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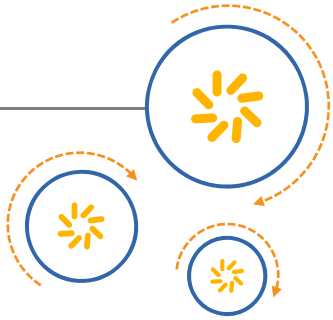

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Qualcomm Technologies International, Ltd.
Churchill House
Cambridge Business Park
Cambridge, CB4 0WZ
United Kingdom

Push every boundary.™

CSR µEnergy™

Keyless Entry System (KES)

User Guide

Issue 3

Document History

Revision	Date	History
1	31 JAN 14	Original publication of this document
2	07 NOV 14	Updated USB dongle information, removed references to Windows XP
3	14 JAN 16	Added support for OTA Update

Contacts

General information	www.csr.com
Information on this product	sales@csr.com
Customer support for this product	www.csrsupport.com
More detail on compliance and standards	product.compliance@csr.com
Help with this document	comments@csr.com

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Contents

Tables, Figures and Equations

1. Introduction

This document describes how to use the CSR µEnergy™ Keyless Entry System (KES) automotive applications supplied with the CSR µEnergy Software Development kit (SDK).

The KES applications demonstrate the following use cases:

1.1. Automotive Keyless Entry System

A Keyless Entry System (KES) allows the vehicle, the *Host*, to be locked and unlocked wirelessly using a remote Key Fob, the *Client*, that has previously been paired to it.

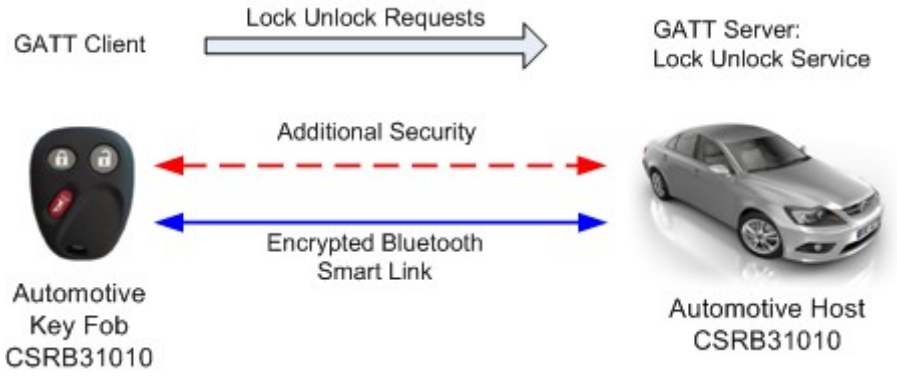

Figure 1.1: Keyless Entry Use Case

1.2. Key Bridge

The Key Fob application implements the CSR custom-defined Key Bridge profile. In normal use, the Key Fob stores vehicle information received over the Bluetooth Smart link, see Figure 1.2. See *Bluetooth Core Specification Version 4.1* for more information on the Bluetooth Smart link.

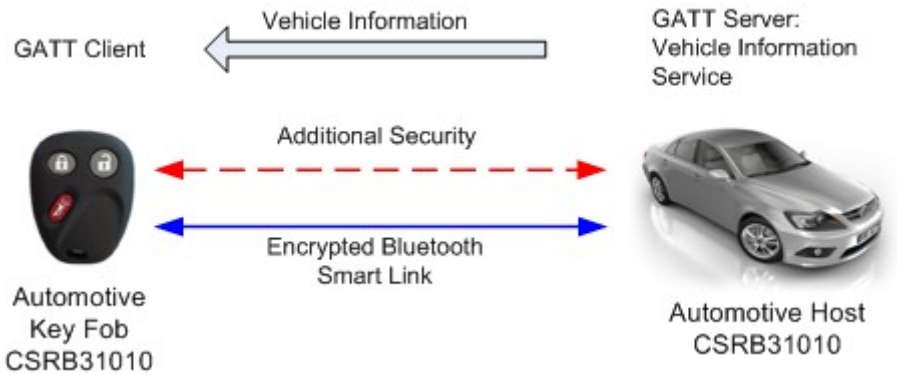

Figure 1.2: Key Bridge Use Case - Storing Vehicle Information on Key Fob

The key bridge client, typically a smart phone, can create a new Bluetooth Smart link to read the vehicle information stored on the Key Fob, see Figure 1.3.

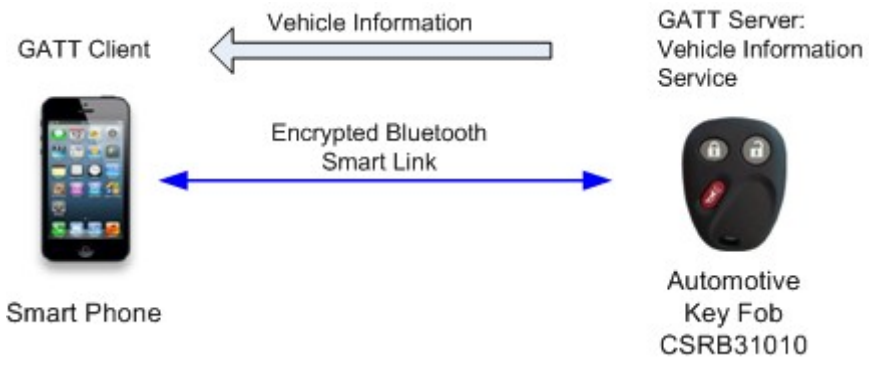

Figure 1.3: Key Bridge Use Case - Reading Vehicle Information on a Smart Phone

1.3. Passive Entry Use Case

When the vehicle detects a door handle being held whilst the paired Key Fob is within a configured detection range, the Host authenticates the Key Fob and unlocks the vehicle, see Figure 1.4.

Figure 1.4: Passive Entry Use Case - Holding Handle to Unlock

1.4. Welcome & Farewell Feature

When the paired Key Fob enters the proximity of the vehicle as determined by the received signal strength (RSSI), the Host issues a Welcome notification. When the paired Key Fob leaves the proximity of the vehicle, the Host issues a Farewell notification. These notifications can typically be used as triggering events for comfort or courtesy features by the vehicle, see Figure 1.5.

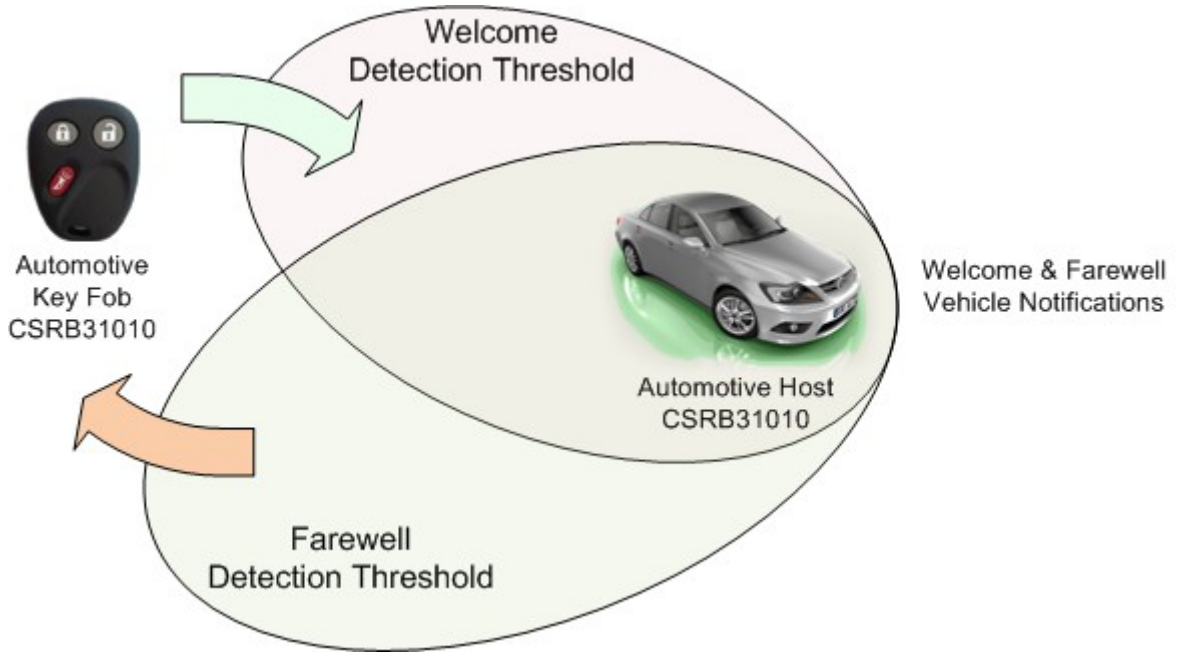

Figure 1.5: Welcome & Farewell Feature Use Case - Key Fob Enters and Leaves Proximity

2. KES Software Components

The following applications are provided to demonstrate the KES use cases.

2.1. Key Fob On-Chip Application

- Implements the Bluetooth Smart enabled remote Key Fob device.
- Communicates with the Host over a Bluetooth Smart link and uses an externally generated Long Term Key (LTK) to encrypt the link.
- Designed for the R13056 CSRB31010 development board and R13154 CSRB31010 Key Fob add-on module board.
- Developed, configured and programmed using CSR µEnergy xIDE and other development tools included in the SDK.
- Supports Over-the-Air (OTA) Update of its application software.
- Further information can be found in the *KES Automotive Key Fob Application Note*.

2.2. In-vehicle Host On-Chip Application

- Implements the Bluetooth Smart enabled Host device using the CSRB31010 device.
- Communicates with the Key Fob over a Bluetooth Smart link and uses an externally generated Long Term Key (LTK) to encrypt the link.
- Designed for the R13056 CSRB31010 development board.
- Developed, configured and programmed using CSR µEnergy xIDE and other development tools included in the SDK.
- Supports Over-the-Air (OTA) Update of its application software.
- Further information can be found in the *KES Automotive Host Application Note*.

2.3. KES Demonstrator Application for Windows

- Provides a simplified GUI to emulate the vehicle system.
- Requires a PC running Windows 7 (32-bit and 64-bit) or Windows 8 (32-bit and 64-bit).
- Provides support for switching the In-vehicle Host Application to bootloader mode. The CSR µEnergy Over-the-Air Updater host application included in the SDK can then be used to update the device. For more information on OTA procedure, see section 3.5 .

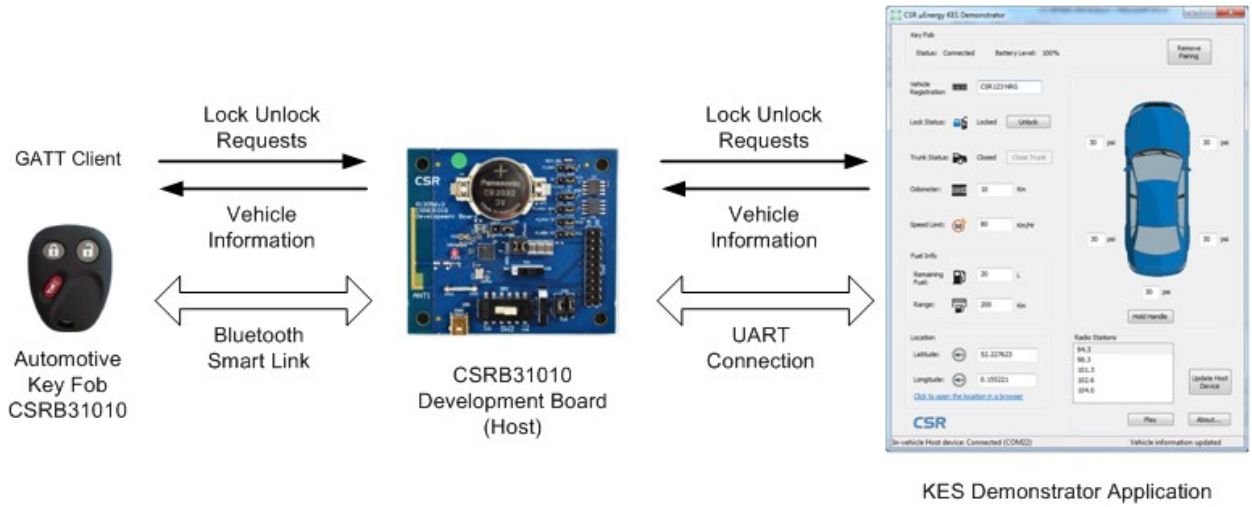

Figure 2.1: KES Demonstrator Communicating with Host

2.4. KES Pairing Demonstrator Application for Windows

- Provides a simple and visual method to pair the Key Fob to the In-Vehicle Host.
- Requires a PC running Windows 7 (32-bit and 64-bit) or Windows 8 (32-bit and 64-bit).
- Further information on using externally generated LTKs can be found in the *Long Term Key (LTK) Application Note*.

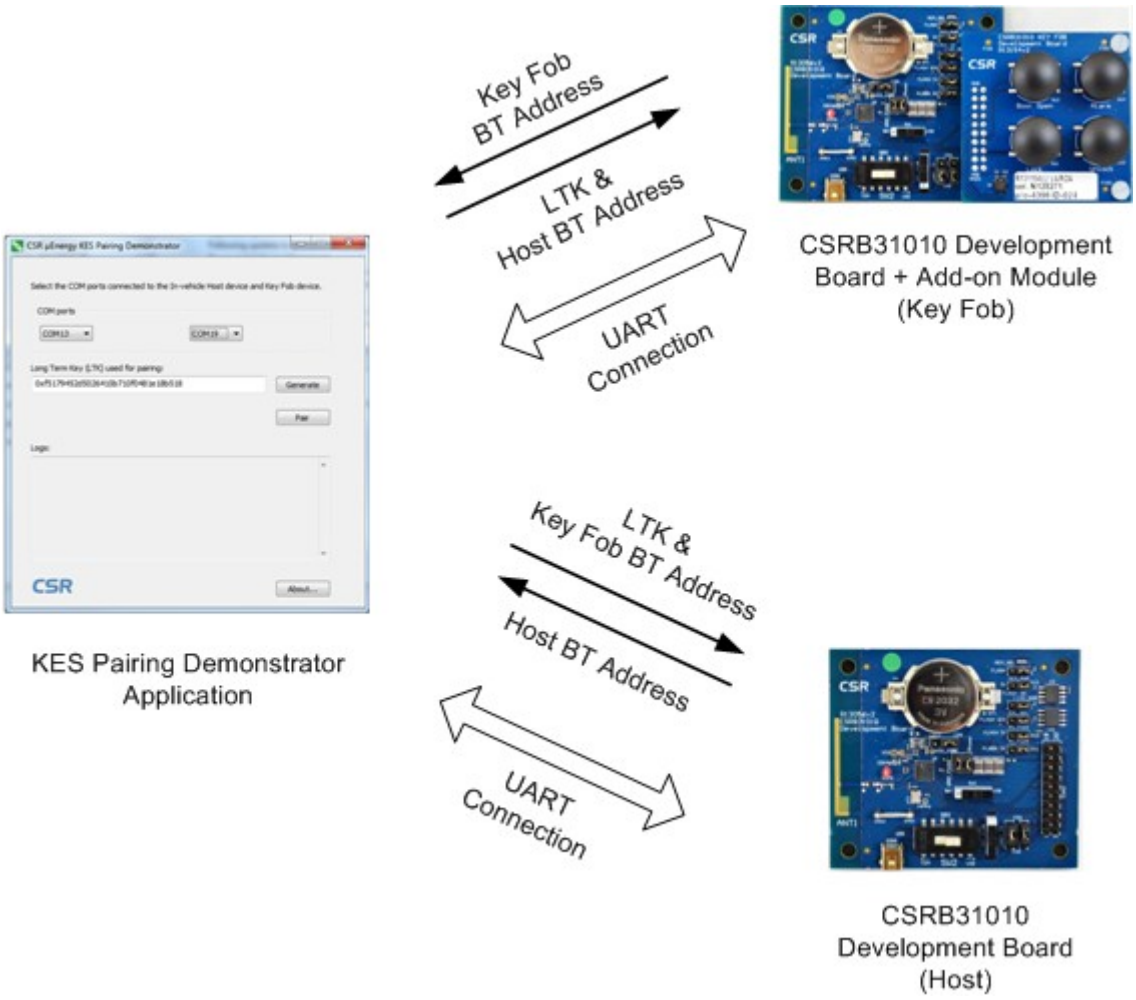

Figure 2.2: Pairing using the KES Pairing Demonstrator

2.5. Profile Demonstrator Application for Windows

- Implements the key bridge client by providing a simple GUI for reading data from the Key Fob.
- Requires a PC running Windows 7 (32-bit and 64-bit) or Windows 8 (32-bit and 64-bit).
- Requires the CSR µEnergy Bluetooth USB dongle with correct drivers installed, see the *CSR µEnergy Bluetooth USB Dongle Driver Installation User Guide*.

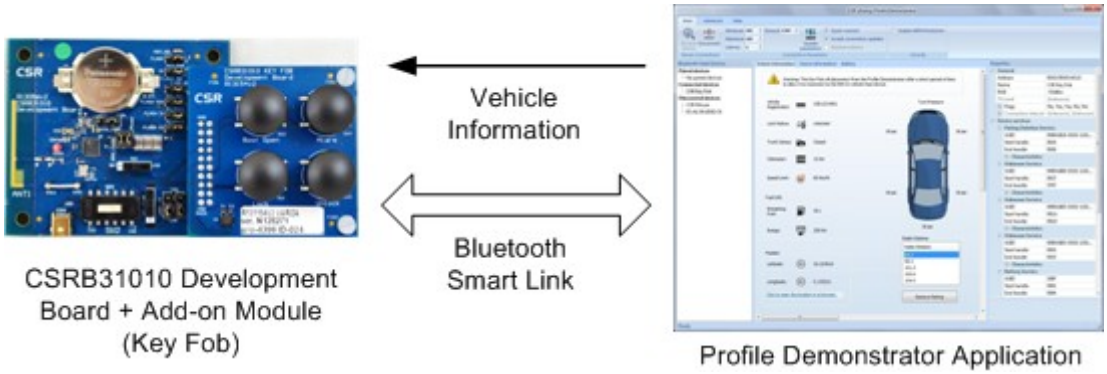

Figure 2.3: Profile Demonstrator Reading Vehicle Information from Key Fob

3. Suggested Demonstration Sequence

1. Program and configure a CSRB31010 development board as a Host device, see section 3.1.
2. Program and configure a CSRB31010 development board fitted with the Key Fob add-on module as a Key Fob device, see section 3.2.
3. Pair the Key Fob device to the Host device, see sections 3.3 and 3.4.
4. Launch the KES Demonstrator application to monitor information transferred across the Bluetooth Smart link between the Key Fob and the Host device, see section 3.5.
5. Disconnect the Key Fob from the Host and connect to the Key Fob using the Profile Demonstrator application (key bridge client), see section 3.6.

Note:

As the Key Fob can be connected to only one device, the Key Fob must be disconnected from the Host (e.g. taking the Key Fob out of the connection range or powering down the Host) before it can be connected to the Profile Demonstrator.

3.1. Program and Configure the Host Device

The CSR µEnergy SDK is used to build and download the Host application to the development board. See the *CSR µEnergy xIDE User Guide* and *KES Automotive Host Application Note* for further information.

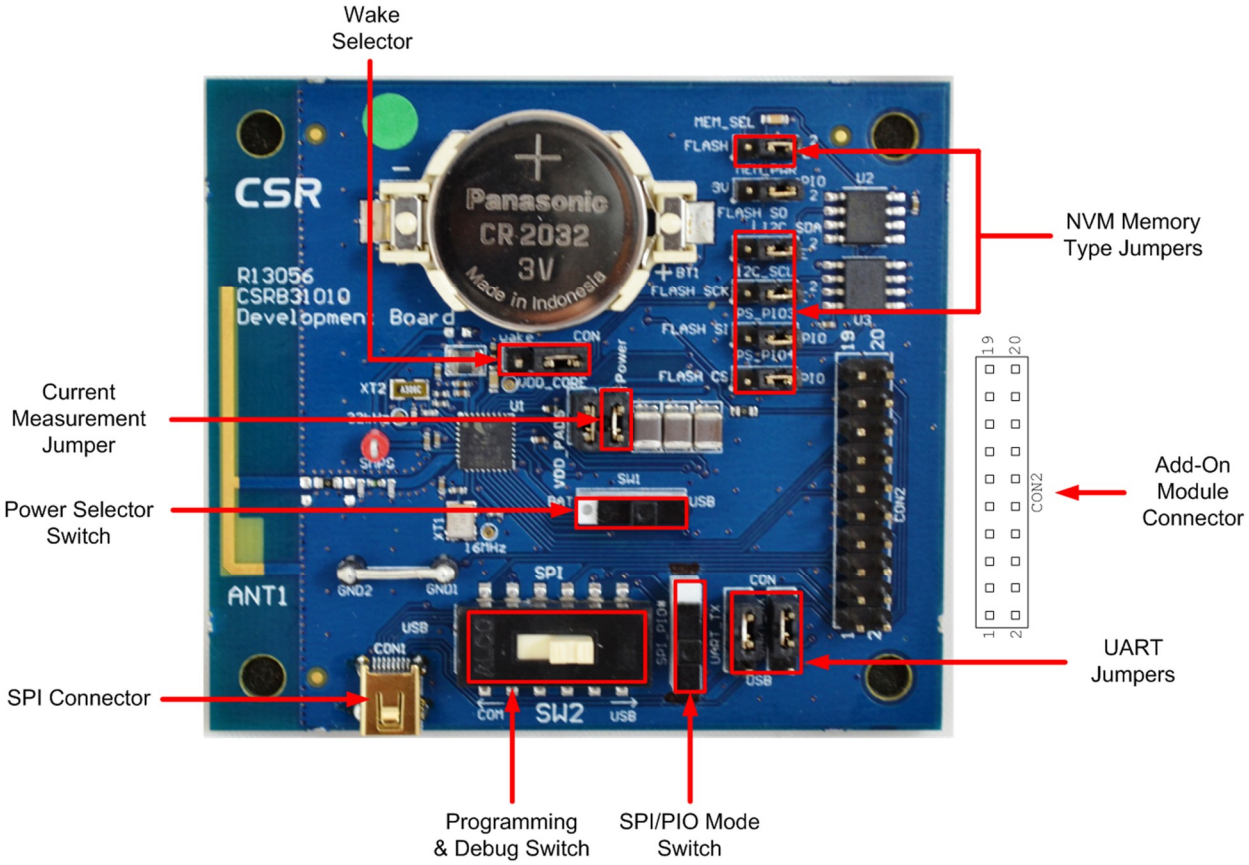

Figure 3.1: CSRB31010 Development Board

Ensure that the correct power source is selected using the power selector switch **SW1**. Figure 3.2 shows the switch in the **USB** position.

Note:

When connected to the USB to SPI adapter (included in the development kit), wait at least 1 minute before switching the board on. This allows any residual charge received from the SPI connector to be dissipated.

To program the image, the jumpers and switches must be positioned as shown in Figure 3.2.

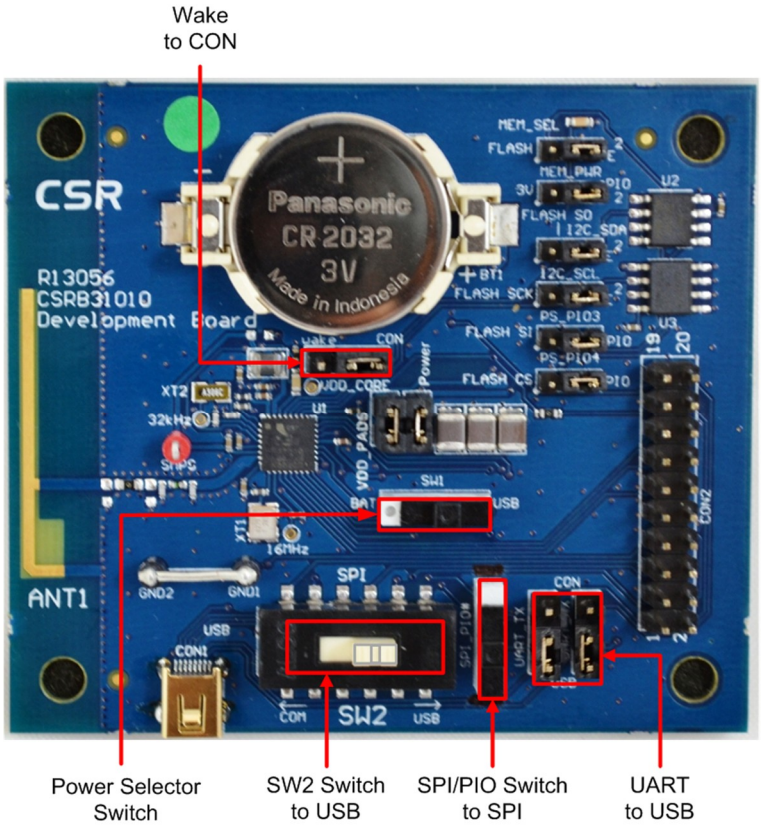

Figure 3.2: CSRB31010 Host Configuration for Programming & Running

3.2. Program and Configure the Key Fob Device

The CSR µEnergy SDK is used to build and download the Key Fob application to the development board. See the *CSR µEnergy xIDE User Guide* and *KES Automotive Key Fob Application Note* for further information.

Attach the Key Fob add-on development board to the on-board add-on module connector, see Figure 3.1 and Figure 3.3.

Figure 3.3: CSRB31010 Key Fob Add-On Development Board

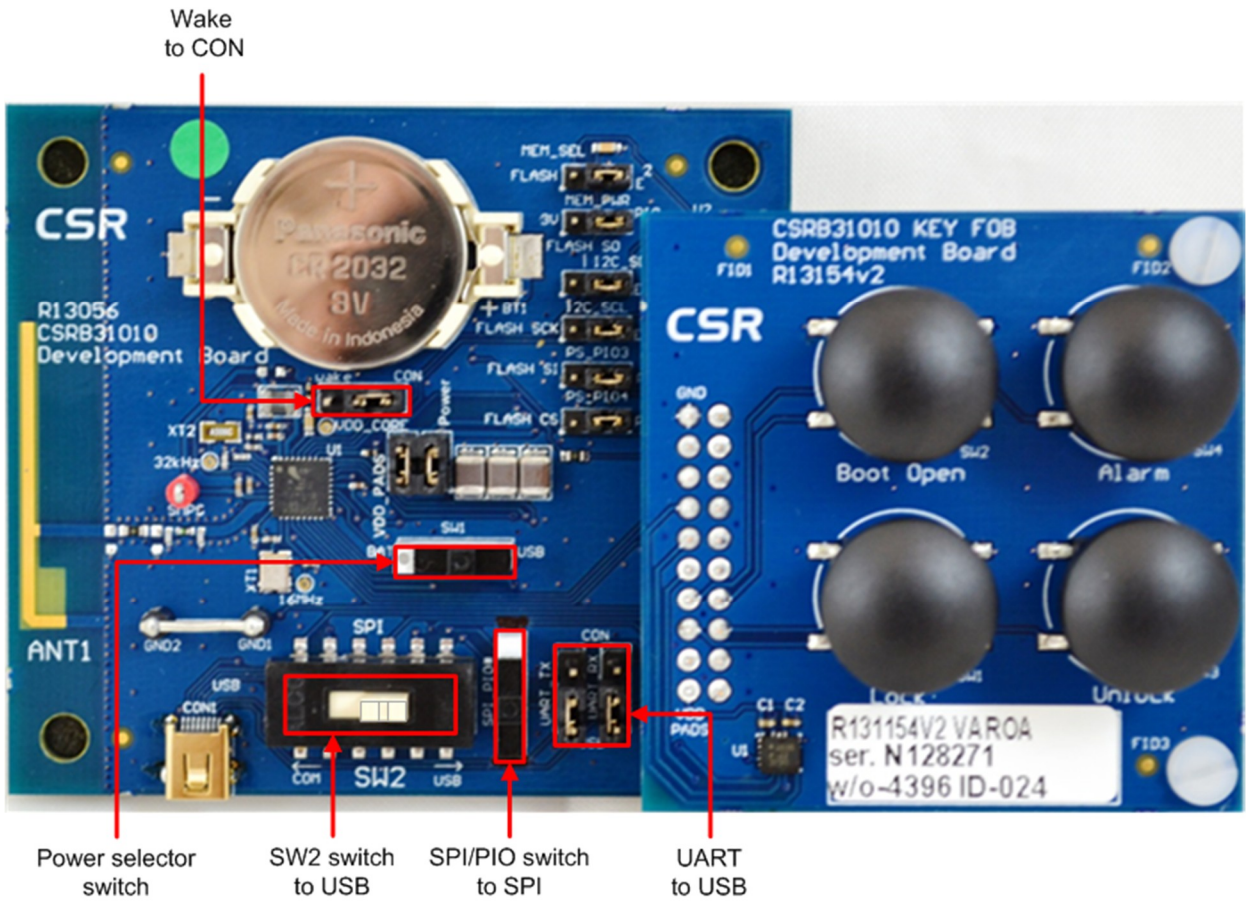

Figure 3.4: CSRB31010 Key Fob Configuration for Programming

Ensure that the correct power source is selected using the power slider switch. Figure 3.4 shows the switch in the **USB** position.

Note:

When connected to the USB to SPI adapter (included in the development kit), wait at least 1 minute before switching the board on. This allows any residual charge received from the SPI connector to be dissipated.

To program the image, the jumpers and switches must be positioned as shown in Figure 3.4.

Once programmed, the jumpers and switches must be positioned as shown in Figure 3.5, before power cycling the device to reset the device.

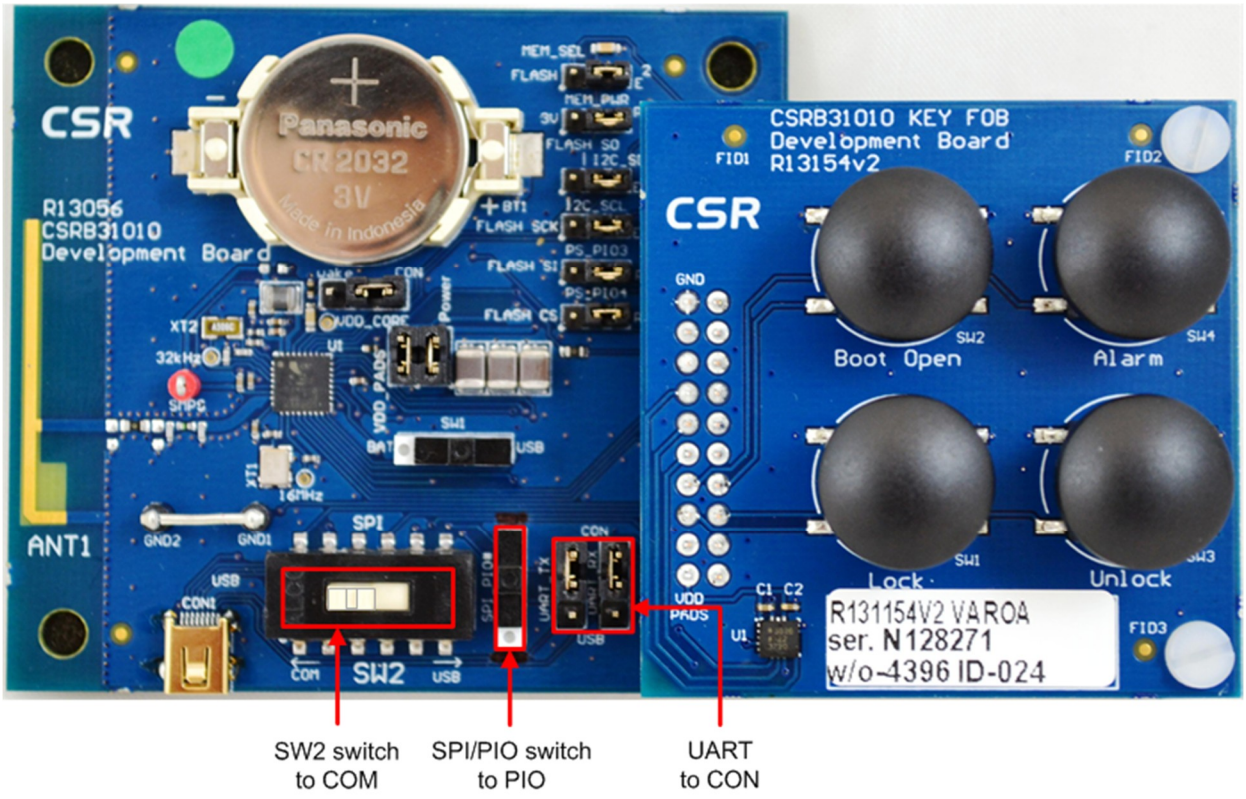

Figure 3.5: CSRB31010 Key Fob Configuration for Runtime

3.3. Pair the Key Fob Device to the Host Device

3.3.1. Pairing Process Overview

The CSR µEnergy KES Pairing Demonstrator distributes the LTK and sets the paired Bluetooth address on each device. As the application can determine if either a Key Fob or Host device is connected to a selected COM port, *Device #1* refers to the first COM port selection, and *Device #2* refers to the second COM port selection in the following descriptions.

The pairing procedure can be divided into three sub-procedures:

1. Communication of LTK to Device #1.
2. Communication of LTK to Device #2.
3. Communication exchange of Bluetooth addresses for Device #1 and Device #2.

3.3.2. Communication of LTK to Device #1

When the **Pair** button is pressed, the KES Pairing Demonstrator:

1. Connects to Device #1 using the selected COM port.
2. Queries Device #1 to establish its role (in-vehicle Host or Key Fob).
3. Retrieves the Bluetooth address of Device #1.
4. Configures the LTK on Device #1 for the encrypted link with Device #2.

3.3.3. Communication of LTK to Device #2

Once Device #1 has been successfully configured with the LTK, the KES Pairing Demonstrator:

1. Connects to Device #2 using the selected COM port.
2. Queries Device #2 to verify that its role complements the role of Device #1.
3. Retrieves the Bluetooth address of Device #2.
4. Configures the LTK on Device #2 for the encrypted link with Device #1.

3.3.4. Communication Exchange of Bluetooth Addresses

Once Device #2 has been successfully configured with the LTK, the KES Pairing Demonstrator:

1. Provides the Bluetooth address of Device #1 to Device #2, and the Bluetooth address of Device #2 to Device #1 for future Bluetooth Smart communication.
2. Once successful, the COM port connections are closed and the devices can be disconnected from the PC.

3.4. Using the KES Pairing Demonstrator

1. For the Key Fob to be paired, the UART jumpers must be set to USB before power cycling the device.
2. Connect the Host and Key Fob devices to a Windows PC using two CSR µEnergy USB to SPI adapters (included in the development kit).
3. Launch the KES Pairing Demonstrator application from the Windows Start Menu or shortcut, see Figure 3.6.

Figure 3.6: CSR µEnergy KES Pairing Demonstrator Application Icon

4. The start-up screen is shown in Figure 3.7.

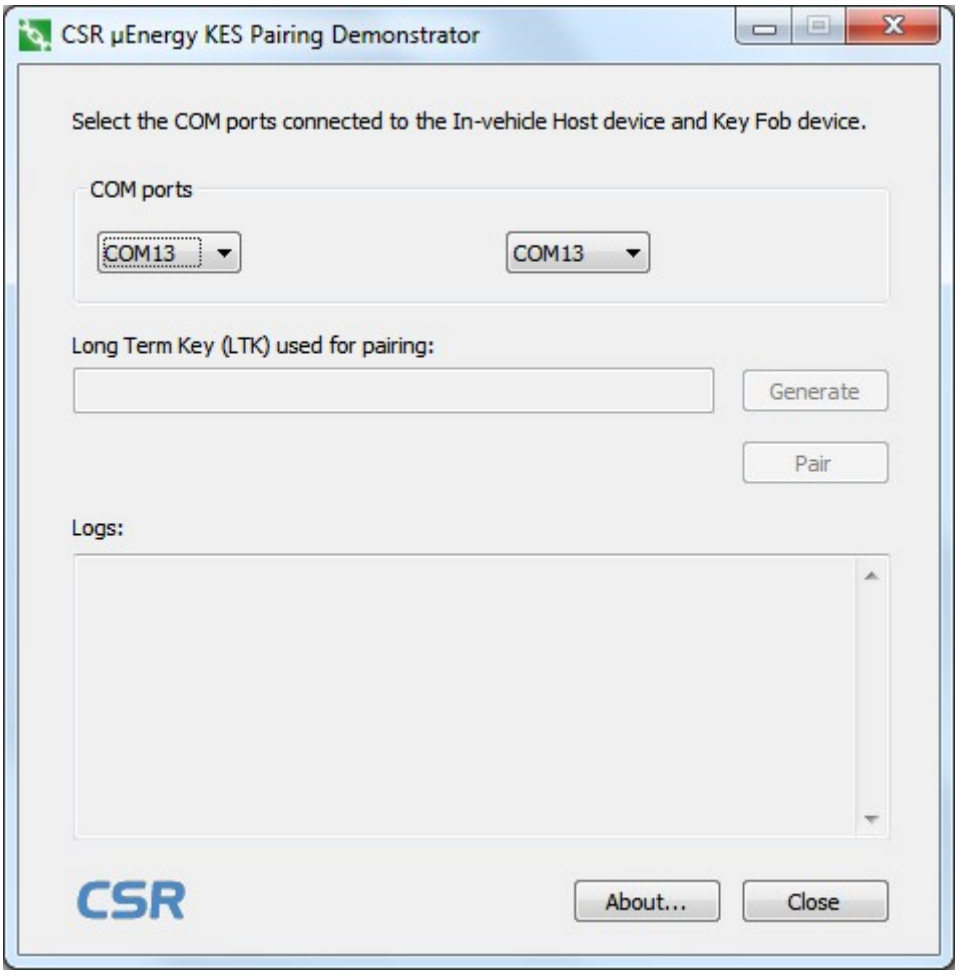

Figure 3.7: Start-up Screen

6. Select the COM ports for the Key Fob and Host devices.
7. Press the **Generate** button to use a 128-bit randomly generated LTK or manually enter the LTK (hexadecimal format), see Figure 3.8:

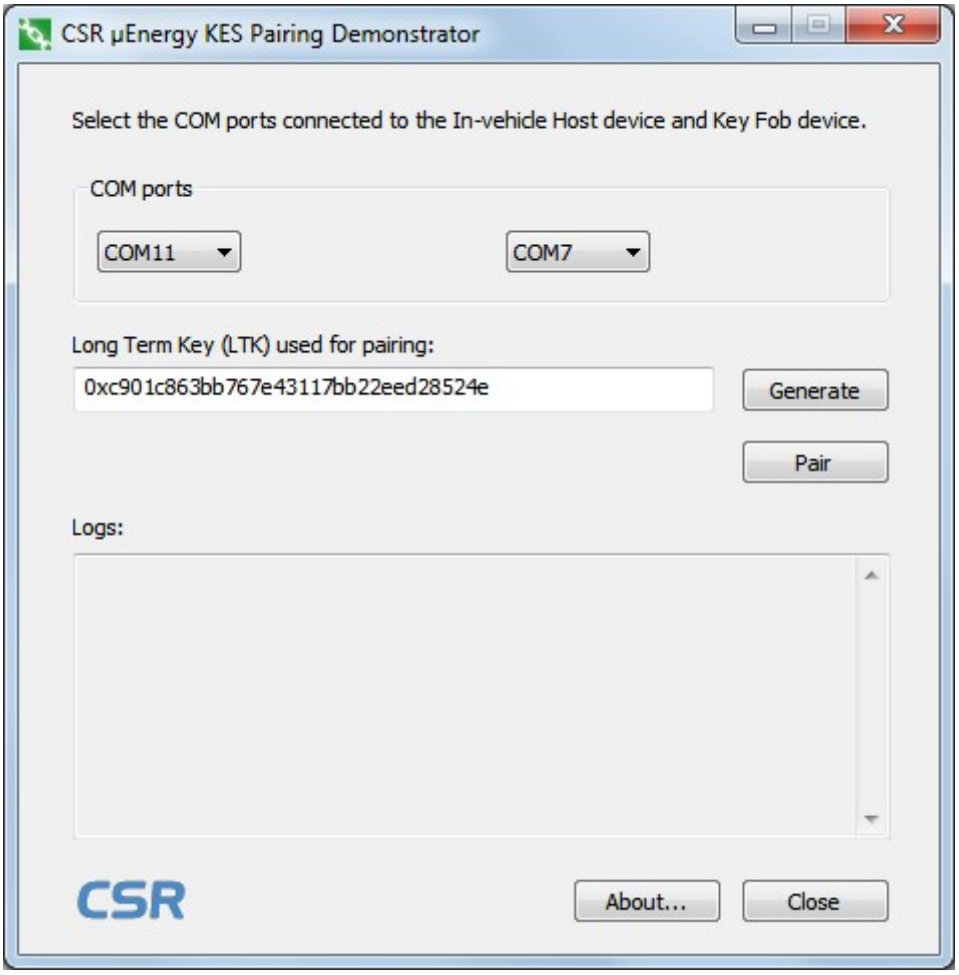

Figure 3.8: Enter or Generate the Long Term Key (LTK)

8. Press the **Pair** button to initiate the pairing process. A confirmation will be displayed once the pairing process is complete, see Figure 3.9:

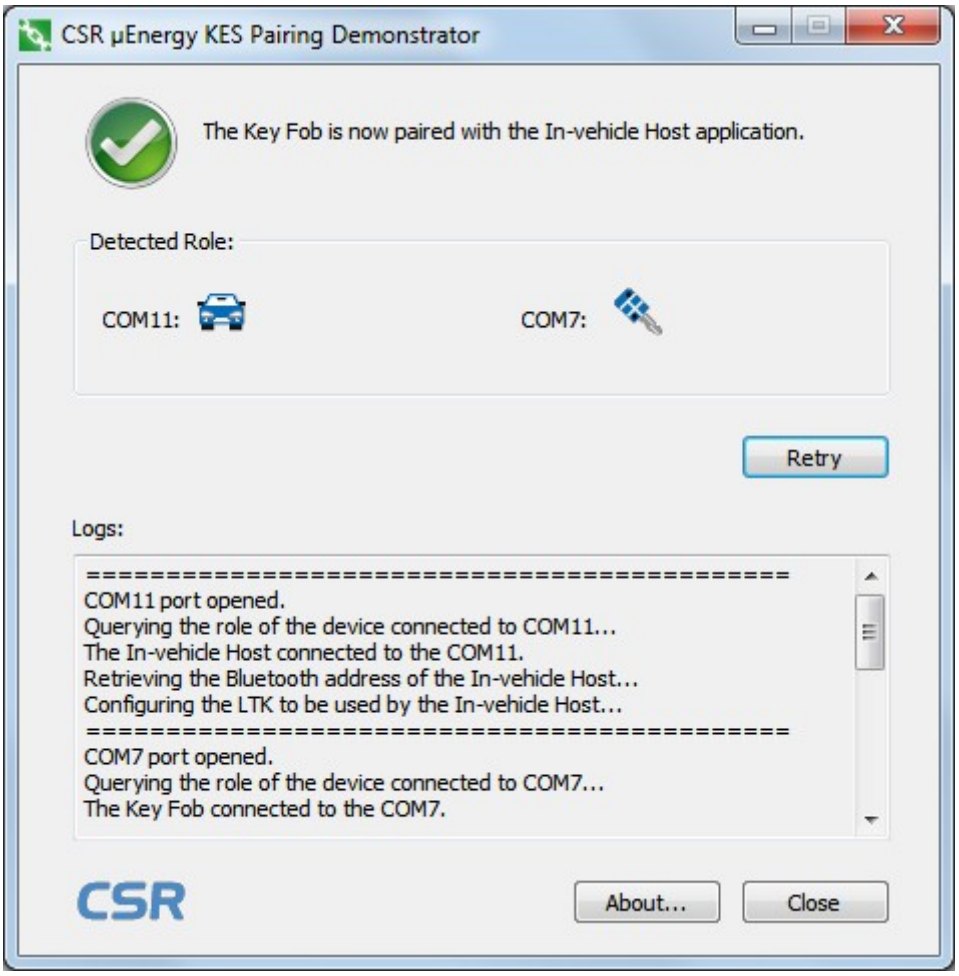

Figure 3.9: Pairing Complete

9. Once paired, the Key Fob requires the UART jumpers to be set back to CON before power cycling the device.

10. If the pairing procedure fails, see Figure 3.10 and Figure 3.11, the Logs window can be used to diagnose the failure, see Appendix B.

Figure 3.10: Pairing Failure - Device #1 Not Responding

Figure 3.11: Pairing Failure - Device #2 Not Responding

3.5. Connect the KES Demonstrator to the Host Device

The CSR µEnergy KES Demonstrator application communicates with the Host application over the UART connection.

Note:

The KES Demonstrator application automatically sends a command over each available COM port until the Host is detected. CSR recommends disconnecting any equipment which may be sensitive to the binary commands being received over the UART.

1. Launch the KES Demonstrator Application from the Windows Start Menu or shortcut, see Figure 3.12.

Figure 3.12: CSR µEnergy KES Demonstrator Application Icon

2. On start-up, the KES Demonstrator application queries the available COM ports to identify and connect to the Host application. The status of the connection with the Host is displayed in the bottom left corner of the screen, see Figure 3.13.

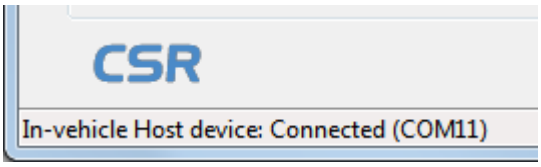

Figure 3.13: KES Demonstrator: Host Connection Status

3. Once connected, the KES Demonstrator application updates the Host device with the current vehicle information, see Figure 3.14. The Host device can also be updated by pressing the **Update Host Device** button at any time.

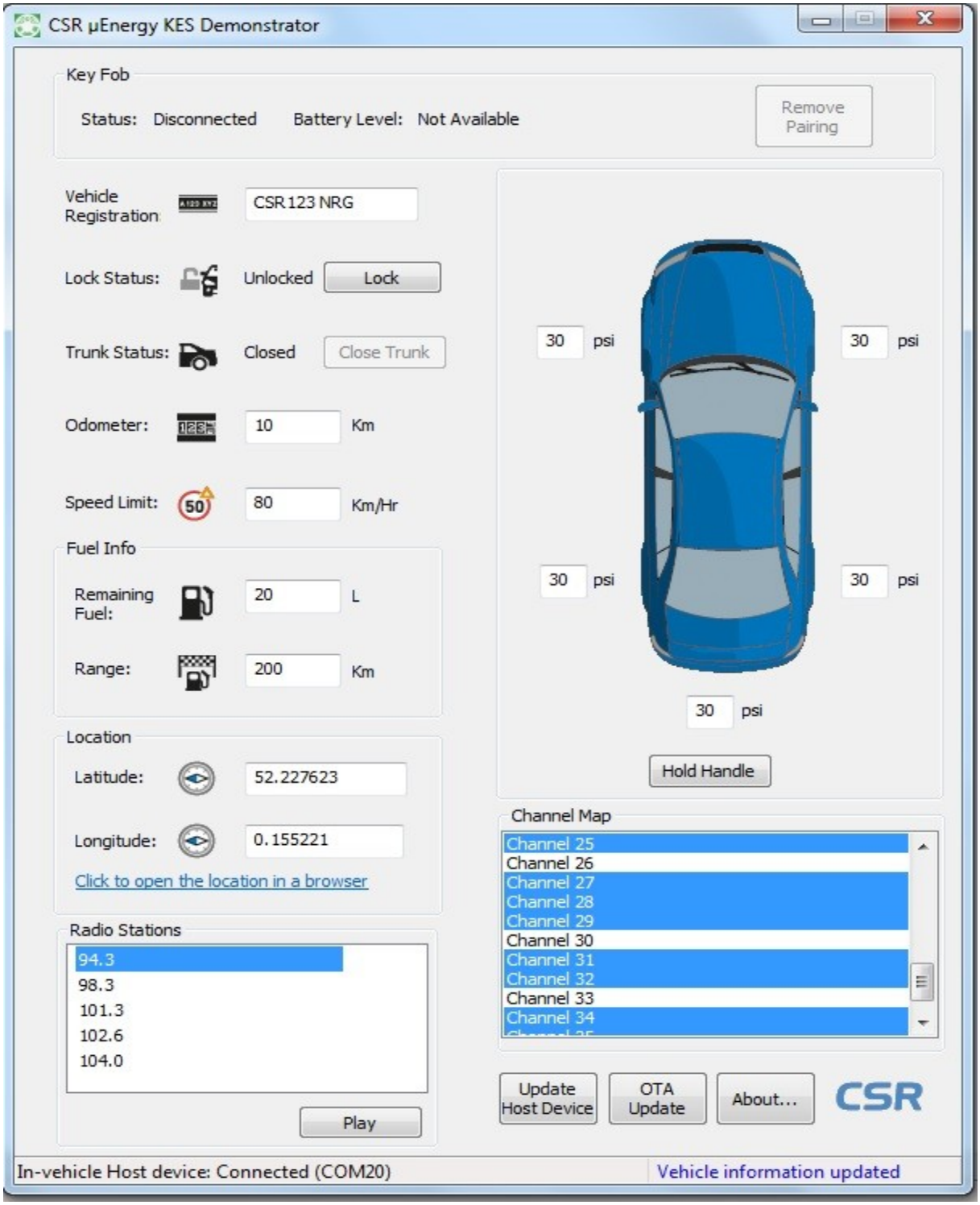

Figure 3.14: KES Demonstrator: Host Connected, Key Fob Disconnected

4. Once the Key Fob has connected to the Host via the Bluetooth Smart link, the connection status changes from **Disconnected** to **Connected**, see Figure 3.15.

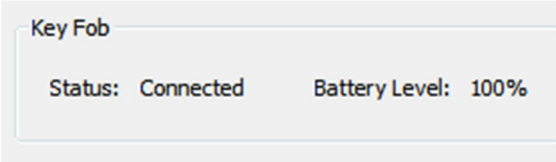

Figure 3.15: KES Demonstrator: Key Fob Connected

5. **Lock/Unlock Behaviour:** Figure 3.16 shows the vehicle's current lock status as **Locked**.

Figure 3.16: KES Demonstrator: Vehicle Locked

6. Pressing the **Unlock** button on the Key Fob unlocks the vehicle and the lock status changes to **Unlocked**, see Figure 3.17.

Figure 3.17: KES Demonstrator: Vehicle Unlocked

7. **Handle Hold Behaviour:** Whilst the Key Fob is within the pre-configured handle hold range (determined by RSSI), a green glow is displayed around the vehicle, see Figure 3.18, and pressing the **Hold Handle** button on the KES Demonstrator unlocks the vehicle.

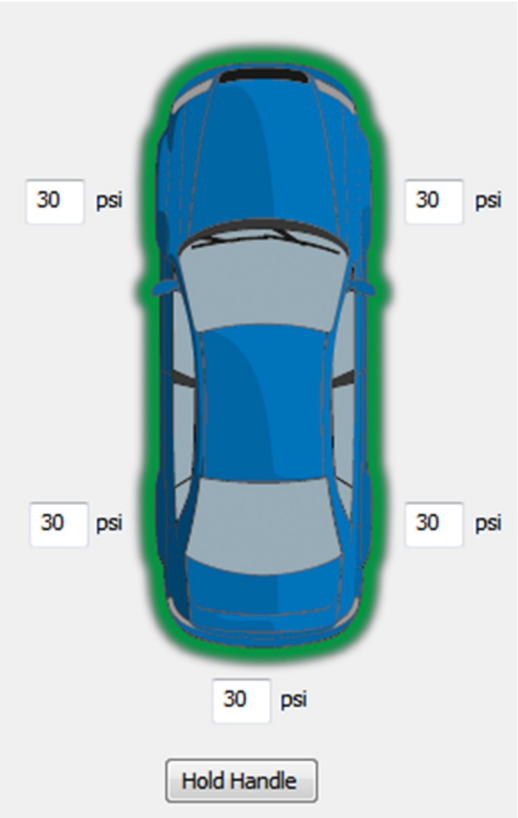

Figure 3.18: KES Demonstrator: Key Fob within Handle Hold Range

8. **Welcome/Farewell Feature:** When the Key Fob enters the pre-configured Welcome range (determined by RSSI), the Welcome message is displayed, see Figure 3.19.

Figure 3.19: KES Demonstrator: Key Fob Enters Welcome Range

9. When it leaves the pre-configured Farewell range, the Farewell message is displayed, see Figure 3.20.

Figure 3.20: KES Demonstrator: Key Fob Leaves Farewell Range

10. Pressing the **Panic** button on the Key Fob triggers a panic notification on the Host, see Figure 3.21.

Figure 3.21: KES Demonstrator: Panic Message

11. Pressing the **Play** button on the KES Demonstrator configures the selected radio station as the current radio station, see Figure 3.22.

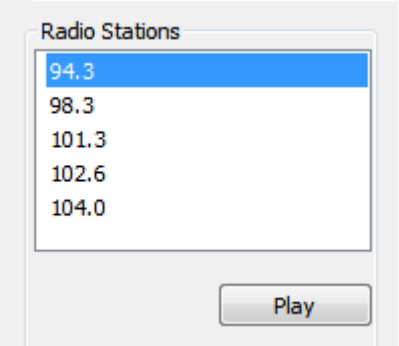

Figure 3.22: KES Demonstrator: Play Radio Station

12. Pressing the **Open Trunk** button on the Key Fob opens the vehicle trunk and pressing the **Close Trunk** button on the KES Demonstrator, see Figure 3.23, closes the vehicle trunk.

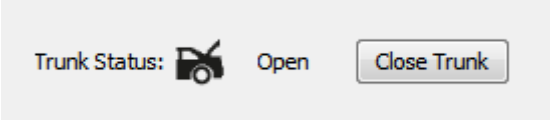

Figure 3.23: KES Demonstrator: Trunk Status and Close

13. Pressing the **Remove Pairing** button on the KES Demonstrator, see Figure 3.24, deletes any key bridge client pairing information present on the Key Fob, allowing a new key bridge client to pair with the Key Fob.

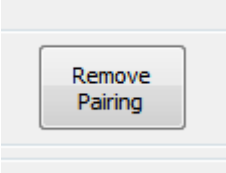

Figure 3.24: KES Demonstrator: Button to Remove Key Bridge Pairing Information on Key Fob

14. Pressing the **OTA Update** button on the KES Demonstrator, see Figure 3.25, switches the Host application to Bootloader mode. The bootloader supports CSR OTA Update Application service which enables wireless update of the application software. The CSR µEnergy Over-the-Air Updater host application included in the SDK can be used to update the device.

    For more information, see *CSR µEnergy Over-the-Air (OTA) Update System Application Note, CSR µEnergy Modifying an Application to Support OTA Update Application Note*, *CSR µEnergy Over-the-Air*

(OTA) Update Application and Bootloader Services Specification and *Interfacing Large Serial Flash and EEPROM Application Note*.

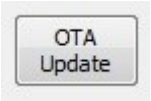

Figure 3.25: KES Demonstrator: OTA Update

3.6. Use the Profile Demonstrator as the Key Bridge Client

The CSR µEnergy Profile Demonstrator application provides key bridge client support for the Key Fob.

As the Key Fob can be connected to only one device, the Key Fob must be disconnected from the Host (e.g. taking the Key Fob out of the connection range or powering down the Host) before it can be connected to the Profile Demonstrator.

The CSR µEnergy Bluetooth USB dongle shown in Figure 3.26 must be used with the Profile Demonstrator application to complete the Bluetooth Smart link between the Key Fob and the key bridge client. To use the USB dongle, the default Bluetooth Windows device driver must be replaced with the CSR BlueCore device driver as described in *CSR µEnergy Bluetooth USB Dongle Driver Installation User Guide*.

Figure 3.26: CSR µEnergy Bluetooth USB dongle

1. Launch the KES Demonstrator Application from the Windows Start Menu or shortcut, see Figure 3.27, once the USB dongle is attached to the PC and the driver has been loaded.

Figure 3.27: CSR µEnergy Profile Demonstrator Application Icon

2. Connect to the **CSR Key Fob** once discovered and displayed in the **Connected devices** list. The **Vehicle Information** tab will be shown, see Figure 3.28.

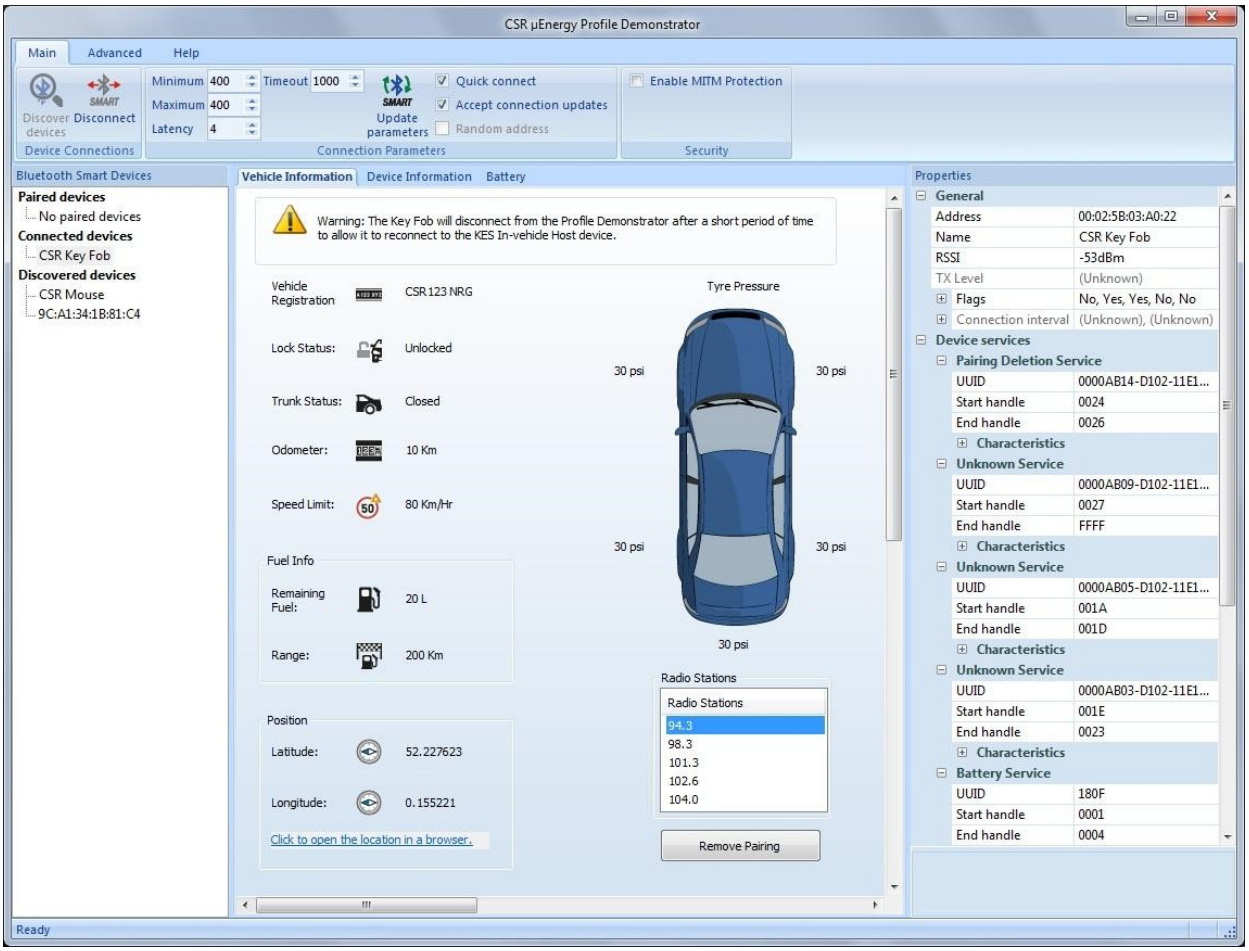

Figure 3.28: Profile Demonstrator - Vehicle Information Tab

3. Pressing the **Remove Pairing** button on the Profile Demonstrator deletes any key bridge client pairing information present on the Key Fob, allowing a new key bridge client to pair with the Key Fob.
4. Press and hold the **Open Trunk** button on the Key Fob for 4 seconds to start advertising to allow connections to be established by new key bridge clients.

Notes:

1. If any button on the Key Fob is pressed when it is connected to the Profile Demonstrator, the Key Fob disconnects the link and starts directed advertisements to connect to the Host.
2. The Key Fob disconnects automatically after a few minutes of inactivity to save power (pre-configured).

Appendix A EEPROM/Flash Jumper Configuration

To use EEPROM NVM, the NVM jumpers should be configured as shown in Figure 3.1. To use SPI Flash NVM, the NVM jumpers must be moved towards the coin cell (battery).

Appendix B Pairing Fault Diagnosis

Logs Window Message	Failure Reasons
Failed to connect to COM<x>.	1. The COM port could not be opened. Ensure the port is available and it is not currently in use by another application. 2. The device connected to the COM port has not been recognised as a CSR µEnergy device.
Device not responding.	The pairing process has timed out due to: 1. The device has been disconnected from the COM port. 2. The device connected to the COM port has not been recognised as a CSR µEnergy device. 3. The device connected to the COM port is not running either the Host or Key Fob application.
Two devices with the same roles have been detected. Aborting the pairing process...	Both the devices connected to the COM ports have the same role. Ensure one is the Host and the other the Key Fob.
Configuring the LTK to be used by the <device role> (connected to COM<x>) failed.	The device connected to the COM port has failed to configure the LTK. See the *KES Automotive Host Application Note* or *KES Automotive Key Fob Application Note* for more details.
Failed to configure the <device role>'s BT address to be used by the <complementary device role>.	The device with the role specified by <complementary device role> sent an error response to the request to set the Bluetooth address of the device in the role <device role>. To know the reasons for the device sending an error response, see the particular device's application note.
Failed to query the role of the device connected to COM<x>	The connection to the device connected to COM<x> has been closed by the application.
Failed to retrieve the Bluetooth address of the <device role> (connected to COM<x>).	
Configuring the LTK to be used by the <device role> (connected to COM<x>) failed.	
Failed to configure the <device role>'s BT address to be used by the COM<x>.	

Table B.1: Pairing Fault Diagnosis

Document References

Document	Reference
KES Automotive Host Application Note	CS-307920-AN
KES Automotive Key Fob Application Note	CS-309402-AN
Long Term Key (LTK) Application Note	CS-301410-AN
CSR µEnergy xIDE User Guide	CS-212742-UG
CSR µEnergy Bluetooth USB Dongle Driver Installation User Guide	CS-315781-UG
CSR µEnergy Modifying an Application to Support OTA Update Application Note	CS-304564-AN
CSR µEnergy Over-the-Air (OTA) Update System Application Note	CS-316019-AN
Over-the-Air Update Application and Bootloader Services Specification	CS-316220–SP
Interfacing Large Serial Flash and EEPROM Application Note	CS-324434-AN

Terms and Definitions

ATT	Attribute Protocol
BLE	Bluetooth Low Energy, a Bluetooth technology designed for ultra-low power consumption
BlueCore®	Group term for CSR's range of Bluetooth wireless technology chips
Bluetooth®	Set of technologies providing audio and data transfer over short-range radio connections
BT	Bluetooth
COM	Communication port
CSR	Cambridge Silicon Radio
DK	Development Kit
EEPROM	Electrically Erasable Programmable Read Only Memory
e.g.	*exempli gratia*, for example
etc	*et cetera*, and the rest, and so forth
GAP	Generic Access Profile
GATT	Generic Attribute Profile
GUI	Graphical User Interface
IDE	Integrated Development Environment
i.e.	*Id est*, that is
KES	Keyless Entry System
LM	Link Manager
LTK	Long Term Key
NVM	Non Volatile Memory
OTA	Over The Air
PC	Personal Computer
PIO	Programmable Input Output
RSSI	Received Signal Strength Indication
SDK	Software Development Kit
SIG	Special Interest Group
SPI	Serial Peripheral Interface
Tx	Transmit
UART	Universal Asynchronous Receiver Transmitter
USB	Universal Serial Bus