AN5602

Application note

Modification of B-UWB-MEK1 superframe information

Introduction

This application note details how to adapt the ultra-wideband communication protocol, based on superframes, between the various B-UWB-MEK1 boards of a real-time locating system.

It presents the pre-defined superframes available from the software development kit (SDK) and explains how users can customize their own superframes as a function of the number of devices, operating range, and refresh rate of their target application.

This application note complements the information available in the SDK. It is intended for advanced users already familiar with the quick start guide. It is based on system version 3.x.

1 General information

B-UWB-MEK1 embeds the B-UWB-MOD1, which features the STM32L476JE 32-bit microcontroller based on the Arm® 32-bit Cortex®-M4 processor.

Note: Arm is a registered trademark of Arm Limited (or its subsidiaries) in the US and/or elsewhere.

Definitions

Table 1 presents the definition of acronyms that are relevant for a better understanding of this document.

Table 1. List of acronyms

Term	Definition
3D_SELF	3D single self-positioning
BLR	Beacon-listening rate
HF	Hyperframe
PHS	Protocol hyperframe size
PSN	Protocol slot number
PSS	Protocol slot size
RTLS	Real-time locating system
RV	Rendez-vous (slot and zone)
SF	Superframe
SFI	Superframe information
TDMA	Time-division multiple access
UWB	Ultra-wideband

References

Refer to the following documents for an introduction to the B-UWB-MEK1 and B-UWB-MOD1 products in indoor location systems:

- Ultra-wideband module for high-precision indoor location (DB4404)
- Evaluation kit for the B-UWB-MOD1 ultra-wideband module (DB4392)
- B-UWB-MEK1 quick start guide (UM2798)
- SDK advanced documentation

Demonstration software

Contact the local STMicroelectronics sales office or distributor (refer to *www.st.com*) for the latest software and associated documentation.

2 What is the superframe information (SFI)?

The UWB location systems proposed by STMicroelectronics around the B-UWB-MEK1 are based on a synchronized time-division multiple access (TDMA) protocol. Time is split in slots, which have different roles and are grouped in superframes (SF). Superframes are grouped in hyperframes (HF). The superframe gives the first recurrence of the protocol.

The superframe information (SFI) describes how the superframe is partitioned and which is the role of each slot within it.

Important: All devices used in a real-time locating system must be set with the same SFI.

Figure 1 and Table 2 describe the structure of a superframe and its contributing slots.

Figure 1. Superframe information

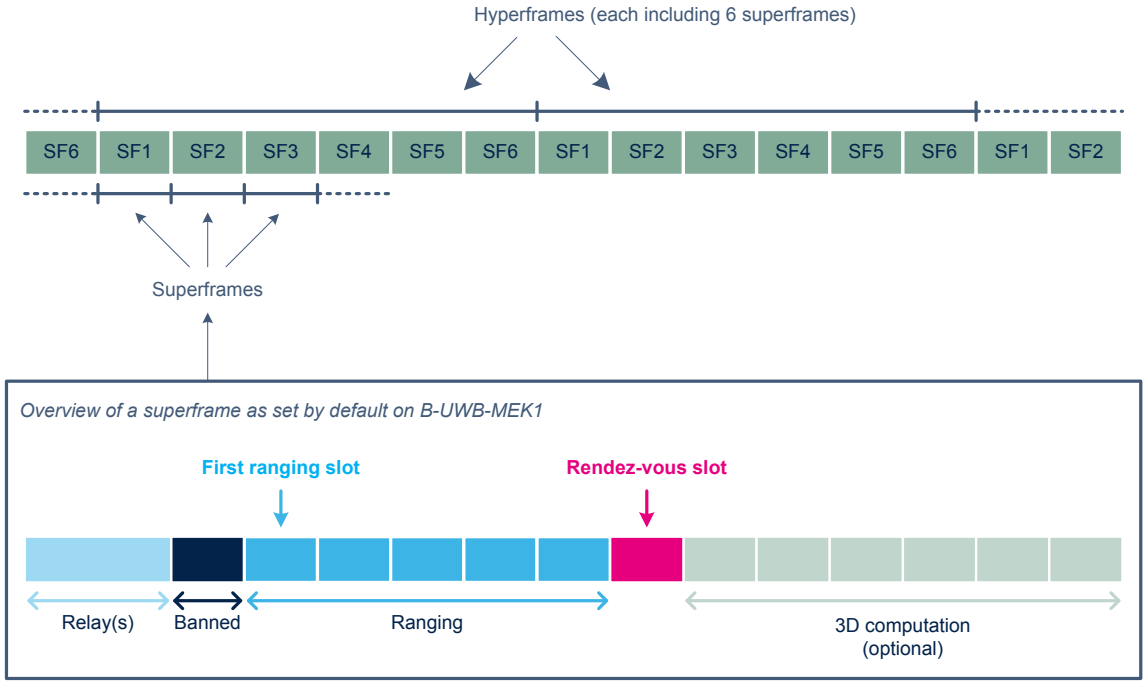


Table 2. Superframe slot types

Slot	Description
Relay	Relay devices are fixed devices which repeat the beacon frame used for the UWB synchronization. This synchronization needs double-sized slots, whose amount depends on the quantity of relay devices in the topology chosen.
Banned	Time reserved for UWB device time computation and chipset programing. Number depending on the slot size.
Ranging	Ranging (location) of UWB devices. Number depending on the number of devices.
Rendez-vous	One single slot for UWB communication (uplink and downlink), located device registration, slot assignment, and others.
3D computation	Time reserved for the 3D computation; needed for using the device in the 3D single self-positioning (3D_SELF) mode.

Detailed information about all SFI rules is available in section SFI detailed rules.

3 How does the operation distance shape the superframe?

The main dependences of the superframe on operation distance is the following:

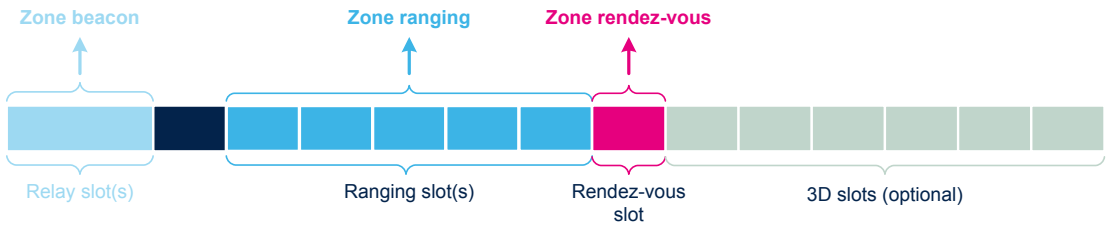
- The longer the operation distance, the bigger the slot size
- The bigger the slot size, the lower the refresh rate

As the superframe size is limited, setting a superframe means finding the right balance between operation distance, amount of ranging devices, and refresh rate.

In STMicroelectronics UWB protocol for real-time locating systems with B-UWB-MEK1, the operation distance is defined by three settings, called zones, which vary according to the time slots within the superframe. Table 3 presents these three zones.

Table 3. UWB signal zones

Zone	Description
Beacon	Defines the operation distance of the signal emitted during the relay slot(s).
Ranging	Defines the operation distance of the signal emitted during the the ranging slot(s).
Rendez-vous	Defines the operation distance of the signal emitted during the the rendez-vous slot.



Operation distances available in STMicroelectronics systems (notional values in best possible conditions)

- Zone 1: shortest range, used for special data transfer purposes only
- Zone 2: up to 100 m
- Zone 3 & 4: 40 to 400 m
- Zone 5: over 400 m, not used in the European Union and the United Kingdom

Typical fixed device densities based on proven industrial experience

- Long distance: one fixed device every 15 to 30 m indoor
  - Zone beacon: 4
  - Zone ranging: 4
  - Zone rendez-vous: 3
- Short distance: one fixed device every 10 to 20 m indoor
  - Zone beacon: 2
  - Zone ranging: 2
  - Zone rendez-vous: 2

4 Superframe examples for B-UWB-MEK1 module evaluation kits, without server

MEK (existing preset)

Long operation distance - Low amount of ranging devices - Fast refresh rate - 5 devices ranging at 13.1 Hz.

B-UWB-MEK1 default superframe setting for small setups and 3D single self-positioning; enables filtered 1D measurement with up to 5 devices.

Single self-positioning with 10 B-UWB-MEK1 boards

Long operation distance - Low amount of ranging devices - Fast refresh rate - 9 ranging slots at 9 Hz.

Same purpose as the existing MEK preset, but for setups with 10 boards.

Single self-positioning for drone tracking

Short operation distance - High amount of ranging devices - Fast refresh rate - 47 ranging slots at 5.2 Hz.

5 Superframe examples used in real-time locating systems (RTLS), with server

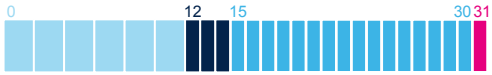
Slow

Long operation distance - High amount of ranging devices - Slow refresh rate - 18 devices ranging at 4 Hz.

Server-centric and device-centric use. Optimum setting to track slow moving devices with minimum power consumption.

Fast

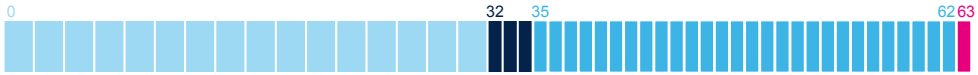
Short operation distance - High amount of ranging devices - Fast refresh rate - 16 devices ranging at 16 Hz.



Server-centric and device-centric use. Optimum setting for large amounts of fast moving devices. Robustness ensured by multiple relays, fast speed, high-tracking capacity.

omlox (existing preset)

Short operation distance - High amount of ranging devices - Fast refresh rate - 28 devices ranging at 8 Hz.



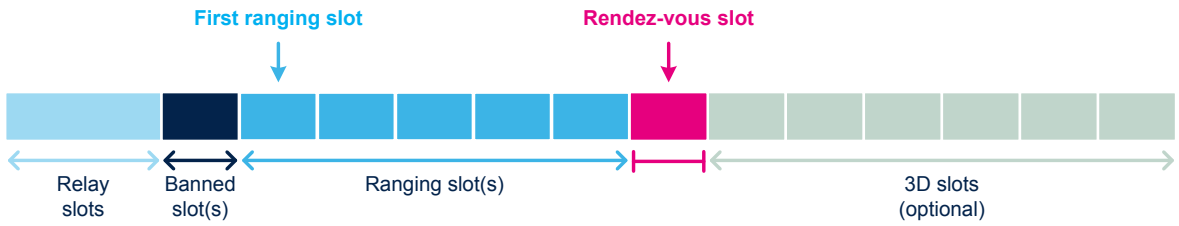
Server-centric and device-centric use. Optimized rate for different kinds of devices in industrial environments.

6 SFI detailed rules

General protocol rules

This section presents a superframe overview based on the superframe structure shown in Figure 2.

Figure 2. Superframe structure



The time base for protocol slot duration, called TS, is a 32 KHz clock period: TS = 1/32768 ≈ 30.5 µs.

The following values are considered during the superframe setup:

- PHS: protocol hyperframe size
- PSN: protocol slot number (total amount of slots in the superframe)
- PSS: protocol slot size

  PSS in TS = n × 64

Important: *Superframes are constrained as follows:*

- *Minimum PSS: 64 TS ≈ 1.95 ms*
- *Maximal PSN limit: 255*
- *Relay slots are double-sized slots (PSS × 2)*

The first slot in the superframe is numbered as position 0.

The settings PHS (protocol hyperframe size) and beacon-listening rate (the rate of occurence in the hyperframe) are editable for testing. They must be ignored by end users. Contact STMicroelectronics in case of specific requirements.

Specific protocol rules

This section summarizes in Table 4 the rules for SFI design and MOD1/MEK1 programming tool setup as a function of the target use case.

Table 4. Specific protocol rules

Proceedings	Parameters(1)	Rules
No field in the MOD1/ MEK1 programming tool; To be considered in SFI design	Operation range	Choose a zone according to the operation distance: • For about 20 to 70 m: zone 2 • For about 70 to 200 m: zone 3 & 4
To be set in the MOD1/ MEK1 programming tool	Zone ranging	Set the zones and take note of the assigned PSS value: • Zone 4: PSS ≥ 192 • Zone 3: PSS = 128 • Zone 2: PSS = 64
	Zone beacon	
	PSS	Set according to the selected ranging and beacon zone.
	Zone rendez-vous	• Ranging and beacon zone 4: rendez-vous zone 3 • Ranging and beacon zone 2 & 3: rendez-vous zone 2
No field in the MOD1/ MEK1 programming tool; To be considered in SFI design	3D slots (option)	For single self-positioning only. Set the quantity of slots to be reserved according to the PSS value defined by zone selection and to the amount of ranging devices.
		Up to 8 devices: • PSS = 256: 3 slots • PSS = 192: 4 slots • PSS = 128: 6 slots • PSS = 64: 11 slots More than 8 devices: • PSS = 256: 4 slots • PSS = 192: 6 slots • PSS = 128: 8 slots • PSS = 64: 16 slots
	Banned slot(s)	Set the quantity of slots to be reserved according to the PSS value defined by zone selection: • PSS ≥ 192: 1 slot • PSS = 128: 2 slots • PSS = 64: 3 slots
To be set in the MOD1/ MEK1 programming tool	Relay number	Set according to the quantity of relays in the infrastructure: [1...8]
	First ranging slot	First slot number = relay number x 2 + quantity of banned slots - 1
	PSN	Define the PSN depending on: • The number of tracked devices • The number of relays • The ranging frequence: [7...255]
	Rendez-vous slot	Number of slots = PSN - number of 3D slots - 1
	PHS	Set at fixed standard value: 6
	Beacon-listening rate	Set the value that corresponds to the closest pre-defined rate: [1...6]

1. *Table cell colors refer to the SF slot color code throughout this application note.*

7 How to modify the SFI in the MOD1/MEK1 programming tool?

7.1 Switch to pre-defined settings

The default SFI settings of B-UWB-MEK1 intend to meet the needs of a real-time locating system equipped with only a few devices. This protocol rate, named MEK, has the following characteristics:

- fast and long distance ranging
- filtered 1D measurement available for up to five devices
- computation space for 3D single self-positioning

If the system environment requires other settings, the MOD1/MEK1 programming tool offers to switch to six other pre-defined protocol rates. These rates are available without exiting the basic setting interface: the pre-defined protocol rates update all SFI parameters without showing the details. To set a pre-defined protocol rate on a B-UWB-MEK1 kit, apply the following procedure to each board (master/secondaries):

Step 1. Connect the board to the host computer.

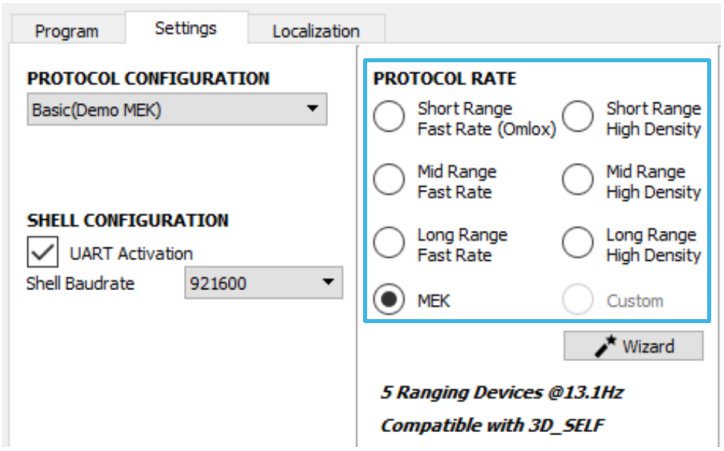
Step 2. Open the MOD1/MEK1 programming tool and turn on the board.

Step 3. In the menu on the right, select the board serial port.
The programming tool displays a progress bar and device information.

Step 4. Open the *Settings* tab.

Step 5. Select a [**PROTOCOL RATE**] as shown in Figure 3 (see examples in chapters Superframe examples for B-UWB-MEK1 module evaluation kits, without server and Superframe examples used in real-time locating systems (RTLS), with server).

Figure 3. Pre-defined settings in the programming tool



Step 6. Click on [**Apply Settings**].

Step 7. Wait until the progress bar displays `OK`.
The new SFI is activated.

7.2 Modify the superframe with the Wizard assistance

The pre-defined SFI detailed in section Switch to pre-defined settings deals with multiple use situations. If the system environment requires some adjustments, favour the procedure described below, which makes use of the MOD1/MEK1 programming tool wizard functionality to provide a guarantee for compliant rates, while the free extensive customization procedure described in section Customize the superframe manually does not.

The wizard assistance enables a limited customization of the SFI without exiting the basic use menus, by taking one of the pre-defined rates as base and tuning only two parameters:

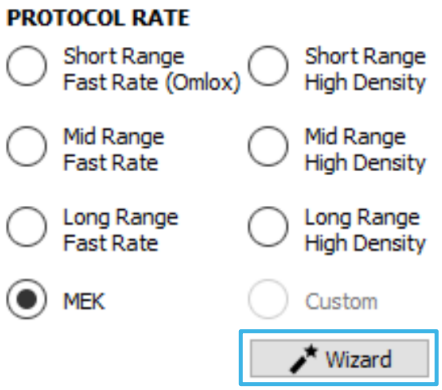
- The 3D single self-positioning mode (3D_SELF)
- The maximum number of ranging devices

To set an SFI based on one of the pre-defined protocol rates with the wizard, apply the following procedure to each board (master/secondary):

Step 1. Set the board ready for configuration as described from 1. to 5. in section Switch to pre-defined settings.

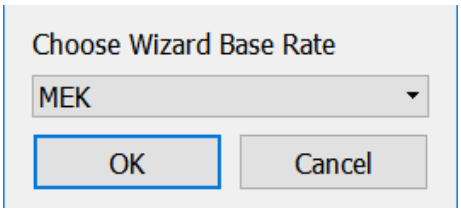
Step 2. In [**MOD1/MEK1 programming tool**]>[**Settings**]>[**PROTOCOL RATE**], click on the [**Wizard**] button as shown in Figure 4.

Figure 4. Wizard selection



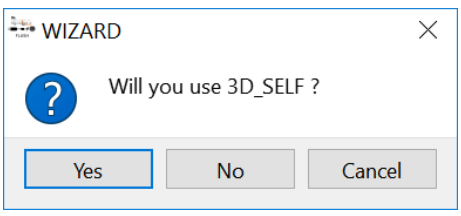
Step 3. Select the pre-defined SFI to be used as a base in the *Wizard Base Rate* menu and validate with [**OK**].

Figure 5. Pre-defined base rate selection



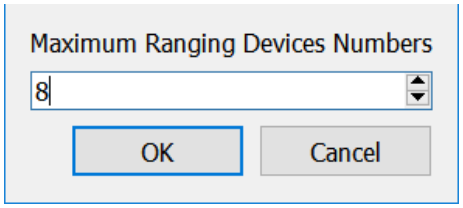
Step 4. Indicate whether the 3D single self-positioning mode (3D_SELF) must be used or not.

Figure 6. Use of the 3D single self-positioning mode



Step 5. Enter the maximum number of ranging devices, which is the maximum number of secondary boards used, and validate with [**OK**].

Figure 7. Number of ranging devices

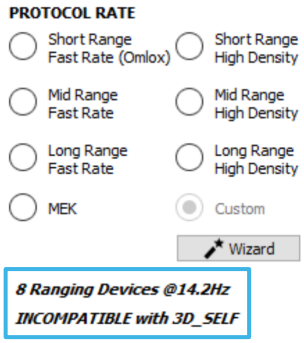


The application displays the new number of ranging devices, the new frequency or both, as well as an indication about 3D_SELF compatibility.

The screeenshot example in Figure 8 shows a wizard customization based on the MEK default SFI:

– No more slots reserved for 3D computation
– Maximum 8 ranging devices instead of 5

Figure 8. Wizard result information



The number of ranging slots increases but the total quantity of slots in the superframe decreases.

Step 6. Click on [**Apply Settings**].

Step 7. Wait until the progress bar displays `OK`.

The new SFI is activated.

7.3 Customize the superframe manually

Important:
The versatility and robustness of STMicroelectronics potitioning protocol relies on a complex UWB pattern. Users must ensure they have become familiar with the explanations given in Section 2 What is the superframe information (SFI)?. to Section 6 SFI detailed rules before starting with manual superframe customization.

To customize the superframe manually, apply the following procedure to each board (master/secondary):

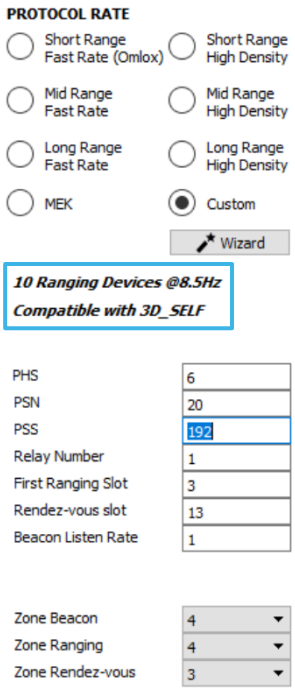
Step 1. Set the board ready for configuration as described from 1. to 5. in section Switch to pre-defined settings.

Step 2. In [**PROTOCOL CONFIGURATION**], select [**Advanced**].
The detailed SFI values appear shaded under [**PROTOCOL RATE**].

Step 3. In [**PROTOCOL RATE**], select the [**Custom**] checkbox.
The detailed SFI values under [**PROTOCOL RATE**] become editable.

Step 4. Modify the values according to the rules explained in Section 6 SFI detailed rules.

Figure 9. Manual SFI customization and results



As soon as a new value is validated by tabulator in fields [**PSN**], [**PSS**], [**First Ranging Slot**] or [**Rendez-vous Slot**], the number of ranging devices, the frequency, or both is updated accordingly as shown highlighted in Figure 9.

Step 5. Click on [**Apply Settings**].

Step 6. Wait until the progress bar displays `OK`.
The new SFI is activated.

8 Ask for support

Additional information is available from the documents listed in References. All documents may be updated without notice to individual users beforehand.

For up-to-date support or information about standardized as well as customized solutions, refer to the UWB and product pages on *www.st.com*, or to the nearest STMicroelectronics office.

Revision history

Table 5. **Document revision history**

Date	Revision	Changes
13-Apr-2021	1	Initial release.

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