
Chipsmall
深圳市津利帝科技有限公司
Geelead Technology Limited
Chipsmall
采购部

ZAURA™ RF Wireless Technology

ZAURA RF Wireless Library

Programmer's Reference Manual

RM006003-1011

Warning: DO NOT USE THIS PRODUCT IN LIFE SUPPORT SYSTEMS.

LIFE SUPPORT POLICY

ZILOG'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS PRIOR WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF ZILOG CORPORATION.

As used herein

Life support devices or systems are devices which (a) are intended for surgical implant into the body, or (b) support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in a significant injury to the user. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system or to affect its safety or effectiveness.

Document Disclaimer

Revision History

Each instance in this document's revision history reflects a change from its previous version. For more details, refer to the corresponding pages linked in the table below.

Date	Revision Level	Description	Page No.
Oct 2011	03	Corrected ZAURA_RF_ UserParams value in Additional Radio Configuration Variables table.	20
Oct 2011	02	Updated Library/APIs to accommodate expanding radio frequencies.	All
Feb 2011	01	Original issue.	All

Table of Contents

List of Figures

List of Tables

The ZAURA RF Wireless Library

This ZAURA RF Wireless Library Programmer's Reference Manual describes the architecture and application programming interface that allows software developers to integrate ZAURA RF Wireless modules into their products.

Zilog's ZAURA RF Wireless Modules can be designed into any system to enable wireless control. The ZAURA RF Wireless Library is used to establish an ad-hoc peer-to-peer network over radio frequencies in the Industrial, Scientific and Medical (ISM) band with raw data rates of 50 Kbits/sec. Nodes with compatible configurations within radio range of each other can communicate directly using either point-to-point or point-to-multipoint data transfers. The ZAURA RF Library allows developers to configure, transmit and receive packets on the networks.

ZAURA RF Wireless Module Topology

The ZAURA RF Wireless Module uses an ad-hoc topology. Nodes with compatible configurations within radio range of each other communicate directly using either point-to-point (unicast) or point-to-multipoint (broadcast) data transfer. There is no central coordinating unit in the ZAURA RF Wireless Network through which nodes must communicate. This network does not provide routing of any kind between nodes that are not within radio range of each other. There is no concept of master or slave in the ZAURA RF Wireless Network; all nodes operate as equal peers. The modules' configuration parameters determine whether nodes will be able communicate with one another when they are within range.

The ZAURA RF Wireless Network configuration parameters consist of the RF Channel, Network ID and Frame Format. There are two versions of the ZAURA RF Wireless Module, one using the 868 MHz Frequency band and the other using the 915 MHz frequency band. The ZAURA RF channel determines which subset of frequencies within the band are used for communications. The Network ID is user-configurable value 1-4 bytes long that logically subdivides a channel into separate groups or cells. ZAURA RF Modules using the same channel but different Network ID's will not be able to communicate with each other.

The ZAURA RF Wireless Network provides both unreliable and reliable data transfer services, depending on the value of the Frame Format configuration parameter. There are three different frame formats. The first, a DA format, is an unreliable data transfer service with CRC checking and up to 58 bytes of application data sent per frame. The second frame format, DA_SA, is the same as the DA frame format except that it adds the source address to the headers. The third frame format, DA_SA_CTRL, provides a reliable data transfer service. Of the three frame formats, the DA_SA_CTRL format incurs the most overhead and is designed for instances in which reliable data transfer is more important than throughput.

Node Addresses

Each node within the ZAURA RF Wireless Network should have a unique 8-bit address that allows all other nodes to identify that node. This is a mandatory requirement if the ZAURA RF Wireless Network is configured to use a frame format that includes the source address field. However, if all nodes are configured to use frames that only carry a destination address and all transmissions are broadcast, then there is no requirement for unique node addresses.

A node can be assigned an address in the range `0x01` to `0xFE` (i.e., 254 unique node addresses). Node address `0xFF` is used as the broadcast address; i.e., when a frame is transmitted to the `0xFF` address, it will be received by all nodes within radio range of the transmitter. Node address `0x00` is reserved; it must not be used as a node address and should not be transmitted in either the destination or source address fields of a packet.

The manner in which addresses are assigned to nodes is up to the implementer. The ZAURA RF Wireless Library contains a user-configurable node address that is stored in Flash.

Radio Frequencies

The ZAURA RF Wireless Module uses radio frequencies in the 863–870MHz or 902–928MHz bands. There are separate ZAURA RF Wireless Module libraries for each band.

The 863–870MHz band is divided into 4 channels with 600kHz channel spacing and with the center frequencies indicated in Table 1.

Table 1. Center Frequencies in the 863–870MHz Band

Channel	Center Frequency (MHz)
0	865.6
1	866.2
2	866.8
3	867.4

The 902–928MHz band is divided into 25 channels with 1MHz channel spacing and with the following center frequencies indicated in Table 2.

Table 2. Center Frequencies in the 902–928MHz Band

Channel	Center Frequency (MHz)	Channel	Center Frequency (MHz)
0	903	13	916
1	904	14	917
2	905	15	918
3	906	16	919
4	907	17	920

Table 2. Center Frequencies in the 902–928 MHz Band (Continued)

Channel	Center Frequency (MHz)	Channel	Center Frequency (MHz)
5	908	18	921
6	909	19	922
7	910	20	923
8	911	21	924
9	912	22	925
10	913	23	926
11	914	24	927
12	915		

All data communication occurs at 50 kbps with a Frequency Deviation (FDEV) of 100 kHz and a Modulation Index (MI) of 4, regardless of the frequency band used.

The ZAURA RF Wireless Network does not implement frequency hopping. After a node has been configured to operate on a particular channel, it will continue to use that channel until the node is configured to use a different channel.

ZAURA RF Wireless Cell Network Identifiers

A ZAURA RF Wireless cell is composed of up to 254 peer nodes. Each ZAURA RF Wireless cell operates independently of all other cells; each cell uses a unique Network Identifier (NID). The size of the NID is a user-configurable parameter that must be between 1 and 4 bytes in length. Because it may at times be difficult for the radio hardware to distinguish between a valid Network ID and noise (or the absence of any FSK signal), network identifiers should not contain long sequences of repeated binary digits. For example, the 16-bit Network ID `0x0001` is a poor choice; whereas `0xA5B9` provides much better immunity to noise.

ZAURA RF Wireless cells operating within radio range of one another can cause interference. Therefore, overlapping cells must have different NID values. If possible, overlapping cells should use different RF channels. ZAURA RF Wireless addresses are not globally unique and can be reused in adjacent cells.

ZAURA RF Wireless Framing

This section describes the format of frames the ZAURA RF Wireless nodes use to communicate. In this document a frame is used to describe the collection of bits transmitted and received by the radio and a packet is used to describe the portion of the frame that resides in host memory.

Data Transfer Methods

Each ZAURA RF Wireless Module accommodates two methods of data transfer: *reliable* and *unreliable*. Each is described in this section.

Unreliable Data Transfer

The unreliable data transfer mechanism employed by the ZAURA RF Wireless Library allows for either broadcast (point-to-multipoint) or unicast (point-to-point) communication. After an unreliable data frame has been successfully transmitted, the sender does not receive any indication that the frame was received by the intended recipient(s). This type of data transfer is supported by all frame formats.

Reliable Data Transfer

Reliable data transfer is only possible when all nodes within the ZAURA RF Wireless cell are configured to use the DA_SA_CTRL frame format. In addition, reliable data transfer is only supported for point-to-point communication; i.e., if a broadcast frame is transmitted using the DA_SA_CTRL frame format, the data transfer will be unreliable.

This transfer mechanism requires the recipient of an SDATA frame to provide feedback if the frame is actually received. This feedback arrives in the form of an Acknowledgement (ACK) frame. Reception of an ACK informs the transmitter that the recipient received the SDATA frame as well as whether the SDATA frame was accepted or rejected (invalid sequence number or no buffer space); it can optionally request the transmitter to delay the transmission of the next directed frame (reliable or unreliable) targeting the requestor.

If a transmitter does not receive an ACK within a certain period of time after transmitting an SDATA frame, it will automatically retransmit the frame a user-configurable number of times before it aborts the transmission. If an ACK has not been received after exhausting all retransmission attempts, the transmitting application should not assume that the target failed to receive the SDATA frame. In this instance, the user application must perform some form of polling to determine if the target actually received the frame.

When a wireless node retransmits a frame, it is possible for the target to receive multiple copies of the same frame. Therefore, ZAURA RF Wireless SDATA frames carry a sequence number and a retransmission bit that recipients use to distinguish between new and duplicate frames.

Frame Formats

The ZAURA RF Wireless Network can be configured to use one of three different frame formats: DA, DA_SA and DA_SA_CTRL. These frame formats differ in the length of the header included in every frame. Extra header bytes reduce the effective data rate of the RF channel but allow for more complex data transfer modes (e.g., reliable data transfer). A user-configurable frame format allows the ZAURA RF Wireless Network to be deployed in a wide range of applications. For proper communications, all nodes within a ZAURA RF Wireless cell must be configured to use the same frame format.

DA Frame Format

The simplest of the ZAURA RF Wireless frame formats is DA. Fields within the DA frame are depicted in Figure 1.

PA(2)	NID(1–4)	Len(1)	DA(1)	Data(58)	CRC(2)

Figure 1. Fields within the DA Frame

Fields shown in white are configured by the ZAURA RF Wireless Library and cannot be modified by the user. The preamble (PA) is a fixed pattern of repeating 1010 bits (`0xAA`). The radio hardware uses the preamble for synchronizing the receiver's clock to the transmitter's clock. The ZAURA RF Library is configured to transmit two preamble bytes, but the radio will typically emit an extra PA as it prepares for transmission.

The CRC is calculated over the Len, DA and Data fields. The ZAURA RF Wireless Module configures the radio hardware to automatically generate the CRC on transmission and validate the CRC upon packet reception. The ZAURA Module only processes frames with a valid CRC; the radio hardware automatically rejects frames with an invalid CRC.

The ZAURA Module configures the radio to only accept packets that match the user-configurable Network ID (NID). The NID can be between 1 and 4 bytes. The longer the NID, the less susceptible the receiver will be to noise at a cost of a lower effective data rate. Zilog recommends using a NID of at least 2 bytes; this NID should not contain long sequences of repeated binary 1 or 0 digits.

The length field (Len) contains the number of bytes in the Data field. Note that the Len fields of the RF frames include the number of bytes between the Len field and the CRC. The ZAURA RF Wireless Library automatically adjusts the length field of received and transmitted packets so that the application only has to process the length of the application data.

The DA field contains the 8-bit target address of this frame. Addresses `0x01` to `0xFE` identify unique nodes within the ZAURA RF Wireless cell. Address `0x00` is reserved and must not be used as a node address or sent in the DA or SA address of any frame. Address `0xFF` is used to broadcast data to all nodes within the same ZAURA RF Wireless cell that are in radio range of the transmitter. The ZAURA RF Wireless Module will only receive a frame targeting the broadcast address or its unique 8-bit address. Promiscuous packet reception is not supported.

The Data field contains up to 58 bytes of application data. The ZAURA RF Wireless Module does not examine or interpret the Data field during packet transmission or reception.

Limitations and Utility of the DA Format. The DA frame format includes the least amount of RF header bytes and will be able to achieve the highest effective data rate of any of the ZAURA RF Wireless frame formats. This frame format is most useful in applications where data flow is either unidirectional or all broadcast. In these applications, knowing the identity of the node that transmitted the frame is not required.

This data transfer mode is also useful in customer applications that use a proprietary frame format and protocol. The application is free to define additional header bytes within the ZAURA RF data fields.

Reliable ZAURA RF data services cannot be used with the DA frame format. Successful transmission of a frame using the DA frame format does not imply that the target actually received the frame; it only implies that no errors were encountered during transmission.

DA_SA Frame Format

The only difference between the DA_SA frame format and the DA format is the addition of a Source Address (SA), as shown in Figure 2.

PA(2)	NID(1–4)	Len(1)	DA(1)	SA(1)	Data(58)	CRC(2)

Figure 2. Fields within the DA_SA Frame

The ZAURA RF Wireless Library adds the SA field to all transmitted frames and makes the SA available to the application on all received packets.

Limitations and Utility of the DA_SA Format. The DA_SA format allows the recipient of a frame to know the identity of the node that transmitted the frame. This frame format is useful in applications that require unreliable bidirectional communications or point-to-point communication between unique nodes.

As with the DA format, the DA_SA format also allows the use of broadcast traffic (point-multipoint) and cannot be used with the ZAURA RF reliable data transfer protocol.

DA_SA_CTRL Frame Format

The DA_SA_CTRL frame format uses a 3-byte RF header consisting of the destination address (DA), source address (SA) and the Control (CTRL) field. The DA and SA fields are identical to the corresponding fields in the DA_SA frame format, and the control field is used to identify the type of frame being transmitted as well as the target Service Access Point (SAP).

The ZAURA RF Library uses the following frame types:

DATA. Used to transmit application data on a best-effort basis (unreliable data transmission)

SDATA. Used to transmit application data using the ZAURA RF Reliable Data Transfer and Flow Control (RDTFC) protocol (reliable data transmission).

ACK. Used by the RDTFC to acknowledge receipt of an SDATA frame

The SAP field can be used to segregate application data into different logical streams. See the Service Access Points section on page 11 for more information.

The DA_SA_CTRL format is shown in Figure 3.

PA(2)	NID(1–4)	Len(1)	DA(1)	SA(1)	CTRL(1)	Data(58)	CRC(2)

Figure 3. Fields within the DA_SA_CTRL Frame

This DA_SA_CTRL frame format must be used to enable ZAURA RF reliable data services. The ZAURA RF Wireless Library is configured to use this frame format by default.

Limitations and Utility of the DA_SA_CTRL Format. The DA_SA_CTRL format allows the transmitter to determine if the intended recipient of a packet actually received the data that was sent. This frame format also allows a simple point-to-point flow control mechanism to be implemented through the use of ACK frames.

When this frame format is used, the effective application data rate will typically be lower than that of the other frame formats because of a longer header as well as software overhead incurred with the operation of the reliable data transfer protocol.

This frame format is most useful in applications where it is more important to know whether a frame was successfully received than to transmit data as fast as possible.

Reliable Data Transfer & Flow Control Protocol

When the ZAURA RF Wireless Library is configured to use the DA_SA_CTRL frame format, the application can choose to send unicast frames unreliably or reliably via the Reliable Data Transfer & Flow Control (RDTFC) protocol. Broadcast frames cannot be transmitted using RDTFC and will be sent unreliably even if the application requests reliable delivery.

The wireless reliable data transfer protocol cannot guarantee that a transmitted packet will be received by the target (e.g., the target is out of radio range). In some cases it is not even possible for the transmitter to determine that a target successfully received a frame (e.g., ACK lost). Even with these limitations, the RDTFC protocol ensures that the receiver will not accept duplicate frames. If the RDTFC indicates that a reliable data transfer succeeded, it guarantees the target actually received the frame.

Service Access Points

When the ZAURA RF Library is configured to use the DA_SA_CTRL frame format, the least significant four bits of the control field of DATA and SDATA frames identify the target Service Access Point (SAP). A Service Access Point is a process that expects data in a certain format and performs a specific function on that data. Of the 16 possible SAP values, 4 are reserved for the use of the ZAURA RF Library and the remaining 12 can be arbitrarily defined by the user's application.

Table 3. Service Access Point Labels and Functions

SAP	Label	Function
0–11	SAP_APP_0 to SAP_APP_11	Defined by the application.
12	SAP_RESERVED_12	Reserved.
13	SAP_RESERVED_13	Reserved.

Table 3. Service Access Point Labels and Functions (Continued)

SAP	Label	Function
14	SAP_UART_0	UART_0 Output.
15	SAP_CMD_INTRPTR	Command Interpreter Input.

The application can use the SAP field as a simple means to segregate data streams without having to use any byte(s) from the payload. It is up to the application to implement SAP handling for receiving and transmitting SAP_APP packets. The use of the SAP field is optional; therefore, this field is safe to ignore for receiving and transmitting data.

The ZAURA RF Wireless Library defines two SAP values that applications may target when sending data: SAP_UART_0 and SAP_CMD_INTRPTR. Data sent to SAP_UART_0 will be bridged to UART_0 on the target device(s). The data field received is not interpreted by the receiving ZAURA RF Wireless Module prior to transmission on UART_0.

Data sent to the SAP_CMD_INTRPTR must be ASCII text that contains a valid console command. The string is not required to be NULL terminated. Upon receipt of the ASCII string, the remote ZAURA RF Wireless Module will process the command and send any output to `ZAURA_RF_RemoteConsoleSap` (a user-configurable parameter defaulting to SAP_UART_0) of the node that issued the remote console command.

Channel Access Rules

The ZAURA RF Wireless Library can optionally be configured to perform a carrier sense prior to transmitting a DATA or SDATA frame to help prevent (but not eliminate) the possibility that one node initiates a transmit operation while another node is already transmitting. If more than one node is transmitting at any given moment, it is unlikely that a receiver in range of the transmitters will be able to successfully receive any frames.

To perform a carrier sense before transmission, the ZAURA_RF_CsAttempts configuration variable must be set to a nonzero value. In this instance, the radio is placed into receive mode long enough to capture the current Receive Signal Strength Indicator (RSSI). The higher the RSSI value, the more RF energy the radio is detecting, and the more likely another station is already transmitting. If ZAURA_RF_CsAttempts is set to zero, RSSI is not sampled prior to transmission (i.e., no carrier sense is performed).

If the sampled RSSI is below ZAURA_RF_RssiThresh, the node will initiate transmission of the DATA or SDATA frame. If the RSSI value is greater than or equal to ZAURA_RF_RssiThresh, the transmitting station determines that the channel is in use. In this instance, the node will increment a ChBusy counter (initialized to 0 each time the ZAURA_RF_Transmit API is called) and will wait for a pseudo-random back-off period. After this pseudorandom delay, the node will again sample RSSI if ChBusy is less than ZARA_RF_CsAttempts. This process continues until the frame is transmitted (RSSI < ZAURA_RF_RssiThresh) or the transmission is aborted (ChBusy reaches the value of ZARA_RF_CsAttempts) and a status of ZAURA_RF_TX_CHANNEL_BUSY is returned to the caller.

The back-off period is chosen at random on an interval of 164 to 419 ticks of the external 32.768 kHz oscillator corresponding to a delay of approximately 5.0 ms to 12.8 ms.

Prior to sending an ACK frame, the ZAURA RF node will sample RSSI if ZAURA_RF_CsAttempts is nonzero. However, unlike sending a DATA or SDATA frame, there is no random back-off, and a ChBusy counter is not used. Instead, the node attempting to send an ACK will initiate transmission as soon as RSSI < ZAURA_RF_RssiThresh. If the channel remains busy for a period of approximately 8 ms, then the node will abort transmission of the ACK. If ZAURA_RF_CsAttempts is zero, then the