-specific phase to notify the receiving end of the application replication that the process is being aborted.

4.4.1.1.4 ADD_NODE_OPTION_NORMAL_POWER option

The default power level for Z-Wave communication is the high power level. Therefore, the high power level is frequently referred to as the normal power level.
When including a new node, the ADD_NODE_OPTION_NORMAL_POWER option SHOULD be added to the bMode parameter.

If special application requirements dictate the need for low power transmission during inclusion of a new node, a primary controller MAY omit the ADD_NODE_OPTION_NORMAL_POWER option from the bMode parameter. However, this is NOT RECOMMENDED.

4.4.1.1.5 ADD_NODE_OPTION_NETWORK_WIDE option

Network-Wide Inclusion (NWI) allows a new node to be included across an existing Z-Wave network without direct range connectivity between the primary controller and the new node. The ADD_NODE_OPTION_NETWORK_WIDE option enables NWI. NWI inclusion is backwards compatible with old nodes that do not implement NWI support.

When including a new node, the ADD_NODE_OPTION_NETWORK_WIDE option MUST be added to the bMode parameter.

4.4.1.2 completedFunc parameter

Being the exception to the rule, an application calling AddNodeToNetwork(ADD_NODE_STOP) to confirm the reception of a ADD_NODE_STATUS_DONE return code MUST specify the NULL pointer for the completedFunc parameter.

In all other cases, an application calling the AddNodeToNetwork function with any command and option combination MUST specify a valid pointer to a callback function provided by the application. The callback function MUST accept a pointer parameter to a LEARN_INFO struct. The parameter provides access to actual status as well as companion data presenting a new node. The LEARN_INFO struct only contains a valid pointer to the Node Information Frame of the new node when the status of the callback is ADD_NODE_STATUS_ADDING_SLAVE or ADD_NODE_STATUS_ADDING_CONTROLLER.

Table 14. AddNode :: completedFunc :: learnNodeInfo

LEARN_NODE struct member	Description
*learnNodeInfo.bStatus	Callback status code
*learnNodeInfo.bSource	NodeID of the new node
*learnNodeInfo.bLen	Length of pCmd element following the bLen element. If bLen is zero, there is no valid pCmd element.
*learnNodeInfo.pCmd	Pointer to Application Node Information (see ApplicationNodeInformation - nodeParm). NULL if no information present.

Individual status codes are presented in the following sections.

Table 15. AddNode :: completedFunc :: learnNodeInfo.bStatus

LEARN_NODE.bStatus	Description
ADD_NODE_STATUS_LEARN_READY	Z-Wave protocol is ready to include new node.
ADD_NODE_STATUS_NODE_FOUND	Z-Wave protocol detected node.
ADD_NODE_STATUS_ADDING_SLAVE	Z-Wave protocol included a slave type node
ADD_NODE_STATUS_ADDING_CONTROLLER	Z-Wave protocol included a controller type node
ADD_NODE_STATUS_PROTOCOL_DONE	Z-Wave protocol completed operations related to inclusion. If new node type is controller, the controller application MAY invoke application replication.
ADD_NODE_STATUS_DONE	All operations completed. Protocol is ready to return to idle state.
ADD_NODE_STATUS_FAILED	Z-Wave protocol reports that inclusion was not successful. New node is not ready for operation
ADD_NODE_STATUS_NOT_PRIMARY	Z-Wave protocol reports that the requested operation cannot be performed since it requires that the node is in primary controller state.

Refer to Figure 38 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.1.2.1 ADD_NODE_STATUS_LEARN_READY status

Z-Wave protocol is ready to include new node. An application MAY time out waiting for the ADD_NODE_STATUS_LEARN_READY status if it does not receive the indication within 10 sec after calling AddNodeToNetwork(ADD_NODE_ANY)

If the application times out waiting for the ADD_NODE_STATUS_LEARN_READY status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP, NULL).

4.4.1.2.2 ADD_NODE_STATUS_NODE_FOUND status

Z-Wave protocol detected node. An application MUST time out waiting for the ADD_NODE_STATUS_NODE_FOUND status if it does not receive the indication after calling AddNodeToNetwork(ADD_NODE_ANY). The RECOMMENDED timeout interval is 60 sec.

If the application times out waiting for the ADD_NODE_STATUS_NODE_FOUND status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP, NULL).

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.3 ADD_NODE_STATUS_ADDING_SLAVE status

Z-Wave protocol included a slave type node.

An application MUST time out waiting for the ADD_NODE_STATUS_ADDING_SLAVE status if it does not receive the indication within a time period after receiving the ADD_NODE_STATUS_NODE_FOUND status. The RECOMMENDED timeout interval is 60 sec.

If the application times out waiting for the ADD_NODE_STATUS_ADDING_SLAVE status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.4 ADD_NODE_STATUS_ADDING_CONTROLLER status

Z-Wave protocol included a controller type node.

An application MUST time out waiting for the ADD_NODE_STATUS_ADDING_CONTROLLER status if it does not receive the indication within a time period after receiving the ADD_NODE_STATUS_NODE_FOUND status. The RECOMMENDED timeout interval is 60 sec.

If the application times out waiting for the ADD_NODE_STATUS_ADDING_CONTROLLER status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive an ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.5 ADD_NODE_STATUS_PROTOCOL_DONE status

Z Wave protocol completed operations related to inclusion. If new node type is controller, the controller application MAY invoke application replication.

In response to the ADD_NODE_STATUS_PROTOCOL_DONE , the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive an ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

An application MUST time out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status if it does not receive the indication within a time period after receiving the ADD_NODE_STATUS_NODE_FOUND status. The time period depends on the network size and the node types in the network. Refer to 4.4.1.3.3.

If the application times out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status, the application MUST call AddNodeToNetwork(ADD_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a ADD_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call AddNodeToNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.1.2.6 ADD_NODE_STATUS_DONE status

All operations completed. Protocol is ready to return to idle state.

In response to the ADD_NODE_STATUS_DONE status callback, the application MUST call AddNodeToNetwork(ADD_NODE_STOP, NULL). The application MUST specify the NULL pointer for the callback function.

4.4.1.2.7 ADD_NODE_STATUS_FAILED status

An application may time out waiting for the ADD_NODE_STATUS_PROTOCOL_DONE status callback or the application may receive an ADD_NODE_STATUS_PROTOCOL_FAILED status callback. In either case, the application MUST terminate the inclusion process by calling AddNodeToNetwork(ADD_NODE_STOP). Refer to 4.4.1.1.2.

4.4.1.2.8 ADD_NODE_STATUS_NOT_PRIMARY status

An application MUST NOT call the AddNodeToNetwork function if the application is not running in a primary controller. If the function is called by an application running in slave or a secondary controller, the API MUST return the ADD_NODE_STATUS_NOT_PRIMARY status callback.

4.4.1.3 completedFunc callback timeouts

4.4.1.3.1 ProtocolReadyTimeout

The API MUST return an ADD_NODE_STATUS_LEARN_READY status callback within less than 10 sec after receiving a call to AddNodeToNetwork(ADD_NODE_ANY).

If an application has not received an ADD_NODE_STATUS_LEARN_READY status callback 200 msec after calling AddNodeToNetwork(ADD_NODE_ANY), the application MAY time out and return to its idle state.

4.4.1.3.2 NodeTimeout

An application MUST implement a timeout for waiting for an ADD_NODE_STATUS_NODE_FOUND status callback.

The application SHOULD NOT wait for an ADD_NODE_STATUS_NODE_FOUND status callback for more than 60 sec after calling AddNodeToNetwork(ADD_NODE_ANY). If timing out, the application SHOULD abort inclusion.

4.4.1.3.3 AddNodeTimeout

An application MUST implement a timeout for waiting for the protocol library to complete inclusion. The timeout MUST be calculated according to the formulas presented in sections 4.4.1.3.3.1 and 4.4.1.3.3.2.

4.4.1.3.3.1 New slave

AddNodeTimeout.NewSlave = 76000ms +
*LISTENINGNODES*217ms +*
*FLIRSNODES*3517ms*

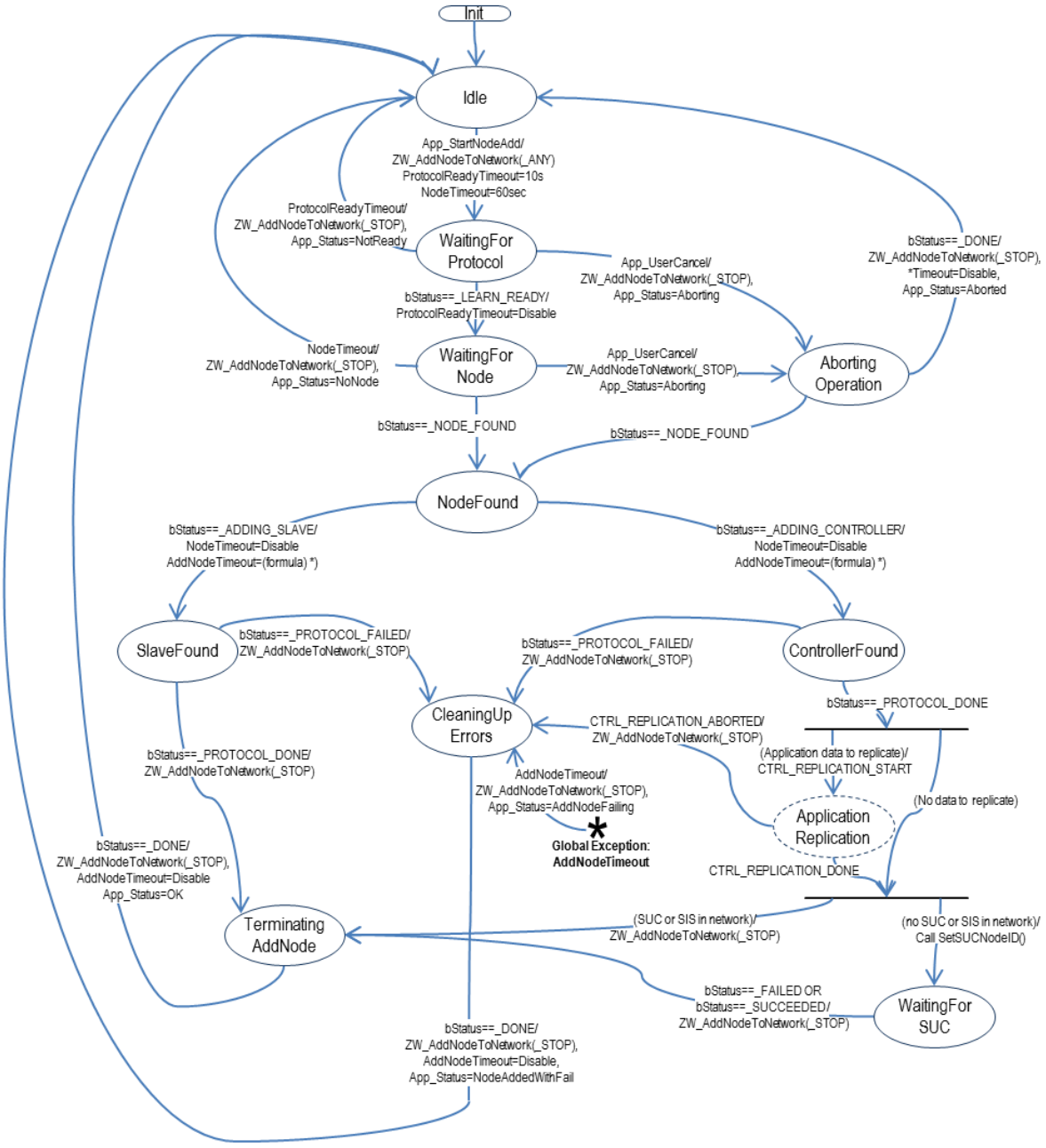
where LISTENINGNODES is the number of listening nodes in the network,
and FLIRSNODES is the number of nodes in the network that are reached via beaming.

4.4.1.3.3.2 New controller

AddNodeTimeout.NewController = 76000ms +
*LISTENINGNODES*217ms +*
*FLIRSNODES*3517ms +*
*NETWORKNODES*732ms,*

where LISTENINGNODES is the number of listening nodes in the network,
and FLIRSNODES is the number of nodes in the network that are reached via beaming.

NETWORKNODES is the total number of nodes in the network, i.e.
NONLISTENINGNODES + LISTENINGNODES + FLIRSNODES.



Formula for calculating AddNodeTimeout: New slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms
New controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms

NETWORKNODES is the total number of nodes of any type

Figure 38. Adding a node to the network

Table 16. AddNode : State/Event processing – 1

States	
(Any State)	Event: AddNodeTimeout => // GLOBAL Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
Idle	Event: (Init) => // Initialize timers, etc. Event: App_StartNodeAdd => // Higher layer application event calls for node to be added New state: <WaitingForProtocol> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_ANY) ProtocolReadyTimeout=10s AddNodeTimeout=60sec
WaitingForProtocol	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==ADD_NODE_STATUS_LEARN_READY => //Callback New state: <WaitingForNode> Actions: Disable ProtocolReadyTimeout timer Event: ProtocolReadyTimeout => // Timer event New state: <Idle> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP, func=NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NotReady event for application
WaitingForNode	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: < AbortingOperation> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==ADD_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Event: NodeTimeout => // Timer event New state: <Idle> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP, func=NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NoNode event for application

Table 17. AddNode : State/Event processing – 2

States	
NodeFound	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: < AbortingOperation> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==ADD_NODE_STATUS_ADDING_SLAVE => //Callback New state: <SlaveFound> Actions: AddNodeTimeout= (calculated as follows:) Slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms Controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms, where NETWORKNODES is the total number of nodes of any type Event: bStatus==ADD_NODE_STATUS_ADDING_CONTROLLER => //Callback New state: <ControllerFound> Actions: AddNodeTimeout= (calculated as follows:) Slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms Controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms, where NETWORKNODES is the total number of nodes of any type Event: NodeFoundTimeout => // Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
SlaveFound	Event: bStatus==ADD_NODE_STATUS_PROTOCOL_DONE => //Callback New state: <TerminatingAddNode> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Event: bStatus==ADD_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Event: AddNodeTimeout => // Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)

ControllerFound	Event: bStatus==ADD_NODE_STATUS_PROTOCOL_DONE => //Callback
	IF (Application data to replicate) THEN
	New state: <ApplicationReplication>
	Actions: Generate CTRL_REPLICATION_START for
	<ApplicationReplication> sub-state machine
	ELSE // No data to replicate
	IF (No SUC or SIS in the network) THEN
	New state: <WaitingForSUC>
	Actions: Call ZW_SetSUCNodeID(NodeID)
	ELSE
	New state: <TerminatingAddNode>
	Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
	ENDIF
	ENDIF
	
	Event: bStatus==ADD_NODE_STATUS_FAILED => //Callback
	New state: <CleaningUpErrors>
	Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)

Table 18. AddNode : State/Event processing – 3

<ApplicationReplication>	<Application Replication> is a self-contained state diagram. Stay here until finished.
	
	Event: CTRL_REPLICATION_ABORTED
	New state: <CleaningUpErrors>
	Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
	
	Event: CTRL_REPLICATION_DONE
	IF (No SUC or SIS in the network) THEN
	New state: <WaitingForSUC>
	Actions: Call ZW_SetSUCNodeID(NodeID)
	ELSE
	New state: <TerminatingAddNode>
	Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
	ENDIF

WaitingForSUC	Event: bStatus==ZW_SUC_SET_SUCCEEDED => //Callback New state: <TerminatingAddNode> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Event: bStatus==ZW_SUC_SET_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Event: AddNodeTimeout => // Timer event New state: <CleaningUpErrors> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP)
TerminatingAddNode	Event: bStatus==ADD_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Call ZW_AddNodeToNetwork(ADD_NODE_STOP) Actions: AddNodeTimeout=Disable Actions: Generate App_Status=OK event for application
CleaningUpErrors	Event: bStatus==ADD_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_AddNodeToNetwork(ADD_NODE_STOP, NULL) Generate App_Status=NodeAddedWithFail event for application
AbortingOperation	Event: bStatus==ADD_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_AddNodeToNetwork(ADD_NODE_STOP, NULL) Generate App_Status=Aborted event for application Event: bStatus==ADD_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Actions: AddNodeTimeout= (calculated as follows:) Slave: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms Controller: AddNodeTimeout = 76000ms + LISTENINGNODES*217ms + FLIRSNODES*3517ms + NETWORKNODES*732ms, where NETWORKNODES is the total number of nodes of any type

4.4.2 ZW_AreNodesNeighbours

BYTE ZW_AreNodesNeighbours (BYTE bNodeA,
BYTE bNodeB)

Macro: ZW_ARE_NODES_NEIGHBOURS (nodeA, nodeB)

Used check if two nodes are marked as being within direct range of each other

Defined in: ZW_controller_api.h

Return value:

BYTE	FALSE	Nodes are not neighbours.
	TRUE	Nodes are neighbours.

Parameters:

bNodeA IN Node ID A (1...232)

bNodeB IN Node ID B (1...232)

Serial API

HOST->ZW: REQ | 0xBC | nodeID | nodeID

ZW->HOST: RES | 0xBC | retVal

4.4.3 ZW_AssignReturnRoute

BOOL ZW_AssignReturnRoute(BYTE bSrcNodeID,
BYTE bDstNodeID,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_ASSIGN_RETURN_ROUTE(routingNodeID,destNodeID,func)

Use to assign static return routes (up to 4) to a Routing Slave or Enhanced 232 Slave node. This allows the Routing Slave node to communicate directly with either controllers or other slave nodes. The API call calculates the shortest routes from the Routing Slave node (bSrcNodeID) to the destination node (bDestNodeID) and transmits the return routes to the Routing Slave node (bSrcNodeID). The destination node is part of the return routes assigned to the slave. Up to 5 different destinations can be allocated return routes in a Routing Slave. Attempts to assign new return routes when all 5 destinations already are allocated will be ignored. It is possible to allocate up to 232 different destinations in an Enhanced 232 Slave. Call **ZW_AssignReturnRoute** repeatedly to allocate more than 5 destinations in an Enhanced 232 Slave. Use the API call **ZW_DeleteReturnRoute** to clear assigned return routes.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If Assign return route operation started
	FALSE	If an “assign/delete return route” operation already is active.

Parameters:

bSrcNodeID IN	Node ID (1...232) of the routing slave that should get the return routes.
bDstNodeID IN	Destination node ID (1...232)
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN	Status of return route assignment	
	(all status codes from ZW_SendData)	See **ZW_SendData**, section 4.3.3.1
	TRANSMIT_COMPLETE_NOROUTE	No routes assigned because a route between source and destination node could not be found.

Serial API:

HOST->ZW: REQ | 0x46 | bSrcNodeID | bDstNodeID | funcID

ZW->HOST: RES | 0x46 | retVal

ZW->HOST: REQ | 0x46 | funcID | bStatus

4.4.4 ZW_AssignSUCReturnRoute

BOOL ZW_AssignSUCReturnRoute (BYTE bSrcNodeID,
VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))

Macro: ZW_ASSIGN_SUC_RETURN_ROUTE(srcnode,func)

Notify presence of a SUC/SIS to a Routing Slave or Enhanced 232 Slave. Furthermore is static return routes (up to 4) assigned to the Routing Slave or Enhanced 232 Slave to enable communication with the SUC/SIS node. The return routes can be used to get updated return routes from the SUC/SIS node by calling ZW_RequestNetWorkUpdated in the Routing Slave or Enhanced 232 Slave.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If the assign SUC return route operation is started.
	FALSE	If an “assign/delete return route” operation already is active.

Parameters:

bSrcNodeID IN	The node ID (1...232) of the routing slave that should get the return route to the SUC/SIS node.
completedFunc IN	Transmit complete call back.

Callback function Parameters:

bStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x51 | bSrcNodeID | funcID | funcID

The extra funcID is added to ensures backward compatible. This parameter has been removed starting from dev. kit 4.1x. and onwards and has therefore no meaning anymore.

ZW->HOST: RES | 0x51 | retVal

ZW->HOST: REQ | 0x51 | funcID | bStatus

4.4.5 ZW_ControllerChange

void ZW_ControllerChange (BYTE mode,
VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))

Macro: ZW_CONTROLLER_CHANGE(mode, func)

ZW_ControllerChange is used to add a controller to the Z-Wave network and transfer the role as primary controller to it.

This function has the same functionality as ZW_AddNodeToNetwork(ADD_NODE_ANY,…) except that the new controller will be a primary controller and the controller invoking the function will become secondary.

Defined in: ZW_controller_api.h

Parameters:

mode IN	The learn node states are:	
	CONTROLLER_CHANGE_START	Start the process of adding a controller to the network.
	CONTROLLER_CHANGE_STOP	Stop the controller change
	CONTROLLER_CHANGE_STOP_FAILED	Stop the controller change and report a failure
completedFunc IN	Callback function pointer (Should only be NULL if state is turned off).	

Callback function Parameters (completedFunc):

*learnNodeInfo.bStatus IN	Status of learn mode:	
	ADD_NODE_STATUS_LEARN_READY	The controller is now ready to include a node into the network.
	ADD_NODE_STATUS_NODE_FOUND	A node that wants to be included into the network has been found
	ADD_NODE_STATUS_ADDING_CONTROLLER	A new controller has been added to the network
	ADD_NODE_STATUS_PROTOCOL_DONE	The protocol part of adding a controller is complete, the application can now send data to the new controller using **ZW_ReplicationSend()**
	ADD_NODE_STATUS_DONE	The new node has now been included and the controller is ready to continue normal operation again.
	ADD_NODE_STATUS_FAILED	The learn process failed
*learnNodeInfo.bSource IN	Node id of the new node	
*learnNodeInfo.pCmd IN	Pointer to Application Node information data (see **ApplicationNodeInformation** - nodeParm**)**. NULL if no information present. The pCmd only contain information when bLen is not zero, so the information should be stored when that is the case. Regardless of the bStatus.	
*learnNodeInfo.bLen IN	Node info length.	

Serial API:

HOST->ZW: REQ | 0x4D | mode | funcID

ZW->HOST: REQ | 0x4D | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[ ]

4.4.6 ZW_DeleteReturnRoute

BOOL ZW_DeleteReturnRoute(BYTE nodeID,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_DELETE_RETURN_ROUTE(nodeID, func)

Delete all static return routes from a Routing Slave or Enhanced 232 Slave node.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If Delete return route operation started
	FALSE	If an “assign/delete return route” operation already is active.

Parameters:

nodeID IN	Node ID (1...232) of the routing slave node.
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x47 | nodeID | funcID

ZW->HOST: RES | 0x47 | retVal

ZW->HOST: REQ | 0x47 | funcID | bStatus

4.4.7 ZW_DeleteSUCReturnRoute

BOOL ZW_DeleteSUCReturnRoute (BYTE bNodeID,
VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus))

Macro: ZW_DELETE_SUC_RETURN_ROUTE (nodeID, func)

Delete the return routes of the SUC/SIS node from a Routing Slave node or Enhanced 232 Slave node.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If the delete SUC return route operation is started.
	FALSE	If an “assign/delete return route” operation already is active.

Parameters:

bNodeID IN	Node ID (1..232) of the routing slave node.
completedFunc IN	Transmit complete call back.

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x55 | nodeID | funcID

ZW->HOST: RES | 0x55 | retVal

ZW->HOST: REQ | 0x55 | funcID | bStatus

The Serial API implementation do not return the callback function (no parameter in the Serial API frame refers to the callback), this is done via the **ApplicationControllerUpdate** callback function:

- If request nodeinfo transmission was unsuccessful (no ACK received) then the **ApplicationControllerUpdate** is called with UPDATE_STATE_NODE_INFO_REQ_FAILED (status only available in the Serial API implementation).
- If request nodeinfo transmission was successful there is no indication that it went well apart from the returned Nodeinfo frame which should be received via the **ApplicationControllerUpdate** with status UPDATE_STATE_NODE_INFO_RECEIVED.

4.4.8 ZW_GetControllerCapabilities

BYTE ZW_GetControllerCapabilities (void)

Macro: ZW_GET_CONTROLLER_CAPABILITIES()

ZW_GetControllerCapabilities returns a bitmask containing the capabilities of the controller. It's an old type of primary controller (node ID = 0xEF) in case zero is returned.

NOTE: Not all status bits are available on all controllers' types

Defined in: ZW_controller_api.h

Return value:

BYTE	CONTROLLER_IS_SECONDARY	If bit is set then the controller is a secondary controller
	CONTROLLER_ON_OTHER_NETWORK	If this bit is set then this controller is not using its built-in home ID
	CONTROLLER_IS_SUC	If this bit is set then this controller is a SUC
	CONTROLLER_NODEID_SERVER_PRESENT	If this bit is set then there is a SUC ID server (SIS) in the network and this controller can therefore include/exclude nodes in the network. This is called an inclusion controller.
	CONTROLLER_IS_REAL_PRIMARY	If this bit is set then this controller was the original primary controller in the network before the SIS was added to the network

Serial API:

HOST->ZW: REQ | 0x05

ZW->HOST: RES | 0x05 | RetVal

4.4.9 ZW_GetNeighborCount

BYTE ZW_GetNeighborCount(BYTE nodeID)

Macro: ZW_GET_NEIGHBOR_COUNT (nodeID)

Used to get the number of neighbors the specified node has registered.

Defined in: ZW_controller_api.h

Return value:

BYTE	0x00-0xE7	Number of neighbors registered.
	NEIGHBORS_ID_INVALID	Specified node ID is invalid.
	NEIGHBORS_COUNT_FAILED	Could not access routing information - try again later.

Parameters:

nodeID IN	Node ID (1...232) on the node to count neighbors on.

Serial API

HOST->ZW: REQ | 0xBB | nodeID

ZW->HOST: RES | 0xBB | retVal

4.4.10 ZW_GetLastWorkingRoute

BOOL ZW_GetLastWorkingRoute(BYTE bNodeID, XBYTE *pLastWorkingRoute)

Macro: ZW_GET_LAST_WORKING_ROUTE(bNodeID, pLastWorkingRoute)

Use this API call to get the Last Working Route (LWR) for a destination node if any exist. The LWR is the last successful route used between sender and destination node. The LWR is stored in NVM.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	A LWR exists for bNodeID and the found route placed in the 5-byte array pointed out by pLastWorkingRoute.
	FALSE	No LWR found for bNodeID.

Parameters:

bNodeID IN	The Node ID (1...232) specifies the destination node whom the LWR is wanted from.
pLastWorkingRoute IN	Pointer to a 5-byte array where the wanted LWR will be written. The 5-byte array contains in the first 4 byte the max 4 repeaters (index 0 - 3) and 1 routespeed byte (index 4) used in the LWR. The LWR which pLastWorkingRoute points to is valid if function return value equals TRUE. The first repeater byte (starting from index 0) equaling zero indicates no more repeaters in route. If the repeater at index 0 is zero then the LWR is direct. The routespeed byte (index 4) can be either ZW_LAST_WORKING_ROUTE_SPEED_9600, ZW_LAST_WORKING_ROUTE_SPEED_40K or ZW_LAST_WORKING_ROUTE_SPEED_100K

Serial API

HOST->ZW: REQ | 0x92 | bNodeID

ZW->HOST: RES | 0x92 | bNodeID | retVal | repeater0 | repeater1 | repeater2 | repeater3 | routespeed

4.4.11 ZW_SetLastWorkingRoute

BOOL ZW_SetLastWorkingRoute(BYTE bNodeID, XBYTE *pLastWorkingRoute)

Macro: ZW_SET_LAST_WORKING_ROUTE(bNodeID, pLastWorkingRoute)

Use this API call to set the Last Working Route (LWR) for a destination node. The LWR is the last successful route used between sender and destination node. The LWR is stored in NVM.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	The LWR for bNodeID was successfully set to the specified 5-byte LWR pointed out by pLastWorkingRoute.
	FALSE	The specified bNodeID was not valid and no LWR was set.

Parameters:

bNodeID IN	The Node ID (1...232) - specifies the destination node for whom the LWR is to be set.
pLastWorkingRoute IN	Pointer for a 5-byte array containing the new LWR to be set. The 5-byte array contains 4 repeater node bytes (index 0 - 3) and 1 routespeed byte (index 4). The first repeater byte (starting from index 0) equaling zero indicates no more repeaters in route. If the repeater at index 0 is zero then the LWR is direct. The routespeed byte (index 4) can be either ZW_LAST_WORKING_ROUTE_SPEED_9600, ZW_LAST_WORKING_ROUTE_SPEED_40K or ZW_LAST_WORKING_ROUTE_SPEED_100K

Serial API

HOST->ZW: REQ | 0x93 | bNodeID | repeater0 | repeater1 | repeater2 | repeater3 | routespeed

ZW->HOST: RES | 0x93 | bNodeID | retVal

4.4.12 ZW_GetNodeProtocolInfo

void ZW_GetNodeProtocolInfo(BYTE bNodeID,
NODEINFO *nodeInfo)

Macro: ZW_GET_NODE_STATE(nodeID, nodeInfo)

Return the Node Information Frame without command classes from the NVM for a given node ID:

Byte descriptor \ Bit number	7	6	5	4	3	2	1	0
Capability	Liste-ning	Z-Wave Protocol Specific Part						
Security	Opt. Func.	Sensor 1000ms	Sensor 250ms	Z-Wave Protocol Specific Part				
Reserved	Z-Wave Protocol Specific Part							
Basic	Basic Device Class (Z-Wave Protocol Specific Part)							
Generic	Generic Device Class (Z-Wave Appl. Specific Part)							
Specific	Specific Device Class (Z-Wave Appl. Specific Part)							

Figure 39. Node Information frame structure without command classes

All the Z-Wave protocol specific fields are initialised by the protocol. The Listening flag, Generic, and Specific Device Class fields are initialized by the application. Regarding initialization, refer to the function **ApplicationNodeInformation**.

Defined in: ZW_controller_api.h

Parameters:

bNodeID IN	Node ID	1..232
nodeInfo OUT	Node info buffer (see figure above)	If (*nodeInfo).nodeType.generic is 0 then the node doesn't exist.

Serial API:

HOST->ZW: REQ | 0x41 | bNodeID

ZW->HOST: RES | 0x41 | nodeInfo (see figure above)

4.4.13 ZW_GetRoutingInfo

void ZW_GetRoutingInfo(BYTE bNodeID,
BYTE_P pMask,
BYTE bRemove)
Macro: ZW_GET_ROUTING_INFO(bNodeID, pMask, bRemove)

ZW_GetRoutingInfo is a function that can be used to read out neighbor information from the protocol.

This information can be used to ensure that all nodes have a sufficient number of neighbors and to ensure that the network is in fact one network.

The format of the data returned in the buffer pointed to by pMask is as follows:

pMask[i] (0 ≤ i < (ZW_MAX_NODES/8)								
Bit	0	1	2	3	4	5	6	7
NodeID	i*8+1	I*8+2	i*8+3	i*8+4	i*8+5	i*8+6	i*8+7	i*8+8

If a bit n in pMask[i] is 1 it indicates that the node bNodeID has node (i*8)+n+1 as a neighbour. If n in pMask[i] is 0, bNodeID cannot reach node (i*8)+n+1 directly.

Defined in: ZW_controller_api.h

Parameters:

bNodeID IN	Node ID (1…232) specifies the node whom routing info is needed from.	
pMask OUT	Pointer to buffer where routing info should be put. The buffer should be at least ZW_MAX_NODES/8 bytes	
bRemove IN	GET_ROUTING_INFO_REMOVE_NON_REPS	Remove non-repeaters from the routing info.
	ZW_GET_ROUTING_INFO_9600 or ZW_GET_ROUTING_INFO_40K or ZW_GET_ROUTING_INFO_100K or ZW_GET_ROUTING_INFO_ANY	Return only nodes supporting this speed. Only one option may be used at a time.

Serial API:

HOST->ZW: REQ | 0x80 | bNodeID | bRemoveBad | bRemoveNonReps | funcID

ZW->HOST: RES | 0x80 | NodeMask[29]

4.4.14 ZW_GetSUCNodeID

BYTE ZW_GetSUCNodeID(void)

Macro: ZW_GET_SUC_NODE_ID()

API call used to get the currently registered SUC/SIS node ID.

Defined in: ZW_controller_api.h

Return value:

BYTE	The node ID (1..232) on the currently registered SUC/SIS, if ZERO then no SUC/SIS available.

Serial API:

HOST->ZW: REQ | 0x56

ZW->HOST: RES | 0x56 | SUCNodeID

4.4.15 ZW_IsFailedNode

BYTE ZW_isFailedNode(BYTE nodeID)

Macro: ZW_IS_FAILED_NODE_ID(nodeID)

Used to test if a node ID is stored in the failed node ID list.

Defined in: ZW_controller_api.h

Return value:

BYTE	TRUE	If node ID (1..232) is in the list of failing nodes.

Parameters:

nodeID IN	The node ID (1...232) to check.

Serial API:

HOST->ZW: REQ | 0x62 | nodeID

ZW->HOST: RES | 0x62 | retVal

4.4.16 ZW_IsPrimaryCtrl

BOOL ZW_IsPrimaryCtrl (void)

Macro: ZW_PRIMARYCTRL()

This function is used to request whether the controller is a primary controller or a secondary controller in the network.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	Returns TRUE when the controller is a primary controller in the network.
	FALSE	Return FALSE when the controller is a secondary controller in the network.

Serial API (Not supported)

4.4.17 ZW_RemoveFailedNode

BYTE ZW_RemoveFailedNode(BYTE NodeID,
BOOL bNormalPower,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_REMOVE_FAILED_NODE_ID(node,func)

Used to remove a non-responding node from the routing table in the requesting controller. A non-responding node is put onto the failed node ID list in the requesting controller. In case the node responds again at a later stage then it is removed from the failed node ID list. A node must be on the failed node ID list and as an extra precaution also fail to respond before it is removed. Responding nodes can't be removed. The call works on a primary controller and an inclusion controller.

A call back function should be provided otherwise the function will return without removing the node.

Defined in: ZW_controller_api.h

Return value (If the replacing process started successfully then the function will return):

BYTE	ZW_FAILED_NODE_REMOVE_STARTED	The removing process started

Return values (If the replacing process cannot be started then the API function will return one or more of the following flags):

BYTE	ZW_NOT_PRIMARY_CONTROLLER	The removing process was aborted because the controller is not the primary one.
	ZW_NO_CALLBACK_FUNCTION	The removing process was aborted because no call back function is used.
	ZW_FAILED_NODE_NOT_FOUND	The requested process failed. The nodeID was not found in the controller list of failing nodes.
	ZW_FAILED_NODE_REMOVE_PROCESS_BUSY	The removing process is busy.
	ZW_FAILED_NODE_REMOVE_FAIL	The requested process failed. Reasons include: • Controller is busy • The node responded to a NOP; thus the node is no longer failing.

Parameters:

nodeID IN	The node ID (1..232) of the failed node to be deleted.
bNormalPower IN	If TRUE then using Normal RF Power.
completedFunc IN	Remove process completed call back function

Callback function Parameters:

txStatus IN	Status of removal of failed node:	
	ZW_NODE_OK	The node is working properly (removed from the failed nodes list).
	ZW_FAILED_NODE_REMOVED	The failed node was removed from the failed nodes list.
	ZW_FAILED_NODE_NOT_REMOVED	The failed node was not removed because the removing process cannot be completed.

Serial API:

HOST->ZW: REQ | 0x61 | nodeID | funcID

ZW->HOST: RES | 0x61 | retVal

ZW->HOST: REQ | 0x61 | funcID | txStatus

4.4.18 ZW_ReplaceFailedNode

BYTE ZW_ReplaceFailedNode(BYTE NodeID,
BOOL bNormalPower,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_REPLACE_FAILED_NODE(node,func)

This function replaces a non-responding node with a new one in the requesting controller. A non-responding node is put onto the failed node ID list in the requesting controller. In case the node responds again at a later stage then it is removed from the failed node ID list. A node must be on the failed node ID list and as an extra precaution also fail to respond before it is removed. Responding nodes can't be replace. The call works on a primary controller and an inclusion controller.

A call back function should be provided otherwise the function would return without replacing the node.

Defined in: ZW_controller_api.h

Return value (If the replacing process started successfully then the function will return):

BYTE	ZW_FAILED_NODE_REMOVE_STARTED	The replacing process has started.

Return values (If the replacing process cannot be started then the API function will return one or more of the following flags:):

BYTE	ZW_NOT_PRIMARY_CONTROLLER	The replacing process was aborted because the controller is not a primary/inclusion/SIS controller.
	ZW_NO_CALLBACK_FUNCTION	The replacing process was aborted because no call back function is used.
	ZW_FAILED_NODE_NOT_FOUND	The requested process failed. The nodeID was not found in the controller list of failing nodes.
	ZW_FAILED_NODE_REMOVE_PROCESS_BUSY	The removing process is busy.
	ZW_FAILED_NODE_REMOVE_FAIL	The requested process failed. Reasons include: • Controller is busy • The node responded to a NOP; thus the node is no longer failing.

Parameters:

nodeID IN	The node ID (1…232) of the failed node to be deleted.
bNormalPower IN	If TRUE then using Normal RF Power.
completedFunc IN	Replace process completed call back function

Callback function Parameters:

txStatus IN	Status of replace of failed node:	
	ZW_NODE_OK	The node is working properly (removed from the failed nodes list). Replace process is stopped.
	ZW_FAILED_NODE_REPLACE	The failed node is ready to be replaced and controller is ready to add new node with the nodeID of the failed node. Meaning that the new node must now emit a nodeinformation frame to be included.
	ZW_FAILED_NODE_REPLACE_DONE	The failed node has been replaced.
	ZW_FAILED_NODE_REPLACE_FAILED	The failed node has not been replaced.

Serial API:

HOST->ZW: REQ | 0x63 | nodeID | funcID

ZW->HOST: RES | 0x63 | retVal

ZW->HOST: REQ | 0x63 | funcID | txStatus

4.4.19 ZW_RemoveNodeFromNetwork

void ZW_RemoveNodeFromNetwork(BYTE mode,
VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))

Macro: ZW_REMOVE_NODE_FROM_NETWORK(mode, func)
Defined in: ZW_controller_api.h

Serial API: Func_ID = 0x4B
HOST->ZW: REQ | 0x4B | mode | funcID
ZW->HOST: REQ | 0x4B | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[ ]

ZW_RemoveNodeFromNetwork is used to remove a node from a Z-Wave network.

The RemoveNodeFromNetwork function MAY be called by a primary controller application to invoke the removal of nodes from a Z-Wave network. Slave and secondary controller applications MUST NOT call this function.
A controller application MUST implement support for the RemoveNodeFromNetwork function. The controller application MUST provide a user interface for activation of the RemoveNodeFromNetwork function.

The bMode and completedFunc parameters MUST be specified for the RemoveNodeFromNetwork function.

Refer to Figure 40 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.19.1 bMode parameter

The bMode parameter MUST be carry one of the commands found in Table 19. The bMode parameter MUST NOT be assigned more than one command. The bMode parameter MAY be assigned one or more option flags. One command and multiple options are combined by logically OR'ing the bMode flags of Table 13.

Table 19. RemoveNode :: bMode

bMode flag	Description	Usage
REMOVE_NODE_ANY	Command to initiate removal of node of any type.	MUST be included when initiating removal.
REMOVE_NODE_SLAVE	-	DEPRECATED. Use REMOVE_NODE_ANY
REMOVE_NODE_CONTROLLER	-	DEPRECATED. Use REMOVE_NODE_ANY
REMOVE_NODE_STOP	Command to abort the removal process. May only be used in certain states.	MAY be used to abort an active removal process. MUST be used to terminate the removal process when completed.

4.4.19.1.1 REMOVE_NODE_ANY command

To invoke removal of a node, a primary controller MUST call the RemoveNodeFromNetwork function with a bMode value including the REMOVE_NODE_ANY command. Slave and secondary controller nodes MUST NOT call the RemoveNodeFromNetwork function.

While defined in Z-Wave protocol libraries, it is NOT RECOMMENDED to use the REMOVE_NODE_SLAVE or REMOVE_NODE_CONTROLLER command codes.

4.4.19.1.2 REMOVE_NODE_STOP command

A controller MAY use the REMOVE_NODE_STOP command to abort an ongoing removal process.

After receiving a REMOVE_NODE_STATUS_DONE status callback, the application MUST terminate the removal process by calling the RemoveNodeFromNetwork function one more time. This time, the completedFunc parameter MUST be the NULL pointer.

4.4.19.2 completedFunc parameter

Being the exception to the rule, an application calling RemoveNodeFromNetwork(REMOVE_NODE_STOP) to confirm the reception of a REMOVE_NODE_STATUS_DONE return code MUST specify the NULL pointer for the completedFunc parameter.

In all other cases, an application calling the RemoveNodeFromNetwork function MUST specify a valid pointer to a callback function provided by the application. The callback function MUST accept a pointer parameter to a LEARN_INFO struct. The parameter provides access to actual status as well as companion data presenting the node being removed. The LEARN_INFO struct only contains a valid pointer to the Node Information Frame of a node when the status of the callback is

REMOVE_NODE_STATUS_REMOVING_SLAVE or
REMOVE_NODE_STATUS_REMOVING_CONTROLLER.

Table 20. RemoveNode :: completedFunc :: learnNodeInfo

LEARN_NODE struct member	Description
*learnNodeInfo.bStatus	Callback status code
*learnNodeInfo.bSource	NodeID of the node that was removed
*learnNodeInfo.bLen	Length of pCmd element following the bLen element. If bLen is zero, there is no valid pCmd element.
*learnNodeInfo.pCmd	Pointer to Application Node Information (see ApplicationNodeInformation - nodeParm). NULL if no information present.

Individual status codes are presented in the following sections.

Table 21. RemoveNode :: completedFunc :: learnNodeInfo.bStatus

LEARN_NODE.bStatus	Description
REMOVE_NODE_STATUS_LEARN_READY	Z-Wave protocol is ready to remove a node.
REMOVE_NODE_STATUS_NODE_FOUND	Z-Wave protocol detected node.
REMOVE_NODE_STATUS_REMOVING_SLAVE	Z-Wave protocol removed a slave type node
REMOVE_NODE_STATUS_REMOVING_CONTROLLER	Z-Wave protocol removed a controller type node
REMOVE_NODE_STATUS_DONE	All operations completed. Protocol is ready to return to idle state.
REMOVE_NODE_STATUS_FAILED	Z-Wave protocol reports that removal was not successful. Node may not have been removed.
ADD_NODE_STATUS_NOT_PRIMARY	Z Wave protocol reports that the requested operation cannot be performed since it requires that the node is in primary controller state.

Refer to Figure 40 for a state diagram outlining the processing of status callbacks and timeouts.

4.4.19.2.1 REMOVE_NODE_STATUS_LEARN_READY status

Z-Wave protocol is ready to remove a node. An application MAY time out waiting for the REMOVE_NODE_STATUS_LEARN_READY status if it does not receive the indication within 200 msec after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY).

If the application times out waiting for the REMOVE_NODE_STATUS_LEARN_READY status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL).

4.4.19.2.2 REMOVE_NODE_STATUS_NODE_FOUND status

Z-Wave protocol detected node. An application MUST time out waiting for the REMOVE_NODE_STATUS_NODE_FOUND status if it does not receive the indication after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY). The RECOMMENDED interval is 60 sec.

If the application times out waiting for the REMOVE_NODE_STATUS_NODE_FOUND status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL).

The application MUST NOT call RemoveNodeFromNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.19.2.3 REMOVE_NODE_STATUS_REMOVING_SLAVE status

Z-Wave protocol is removing a slave type node. The NodeID of the node is included in the callback.

An application MUST time out waiting for the REMOVE_NODE_STATUS_REMOVING_SLAVE status if it does not receive the indication within a 14 sec after receiving the REMOVE_NODE_STATUS_NODE_FOUND status.

If the application times out waiting for the REMOVE_NODE_STATUS_REMOVNG_SLAVE status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive a REMOVE_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call RemoveNodeFromNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.19.2.4 REMOVE_NODE_STATUS_REMOVING_CONTROLLER status

Z-Wave protocol is removing a controller type node. The NodeID of the node is included in the callback.

An application MUST time out waiting for the REMOVE_NODE_STATUS_REMOVING_CONTROLLER status if it does not receive the indication within a 14 sec after receiving the REMOVE_NODE_STATUS_NODE_FOUND status.

If the application times out waiting for the REMOVE_NODE_STATUS_REMOVING_CONTROLLER status, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP). The application MUST specify a valid callback function. This allows the application to receive an REMOVE_NODE_STATUS_DONE once the protocol has completed cleaning up its datastructures.

The application MUST NOT call RemoveNodeFromNetwork() before the timeout occurs. This may cause the protocol to malfunction.

4.4.19.2.5 REMOVE_NODE_STATUS_DONE status

All operations completed. Protocol is ready to return to idle state.

In response to the REMOVE_NODE_STATUS_DONE status callback, the application MUST call RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL). The application MUST specify the NULL pointer for the callback function.

4.4.19.2.6 REMOVE_NODE_STATUS_FAILED status

If an application receives a REMOVE_NODE_STATUS_PROTOCOL_FAILED status callback, the application MUST terminate the removal process by calling RemoveNodeFromNetwork(REMOVE_NODE_STOP). Refer to 4.4.19.1.2.

4.4.19.2.7 ADD_NODE_STATUS_NOT_PRIMARY status

An application MUST NOT call the RemoveNodeFromNetwork function if the application is not running in a primary controller. If the function is called by an application running in slave or a secondary controller, the API MUST return the ADD_NODE_STATUS_NOT_PRIMARY status callback.

4.4.19.3 completedFunc callback timeouts

4.4.19.3.1 ProtocolReadyTimeout

The API MUST return a REMOVE_NODE_STATUS_LEARN_READY status callback within less than 200 msec after receiving a call to RemoveNodeFromNetwork(REMOVE_NODE_ANY).

If an application has not received a REMOVE_NODE_STATUS_LEARN_READY status callback 200 msec after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY), the application MAY time out and return to its idle state.

4.4.19.3.2 NodeTimeout

An application MUST implement a timeout for waiting for an REMOVE_NODE_STATUS_NODE_FOUND status callback.

The application SHOULD NOT wait for a REMOVE_NODE_STATUS_NODE_FOUND status callback for more than 60 sec after calling RemoveNodeFromNetwork(REMOVE_NODE_ANY). If timing out, the application SHOULD abort removal.

4.4.19.3.3 RemoveNodeTimeout

An application MUST time out if removal has not been completed within 14 sec after the reception of the REMOVE_NODE_STATUS_NODE_FOUND status callback.

If timing out, the application MUST evaluate the controller node list to verify that the NodeID was removed. The removal process SHOULD be repeated if the NodeID is still found in the node list.

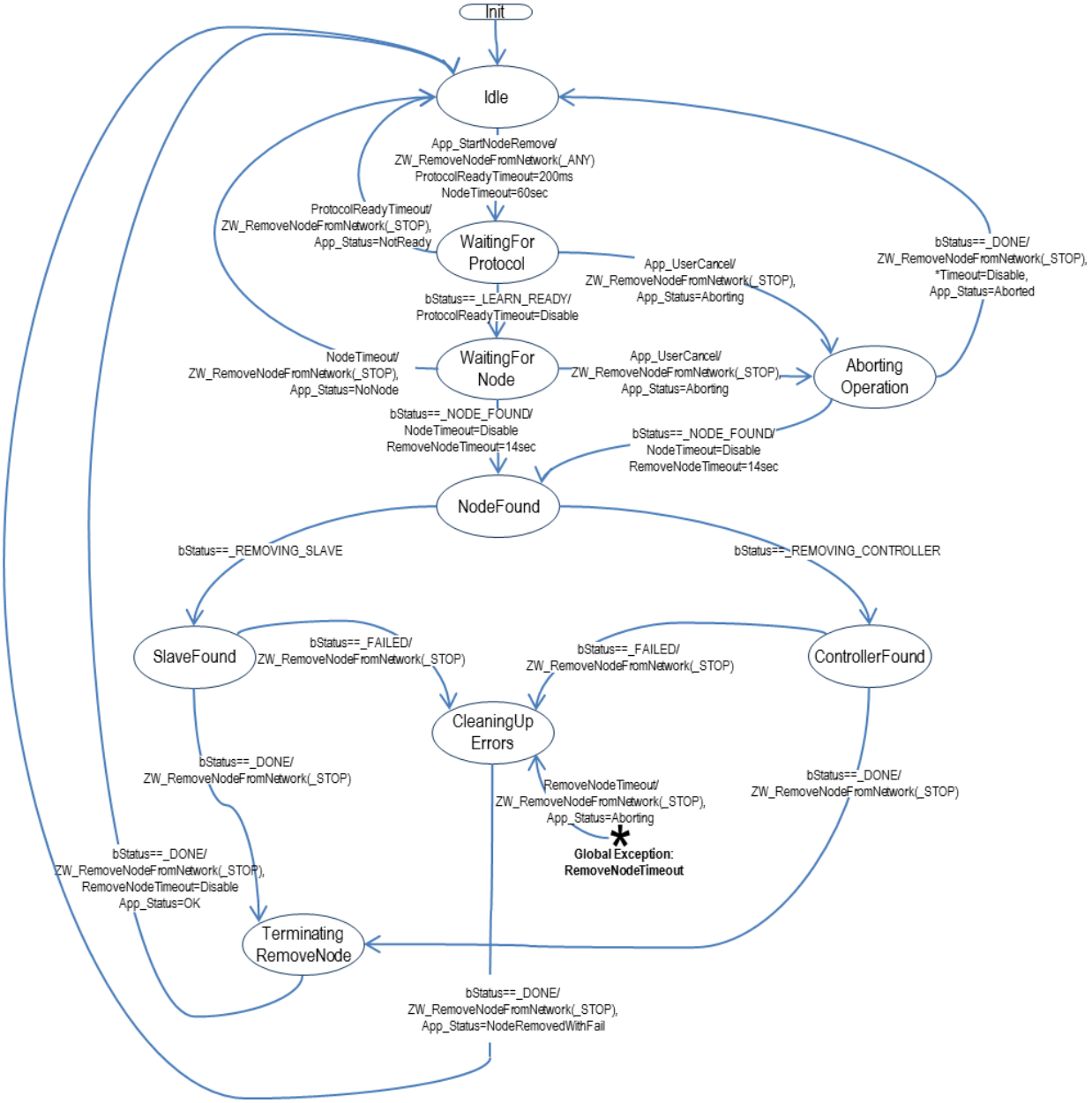


Figure 40. Removing a node from the network

Table 22. RemoveNode : State/Event processing - 1

(Any State)	Event: RemoveNodeTimeout => // GLOBAL Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)
Idle	Event: (Init) => // Initialize timers, etc. Event: App_StartNodeRemove => // Higher layer application event calls for node to be removed New state: <WaitingForProtocol> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_ANY) ProtocolReadyTimeout=200ms NodeTimeout=60sec
WaitingForProtocol	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_AddNodeToNetwork(REMOVE_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==REMOVE_NODE_STATUS_LEARN_READY => //Callback New state: <WaitingForNode> Actions: Disable ProtocolReadyTimeout timer Event: ProtocolReadyTimeout => // Timer event New state: <Idle> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NotReady event for application
WaitingForNode	Event: App_UserCancel => // Higher layer application event calls for process to be stopped New state: <AbortingOperation> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Generate App_Status=Aborting event for application Event: bStatus==REMOVE_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Actions: NodeTimeout=Disable Actions: RemoveNodeTimeout=14 sec Event: NewNodeTimeout => // Timer event New state: <Idle> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) // Stop operation; do not specify a callbackfunction Generate App_Status=NoNode event for application
NodeFound	Event: bStatus==REMOVE_NODE_STATUS_REMOVING_SLAVE => //Callback New state: <SlaveFound> Event: bStatus==REMOVE_NODE_STATUS_REMOVING_CONTROLLER => //Callback New state: <ControllerFound> Event: NodeFoundTimeout => // Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)

Table 23. RemoveNode : State/Event processing - 2

SlaveFound	Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <TerminatingRemoveNode> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Event: bStatus==REMOVE_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Event: RemoveNodeTimeout => // Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)
ControllerFound	Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <TerminatingRemoveNode> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Event: bStatus==REMOVE_NODE_STATUS_FAILED => //Callback New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Event: RemoveNodeTimeout => // Timer event New state: <CleaningUpErrors> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP)
TerminatingRemoveNode	Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP) Actions: RemoveNodeTimeout=Disable Actions: Generate App_Status=OK event for application
CleaningUpErrors	Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) Generate App_Status=NodeRemoveWithFail event for application
AbortingOperation	Event: bStatus==REMOVE_NODE_STATUS_DONE => //Callback New state: <Idle> Actions: Disable all timeouts, Call ZW_RemoveNodeFromNetwork(REMOVE_NODE_STOP, NULL) Generate App_Status=Aborted event for application Event: bStatus==REMOVE_NODE_STATUS_NODE_FOUND => //Callback New state: <NodeFound> Actions: NodeTimeout=Disable Actions: RemoveNodeTimeout=14 sec

4.4.20 ZW_ReplicationReceiveComplete

void ZW_ReplicationReceiveComplete(void)

Macro: ZW_REPLICATION_COMMAND_COMPLETE

Sends command completed to sending controller. Called in replication mode when a command from the sender has been processed and indicates that the controller is ready for next packet.

Defined in: ZW_controller_api.h

Serial API:

HOST->ZW: REQ | 0x44

4.4.21 ZW_ReplicationSend

BYTE ZW_ReplicationSend(BYTE destNodeID,
BYTE *pData,
BYTE dataLength,
BYTE txOptions,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_REPLICATION_SEND_DATA(node,data,length,options,func)

Used when the controller is in replication mode. It sends the payload and expects the receiver to respond with a command complete message (ZW_REPLICATION_COMMAND_COMPLETE).

Messages sent using this command should always be part of the Z-Wave controller replication command class.

Defined in: ZW_controller_api.h

Return value:

BYTE	FALSE	If transmit queue overflow.

Parameters:

destNode IN	Destination Node ID (not equal NODE_BROADCAST).
pData IN	Data buffer pointer
dataLength IN	Data buffer length
txOptions IN	Transmit option flags. (see **ZW_SendData**, but avoid using routing!)
completedFunc IN	Transmit completed call back function

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x45 | destNodeID | dataLength | pData[ ] | txOptions | funcID

ZW->HOST: RES | 0x45 | RetVal

ZW->HOST: REQ | 0x45 | funcID | txStatus

4.4.22 ZW_RequestNodeInfo

BOOL ZW_RequestNodeInfo (BYTE nodeID,
VOID (*completedFunc)(BYTE txStatus))

Macro: ZW_REQUEST_NODE_INFO(NODEID)

This function is used to request the Node Information Frame from a controller based node in the network. The Node info is retrieved using the **ApplicationControllerUpdate** callback function with the status UPDATE_STATE_NODE_INFO_RECEIVED. The **ZW_RequestNodeInfo** API call is also available for routing slaves.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	If the request could be put in the transmit queue successfully.
	FALSE	If the request could not be put in the transmit queue. Request failed.

Parameters:

nodeID IN	The node ID (1...232) of the node to request the Node Information Frame from.
completedFunc IN	Transmit complete call back.

Callback function Parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x60 | NodeID

ZW->HOST: RES | 0x60 | retVal

4.4.23 ZW_RequestNodeNeighborUpdate

BYTE ZW_RequestNodeNeighborUpdate(
NODEID,
VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))

Macro: ZW_REQUEST_NODE_NEIGHBOR_UPDATE(nodeid, func)

Get the neighbors from the specified node. This call can only be called by a primary/inclusion controller. An inclusion controller should call **ZW_RequestNetWorkUpdate** in advance because the inclusion controller may not have the latest network topology.

Defined in: ZW_controller_api.h

Return value:

BYTE	TRUE	The discovery process is started and the function will be completed by the callback
	FALSE	The discovery was not started and the callback will not be called. The reason for the failure can be one of the following: • This is not a primary/inclusion controller • There is only one node in the network, nothing to update. • The controller is busy doing another update.

Parameters:

nodeID IN	Node ID (1...232) of the node that the controller wants to get new neighbors from. Not allowed to use controllers own node ID.
completedFunc IN	Transmit complete call back.

Callback function Parameters:

bStatus IN	Status of command:	
	REQUEST_NEIGHBOR_UPDATE_STARTED	Requesting neighbor list from the node is in progress.
	REQUEST_NEIGHBOR_UPDATE_DONE	New neighbor list received
	REQUEST_NEIGHBOR_UPDATE_FAIL	Getting new neighbor list failed

Serial API:

HOST->ZW: REQ | 0x48 | nodeID | funcID

ZW->HOST: REQ | 0x48 | funcID | bStatus

4.4.24 ZW_SendSUCID

BYTE ZW_SendSUCID (BYTE node,
BYTE txOption,
VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus))

Macro: ZW_SEND_SUC_ID(nodeID, txOption, func)

Transmit SUC/SIS node ID from a primary controller or static controller to the controller node ID specified. Routing slaves ignore this command, use instead ZW_AssignSUCReturnRoute.

Defined in: ZW_controller_api.h

Return value:

TRUE	In progress.
FALSE	Not a primary controller or static controller.

Parameters:

node IN	The node ID (1...232) of the node to receive the current SUC/SIS node ID.
txOption IN	Transmit option flags. (see **ZW_SendData**)
completedFunc IN	Transmit complete call back.

Callback function parameters:

txStatus IN	(see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x57 | node | txOption | funcID

ZW->HOST: RES | 0x57 | RetVal

ZW->HOST: REQ | 0x57 | funcID | txStatus

4.4.25 ZW_SetDefault

void ZW_SetDefault(VOID_CALLBACKFUNC(completedFunc)(void))

Macro: ZW_SET_DEFAULT(func)

This function set the Controller back to the factory default state. Erase all Nodes, routing information and assigned homeID/nodeID from the NVM. In case the previous home ID was randomly generated then a new random home ID written to the NVM (random range: 0xC0000000-0xFFFFFFFE). A home ID outside random range reuses the initially configured home ID (configured during production).

Warning: Use this function with care as it could render a Z-Wave network unusable if the primary controller in an existing network is set back to default.

Defined in: ZW_controller_api.h

Parameters:

completedFunc IN Command completed call back function

Serial API:

HOST->ZW: REQ | 0x42 | funcID

ZW->HOST: REQ | 0x42 | funcID

Timeout: 1000ms

Exception Recovery: Resume normal operation, check nodelist to see if the controller has been reset. A controller MUST have nodeID ==1 after a set default.

4.4.26 ZW_SetLearnMode

void ZW_SetLearnMode (BYTE mode,
VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))

Macro: ZW_SET_LEARN_MODE(mode, func)

ZW_SetLearnMode is used to add or remove the controller to/from a Z-Wave network.

This function is used to instruct the controller to allow it to be added or removed from the network.

When a controller is added to the network the following things will happen:

1. If the current stored ID's are zero and the assigned ID's are nonzero, the received ID's will be stored (node was added to the network).
2. If the received ID's are zero the stored ID's will be set to zero (node was removed from the network).
3. The controller receives updates to the node list and the routing table but the ID's remain unchanged.

This function will probably change the capabilities of the controller so it is recommended that the application calls ZW_GetControllerCapabilities() after completion to check the controller status.

The **learnFunc** is called as the "Assign" process progresses. The returned nodeID is the nodes new Node ID. If no "Assign" is received from the including controller the callback function will not be called. It is then up to the application code to switch of Learn mode. Once the assignment process has been started the Callback function may be called more than once. The learn process is not complete before the callback function is called with LEARN_MODE_DONE.

Network wide inclusion should always be used as the default mode in inclusion to ensure compability with all implementations of Z-Wave controllers.

For information about how to use the different learm modes to make a inclusion that is compatible with all generations of Z-Wave nodes see [4]

NOTE: Learn mode should only be enabled when necessary and disabled again as quickly as possible. It is recommended that learn mode is not enabling for more than 2 second in ZW_SET_LEARN_MODE_CLASSIC mode and 5 seconds in ZW_SET_LEARN_MODE_NWI mode.

NOTE: When the controller is already included into a network (secondary or inclusion controller) the callback status LEARN_MODE_STARTED will not be made but the LEARN_MODE_DONE/FAILED callback will be made as normal.

WARNING: The learn process should not be stopped with ZW_SetLearnMode(FALSE,..) between the LEARN_MODE_STARTED and the LEARN_MODE_DONE status callback.

Defined in: ZW_controller_api.h

Parameters:

mode IN	The learn node states are:	
	ZW_SET_LEARN_MODE_CLASSIC	Start the learn mode on the controller and only accept being included and exluded in direct range.
	ZW_SET_LEARN_MODE_NWI	Start the learn mode on the controller and accept routed inclusion. NWI mode must not be used for exclusion.
	ZW_SET_LEARN_MODE_DISABLE	Stop learn mode on the controller
completedFunc IN	Callback function pointer (Should only be NULL if state is turned off).	

Callback function Parameters (completedFunc):

*learnNodeInfo.bStatus IN	Status of learn mode:	
	LEARN_MODE_STARTED	The learn process has been started
	LEARN_MODE_DONE	The learn process is complete and the controller is now included into the network
	LEARN_MODE_FAILED	The learn process failed.
*learnNodeInfo.bSource IN	Node id of the new node	
*learnNodeInfo.pCmd IN	Pointer to Application Node information data (see **ApplicationNodeInformation** - nodeParm**)**. NULL if no information present. The pCmd only contain information when bLen is not zero, so the information should be stored when that is the case. Regardless of the bStatus.	
*learnNodeInfo.bLen IN	Node info length.	

Serial API:

HOST->ZW: REQ | 0x50 | mode | funcID

ZW->HOST: REQ | 0x50 | funcID | bStatus | bSource | bLen | pCmd[ ]

4.4.27 ZW_SetRoutingInfo

void ZW_SetRoutingInfo(BYTE bNodeID,
BYTE bLength,
BYTE_P pMask)

Macro: ZW_SET_ROUTING_INFO(bNodeID, bLength, pMask)

NOTE: This function is not available in the Static Controller library without repeater functionality.

ZW_SetRoutingInfo is a function that can be used to overwrite the current neighbor information for a given node ID in the protocol locally.

The format of the routing info must be organised as follows:

pMask[i] (0 ≤ i < (ZW_MAX_NODES/8)								
Bit	0	1	2	3	4	5	6	7
NodeID	i*8+1	i*8+2	i*8+3	i*8+4	i*8+5	i*8+6	i*8+7	i*8+8

If a bit n in pMask[i] is 1 it indicates that the node bNodeID has node (i*8)+n+1 as a neighbour. If n in pMask[i] is 0, bNodeID cannot reach node (i*8)+n+1 directly.

Defined in: ZW_controller_api.h

Return value:

BOOL	TRUE	Neighbor information updated successfully.
	FALSE	Failed to update neighbor information.

Parameters:

bNodeID IN	Node ID (1…232) to be updated with respect to neighbor information.
bLength IN	Routing info buffer length in bytes.
pMask IN	Pointer to buffer where routing info should be taken from. The buffer should be at least ZW_MAX_NODES/8 bytes

Serial API (Only Developer's Kit v4.5x):

HOST->ZW: REQ | 0x1B | bNodeID | NodeMask[29]

ZW->HOST: RES | 0x1B | retVal

4.4.28 ZW_SetRoutingMAX

BOOL ZW_SetRoutingMAX(BYTE maxRouteTries)

Use this function to set the maximum number of source routing attempts before the next mechanism kicks-in. Default value with respect to maximum number of source routing attempts is five. See section 3.7 wrt. the routing attempts for a given Z-Wave node. Remember to enable the transmit option flag TRANSMIT_OPTION_AUTO_ROUTE or TRANSMIT_OPTION_AUTO_ROUTE | TRANSMIT_OPTION_EXPLORE in the send data calls.

Defined in: ZW_controller_api.h

Parameters:

maxRouteTries IN	1...20	Maximum number of source routing attempts

Serial API:

HOST->ZW: REQ | 0xD4 | maxRoutesTries

4.4.29 ZW_SetSUCNodeID

BYTE ZW_SetSUCNodeID (BYTE nodeID,
BYTE SUCState,
BYTE bTxOption,
BYTE capabilities,
VOID_CALLBACKFUNC (completedFunc)(BYTE txStatus))

Macro: ZW_SET_SUC_NODE_ID(nodeID, SUCState, bTxOption, capabilities, func)

Used to configure a static/bridge controller to be a SUC/SIS node or not. The primary controller should use this function to set a static/bridge controller to be the SUC/SIS node, or it could be used to stop previously chosen static/bridge controller being a SUC/SIS node (not recommended).

A controller can set itself to a SUC/SIS by **ZW_SetSUCNodeID** with its own node ID. It's recommended to do this when the Z-Wave network only comprise of the primary controller to get the SUC/SIS role distributed when new nodes are included. It is possible to include a virgin primary controller with SUC/SIS capabilities configured into another Z-Wave network.

NOTICE: It is not allowed to call **ZW_SetSUCNodeID** with its own node ID and SUCState = FALSE during upstart because this prevent other nodes to set it to a SUC/SIS node.

Defined in: ZW_controller_api.h

Return value:

TRUE	If the process of configuring the static/bridge controller is started.
FALSE	The process not started because the calling controller is not the master or the destination node is not a static/bridge controller.

Parameters:

nodeID IN	The node ID (1...232) of the static controller to configure.	
SUCState IN	TRUE	Want the static controller to be a SUC/SIS node.
	FALSE	If the static/bridge controller should not be a SUC/SIS node.
bTxOption IN	TRUE	Want to send the frame with low transmission power
	FALSE	Want to send the frame at normal transmission power
capabilities IN	SUC capabilities that is enabled:	
	ZW_SUC_FUNC_NODEID_SERVER	Enable the node ID server functionality to become a SIS.
completedFunc IN	Transmit complete call back.	

Callback function Parameters:

txStatus IN	Status of command:	
	ZW_SUC_SET_SUCCEEDED	The process ended successfully.
	ZW_SUC_SET_FAILED	The process failed.

Serial API:

HOST->ZW: REQ | 0x54 | nodeID | SUCState | bTxOption | capabilities | funcID

ZW->HOST: RES | 0x54 | RetVal

ZW->HOST: REQ | 0x54 | funcID | txStatus

In case **ZW_SetSUCNodeID** is called locally with the controllers own node ID then only the response is returned. In case true is returned in the response then it can be interpreted as the command is now executed successfully.

4.5 Z-Wave Static Controller API

The Static Controller application interface is an extended Controller application interface with added functionality specific for the Static Controller.

4.5.1 ZW_CreateNewPrimaryCtrl

Void ZW_CreateNewPrimaryCtrl(BYTE mode,
VOID_CALLBACKFUNC(completedFunc)(LEARN_INFO *learnNodeInfo))

Macro: ZW_CREATE_NEW_PRIMARY_CTRL

NOTE: Legacy function. This function is no longer relevant for a controller because it is no longer possible to have a SUC without a SIS. This function should not be used.

ZW_CreateNewPrimaryCtrl is used to add a controller to the Z-Wave network as a replacement for the old primary controller.

This function has the same functionality as ZW_AddNodeToNetwork(ADD_NODE_CONTROLLER,…) except that the new controller will be a primary controller and it can only be called by a SUC. The function is not available if the SUC is a node ID server (SIS).

WARNING: This function should only be used when it is 100% certain that the original primary controller is lost or broken and will not return to the network.

Defined in: ZW_controller_static_api.h

Parameters:

mode IN	The learn node states are:	
	CREATE_PRIMARY_START	Start the process of adding a a new primary controller to the network.
	CREATE_PRIMARY_STOP	Stop the process.
	CREATE_PRIMARY_STOP_FAILED	Stop the inclusion and report a failure to the other controller.
completedFunc IN	Callback function pointer (Should only be NULL if state is turned off).	

Callback function Parameters:

*learnNodeInfo.bStatus IN	Status of learn mode:	
	ADD_NODE_STATUS_LEARN_READY	The controller is now ready to include a controller into the network.

	ADD_NODE_STATUS_NODE_FOUND	A controller that wants to be included into the network has been found
	ADD_NODE_STATUS_ADDING_CONTROLLER	A new controller has been added to the network
	ADD_NODE_STATUS_PROTOCOL_DONE	The protocol part of adding a controller is complete, the application can now send data to the new controller using **ZW_ReplicationSend()**
	ADD_NODE_STATUS_DONE	The new controller has now been included and the controller is ready to continue normal operation again.
	ADD_NODE_STATUS_FAILED	The learn process failed
*learnNodeInfo.bSource IN	Node id of the new node	
*learnNodeInfo.pCmd IN	Pointer to Application Node information data (see **ApplicationNodeInformation** - nodeParm**)**. NULL if no information present. The pCmd only contain information when bLen is not zero, so the information should be stored when that is the case. Regardless of the bStatus.	
*learnNodeInfo.bLen IN	Node info length.	

Serial API:

HOST->ZW: REQ | 0x4C | mode | funcID

ZW->HOST: REQ | 0x4C | funcID | bStatus | bSource | bLen | basic | generic | specific | cmdclasses[ ]

4.6 Z-Wave Bridge Controller API

The Bridge Controller application interface is an extended Controller application interface with added functionality specific for the Bridge Controller.

4.6.1 ZW_SendSlaveNodeInformation

BYTE ZW_SendSlaveNodeInformation(BYTE srcNode,
BYTE destNode,
BYTE txOptions,
VOID_CALLBACKFUNC(completedFunc)(BYTE txStatus))

Macro: ZW_SEND_SLAVE_NODE_INFO(srcnode, destnode, option, func)

Create and transmit a Virtual Slave node “Node Information” frame from Virtual Slave node srcNode. The Z-Wave transport layer builds a frame, request the application slave node information (see **ApplicationSlaveNodeInformation**) and queue the “Node Information” frame for transmission. The completed call back function (**completedFunc**) is called when the transmission is complete.

NOTE: ZW_SendSlaveNodeInformation uses the transmit queue in the API, so using other transmit functions before the complete callback has been called by the API might fail.

Defined in: ZW_controller_bridge_api.h

Return value:

BYTE	TRUE	If frame was put in the transmit queue.
	FALSE	If transmitter queue overflow or if bridge controller is primary or srcNode is invalid then completedFunc will NOT be called.

Parameters:

srcNode IN	Source Virtual Slave Node ID	
destNode IN	Destination Node ID (NODE_BROADCAST == all nodes)	
txOptions IN	Transmit option flags:	
	TRANSMIT_OPTION_LOW_POWER	Transmit at low output power level (1/3 of normal RF range). **NOTE:** The TRANSMIT_OPTION_LOW_POWER option should only be used when the two nodes that are communicating are close to each other (<2 meter). In all other cases this option should **not** be used.
	TRANSMIT_OPTION_ACK	Request acknowledge from destination node.
completedFunc IN	Transmit completed call back function	

Callback function Parameters:

txStatus (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0xA2 | srcNode | destNode | txOptions | funcID

ZW->HOST: RES | 0xA2 | retVal

ZW->HOST; REQ | 0xA2 | funcID | txStatus

4.6.2 ZW_SetSlaveLearnMode

BYTE ZW_SetSlaveLearnMode(BYTE node,
BYTE mode,
VOID_CALLBACKFUNC(learnSlaveFunc)(BYTE state, BYTE orgID,
BYTE newID))

Macro: ZW_SET_SLAVE_LEARN_MODE (node, mode, func)

ZW_SetSlaveLearnMode enables the possibility for enabling or disabling “Slave Learn Mode”, which when enabled makes it possible for other controllers (primary or inclusion controllers) to add or remove a Virtual Slave Node to the Z-Wave network. Also is it possible for the bridge controller (only when primary or inclusion controller) to add or remove a Virtual Slave Node without involving other controllers.
Available Slave Learn Modes are:

VIRTUAL_SLAVE_LEARN_MODE_DISABLE – Disables the Slave Learn Mode so that no Virtual Slave Node can be added or removed.

VIRTUAL_SLAVE_LEARN_MODE_ENABLE – Enables the possibility for other Primary/Inclusion controllers to add or remove a Virtual Slave Node. To add a new Virtual Slave node to the Z-Wave Network the provided “node” ID must be ZERO and to make it possible to remove a specific Virtual Slave Node the provided “node” ID must be the nodeID for this specific (locally present) Virtual Slave Node. When the Slave Learn Mode has been enabled the Virtual Slave node must identify itself to the external Primary/Inclusion Controller node by sending a “Node Information” frame (see **ZW_SendSlaveNodeInformation**) to make the add/remove operation commence.

VIRTUAL_SLAVE_LEARN_MODE_ADD - Add Virtual Slave Node to the Z-Wave network without involving any external controller. This Slave Learn Mode is only possible when bridge controller is either a Primary controller or an Inclusion controller.

VIRTUAL_SLAVE_LEARN_MODE_REMOVE - Remove a locally present Virtual Slave Node from the Z-Wave network without involving any external controller. This Slave Learn Mode is only possible when bridge controller is either a Primary controller or an Inclusion controller.

The **learnSlaveFunc** is called as the "Assign" process progresses. The returned “orgID” is the Virtual Slave node put into Slave Learn Mode, the “newID” is the new Node ID. If the Slave Learn Mode is VIRTUAL_SLAVE_LEARN_MODE_ENABLE and nothing is received from the assigning controller the callback function will not be called. It is then up to the main application code to switch of Slave Learn mode by setting the VIRTUAL_SLAVE_LEARN_MODE_DISABLE Slave Learn Mode. Once the assignment process has been started the Callback function may be called more than once.

NOTE: Slave Learn Mode should only be set to VIRTUAL_SLAVE_LEARN_MODE_ENABLE when necessary, and it should always be set to VIRTUAL_SLAVE_LEARN_MODE_DISABLE again as quickly as possible. It is recommended that Slave Learn Mode is never set to VIRTUAL_SLAVE_LEARN_MODE_ENABLE for more than 1 second.

Defined in: ZW_controller_bridge_api.h

Return value:

BYTE	TRUE	If learnSlaveMode change was succesful.
	FALSE	If learnSlaveMode change could not be done.

Parameters:

node IN	Node ID (1...232) on node to set in Slave Learn Mode, ZERO if new node is to be learned.	
mode IN	Valid modes:	
	VIRTUAL_SLAVE_LEARN_MODE_DISABLE	Disable Slave Learn Mode
	VIRTUAL_SLAVE_LEARN_MODE_ENABLE	Enable Slave Learn Mode
	VIRTUAL_SLAVE_LEARN_MODE_ADD	ADD: Create locally a Virtual Slave Node and add it to the Z-Wave network (only possible if Primary/Inclusion Controller).
	VIRTUAL_SLAVE_LEARN_MODE_REMOVE	Remove locally present Virtual Slave Node from the Z-Wave network (only possible if Primary/Inclusion Controller).
learnFunc IN	Slave Learn mode complete call back function	

Callback function Parameters:

bStatus	Status of the assign process.	
	ASSIGN_COMPLETE	Is returned by the callback function when in the VIRTUAL_SLAVE_LEARN_MODE_ENABLE Slave Learn Mode and assignment is done. Now the Application can continue normal operation.
	ASSIGN_NODEID_DONE	Node ID have been assigned. The “orgID” contains the node ID on the Virtual Slave Node who was put into Slave Learn Mode. The “newID” contains the new node ID for “orgID”. If “newID” is ZERO then the “orgID” Virtual Slave node has been deleted and the assign operation is completed. When this status is received the Slave Learn Mode is complete for all Slave Learn Modes except the VIRTUAL_SLAVE_LEARN_MODE_ENABLE mode.
	ASSIGN_RANGE_INFO_UPDATE	Node is doing Neighbour discovery Application should not attempt to send any frames during this time, this is only applicable when in VIRTUAL_SLAVE_LEARN_MODE_ENABLE.
orgID	The original node ID that was put into Slave Learn Mode.	
newID	The new Node ID. Zero if “OrgID” was deleted from the Z-Wave network.	

Serial API:

HOST->ZW: REQ | 0xA4 | node | mode | funcID

ZW->HOST: RES | 0xA4 | retVal

ZW->HOST: REQ | 0xA4 | funcID | bStatus | OrgID | newID

4.6.3 ZW_IsVirtualNode

BYTE ZW_IsVirtualNode(BYTE nodeID)

Macro: ZW_IS_VIRTUAL_NODE (nodeid)

Checks if “nodeID” is a Virtual Slave node.

Defined in: ZW_controller_bridge_api.h

Return value:

BYTE	TRUE	If “nodeID” is a Virtual Slave node.
	FALSE	If “nodeID” is not a Virtual Slave node.

Parameters:

nodeID IN	Node ID (1...232) on node to check if it is a Virtual Slave node.

Serial API:

HOST->ZW: REQ | 0xA6 | nodeID

ZW->HOST: RES | 0xA6 | retVal

4.6.4 ZW_GetVirtualNodes

VOID ZW_GetVirtualNodes(BYTE *pnodeMask)

Macro: ZW_GET_VIRTUAL_NODES (pnodemask)

Request a buffer containing available Virtual Slave nodes in the Z-Wave network.

The format of the data returned in the buffer pointed to by pnodeMask is as follows:

pnodeMask[i] ($0 \leq i <$ (ZW_MAX_NODES/8)								
Bit	0	1	2	3	4	5	6	7
NodeID	i*8+1	i*8+2	i*8+3	i*8+4	i*8+5	i*8+6	i*8+7	i*8+8

If bit n in pnodeMask[i] is 1, it indicates that node (i*8)+n+1 is a Virtual Slave node. If bit n in pnodeMask[i] is 0, it indicates that node (i*8)+n+1 is not a Virtual Slave node.

Defined in: ZW_controller_bridge_api.h

Parameters:

pNodeMask IN Pointer to nodemask (29 byte size) buffer where the Virtual Slave nodeMask should be copied.

Serial API:

HOST->ZW: REQ | 0xA5

ZW->HOST: RES | 0xA5 | pnodeMask[29]

4.7 Z-Wave Portable Controller API

The Portable application interface is basically an extended Controller interface that gives the application access to functions that can be used to create more advanced installation tools, which provide better diagnostics and error locating capabilities.

4.7.1 zwTransmitCount

BYTE zwTransmitCount

Macro: ZW_TX_COUNTER

ZW_TX_COUNTER is a variable that returns the number of transmits that the protocol has done since last reset of the variable. If the number returned is 255 then the number of transmits ≥ 255. The variable should be reset by the application, when it is to be restarted.

Defined in: ZW_controller_portable_api.h

Serial API:

To read the transmit counter:

HOST->ZW: REQ | 0x81| (FUNC_ID_GET_TX_COUNTER)

ZW->HOST: RES | 0x81 | ZW_TX_COUNTER (1 byte)

To reset the transmit counter:

HOST->ZW: REQ | 0x82| (FUNC_ID_RESET_TX_COUNTER)

4.7.2 ZW_StoreNodeInfo

BOOL ZW_StoreNodeInfo(BYTE bNodeID,
BYTE_P pNodeInfo,
VOID_CALLBACKFUNC(func)())

Macro: ZW_STORE_NODE_INFO(NodeID,NodeInfo,function)

ZW_StoreNodeInfo is a function that can be used to restore protocol node information from a backup or the like. The format of the node info frame should be identical with the format used by ZW_GET_NODE_STATE.

NOTE: The restored values will not take effect before the Z-Wave module has been reset.

Defined in: ZW_controller_portable_api.h

Return value:

BOOL	TRUE	If NodeInfo was Stored.
	FALSE	If NodeInfo was not Stored. (Illegal NodeId or MemoryWrite failed)

Parameters:

bNodeID IN	Node ID (1...232) to store information at.
pNodeInfo IN	Pointer to Node Information Frame.
func IN	Callback function. Called when data has been stored.

Serial API:

HOST->ZW: REQ | 0x83 | bNodeID | nodeInfo (nodeInfo is a NODEINFO field) | funcID

ZW->HOST: RES | 0x83 | retVal

ZW->HOST: REQ| 0x83 | funcID

4.7.3 ZW_StoreHomeID

void ZW_StoreHomeID(BYTE_P pHomeID,
BYTE bNodeID)
Macro: ZW_STORE_HOME_ID(pHomeID, NodeID)

ZW_StoreHomeID is a function that can be used to restore HomeID and NodeID information from a backup.

NOTE: The restored values will not take effect before the Z-Wave module has been reset.

Defined in: ZW_controller_portable_api.h

Parameters:

pHomeID IN Pointer to HomeID structure to store

bNodeID IN NodeID to store.

Serial API:

HOST->ZW: REQ | 0x84 | pHomeID[0] | pHomeID[1] | pHomeID[2] | pHomeID[3] | bNodeID

4.8 Z-Wave Slave API

The Slave application interface is an extension to the Basis application interface enabling inclusion/exclusion of Routing Slave, and Enhanced 232 Slave nodes.

4.8.1 ZW_SetDefault

void ZW_SetDefault(void)

Macros: ZW_SET_DEFAULT

This function set the slave back to the factory default state. Erase routing information and assigned homeID/nodeID from the external NVM. Finally write a new random home ID to the external NVM.

Defined in: ZW_slave_api.h

Serial API:

HOST->ZW: REQ | 0x42 | funcID

ZW->HOST: REQ | 0x42 | funcID

4.8.2 ZW_SetLearnMode

void ZW_SetLearnMode(BYTE mode,
VOID_CALLBACKFUNC(learnFunc)(BYTE bStatus, BYTE nodeID))

Macro: ZW_SET_LEARN_MODE(mode, func)

ZW_SetLearnMode enable or disable home and node ID's learn mode. Use this function to add a new Slave node to a Z-Wave network or to remove an already added node from the network again.

The Slave node must identify itself to the including controller node by sending a Node Information Frame (see **ZW_SendNodeInformation**).

When learn mode is enabled, the follwong two actions can be performed by the protocol:

1. If the current stored ID's are zero and the assigned ID's are nonzero, the received ID's will be stored (node was added to the network).
2. If the received ID's are zero the stored ID's will be set to zero (node was removed from the network).

The **learnFunc** is called as the "Assign" process progresses. The returned nodeID is the nodes new Node ID. If no "Assign" is received from the including controller the callback function will not be called. It is then up to the application code to switch of Learn mode. Once the assignment process has been started the Callback function may be called more than once. The learn process is not complete before the callback function is called with ASSIGN_COMPLETE.

NOTE: Learn mode should only be enabled when necessary and disabled again as quickly as possible. It is recommended that learn mode is not enabled for more than 2 seconds in ZW_SET_LEARN_MODE_CLASSIC mode and 5 seconds in ZW_SET_LEARN_MODE_NWI mode.

Defined in: ZW_slave_api.h

Parameters:

mode IN	ZW_SET_LEARN_MODE_CLASSIC	Start the learn mode on the slave and only accept being included and excluded in direct range.
	ZW_SET_LEARN_MODE_NWI	Start the learn mode on the slave and accept routed inclusion. NWI mode must not be used for exclusion.
	ZW_SET_LEARN_MODE_DISABLE	Stop learn mode on the slave
learnFunc IN	Node ID learn mode completed call back function	

Callback function Parameters:

bStatus	Status of the assign process	
	ASSIGN_COMPLETE	Assignment is done and Application can continue normal operation.
	ASSIGN_NODEID_DONE	Node ID has been assigned. More information may follow.
	ASSIGN_RANGE_INFO_UPDATE	Node is doing Neighbor discovery Application should not attempt to send any frames during this time.
nodeID	The new (learned) Node ID (1...232)	

NOTE: The ASSIGN_COMPLETE callback is not synchronized with the ADD_NODE_STATUS_DONE callback on the including controller. The including controller MAY start sending frames to the included node before the ASSIGN_COMPLETE callback. In that case the included node MAY respond before the ASSIGN_COMPLETE callback arrives. Broadcast frames received before the ASSIGN_COMPLETE callback MUST NOT trigger a response transmission.

Serial API:

HOST->ZW: REQ | 0x50 | mode | funcID

ZW->HOST: REQ | 0x50 | funcID | bstatus | nodeID

4.9 Z-Wave Routing and Enhanced 232 Slave API

The Routing and Enhanced 232 Slave application interface is an extension of the Basis and Slave application interface enabling control of other nodes in the Z-Wave network.

4.9.1 ZW_GetSUCNodeID

BYTE ZW_GetSUCNodeID(void)

Macro: ZW_GET_SUC_NODE_ID()

API call used to get the currently registered SUC/SIS node ID. A controller must have called **ZW_AssignSUCReturnRoute** before a SUC/SIS node ID is registered in the routing or enhanced 232 slave.

Defined in: ZW_slave_routing_api.h

Return value:

BYTE	The node ID (1..232) on the currently registered SUC/SIS, if ZERO then no SUC/SIS available.

Serial API:

HOST->ZW: REQ | 0x56

ZW->HOST: RES | 0x56 | SUCNodeID

4.9.2 ZW_IsNodeWithinDirectRange

BYTE ZW_IsNodeWithinDirectRange(BYTE bNodeID)

Macro: ZW_IS_NODE_WITHIN_DIRECT_RANGE (bNodeID)

Check if the supplied nodeID is marked as being within direct range in any of the existing return routes.

Defined in: ZW_slave_routing_api.h

Return value:

TRUE	If node is within direct range
FALSE	If the node is beyond direct range or if status is unknown to the protocol

Parameters:

bNodeID IN Node id to examine

Serial API:

HOST->ZW: REQ | 0x5D | bNodeID

ZW->HOST: RES | 0x5D | retVal

4.9.3 ZW_RediscoveryNeeded

BYTE ZW_RediscoveryNeeded (BYTE bNodeID,
VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))

Macro: ZW_REDISCOVERY_NEEDED(nodeid, func)

This function can request a SUC/SIS controller to update the requesting nodes neighbors. The function will try to request a neighbor rediscovery from a SUC/SIS controller in the network. In order to reach a SUC/SIS controller it uses other nodes (bNodeID) in the network. The application must implement the algorithm for scanning the bNodeID's to find a node which can help.

If bNodeID supports this functionality (routing slave and enhanced 232 slave libraries), bNodeID will try to contact a SUC/SIS controller on behalf of the node that requests the rediscovery. If the functionality is unsupported by bNodeID ZW_ROUTE_LOST_FAILED will be returned in the callback function and the next node can be tried.

NOTICE: It is highly recommended to use the transmit option TRANSMIT_OPTION_EXPLORE to enable dynamic route resolution in API calls such as ZW_SendData as an alternative to ZW_RediscoveryNeeded.

The callback function is called when the request have been processed by the protocol.

Defined in: ZW_slave_routing_api.h

Return value:

FALSE	The node is busy doing another update.
TRUE	The help process is started; status will come in the callback.

Parameters:

bNodeID IN	Node ID (1..232) to request help from
completedFunc IN	Transmit completed call back function

Callback function parameters:

ZW_ROUTE_LOST_ACCEPT	The node bNodeID accepts to forward the help request. Wait for the next callback to determine the outcome of the rediscovery.
ZW_ROUTE_LOST_FAILED	The node bNodeID has responded it is unable to help and the application can try next node if it decides so.
ZW_ROUTE_UPDATE_ABORT	No reply was received before the protocol has timed out. The application can try the next node if it decides so.
ZW_ROUTE_UPDATE_DONE	The node bNodeID was able to contact a controller and the routing information has been updated.

Serial API:

HOST->ZW: REQ | 0x59 | bNodeID | funcID

ZW->HOST: RES | 0x59 | retVal

ZW->HOST: REQ | 0x59 | funcID | bStatus

4.9.4 ZW_RequestNewRouteDestinations

BYTE ZW_RequestNewRouteDestinations(BYTE *pDestList,
BYTE bDestListLen ,
VOID_CALLBACKFUNC (completedFunc)(BYTE bStatus))

Macro: ZW_REQUEST_NEW_ROUTE_DESTINATIONS (pdestList, destListLen, func)

Used to request new return route destinations from the SUC/SIS node.

NOTE: No more than the first ZW_MAX_RETURN_ROUTE_DESTINATIONS will be requested regardless of bDestListLen.

Defined in: ZW_slave_routing_api.h

Return value:

TRUE	If the updating process is started.
FALSE	If the requesting routing slave is busy or no SUC/SIS node known to the slave.

Parameters:

pDestList IN	Pointer to a list of new destinations for which return routes is needed.
bDestListLen IN	Number of destinations contained in pDestList.
completedFunc IN	Transmit completed call back function

Callback function parameters:

ZW_ROUTE_UPDATE_DONE	The update process is ended successfully
ZW_ROUTE_UPDATE_ABORT	The update process aborted because of error
ZW_ROUTE_UPDATE_WAIT	The SUC/SIS node is busy
ZW_ROUTE_UPDATE_DISABLED	The SUC/SIS functionality is disabled

Serial API:

HOST->ZW: REQ | 0x5C | destList[5] | funcID

ZW->HOST: RES | 0x5C | retVal

ZW->HOST: REQ | 0x5C | funcID | bStatus

4.9.5 ZW_RequestNodeInfo

BOOL ZW_RequestNodeInfo (BYTE nodeID,
VOID (*completedFunc)(BYTE txStatus))

Macro: ZW_REQUEST_NODE_INFO(NODEID)

This function is used to request the Node Information Frame from a node in the network. The Node info is retrieved using the **ApplicationSlaveUpdate** callback function with the status UPDATE_STATE_NODE_INFO_RECEIVED. The **ZW_RequestNodeInfo** API call is also available for controllers.

Defined in: ZW_slave_routing_api.h

Return value:

BOOL	TRUE	If the request could be put in the transmit queue successfully.
	FALSE	If the request could not be put in the transmit queue. Request failed.

Parameters:

nodeID IN	The node ID (1…232) of the node to request the Node Information Frame from.
completedFunc IN	Transmit complete call back.

Callback function Parameters:

txStatus IN (see **ZW_SendData**)

Serial API:

HOST->ZW: REQ | 0x60 | NodeID

ZW->HOST: RES | 0x60 | retVal

The Serial API implementation do not return the callback function (no parameter in the Serial API frame refers to the callback), this is done via the **ApplicationSlaveUpdate** callback function:

- If request nodeinfo transmission was unsuccessful, (no ACK received) then the **ApplicationSlaveUpdate** is called with UPDATE_STATE_NODE_INFO_REQ_FAILED (status only available in the Serial API implementation).
- If request nodeinfo transmission was successful, there is no indication that it went well apart from the returned Nodeinfo frame which should be received via the **ApplicationSlaveUpdate** with status UPDATE_STATE_NODE_INFO_RECEIVED.

4.10 Serial Command Line Debugger

The debug driver is a simple single line command interpreter, operated via the serial interface (UART – RS232). The command line debugger is used to dump and edit memory, including the memory mapped registers.

For a controller/slave_enhanced node the debugger startup by displaying the following help text on the debug terminal:

```
Z-Wave Commandline debugger Vx.nn
 Keyes(VT100): BS; ^,<,> arrows; F1.
H                              Help
D[X|E|F] <addr> [<length>]     Dump memory
E[X|E]   <addr>                Edit memory (Key: SP)
W[X|E|F] <addr>                Watch memory location
         is idata (80-FF is SFR)
  X      is xdata
    E    is External EEPROM
      F  is flash
>
```

For a slave node the debugger startup by displaying the following help text on the debug terminal:

```
Z-Wave Commandline debugger Vx.nn
 Keyes(VT100): BS; ^,<,> arrows; F1.
H                              Help
D[X|I|F] <addr> [<length>]     Dump memory
E[X|I]   <addr>                Edit memory (Key: SP)
W[X|I|F] <addr>                Watch memory location
         is idata (80-FF is SFR)
  X      is xdata
    I    is "Internal EEPROM" flash
      F  is flash
>
```

The command debugger is then ready to receive commands via the serial interface.

Special input keys:

F1 (function key 1) same as the help command line.

BS (backspace) delete the character left to the curser.

< (left arrow) move the cursor one character left.

> (right arrow) move the cursor one character right.

^ (up arrow) retrieve last command line.

Commands:

H[elp]		Display the help text.
D[ump]	<addr> [<length>]	Dump idata (0-7F) or SFR memory (80-FF).
DX	<addr> [<length>]	Dump xdata (SRAM) memory.
DI	<addr> [<length>]	Dump “internal EEPROM” flash (slave only).
DE	<addr> [<length>]	Dump external EEPROM (controllers/slave_enhanced only).
DF	<addr> [<length>]	Dump FLASH memory.
E[dit]	<addr>	Edit idata (0-7F) or SFR memory (80-FF).
EX	<addr>	Edit xdata memory.
EI	<addr>	Edit “internal EEPROM” flash (slave only).
EE	<addr>	Edit external EEPROM (controllers/slave_enhanced only).
W[atch]	<addr>	Watch idata (0-7F) or SFR memory (80-FF).
WX	<addr>	Watch xdata memory.
WI	<addr>	Watch “internal EEPROM” flash (slave only).
WE	<addr>	Watch external EEPROM memory (controllers/slave_enhanced only).
WF	<addr>	Watch FLASH memory.

The Watch pointer gives the following log (when memory change):

idata SRAM memory		Rnn	
xdata SRAM memory		Xnn	
Internal EEPROM	flash	Inn	(slave only)
External EEPROM		Enn	(controllers/slave_enhanced only)

Examples:

```
>dx 0                  ; Edit offset 0x0000 and 0x0001 of xdata SRAM
0000  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
>ex 0                  ; Edit offset 0x0000 and 0x0001 of xdata SRAM
0000 00-1 00-2
>dx 0                  ; Dump offset 0x0000 to 0x000f of xdata SRAM
0000  01 02 00 00 00 00 00 00  00 00 00 00 00 00 00 00
>wx 1X02               ; Watch offset 0x0001 of xdata SRAM
>ex 1
0001 02-1X01
>
```

4.10.1 ZW_DebugInit

void ZW_DebugInit(WORD baudRate)

Macro: ZW_DEBUG_CMD_INIT(baud)

Command line debugger initialization. The macro can be placed within the application initialization function (see function **ApplicationInitSW**).

Example:

```
ZW_DEBUG_CMD_INIT(96);  /* setup command line speed to 9600 bps. */
```

Defined in: ZW_debug_api.h

Parameters:

baudRate IN Baud Rate / 100 (e.g. 96 = 9600 bps,
384 = 38400 bps, 1152 = 115200 bps)

Serial API (Not supported)

4.10.2 ZW_DebugPoll

void ZW_DebugPoll(void)

Macro: ZW_DEBUG_CMD_POLL

Command line debugger poll function. Collect characters from the debug terminal and execute the commands.

Should be called via the main poll loop (see function **ApplicationPoll**).

By using the debug macros (ZW_DEBUG_CMD_INIT, ZW_DEBUG_CMD_POLL) the command line debugger can be enabled by defining the compile flag “ZW_DEBUG_CMD” under CDEFINES in the makefile as follows:

```
CDEFINES+=  EU,\
            ZW_DEBUG_CMD,\
            SUC_SUPPORT,\
            ASSOCIATION,\
            LOW_FOR_ON,\
            SIMPLELED
```

Both the debug output (ZW_DEBUG) and the command line debugger (ZW_DEBUG_CMD) can be enabled at the same time.

Defined in: ZW_debug_api.h

Serial API (Not supported)

4.11 RF Settings in App_RFSetup.c file

RF normal and low power transmit levels is determined in the file …\Z-Wave\IO_defines\App_RFSetup.c.

Table 24. App_RFSetup.a51 module definitions for 500 Series Z-Wave SoC

Offset to table start	Define name	Default value	Description
2	FLASH_APPL_NORM_POWER_OFFS_0 FLASH_APPL_NORM_POWER_OFFS_1 FLASH_APPL_NORM_POWER_OFFS_2	0xFF	If 0xFF the default lib value is used: ANZ = 0x20 EU = 0x20 HK = 0x20 IN = 0x20 JP = 0x20 MY = 0x20 RU = 0x20 US = 0x20
5	FLASH_APPL_LOW_POWER_OFFS_0 FLASH_APPL_LOW_POWER_OFFS_1 FLASH_APPL_LOW_POWER_OFFS_2	0xFF	If 0xFF the default lib value is used:0x14

TXnormal Power need maybe adjustment to fulfil FCC compliance tests. According to the FCC part 15, the output-radiated power shall not exceed 94dBuV/m. This radiated power is the result of the module output power and your product antenna gain. As the antenna gain is different from product to product, the module output power needs to be adjusted to comply with the FCC regulations.

The RF power transmit levels can be adjusted directly on the module by the Z-Wave Programmer [8].

5 APPLICATION NOTE: SUC/SIS IMPLEMENTATION

5.1 Implementing SUC/SIS support in all nodes

Having Static ID Server (SIS) support in Z-Wave products requires that several API calls must be used in the right order. This chapter provides details about how SUC/SIS support can be implemented in the different node types in the Z-Wave network.

5.2 Static Controllers

All static controllers has the functionality needed for acting as a SUC/SIS in the network, By default all static controllers has the SUC/SIS functionality enabled A Static Controller will not act as a SUC/SIS until the primary controller in the network has requested it to do so. Or the application on the static controller has forced the controller to become SUC/SIS

5.2.1 Request for becoming a SUC Node ID Server (SIS)

The static controller will accept to become SUC/SIS if/when the primary controller request it by calling **ZW_SetSUCNodeID()** with the Static controllers node ID, or the application on the static controller has forced the controller to become SUC/SIS by calling **ZW_SetSUCNodeID()** with its own node ID.

There can only be one SUC/SIS in a network.

NOTE: There can only be one SUC/SIS in a network, but there can be many static controllers that are enabled for an assignment of the SIS capabilities in a network.

5.2.2 Updates from the Primary Controller

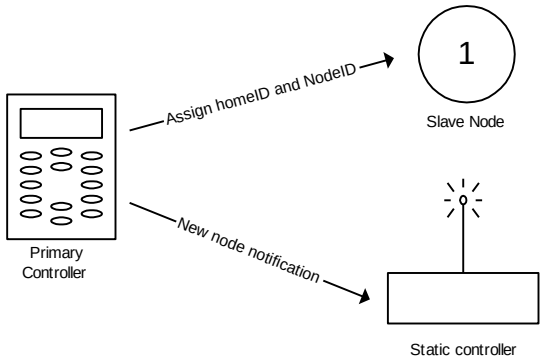


Figure 41. Inclusion of a node having a SUC in the network

When a new node is added to the network or an existing node is removed from the network the inclusion controller will send a network update to the SUC/SIS to notify about the changes in the network. The application in the SUC/SIS will be notified about such a change through the callback function **ApplicationControllerUpdate**). All update of node lists and routing tables is handled by the protocol so the call is just to notify the application in the static controller that a node has been added or removed.

5.2.3 Assigning SUC Routes to Routing Slaves

When the SUC/SIS is present in a Z-Wave network routing slaves can ask it for updates, but the routing slave must first be told that there is a SUC/SIS in the network and it must be told how to reach it. That is done from the SUC/SIS by assigning a set of return routes to the routing slave so it knows how to reach the SUC/SIS. Assigning the routes to routing slaves is done by calling **ZW_AssignSUCReturnRoute** with the nodeID of the routing slave that should be configured.

NOTE: Routing slaves are notified by the presence of a SUC/SIS as a part of the inclusion,but it is good practice to have the application on the SUC/SIS assign SUC/SIS return routes to new nodes so they have a full set of updated return routes.

5.2.4 Receiving Requests for Network Updates

When a SUC/SIS receives a request for sending network updates to a secondary controller or a routing slave, the protocol will handle all the communication needed for sending the update, so the application doesn't need to do anything and it will not get any notifications about the request.

The SUC/SIS will also receive requests for reserving node Ids for use when other controllers add nodes to the network. The protocol will handle all that communication without any involvement from the application.

5.3 The Primary Controller

The primary controller is responsible for choosing what static controller in the network that should act as a SUC/SIS. The application in a primary controller is responsible for choosing the static controller that should be the SUC/SIS. There is no fixed strategy for how to choose the static controller, so it is entirely up to the application to choose the controller that should become SUC/SIS. Once a static controller has been selected the application must use the **ZW_SetSUCNodeID** to request that the static controller becomes SUC/SIS.

Once a SUC/SIS has been selected, the protocol in the primary controller will automatically send notifications to the SUC/SIS about all changes in the network topology.

NOTE: A controller can decline the role as SUC/SIS and in that case, the callback function from **ZW_SetSUCNodeID** will return with a FAILED status. The static controller (legacy controller) can also refuse to become SIS if that was what the primary controller requested, but accept to become a SUC.

5.4 Secondary Controllers

All controllers in a network containing a SUC/SIS can ask it for network topology changes and receive the updates from the SUC/SIS. It is entirely up to the application if and when an update is needed.

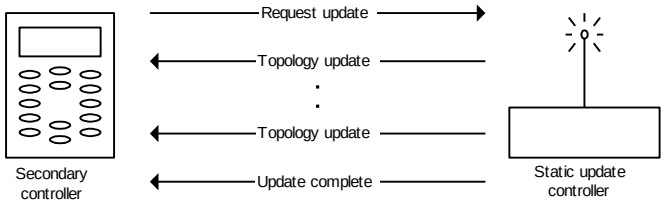


Figure 42. Requesting network updates from a SUC/SIS in the network

5.4.1 Knowing the SUC/SIS

The first thing the secondary controller should check is if it knows a SUC at all. Checking if a SUC is known by the controller is done with the **ZW_GetSUCNodeID** call and until this call returns a valid node ID the secondary controller can't use the SUC. The only time a secondary controller gets information about the presence of a SUC is during controller replication, so it is only necessary to check after a successful controller replication.

5.4.2 Asking for and receiving updates

If a controller knows the SUC/SIS, it can ask for updates from the SUC/SIS. Asking for updates is done using the **ZW_RequestNetWorkUpdate** function. If the call was successful the update process will start and the controller application will be notified about any changes in the network through calls to **ApplicationControllerUpdate**). Once the update process is completed, the callback function provided in **ZW_RequestNetWorkUpdate** will be called.

If the callback functions returns with the status ZW_SUC_UPDATE_OVERFLOW then it means that there has been more that 64 changes made to the network since the last update of this secondary controller and it is therefore necessary to do a controller replication to get this controller updated.

NOTE: The SUC/SIS can refuse to update the controller for several reasons, and if that happens the callback function will return with a value explaining why the update request was refused.

WARNING: Consider carefully how often the topology of the network changes and how important it is for the application that the secondary controller is updated with the latest.

5.5 Inclusion Controllers

When a SIS is present in a Z-Wave network then all the controllers that knows the SIS will change state to Inclusion Controllers, and the concept of primary and secondary controllers will no longer apply for the controllers. The Inclusion controllers has the functionality of a Secondary Controller so the functionality described in section 5.4 also applies for secondary controllers, but Inclusion Controllers are also able to include/exclude nodes to the network on behalf of the SIS. The application in a controller can check if a SIS is present in the network by using the **ZW_GetControllerCapabilities** function call. This allows the application to adjust the user interface according to the capabilities. If a SIS is present in the network then the CONTROLLER_NODEID_SERVER_PRESENT bit will be set and the CONTROLLER_IS_SECONDARY bit will not be set.

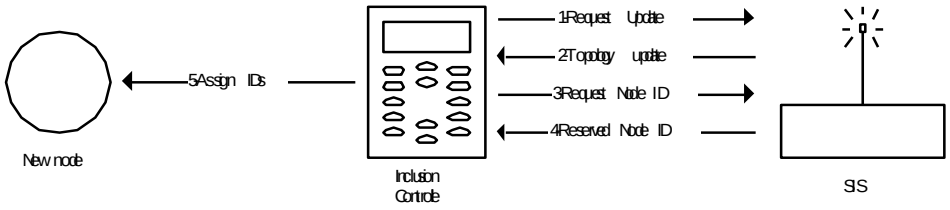


Figure 43. Inclusion of a node having a SIS in the network

5.6 Routing Slaves

The routing slave can request a update of its stored return routes from a SUC/SIS by using the **ZW_RequestNetWorkUpdate** API call. There is no API call in the routing slave to check if the SUC/SIS is known by the slave so the application must just try **ZW_RequestNetWorkUpdate** and then determine from the return value if the SUC/SIS is known or not. If the SUC/SIS was known and the update was a success then the routing slave would get a callback with the status SUC_UPDATE_DONE, the slave will not get any notifications about what was changed in the network.

A SUC/SIS can help a battery-operated routing slave to be re-discovered in case it is moved to a new location. The lost slave initiates the dynamic route resolution process because it will be the first to recognize that it is unable to reach the configured destinations.

The lost battery operated routing slave start to send “I’m lost” frames to each node beginning with node ID = 1. It continues until it find a routing slave which can help it, i.e. the helping routing slave can obtain contact with a SUC/SIS. Scanning through the node ID’s is done on application level. Other strategies to send the “I’m lost” frame can be implemented on the application level.

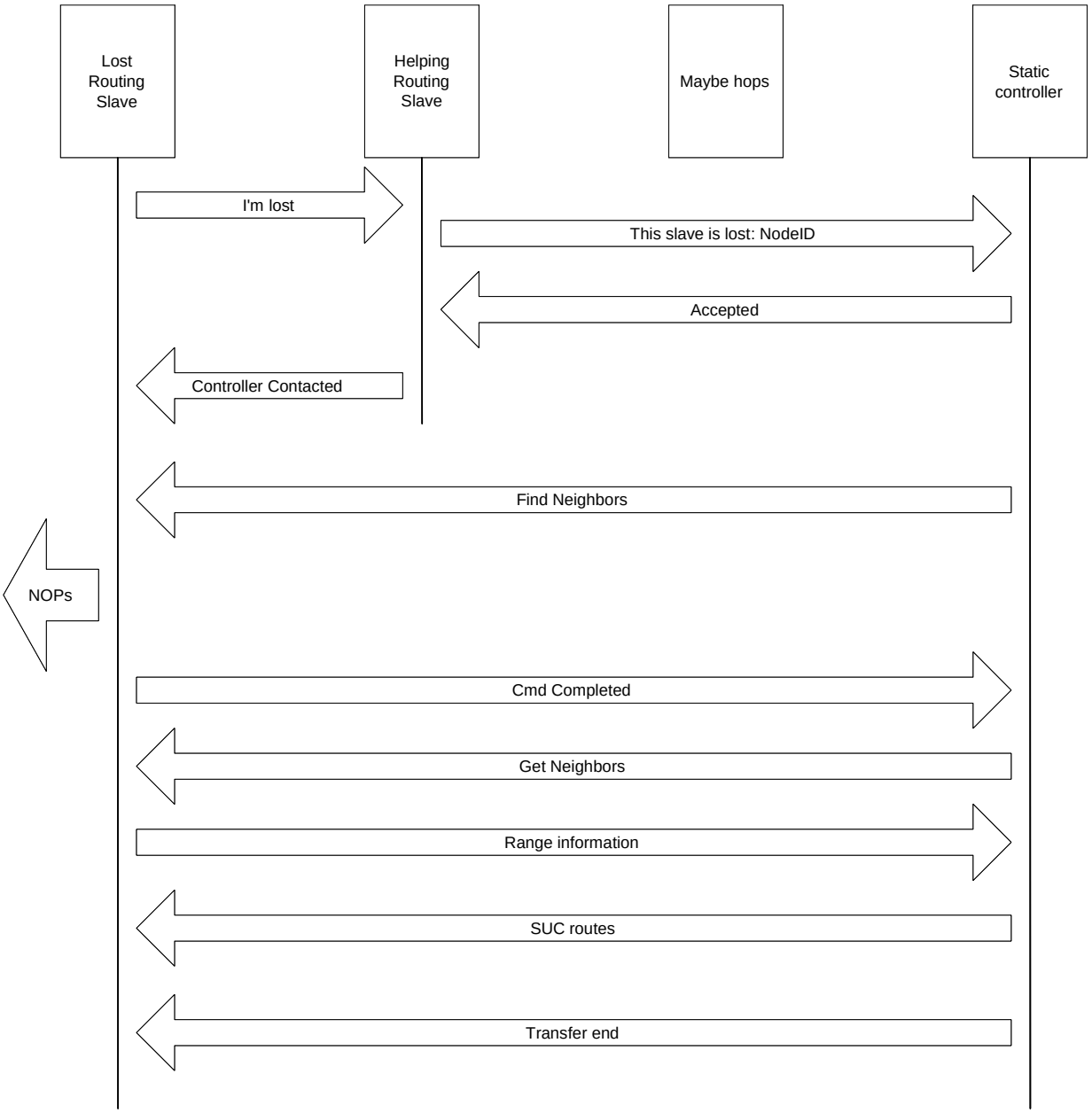


Figure 44. Lost routing slave frame flow

The helping routing slave must maximum use three hops to get to the controller, because it is the fourth hop when the controller issues the re-discovery to the lost routing slave. All handling in the helping slave is implemented on protocol level. In case a primary controller is found then it will check if a SUC/SIS exists in the network. In case a SUC/SIS is available, it will be asked to execute the re-discovery procedure. When the controller receive the request “Re-discovery node ID x” it update the routing table with the new neighbor information. This allows the controller to execute a normal re-discovery procedure.

6 APPLICATION NOTE: CONTROLLER SHIFT IMPLEMENTATION

This note describes how a controller is able to include a new controller that after the inclusion will become the primary controller in the network. The controller that is taking over the primary functionality should just enter learn mode like when it is to be included in a network. The existing primary controller makes the controller change by calling **ZW_ControllerChange**(CONTROLLER_CHANGE_START,..).)

After a successfull change, the controller that called **ZW_ControllerChange** will be secondary and no longer able to include devices.

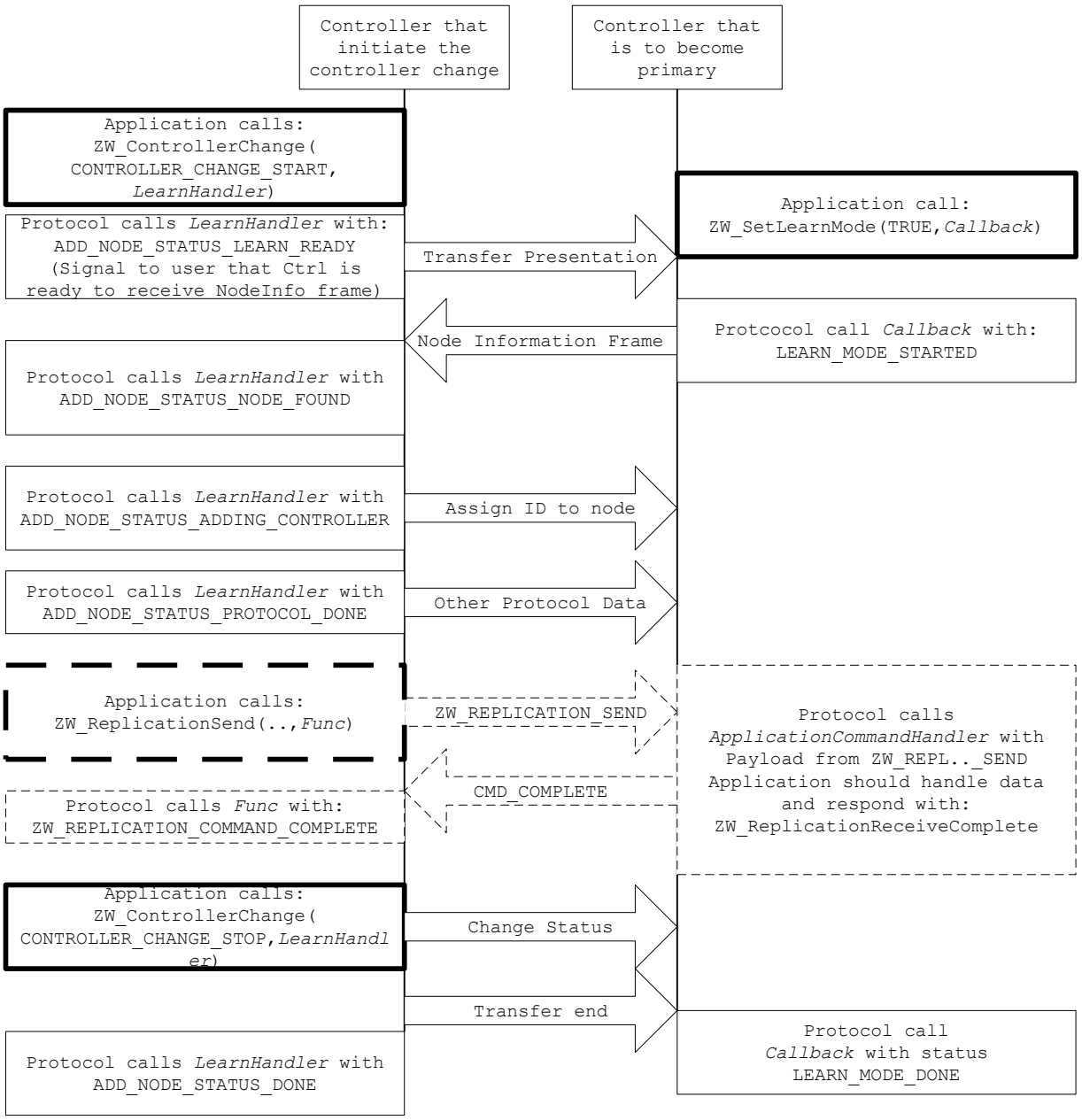


Figure 45. Controller shift frame flow

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