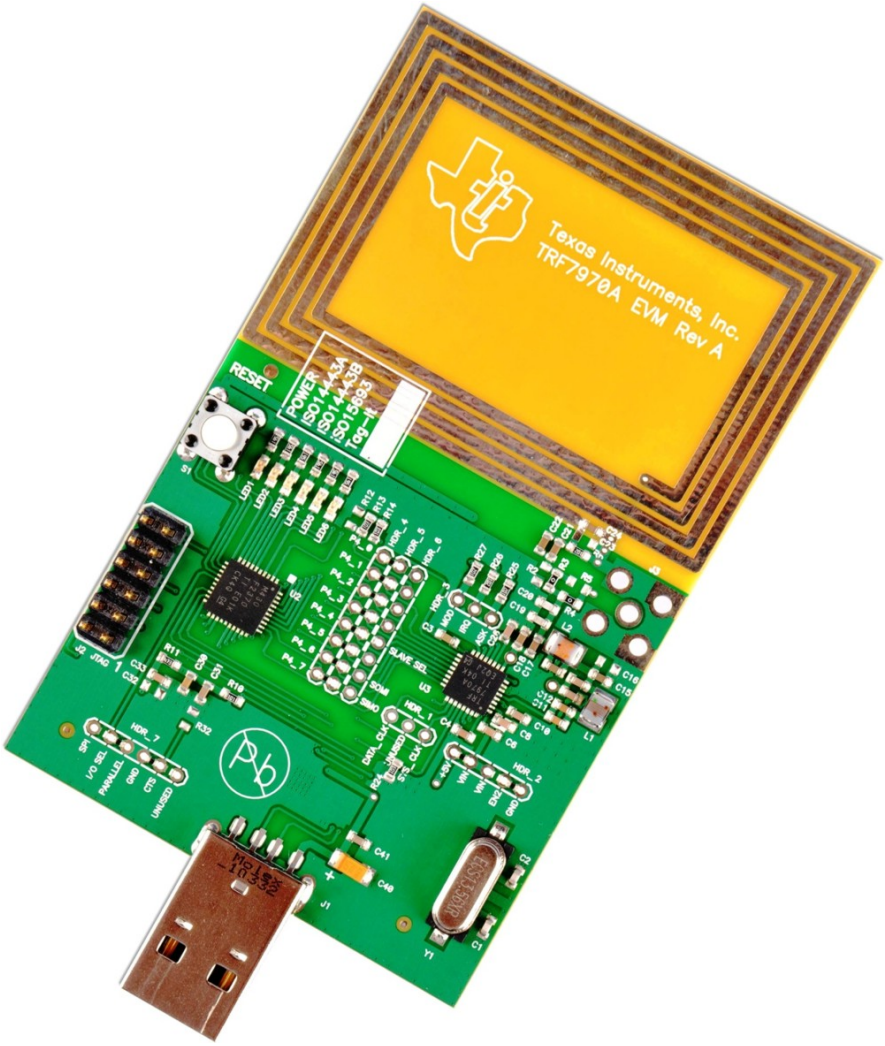
User's Guide
SLOU321–August 2011

TRF7970A Evaluation Module (EVM)

The Texas Instruments TRF7970A evaluation module (EVM) is intended to be used by to demonstrate the capabilities of the TRF7970A and help aid in the development process by providing a working hardware/firmware reference example for traditional HF (13.56 MHz) RFID and also NFC Forum operations.

This manual includes a list of EVM features, a brief description of the module, EVM specifications, details on connecting and using the EVM, and a discussion of the software interface for the EVM.



Contents

List of Figures

List of Tables

1 TRF7970A EVM Description

The TRF7970A EVM features include:

- Support for:
  - ISO15693 standard based transponders
  - ISO14443 standard based transponders (Types A and B)
  - NFC Forum modes (RFID reader\writer, peer to peer, and card emulation)
- FeliCa™ based transponders (UID read only)
- Standalone polling mode for quick demonstration of transponder detection
- Communication with host software graphical user interface (GUI) via USB VCP

The TRF7970A EVM also has the following hardware features specifically for development purposes:

- MSP430F2370 ultra-low power microcontroller with JTAG connectivity to development environment for custom firmware development.
- Parallel or SPI connectivity via 0-Ω jumpers
- Logic analyzer/oscilloscope test points for relevant signal observation during code development
- SMA (edge mount and through-hole) pads for connecting customer designed magnetic dipole circuit

NOTE: Onboard antenna circuit should be disconnected by removing R3 beforehand to maintain 50-Ω impedance.

1.1 Default Configuration

As shipped, the TRF7970A EVM is fully functional as an RFID/NFC Forum reader/writer, NFC Forum Initiator or NFC Forum Target. To evaluate the TRF7970A beyond the standalone mode, which only requires that power be applied via the USB connector, the TRF7970A EVM GUI must be used.

CAUTION

The TRF7970A EVM contains components that can be potentially damaged by electrostatic discharge. Always store and transport the EVM in the supplied ESD bag when not in use. Always handle the TRF7970A EVM in an ESD controlled environment. For more information regarding proper ESD handling procedures see the *Electrostatic Discharge (ESD)* application report, SSYA008.

1.2 Hardware Description

As shown in Figure 1, the TRF7970A EVM is a self contained development platform which can be used to independently evaluate/test the performance of the TRF7970A IC, custom firmware, customer designed magnetic dipole antennas and/or potential transponders for a customer defined RFID/NFC Forum application. The TRF7970AEVM is configured from the factory in parallel communication mode between the MSP430F2370 and the TRF7970A via 0-Ω resistors between HDR_4 and HDR_5 pads. On power up, the preloaded MSP430F2370 firmware also checks the voltage level of P2.3 (pin 15), which is factory configured at HDR_7 to have I/O_SEL connected to Parallel connection via a 0-Ω resistor. If the user wants to change to SPI with Slave Select operation, all that is needed is to move all the 0-Ω resistors connecting HDR_4 and HDR_5 together over so HDR_5 and HDR_6 are connected as well as moving 0-Ω resistor over on HDR_7 so that I/O_SEL and SPI connected instead. The preloaded MSP430 firmware handles either hardware configuration case, parallel or SPI with SS.

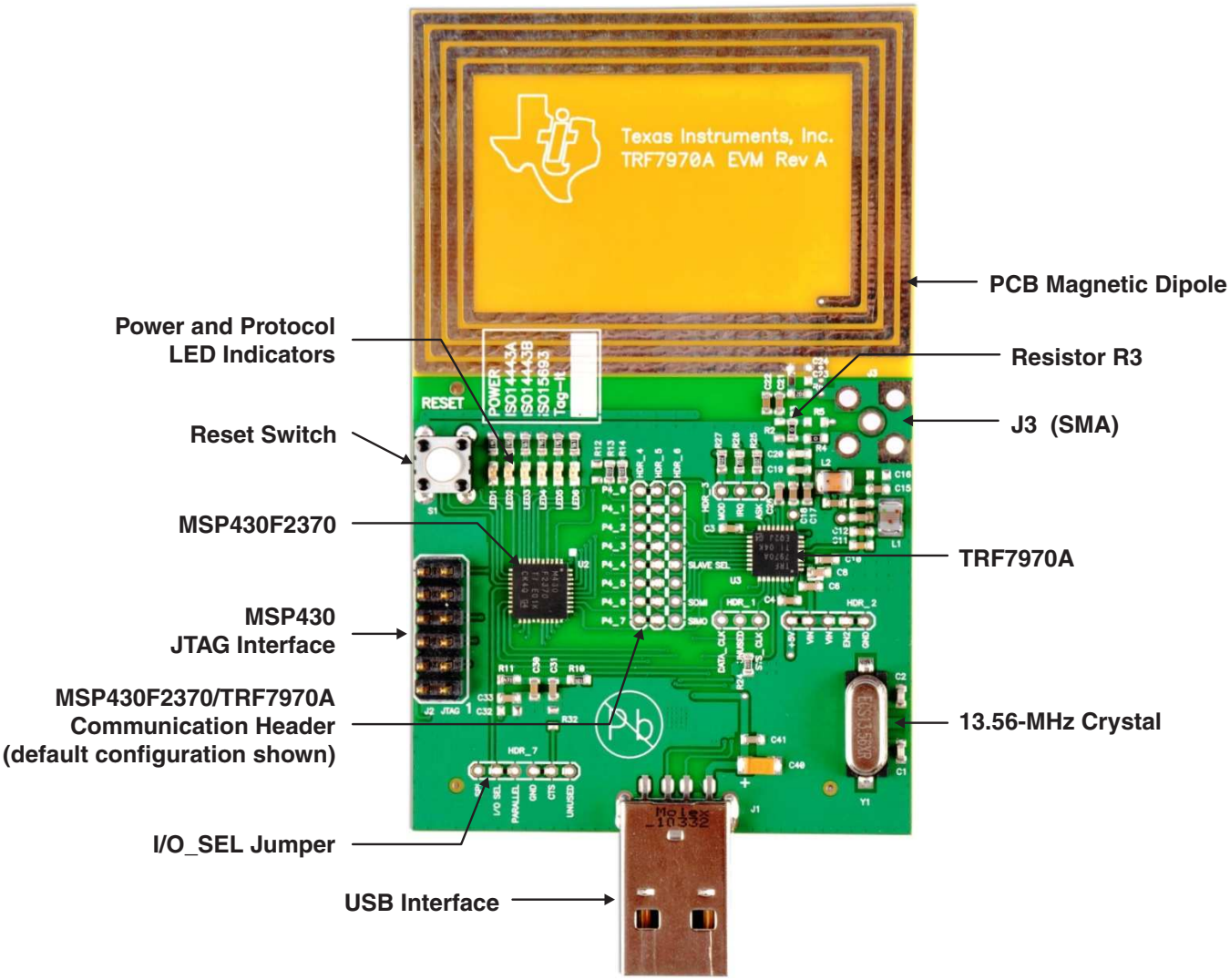


Figure 1. TRF7970A EVM (Top Side)

If a logic analyzer is to be connected to the TRF7970A EVM, the user can install three-position 2-mm board headers at positions HDR_1 and HDR_3 for observation of DATA_CLK and IRQ signals. An 8-position 2-mm board header can be installed at position HDR_5 for observation of the parallel or SPI signals between the MSP430F2370 and the TRF7970A. See the PCBA silkscreen or Table 1 and Table 2 for reference.

Table 1. Logic Analyzer Connection Points on EVM at HDR_5

HDR_5 Pin	Parallel Name	SPI With SS Name	SPI Without SS Name
P5_7	I/O_7	MOSI	MOSI
P5_6	I/O_6	MISO	MISO
P5_5	I/O_5		
P5_4	I/O_4	Slave Select	
P5_3	I/O_3		
P5_2	I/O_2	VDD_I/O voltage level (VDD_X on EVM)	VDD_I/O voltage level (VDD_X on EVM)
P5_1	I/O_1		GND
P5_0	I/O_0	GND	GND

Table 2. Logic Analyzer Connection Points on EVM at HDR_1, HDR_3 and HDR_2

HDR_3 Pin	Parallel Name	SPI With SS Name	SPI Without SS Name
P2	IRQ	IRQ	IRQ
HDR_2 Pin	**Parallel Name**	**SPI With SS Name**	**SPI Without SS Name**
P5	GND	GND	GND
HDR_1 Pin	**Parallel Name**	**SPI With SS Name**	**SPI Without SS Name**
P1	DATA_CLK	DATA_CLK	DATA_CLK

It is also possible to disconnect the MSP430F2370 from the TRF7970A and utilize the above mentioned headers to wire in MCU of choice (for example, other members of the MSP430™, Stellaris™ Cortex™-M3, or Sitara™ ARM8™/ ARM9™ families)

Resistor R3 (0 Ω) makes the electrical connection between the 50-Ω impedance matching circuit from the TRF7970A to the onboard magnetic dipole antenna circuit, also matched to 50 Ω. When testing application specific antennas using J3 (SMA port), disconnect or remove R3 to maintain 50-Ω impedance out from the TRF7970A circuitry to the application specific antenna being tested (see Figure 1).

1.3 Standalone Mode Description

The TRF7970A EVM has a standalone mode in which when power is applied (via the USB connector), then the preloaded MSP430F2370 firmware initializes the TRF7970A IC for full power operation, illuminates the power LED, and begins a polling loop for ISO15693, ISO14443A, and ISO14443B transponders.

When any (or all) of these types of transponders are presented to the onboard antenna, the corresponding LED is illuminated (see silkscreen or actual TRF7970A PCBA in kit or in Figure 1). The TRF7970A EVM kit comes with a sample selection of Texas Instruments ISO15693 transponders.

When the TRF7970A EVM is connected to a PC and the TRF7970A EMV GUI is started, the preloaded MSP430F2370 firmware detects this, stops the polling loop, and turns off any protocol LEDs that were illuminated to take direct host commands.

1.4 GUI Software Description

The TRF7970A EVM can be used with the TRF7970A EVM PC GUI to demonstrate the traditional RFID reader/writer operations as well as NFC Forum Initiator/Target operations. As the EVM enumerates as a serial port on a PC, the EVM can be used with almost any simple serial terminal based program such as (but not limited to) HyperTerminal, Docklight, or LabVIEW. Using the TRF7970A EVM with the GUI is detailed in Section 2.

2 Using the TRF7970A EVM With PC GUI

2.1 USB Driver

The TRF7970A EVM has SiLabs CP2102 USB to UART Bridge IC onboard. The USB driver needs to be loaded onto the PC being used prior to attempting to start the TRF7970A EVM GUI.

https://www.silabs.com/products/mcu/pages/USBtoUARTbridgeVCPdrivers.aspx

2.2 TRF7970A EVM GUI Startup

The TRF7970A EVM GUI has a COM port auto detect function which is limited to COM ports 1 through 12. This being the case, the user is advised that after plugging in TRF7970A EVM but before starting the GUI, they check the COM port it enumerated on via Windows Control Panel, System, Hardware Tab, Device Manager, Ports, Port Properties, Port Settings and ensure it is within this range and also that the COM port settings are for 115200 bps, 8 data bits, no parity, and 1 stop bit (115200 8N1).

The TRF7970A EVM GUI should be downloaded from http://ti.com, unzipped into dedicated folder, and then executable can be launched. Figure 2 shows the first screen the user will see when executable launches and automatically connects to the TRF7970A EVM.

The user can scroll down in the data log window with the slider bar on the right side to see that the GUI has connected to the TRF7970A EVM.

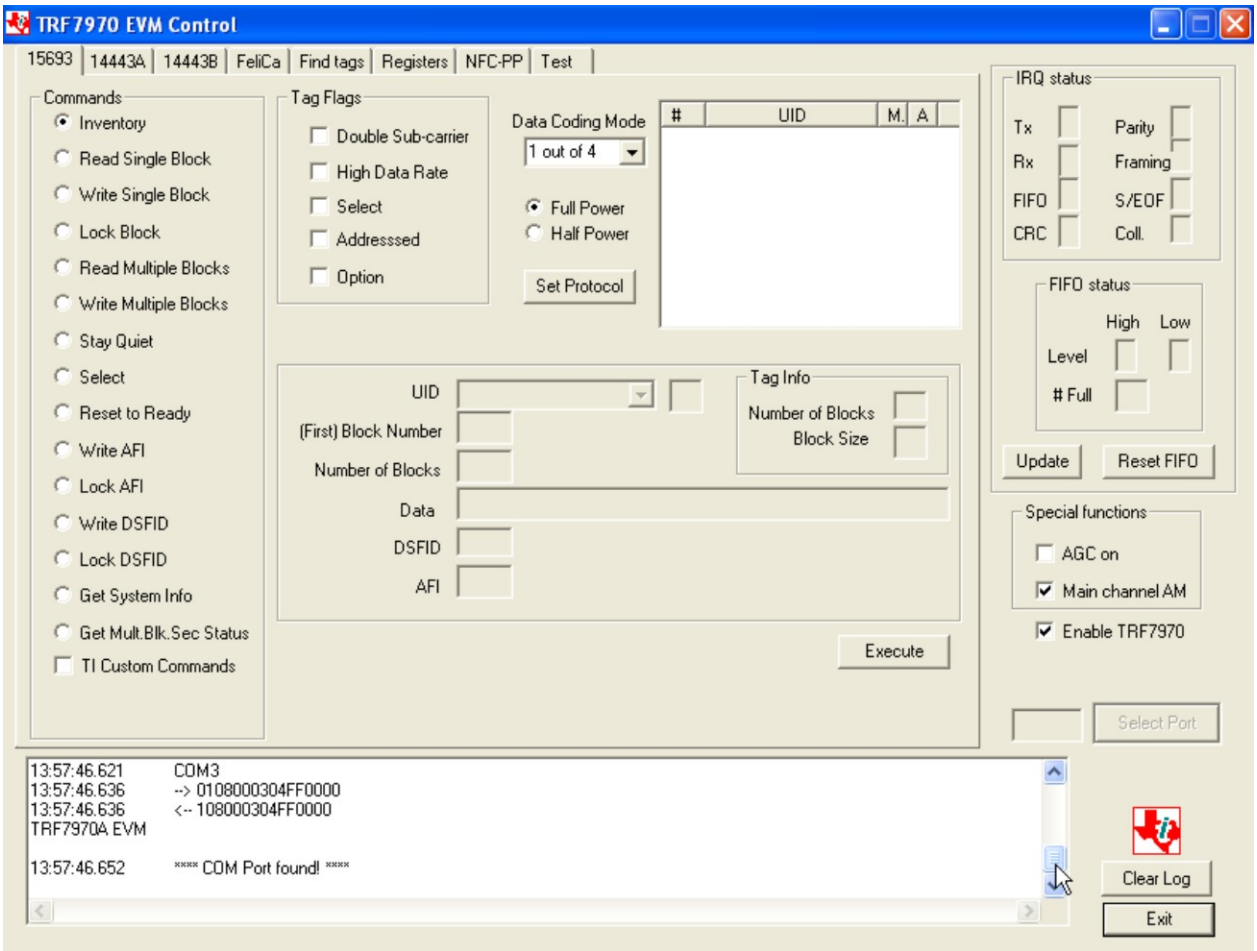


Figure 2. TRF7970A EVM GUI Connected

Figure 2 shows TRF7970A EVM connected to COM3 (as example). The EVM and the GUI are now ready to be used together to demonstrate the RFID reader/writer and NFC Forum operations.

2.3 ISO15693 Tab

By default the TRF7970A EVM GUI starts up with the ISO15693 tab selected. The user should set/select the transponder/tag request flags as appropriate for the given operation (details on this to follow for each command) and by using the Set Protocol button in the GUI first before executing any commands so that the TRF7970A register settings match what is being sent out/expected back to/from the transponder(s) in the field of the EVM antenna. Please note that there are only two mandatory commands in ISO/IEC 15693 standard (Inventory and Stay Quiet). All other available commands are either Optional (as defined by the ISO/IEC 15693 standard) or Custom (as defined by the transponder IC manufacturer by means of the framework outlined in ISO/IEC 15693 standard). The user should always use the transponder/tag IC specific data sheet in conjunction with this guide to ensure settings and commands match what the transponder is designed to support. To avoid any misunderstanding regarding the transponder/tag request flags, see Table 3, Table 4, and Table 5 (taken from the ISO/IEC 15693-3 standard).

Table 3. ISO/IEC 15693 Request Flags (b1 – b4)

Bit	Flag Name	Value	Definition
b1	Sub-carrier_flag	0	A single sub-carrier shall be used by the VICC
		1	Two sub-carriers shall be used by the VICC
b2	Data_rate_flag	0	Low data rate shall be used
		1	High data rate shall be used
b3	Inventory_flag	0	Flags 5 to 8 according to Table 4
		1	Flags 5 to 8 according to Table 5
b4	Protocol Extension_flag	0	No protocol format extension
		1	Protocol format is extended. Reserved for Future Use (RFU)

Table 4. ISO/IEC 15693 Request Flags (b5 – b8) when Inventory Flag is NOT set

Bit	Flag Name	Value	Definition
b5	Select_flag	0	Request shall be executed by any VICC according to the setting of the Address_flag
		1	Request shall be executed by only the VICC in selected state. The Address_flag shall be set to 0 and the UID field shall not be included in the request.
b6	Address_flag	0	Request is not addressed. UID field is not included. It shall be executed by any VICC.
		1	Request is addressed. UID field is included. It shall be executed only by the VICC whose UID matches the UID specified in the request.
b7	Option_flag	0	Meaning defined by command description. It shall be set to 0 if not otherwise defined by the command.
		1	Meaning defined by command description.
b8	RFU	0	RFU

Table 5. ISO/IEC 15693 Request Flags (b5 – b8) when Inventory Flag is set

Bit	Flag Name	Value	Definition
b5	AFI_flag	0	AFI Field is not present
		1	AFI Field is present
b6	Nb_slots_flag	0	16 slots
		1	1 slot
b7	Option_flag	0	Meaning defined by command description. It shall be set to 0 if not otherwise defined by the command.
		1	Meaning defined by command description.
b8	RFU	0	RFU

2.3.1 Inventory (Command Code 0x01)

The ISO/IEC 15693 Inventory command is used to acquire the factory programmed and permanently locked 64 bit unique identifier(s) (UIDs) of transponders that are in within the read zone of the TRF7970A EVM antenna. They are used, as the name implies, to address each VICC uniquely and individually during the anticollision loop and for one to one exchange between a VCD and a VICC. The format of the UID is shown in Table 6.

Table 6. ISO/IEC 15693 UID Format

Byte Position	MSB				LSB	
Bits	64	57	56	49	48	1
Hexadecimal Representation	0xE0		IC Manufacturing Code (TI = 0x07)		IC Serial Number	

As shown in Table 6, the ISO/IEC 15693 standard mandates the MSByte of the UID be 0xE0. The standard also mandates that the IC manufacturing code byte be according to the list shown in ISO/IEC7816-6. The remaining 48 bits (6 bytes) are to be assigned by the IC manufacturer.

There is a slotted ALOHA style anticollision algorithm used for the inventory sequence and as stated above, the purpose is to retrieve the UIDs of the tags in the field. This algorithm does not use timeslots but rather is keyed off nibbles of the UID, starting with the lower half of the LSByte and as collisions are detected, a mask value is incremented until the collisions seen by the VCD are arbitrated.

As indicated above by bit 6 of Table 5, the Inventory command can be issued either as a single slot command or a sixteen slot command. If the command is issued as a single slot and there are two or more transponders in the field only a collision will be indicated and no arbitration will take place. This is useful in applications where only one transponder is allowed to be in the field at a time as the detection of a collision would be considered quite useful.

Another technique of pre-sorting transponders that will be present in the field is to pre-program different AFI values on the transponders, then issue the inventory command (single or sixteen slot) with one of those values in the AFI field and also indicate that this field is present via the request flags (see Table 5, bit 5). Only the tags with the corresponding AFI value respond. See Section 2.3.10 and the ISO/IEC 15693-3 Standard for more information.

To perform single slot inventory using the GUI:

1. Select the radio button for Inventory.
2. Select Tag Flags accordingly (see Figure 3 for one example).
3. Click Set Protocol.
4. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
5. Click Execute.

See Figure 3 and Figure 4 for example results of one tag in field and a collision between two tags, respectively.

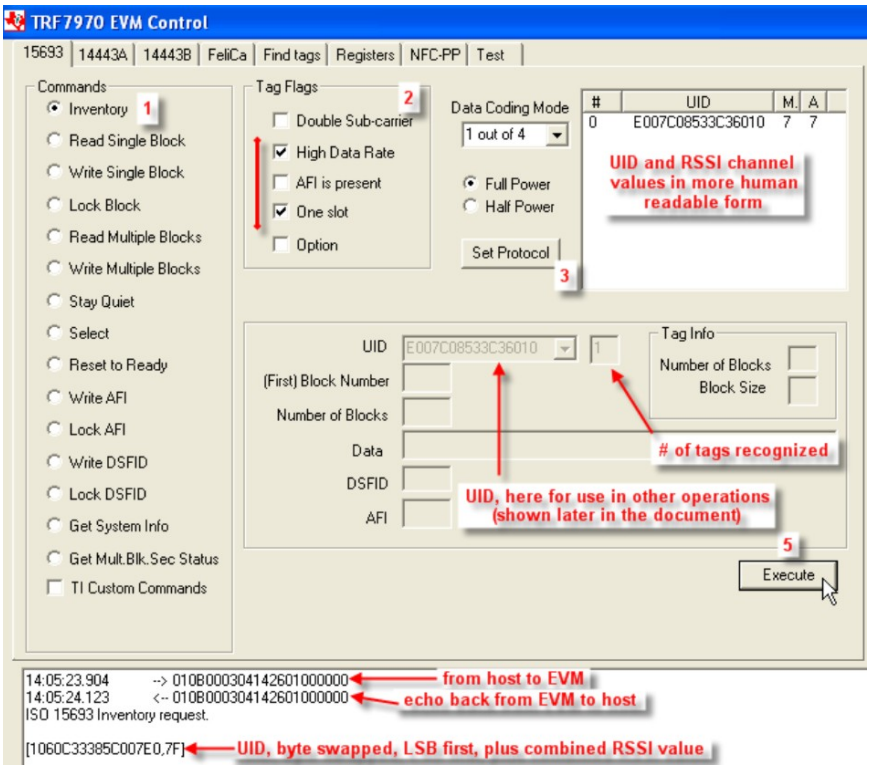


Figure 3. Single Slot Inventory Command (One Tag in Field)

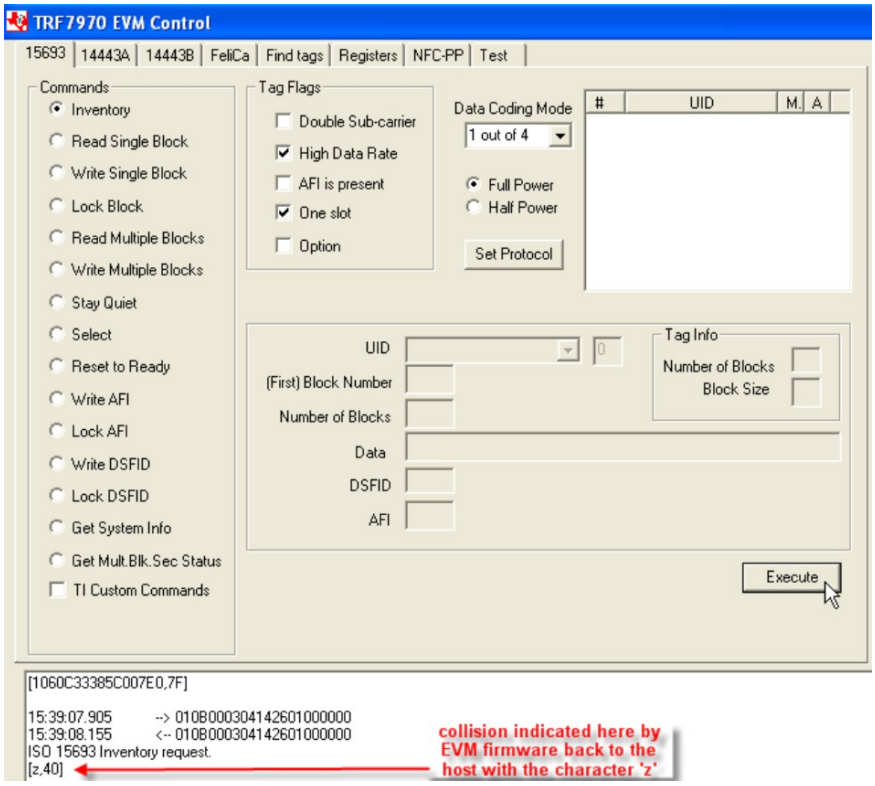


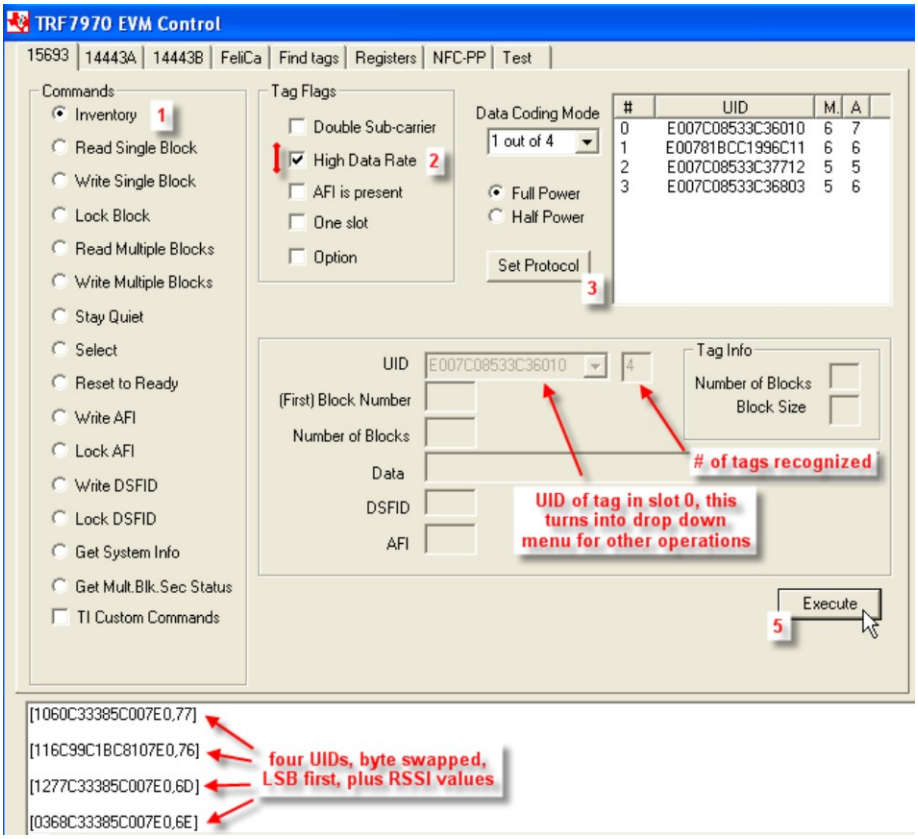
Figure 4. Single Slot Inventory Command (Two Tags in Field/Collision)

In time sensitive applications in which the number of tags that are presented to the field should be one at one time but could be from 1 to n, polling or looking for tags using the single slot method first might be effective. If a collision is detected, the firmware could then change the tag request flags to sixteen slot method and then proceed as described here.

To perform sixteen slot Inventory using the GUI:

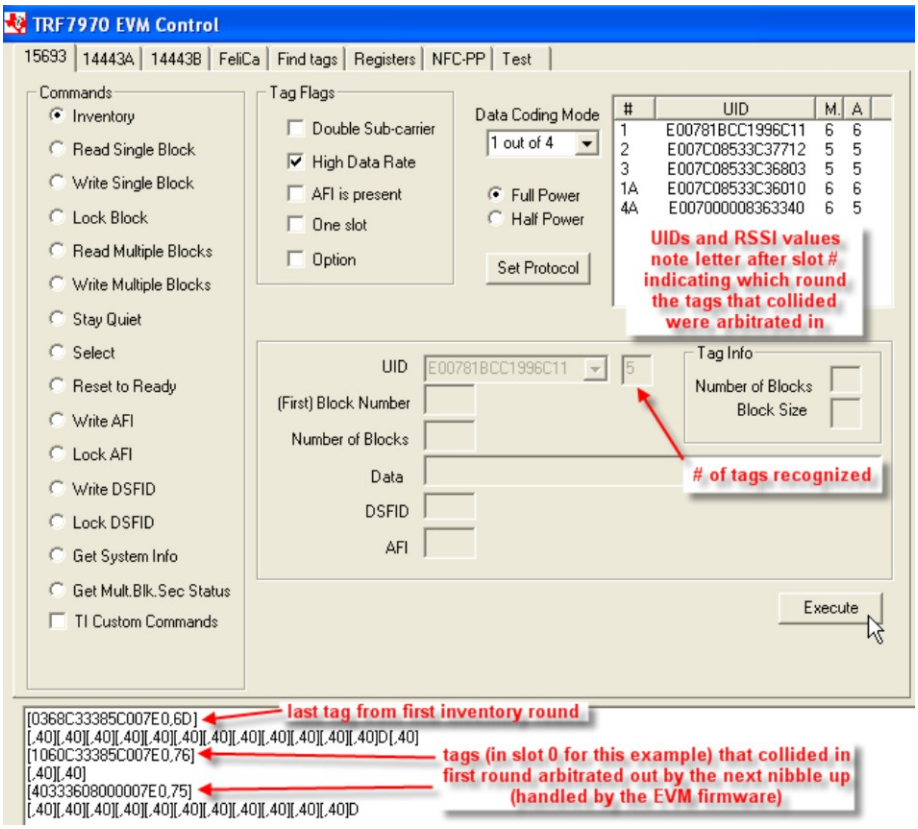
1. Select the radio button for Inventory.
2. Select the Tag Flags accordingly (see Figure 5 for one example).
3. Click Set Protocol.
4. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
5. Click Execute.

See Figure 5 and Figure 6 for example results of multiple tags in the field without and with collisions, respectively.



NOTE: For graphics brevity, only four tags are shown.

Figure 5. Sixteen Slot Inventory Command (Four Tags in Field With No Collision)



NOTE: For graphics brevity, only five tags are shown.

Figure 6. Sixteen Slot Inventory Command (Five Tags in Field, Collision in Slot 0)

2.3.2 Read Single Block (Command Code 0x20)

The Read Single Block Command is an optional command that requests one block of user memory data from a VICC, with the block number specified in the request. If the Option_flag is set in the request, the VICC also will return the block security status. This command can be sent as an addressed or unaddressed request.

To perform Read Single Block using the GUI:

1. Select the radio button for Read Single Block.
2. Select Tag Flags accordingly (see Figure 7 for one example).
3. Click Set Protocol.
4. Enter the Block number to be read (in hex).
5. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
6. Click Execute.

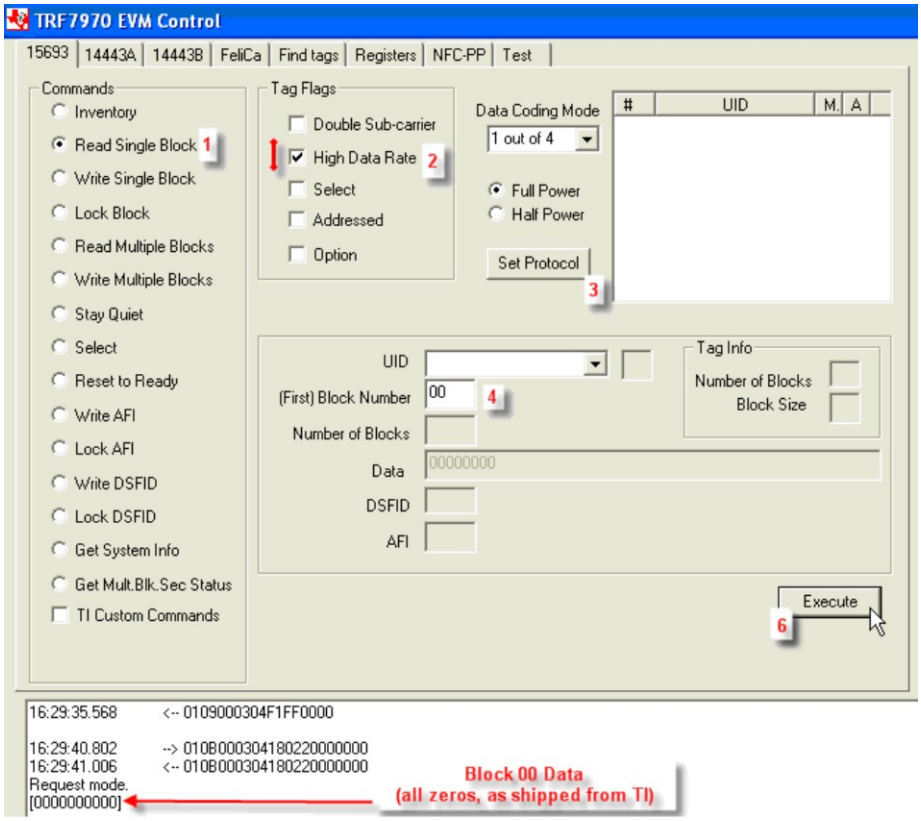


Figure 7. Read Single Block Command Example

2.3.3 Write Single Block (Command Code 0x21)

The Write Single Block Command is an optional command that writes one block of user memory data on a VICC, with the block number and the block data specified in the request. For TI, TI based, and some other manufacturers' VICCs, the Option_flag must be set in the request. This command can be sent as an addressed or unaddressed request, and the VICC returns an error/no error response after the write operation has been completed.

To perform Write Single Block using the GUI:

1. Select the radio button for Write Single Block.
2. Select Tag Flags accordingly (see Figure 8 for one example, and note use of option flag).
3. Click Set Protocol.
4. Enter the Block number to be written (in hex).
5. Enter the Data to be written (in hex).
6. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
7. Click Execute.

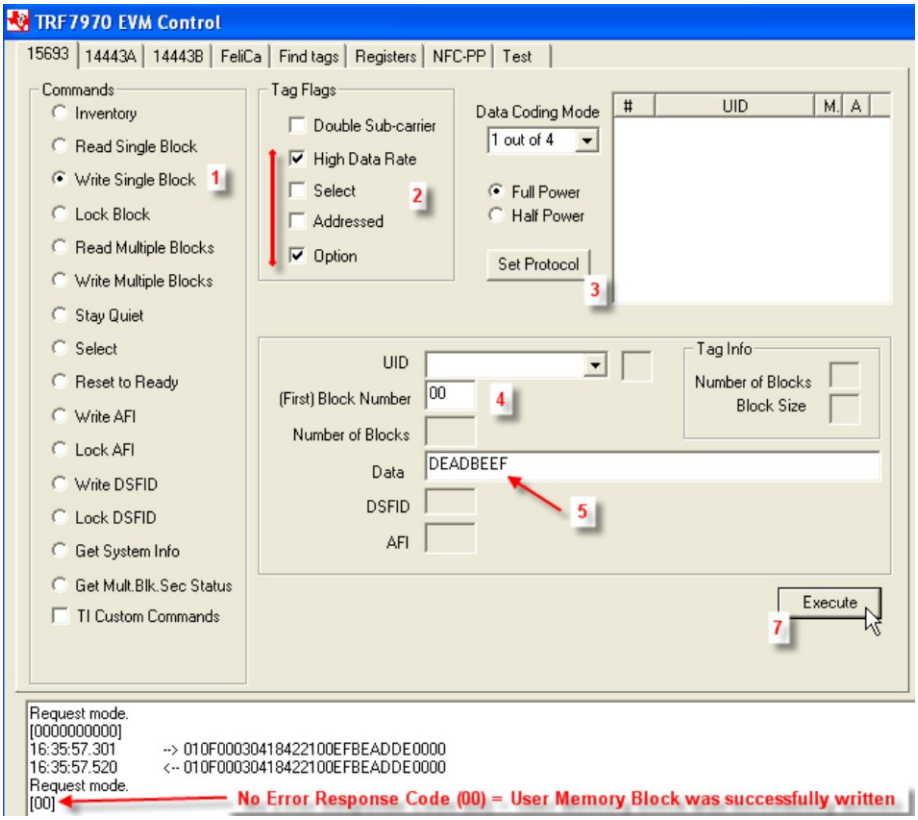


Figure 8. Write Single Block Command Example

2.3.4 Lock Block (Command Code 0x22)

The Lock Block Command is an optional command that locks one block of user memory data on a VICC, with the block number specified in the request. For TI, TI based, and some other manufacturers' VICCs, the Option_flag must be set in the request. This command can be sent as an addressed or unaddressed request, and the VICC returns an error/no error response after the lock operation has been completed.

To perform Lock Block using the GUI:

1. Select the radio button for Lock Block.
2. Select Tag Flags accordingly (see Figure 9 for one example, and note use of option flag)
3. Click Set Protocol.
4. Enter the Block number to be locked.
5. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
6. Click Execute.

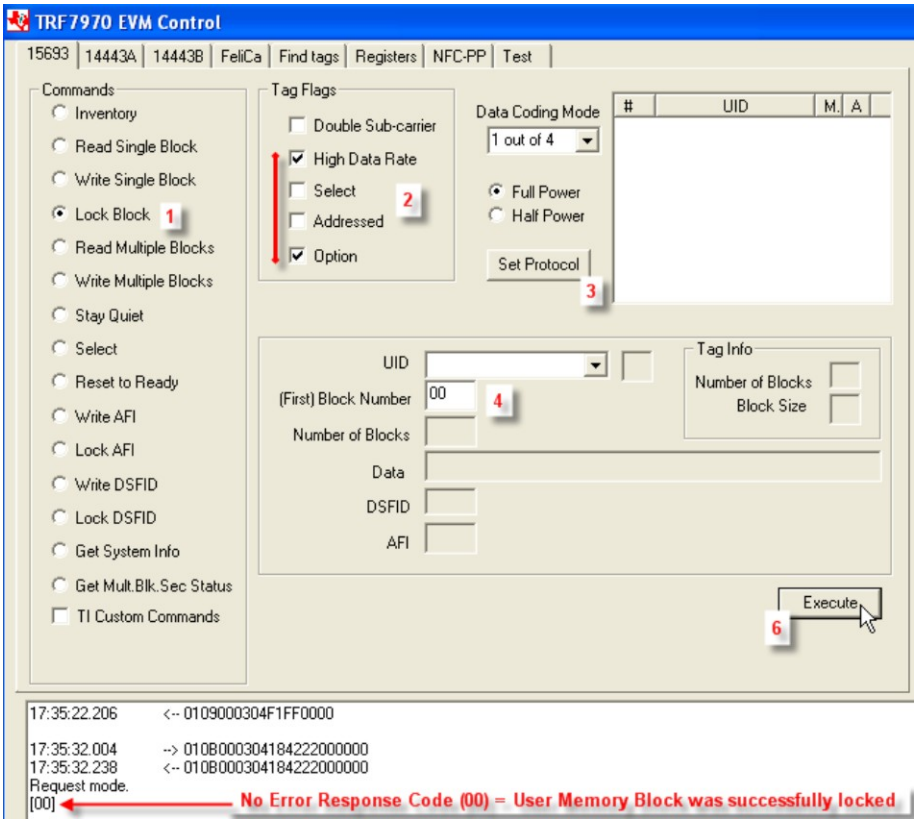


Figure 9. Lock Block Command Example

2.3.5 Read Multiple Blocks (Command Code 0x23)

The Read Multiple Blocks command is an optional command that requests more than one block of user memory data from a VICC at a time, with the first block number and the number of blocks specified in the request. This command can be sent as an addressed or unaddressed request. If the Option_flag is set in the request, the VICC also will return the block security status, followed by the block value, sequentially.

To perform Read Multiple Blocks using the GUI (after connecting) the user should:

1. Select the radio button for Read Multiple Blocks
2. Select Tag Flags accordingly (see Figure 10 for one example)
3. Click Set Protocol.
4. Enter First Block number to be read
5. Enter number of blocks to be read (n-1)
6. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
7. Click Execute

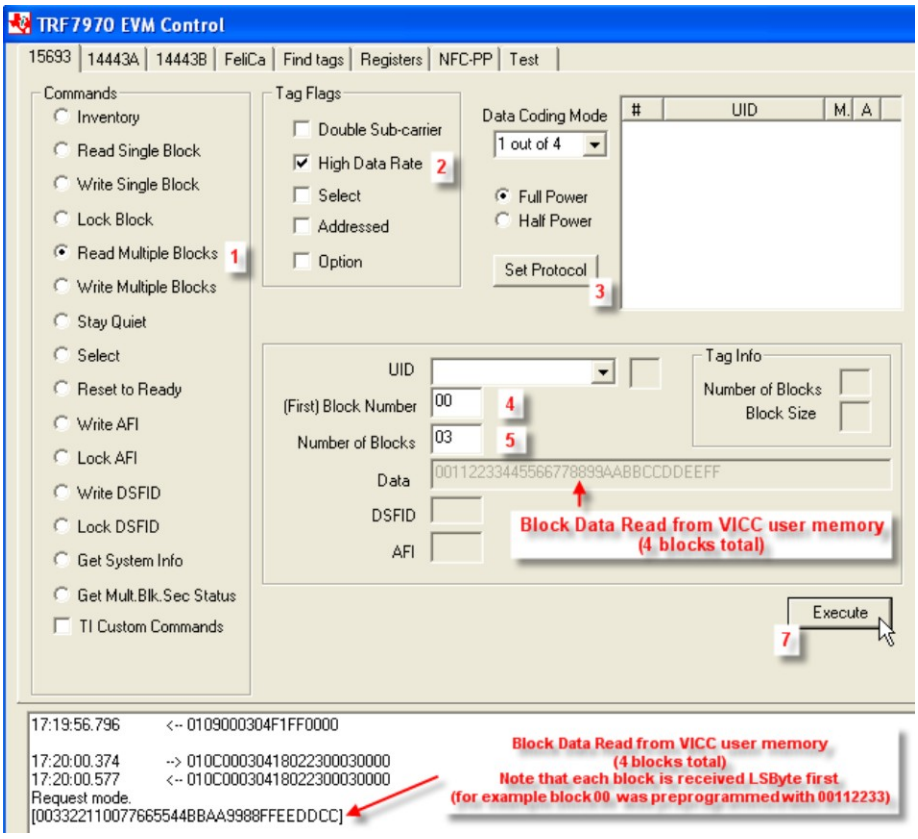


Figure 10. Read Multiple Blocks Command Example

2.3.6 Write Multiple Blocks (Command Code 0x24)

This optional command is not currently known to be supported by any ISO/IEC 15693 transponders available.

2.3.7 Stay Quiet (Command Code 0x02)

The Stay Quiet command is a mandatory command which instructs the VICC to enter the quiet state. The command is always issued as an addressed command and of course there is no response to the Stay Quiet Command. The VICC exits the quiet state when the transponder exits the field, receives a Reset to Ready command or a Select request.

To perform Stay Quiet command using the GUI:

1. Perform Inventory command (see Section 2.3.1) to obtain UID of VICC
2. Leave tag/transponder in field
3. Select the radio button for Stay Quiet
4. Select Tag Flags accordingly (see Figure 11 for one example)
5. Click Set Protocol. (if Data Rate or Sub-carrier Tag Request Flags are changed)
6. Click Execute

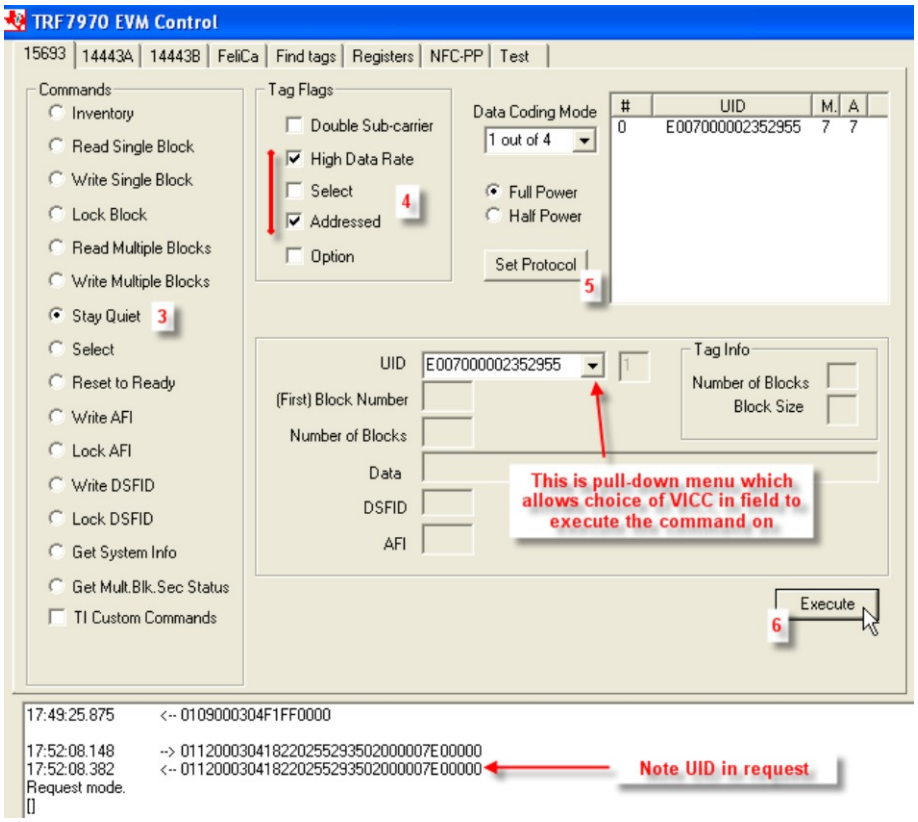


Figure 11. Stay Quiet Command Example

2.3.8 Select (Command Code 0x25)

The Select command is an optional command that is always issued as an addressed command. If the UID sent as the address in the request matches the UID of the VICC, the VICC will enter the Selected state. The intention of the Select Command is that only one VICC in the field should be in the Selected state at any one time.

To perform Select command using the GUI:

1. Perform sixteen slot Inventory command (see Section 2.3.1) to obtain UIDs of VICCs.
2. Leave VICCs in field.
3. Perform Stay Quiet command on each transponder (see Section 2.3.7).
4. Select the radio button for Select.
5. Select from the pulldown menu to choose which one of the tags will be issued the Select Command.
6. Click Execute.

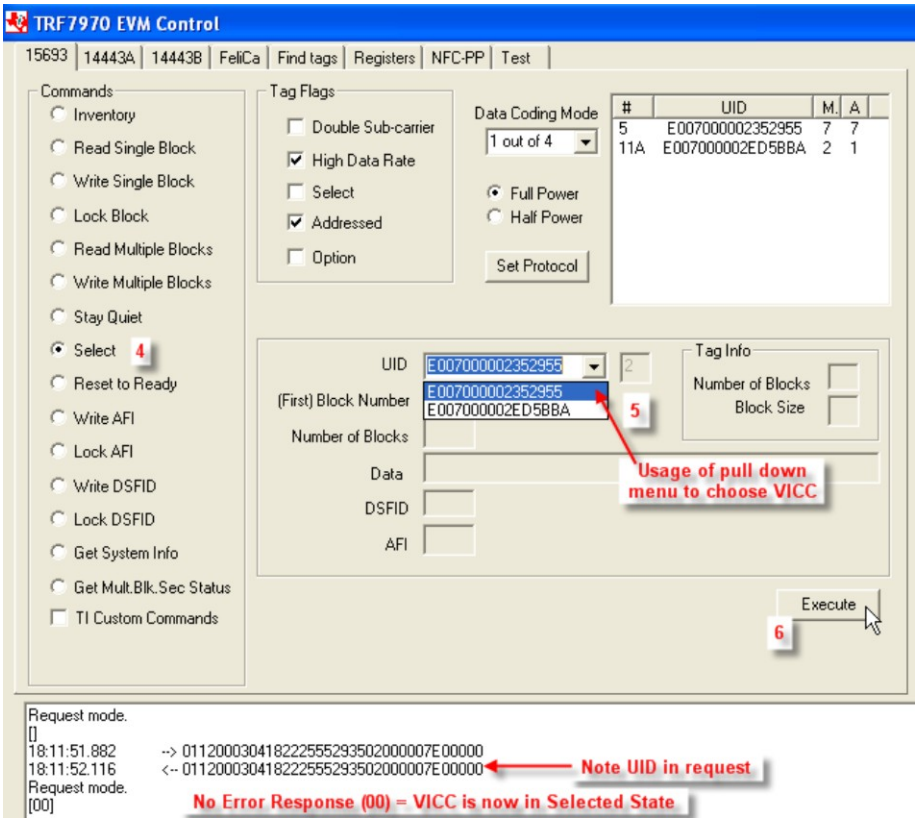


Figure 12. Select Command Example

2.3.9 Reset to Ready (Command Code 0x26)

The Reset to Ready Command is an optional command that returns the VICC(s) in the Quiet state to the Ready state. This command can be sent as an addressed or unaddressed request and the same end result can also be achieved by turning off the activating field from the VCD or removing the VICC(s) from the activating field.

To perform Reset to Ready command using the GUI:

1. Perform sixteen slot Inventory command (see Section 2.3.1) to obtain UIDs of VICCs.
2. Leave VICCs in field.
3. Perform Stay Quiet command on each transponder (see Section 2.3.7).
4. Select the radio button for Reset to Ready.
5. Click Execute.

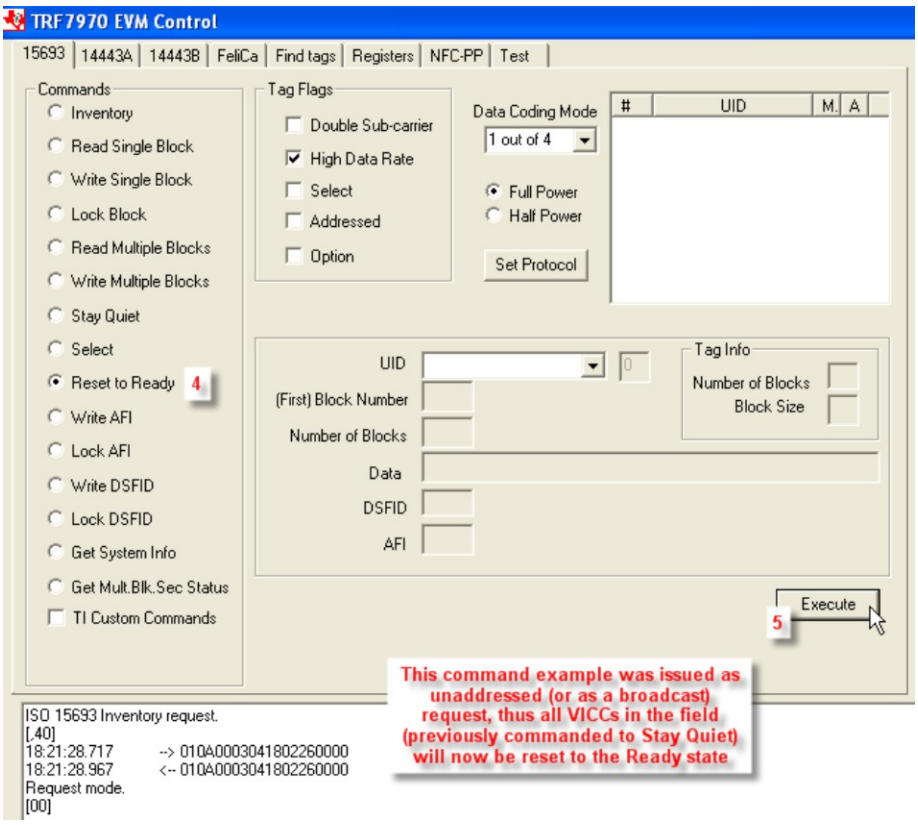


Figure 13. Reset to Ready Command Example

2.3.10 Write AFI (Command Code 0x27)

The Write AFI Command is an optional command that writes a value to the AFI memory block on the VICC. For TI, TI based, and some other manufacturers' VICCs, the Option_flag must be set in the request. This command can be sent as an addressed or unaddressed request, and the VICC returns an error/no error response after the write operation has been completed.

To perform Write AFI using the GUI:

1. Select the radio button for Write AFI.
2. Select Tag Flags accordingly (see Figure 14 for one example, note use of option flag)
3. Click Set Protocol.
4. Enter AFI value to be written (in hex).
5. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
6. Click Execute.

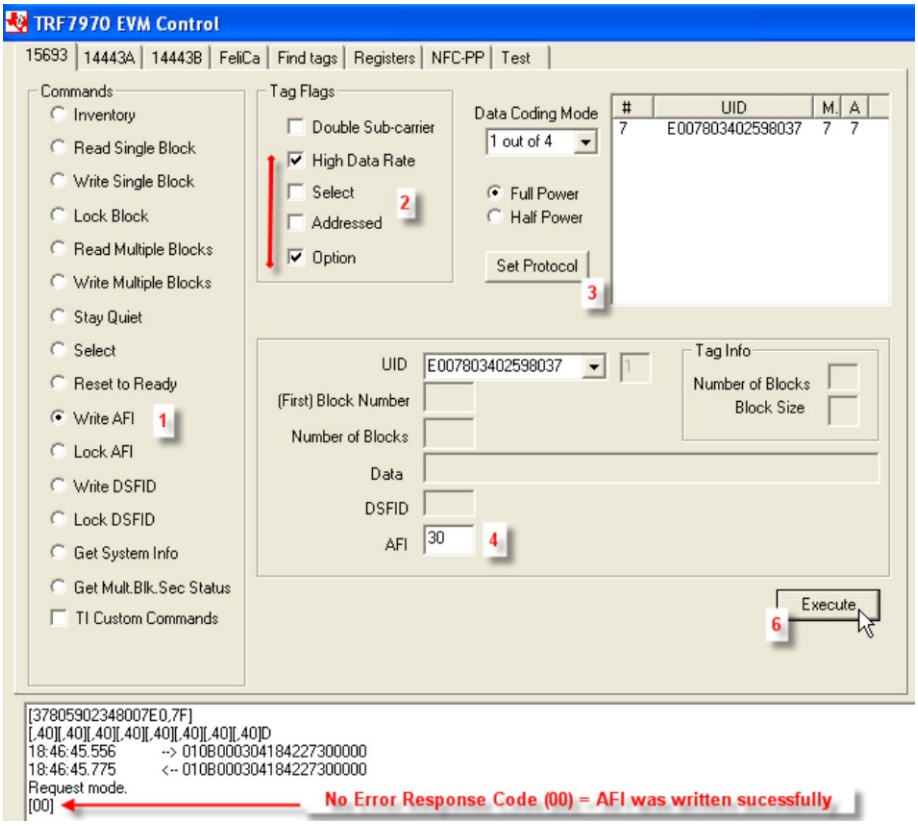


Figure 14. Write AFI Command Example

2.3.11 Lock AFI (Command Code 0x28)

The Lock AFI Command is an optional command that locks the value of the AFI memory block on the VICC. For TI, TI based, and some other manufacturers' VICCs, the Option_flag must be set in the request. This command can be sent as an addressed or unaddressed request, and the VICC returns an error/no error response after the lock operation has been completed.

To perform Lock Block using the GUI:

1. Select the radio button for Lock AFI.
2. Select Tag Flags accordingly (see Figure 15 for one example, note use of option flag).
3. Click Set Protocol.
4. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
5. Click Execute.

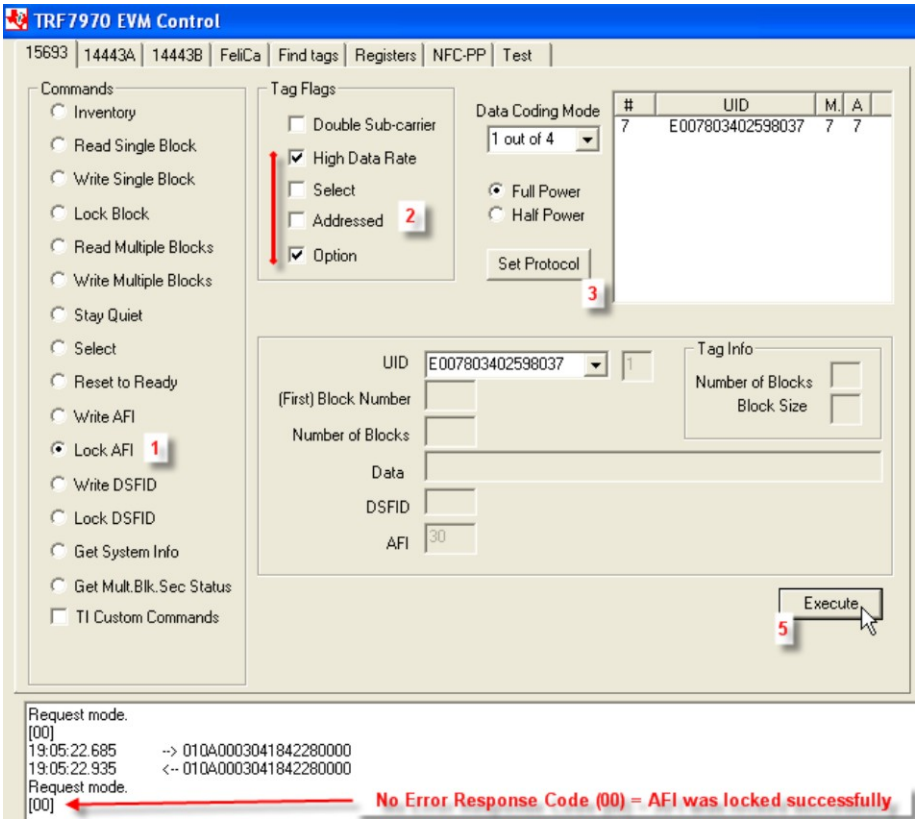


Figure 15. Lock AFI Command Example

2.3.12 Write DSFID (Command Code 0x29)

The Write DSFID Command is an optional command that writes a value to the DSFID memory block on the VICC. For TI, TI based, and some other manufacturers' VICCs, the Option_flag must be set in the request. This command can be sent as an addressed or unaddressed request, and the VICC returns an error/no error response after the write operation has been completed.

To perform Write DSFID using the GUI:

1. Select the radio button for Write DSFID.
2. Select Tag Flags accordingly (see Figure 16 for one example, note use of option flag).
3. Click Set Protocol.
4. Enter Data to be written (in hex).
5. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
6. Click Execute.

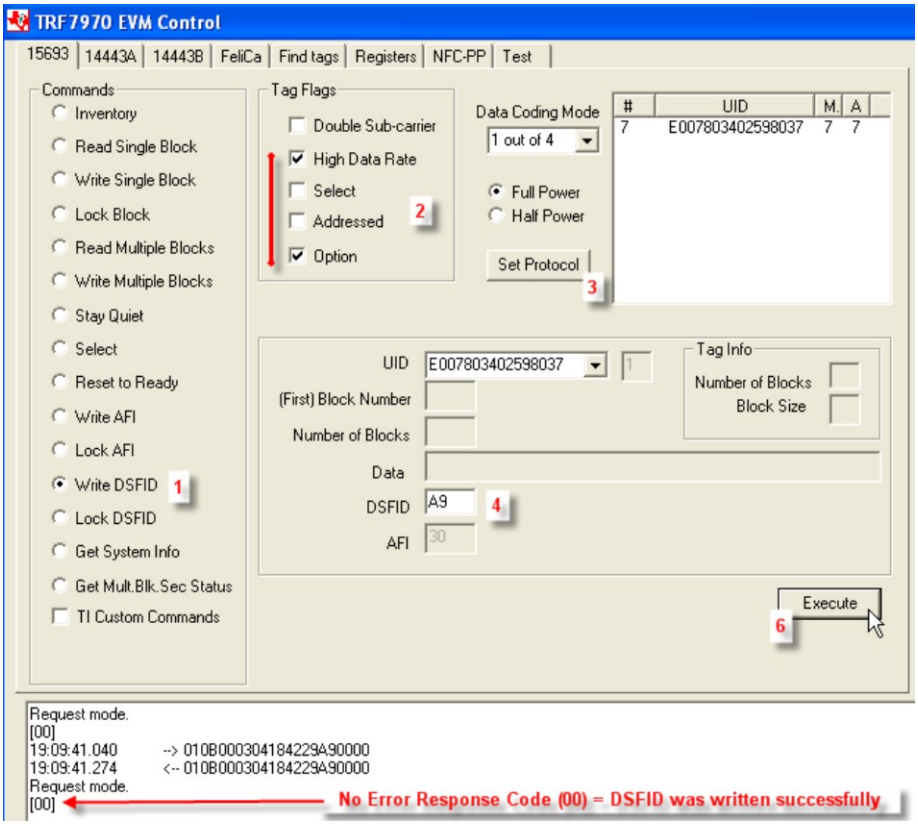


Figure 16. Write DSFID Command Example

2.3.13 Lock DSFID (Command Code 0x2A)

The Lock DSFID Command is an optional command that locks the value of the DSFID memory block on the VICC. For TI, TI based, and some other manufacturers' VICCs, the Option_flag must be set in the request. This command can be sent as an addressed or unaddressed request, and the VICC returns an error/no error response after the lock operation has been completed.

To perform Lock DSFID using the GUI:

1. Select the radio button for Lock DSFID.
2. Select Tag Flags accordingly (see Figure 17 for one example, note use of option flag).
3. Click Set Protocol.
4. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
5. Click Execute.

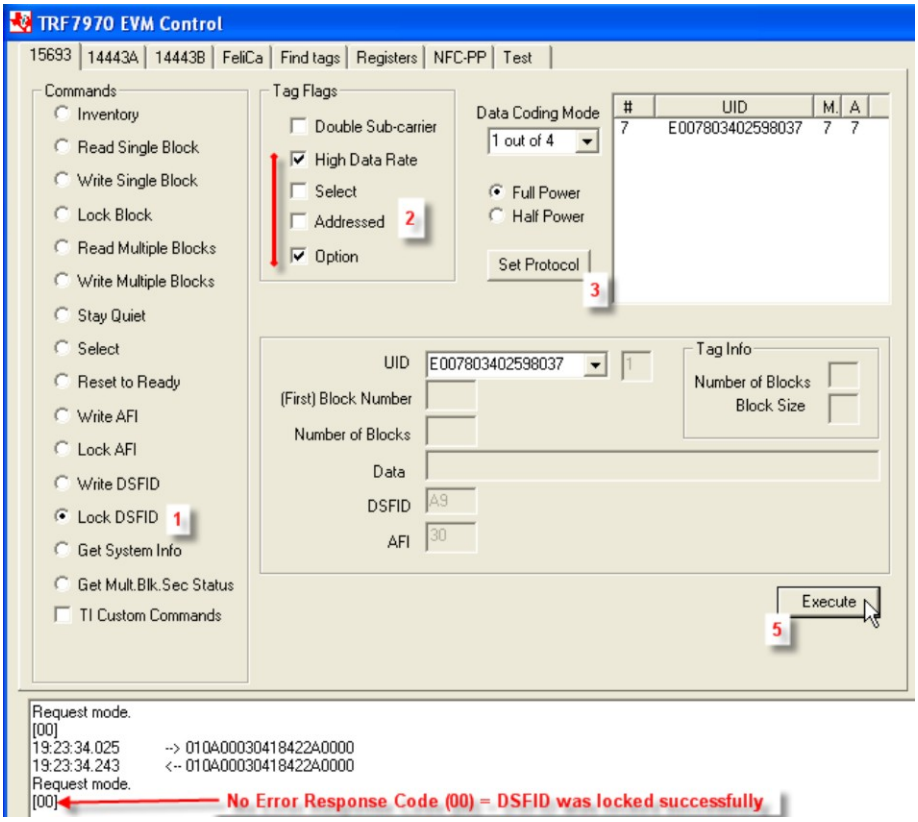


Figure 17. Lock DSFID Command Example

2.3.14 Get System Information (Command Code 0x2B)

The Get System Information Command is an optional command that retrieves the system information values from the VICC information fields. This command can be sent as addressed or unaddressed request. These fields are summary of what is and is not supported on the tag, what the user memory size of the VICC is, and if there is an IC reference field. The IC reference field is defined by the VICC IC manufacturer.

To perform Get System Information using the GUI:

1. Select the radio button for Get System Info.
2. Select Tag Flags accordingly (see Figure 18 for one example).
3. Click Set Protocol.
4. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
5. Click Execute.

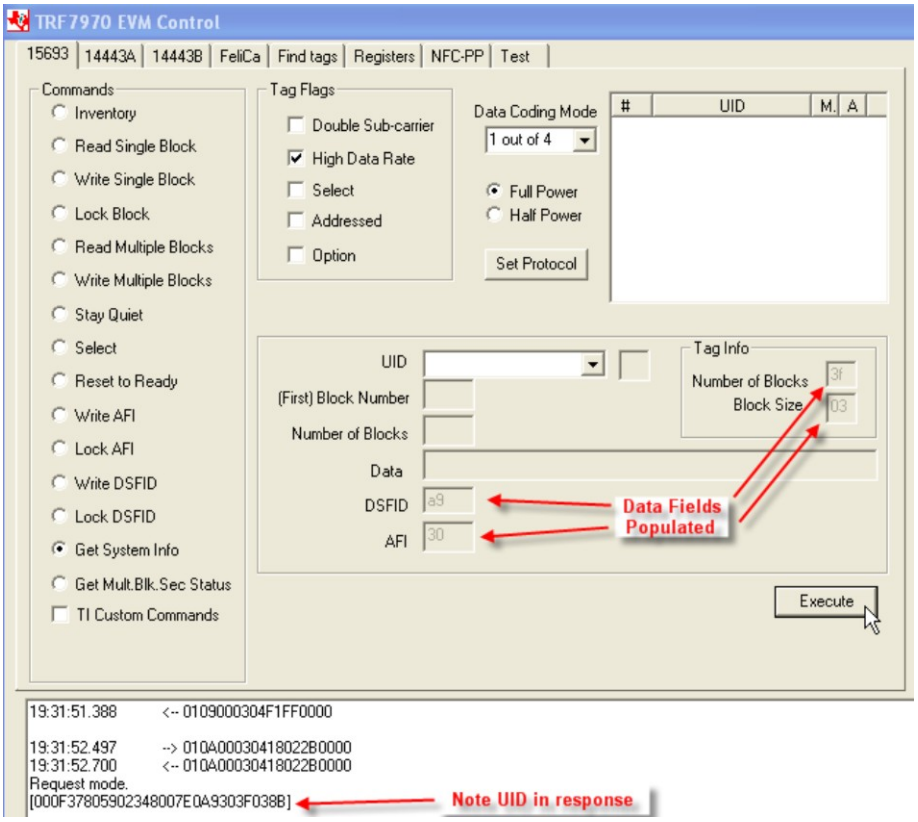


Figure 18. Get System Information Command Example

2.3.15 Get Multiple Block Security Status (Command Code 0x2C)

The Get Multiple Block Security Status Command is an optional command that retrieves the block security status on more than one block at a time, with the first block number and the number of blocks specified in the request. This command can be sent as addressed or unaddressed request.

To perform Get System Information using the GUI:

1. Select the radio button for Get Multiple Block Security Status.
2. Select Tag Flags accordingly (see Figure 19 for one example).
3. Click Set Protocol.
4. Type the first block number.
5. Type the number of blocks.
6. Place tags or transponders near enough to the TRF7970A EVM antenna to be read.
7. Click Execute.

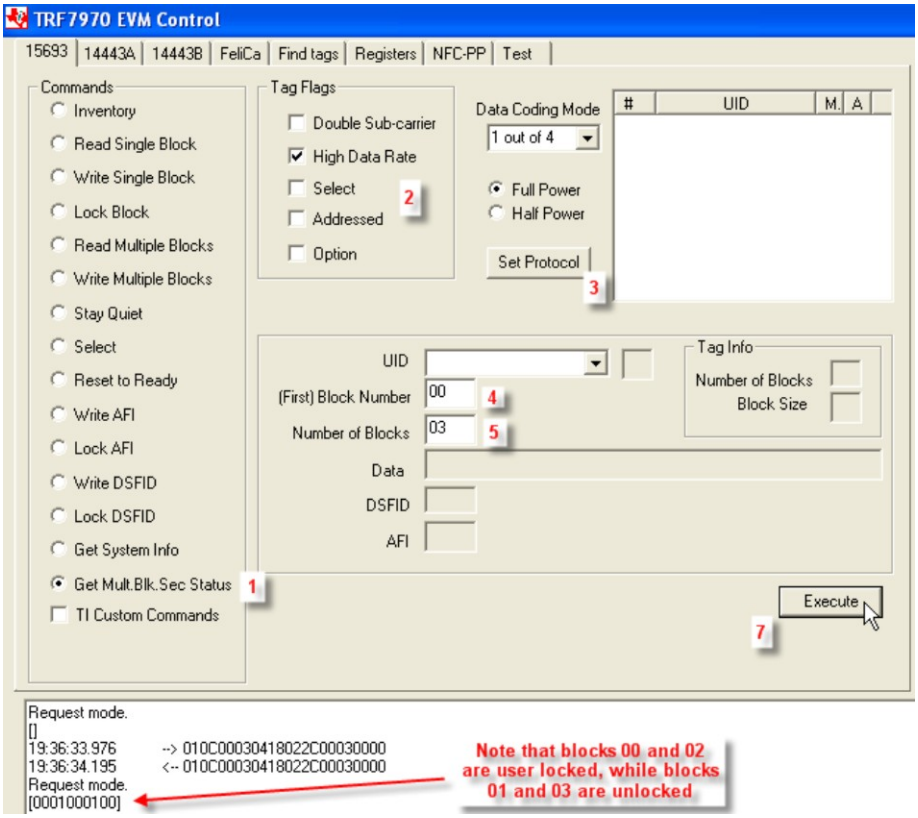


Figure 19. Get Multiple Block Security Status Command Example

2.3.16 TI Custom Commands

The TRF7970A supports the two custom commands that are outlined in the ISO/IEC 15693 standard and defined by Texas Instruments. The format outlined in the standard for custom VICC commands is shown in Table 7. These commands are only supported by TI "Plus" silicon based transponders, which can be identified by part numbers containing RI-xxx-112A.

Table 7. Custom Commands Request Format

SOF	Request Flags	Custom Command Code	Manufacturer Code	Custom Request Parameters	CRC16	EOF
	1 byte	1 byte	1 byte (0x07 = TI)	Custom defined by IC manufacturer	2 bytes (handled by TRF7970A)	

2.3.16.1 Write Two Blocks (Command Code 0xA2)

When receiving the Write 2 Block Command, the transponder programs the requested blocks with the data contained in the request and reports the success of the operation in the response.

The addressed pair of blocks must contain one even and one odd block (for example, block numbers 2 and 3 or block numbers 6 and 7). The start block must have the even address (for example, number2, number4, or number6). If the odd address is used in the start block, the transponder does not execute the write operation and returns the error code 0xA1.

If one or both of the addressed blocks are locked, the transponder does not execute the write operation and returns the error code 0xA2.

The transmitted LSB block data are written to the LSB of the even addressed block (bytes 0-3) and the MSB transmitted data to the odd addressed block (bytes 4-7).

2.3.16.2 Lock Two Blocks (Command Code 0xA3)

When receiving the Lock_2_Block Command, the Transponder shall lock the addressed blocks and report the success of the operation in the Response.

The addressed pair of blocks must contain one even and one odd block (for example, block numbers 2 and 3 or block numbers 6 and 7). The start block must have the even address (for example, number2, number4, or number6). If the odd address is used in the start block, the Transponder does not execute the Lock Block operation and returns the error code 0xA1.

If one or both of the addressed blocks are locked, the VICC returns the error code 0xA2.

2.4 ISO14443A Tab

The ISO14443A tab is used to perform Layer 3 and some Layer 4 operations on ISO14443A PICCs, up to the stage at which transparent data is to be exchanged according to the ISO/IEC144443-4 standard.

2.4.1 Anticollision

In the TRF7970A EVM GUI, this command performs the anticollision loop as outlined in the ISO/IEC14443-3 standard as outlined for one PICC (steps 1-5, flowchart for PCD). The TRF7970A EVM firmware and GUI also have provisions for resolving a collision between two Type A PICCs by using a special combination command (0xE6) and the Test tab. This section demonstrates the remaining steps (6-10) for this operation from the previously mentioned flowchart that occur before the select command is issued.

To perform anticollision loop on one tag using the GUI:

1. Select the radio button for anticollision
2. Click Set Protocol.
3. Place tag or transponder near enough to the TRF7970A EVM antenna to be read.
4. Click Execute.

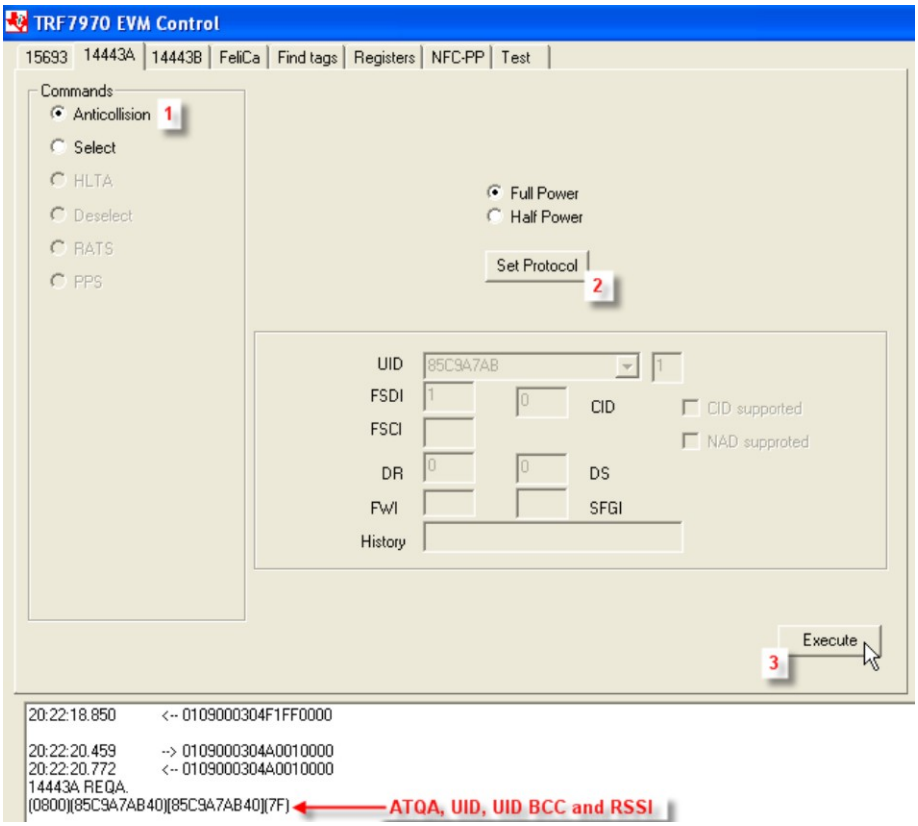


Figure 20. Anticollision Command Example for One Type A PICC

To perform anticollision loop on up to two tags using the GUI:

1. Go to the ISO14443A tab.
2. Click Set Protocol.
3. Go to the Test tab.
4. Type the string *E600* in String to Send window (see Figure 21).
5. Place up to two ISO/IEC14443A PICCs near enough to the TRF7970A EVM antenna to be read.
6. Click Send.

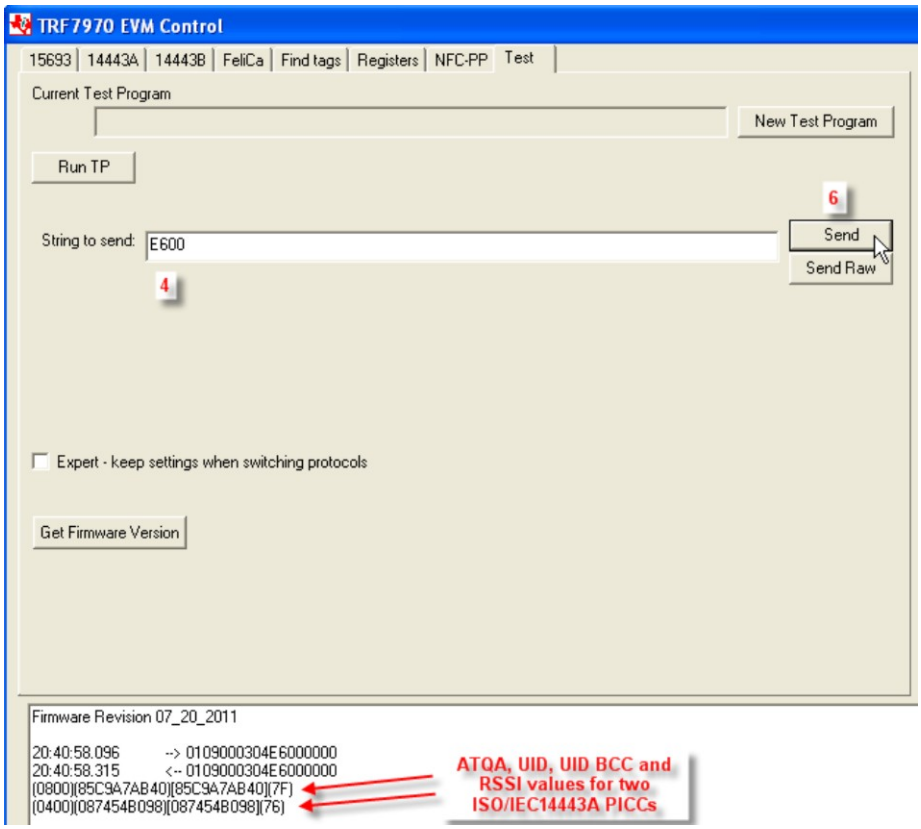


Figure 21. Anticollision Command Example for Two Type A PICCs

2.4.2 Select, RATS, and PPS

The Select command radio button is automatically selected after the anticollision loop is complete when using the ISO14443A tab, because this command cannot be issued to a PICC until the UID is obtained. To issue Select command, leave the PICC in the field and click Execute (see Figure 22).

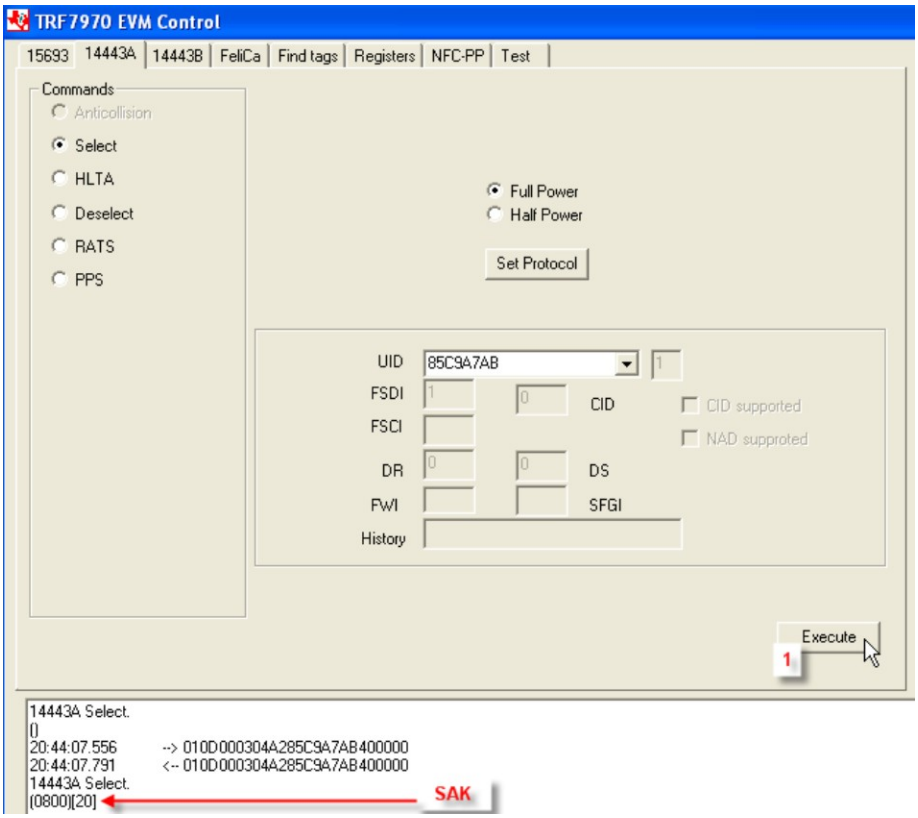


Figure 22. Select Command Example

After the Select command request is sent and a valid response is obtained, the GUI automatically selects the RATS radio button. The user again only needs to select the Execute button to process the command request (see Figure 23). Then the PPS radio button is automatically selected and is available as example, but the PICC must support it.

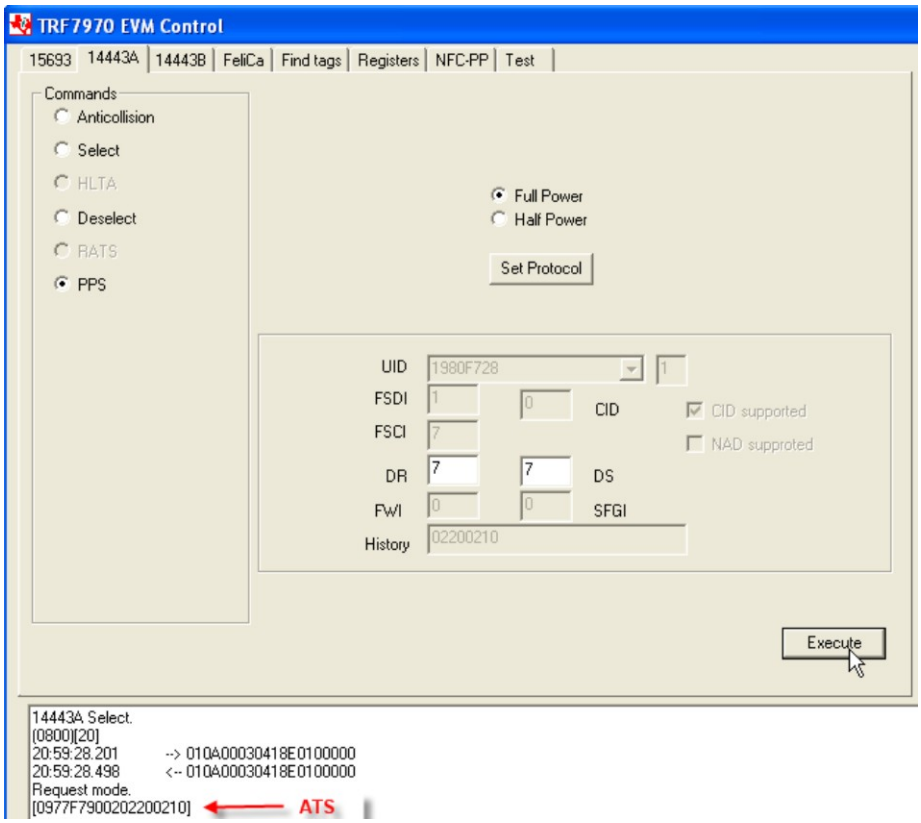


Figure 23. RATS Command Example

2.4.3 HLTA and Deselect

These commands are available in the GUI as needed to demonstrate stopping a card from responding while it remains in the field (HLTA) or to reset a card back to ready state once it has been selected (Deselect). Select the radio buttons as appropriate and click Execute.

2.5 ISO14443B Tab

The ISO14443B tab is used to perform Layer 3 and into Layer 4 operations on ISO14443B PICCs according to the ISO/IEC144443-4 standard. After selecting this tab, select the Set Protocol button.

2.5.1 Request (REQ_B)

This command is used to probe the field for ISO/IEC14443B PICCs, and it retrieves the PUPI and other relevant information needed by the ATTRIB command (see Figure 24).

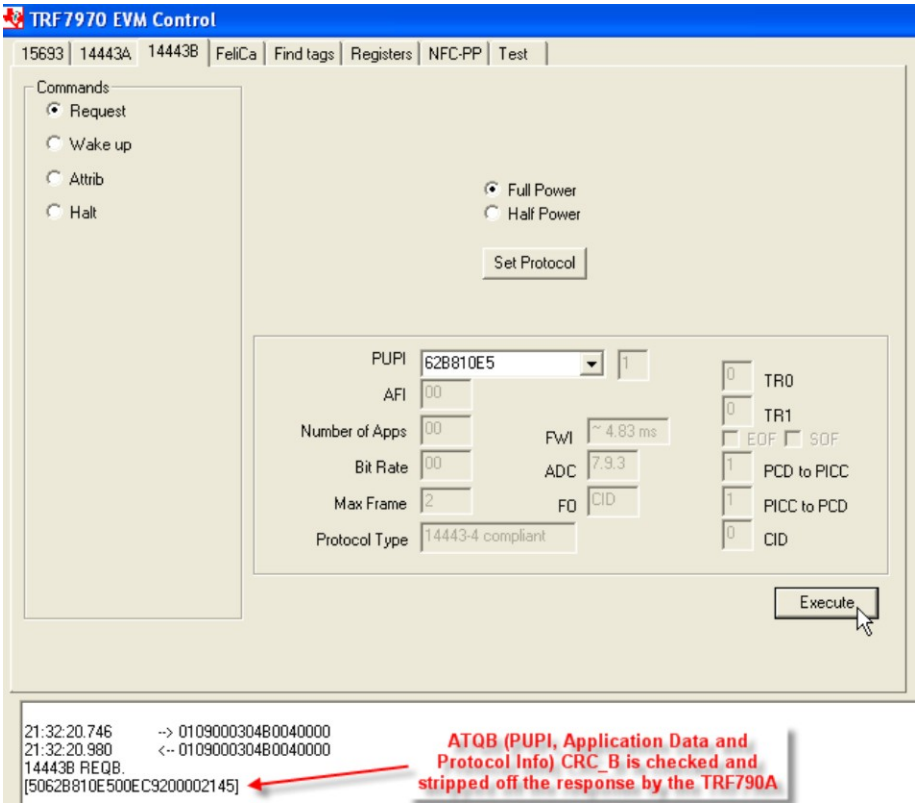


Figure 24. REQ_B Command Example

2.5.2 Wake-Up (WupB)

This command is used to bring ISO14443B PICCs out of the HALT state.

2.5.3 ATTRIB

This command is used to select an ISO14443B PICC and bring it into Layer 4. REQ_B should be sent before this command so that the TRF7970A system has the information that is required in this command (see Figure 25).

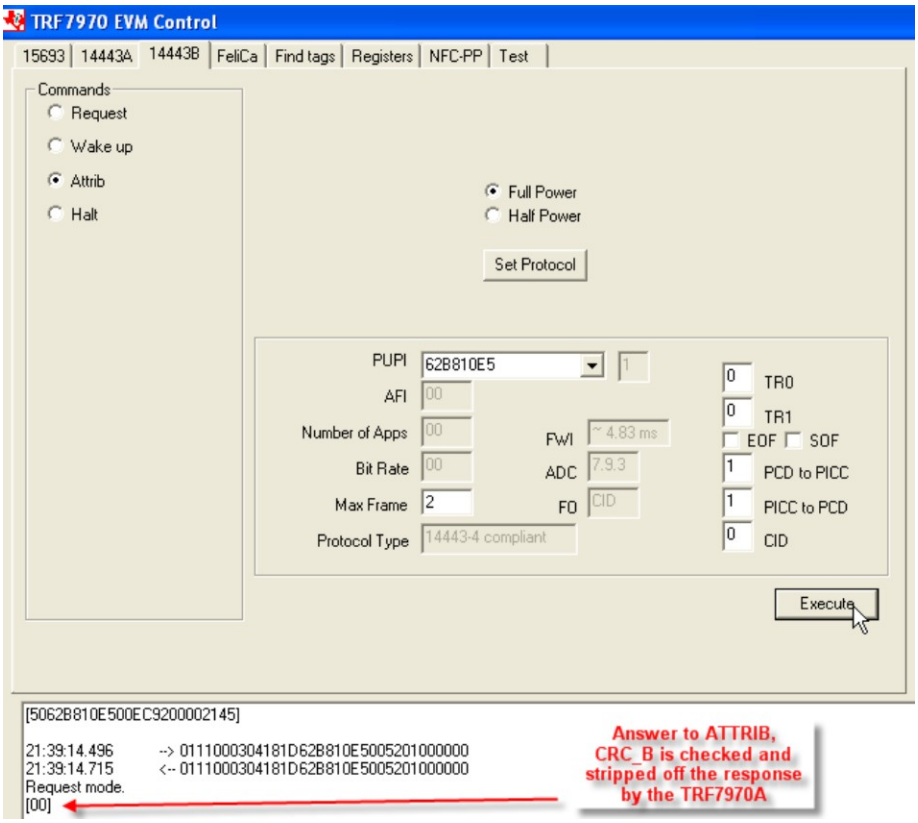


Figure 25. ATTRIB Command Example

2.5.4 Halt

This command is used to halt or stop a card from responding while still in the activation field.

2.6 FeliCa Tab

This tab is used to poll for FeliCa transponders. This transponder technology is from the Sony Corporation and is primarily used for payment, and it is also included in the NFC Forum specification, just like ISO/IEC 15693 and ISO/IEC 14443 transponders.

2.6.1 Polling

When inside the FeliCa tab, first select the radio button to select the protocol and click Set Protocol, then click Execute to retrieve the Manufacturer ID and the Manufacturer Parameters from the tag (see Figure 26). The Polling radio button is automatically selected.

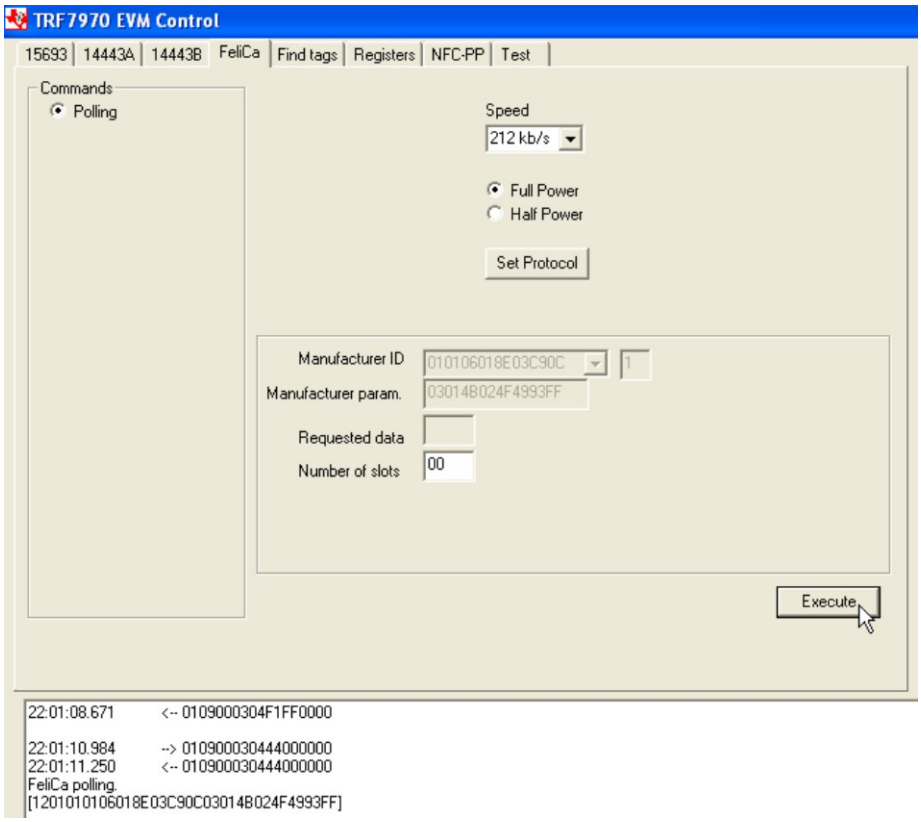


Figure 26. FeliCa Polling Example

2.7 Find Tags Tab

The Find Tags tab is a GUI-controlled version of the standalone mode that the reader defaults to when powered up but before the TRF7970A EVM GUI is executed. When this tab is selected, all of the supported protocols are selected to be polled for. Deselect any of the protocols that are not desired and click Run, which then turns into a Stop button (see Figure 27 and Figure 28). While this tab is useful for showing the multiprotocol capabilities of the TRF7970A EVM, it must be understood that the EVM antenna is a certain size and generates a specific magnetic field and also that the transponders are resonant circuits and can couple with each other, so some appropriate separation between the devices is recommended. The ISO15693 and ISO14443B transponders are polled for with multiple slot commands, while the FeliCa and ISO14443A transponders are polled for with single slot style commands only.

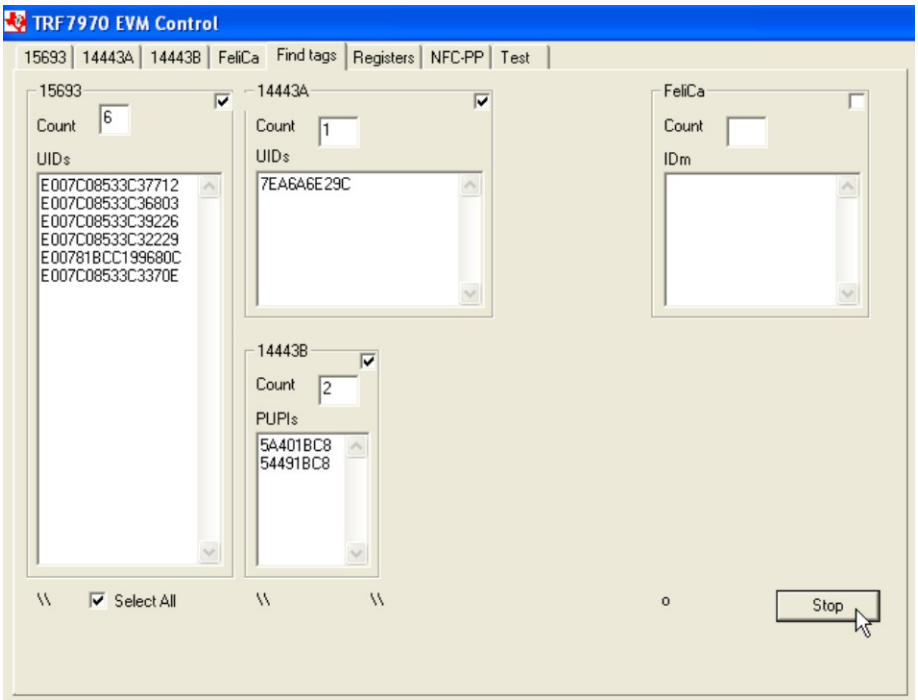


Figure 27. Find Tags Tab Example 1

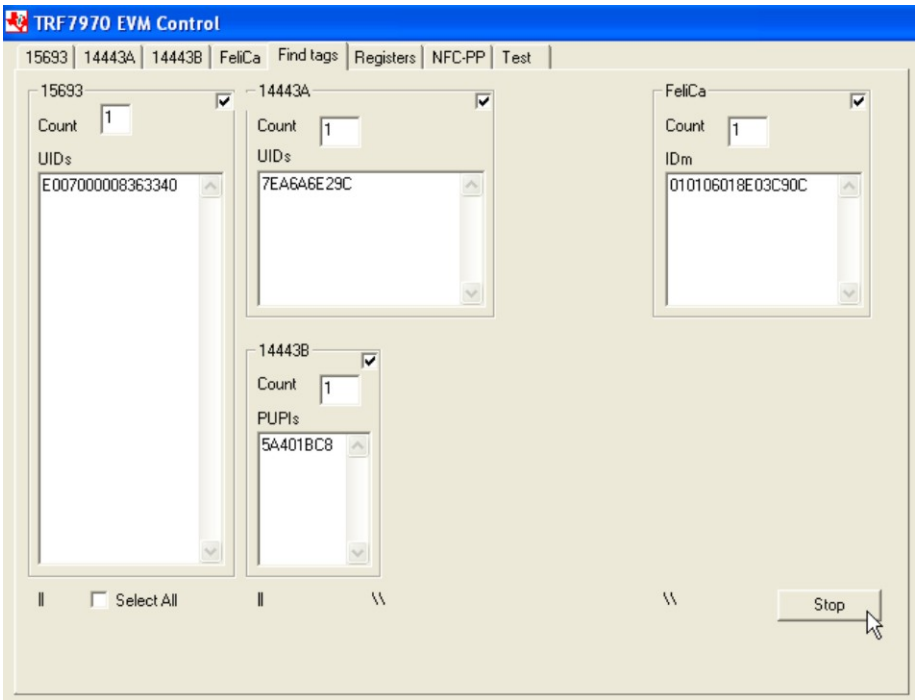


Figure 28. Find Tags Tab Example 2

2.8 Registers Tab

The Registers tab is used to retrieve the values in the TRF7970A registers and to directly change the values of those registers.

Some of the register settings are coded in the TRF7970A EVM firmware for the various protocols commands; therefore, changes made in the Registers tab can be overwritten when going to a protocol tab and setting a different protocol. To keep the values that are manually set, go to the Test Tab and check Expert – keep settings when switching protocols. However, as some register settings are not compatible or do not make sense when looking across the protocols, these values are coded into the EVM firmware to provide (at the very least) sustaining performance. For example, the ISO Control Register value cannot be set to 0x02 (default setting for ISO15693) and still support operation of ISO14443A, ISO14443B, or FeliCa. See Figure 29 for example of this tab with registers set for default operation.

If the Set Defaults button is clicked, the EVM loses communication with the GUI. This is because the Modulator and Sys Clock register (register 0x09) value is changed, so the MSP430 is no longer running at the same clock speed as it was when communications were established. This causes the the UART baud rate to be off time base, and the communications link is broken. To recover, close the GUI and reset the TRF7970A EVM either by pressing the reset button on the board or by removing and USB power; next, reconnect the EVM to USB and restart the GUI.

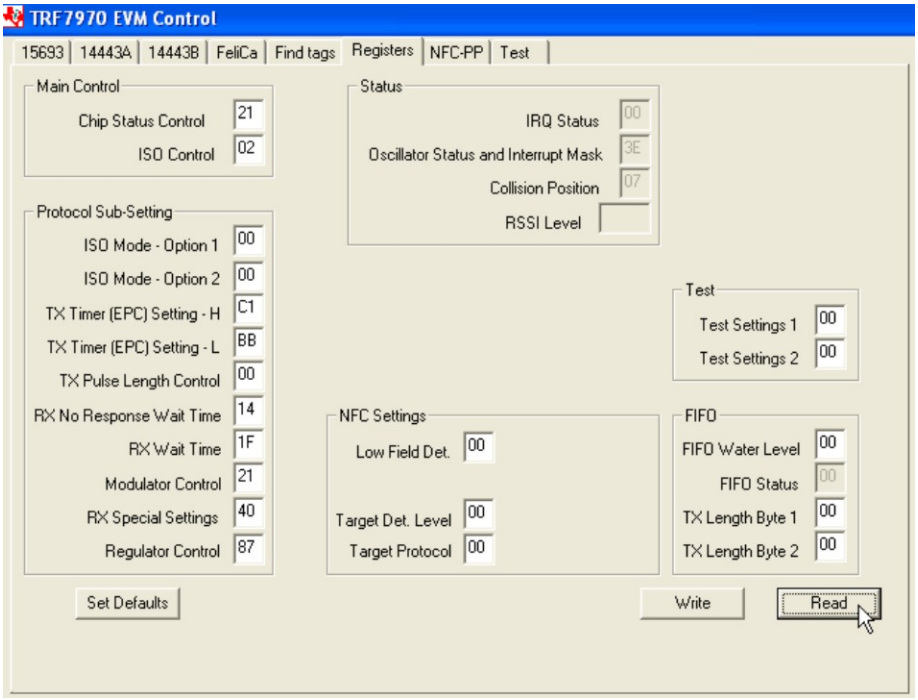


Figure 29. Registers Tab

2.9 NFC-PP Tab

This tab is for demonstrating the Near Field Communications (NFC) capabilities of the TRF7970A. It requires two TRF7970A evaluation modules and two PCs with the TRF7970A EVM GUI loaded. The steps required to demonstrate these functionalities from an Initiator and a Target perspective are described in the following sections.

2.9.1 Initiator Setup

To setup the first TRF7970A as an Initiator (Master) (after connecting on the first PC) (see Figure 30):

1. Click the NFC-PP tab.
2. Click Set Protocol.

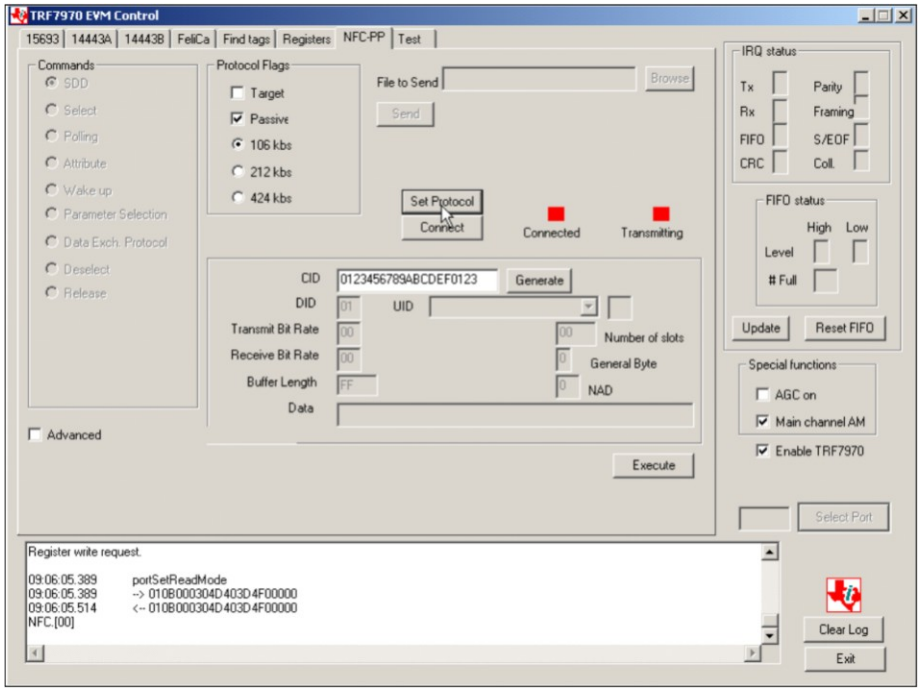


Figure 30. Setting up TRF7970A EVM as Initiator

2.9.2 Target Setup

To set the second TRF7970A as a Target (Slave) (after connecting on the second PC) (see Figure 31):

1. Click the NFC-PP tab.
2. Check the Target Box in the Protocol Flags section of the GUI window.
3. Click Set Protocol.

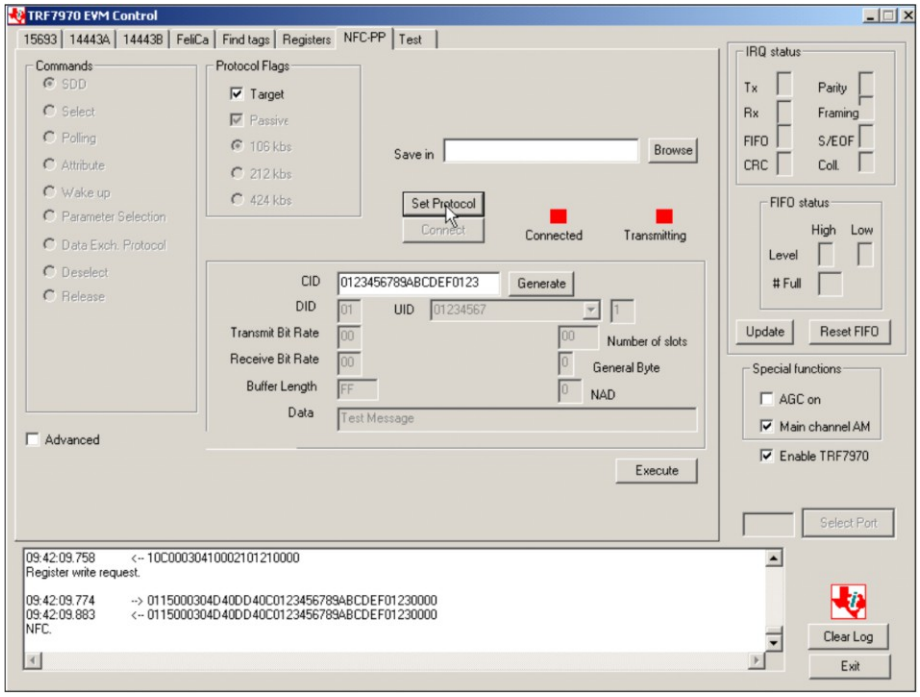


Figure 31. Setting up TRF7970A EVM as Target

After setting up the two separate TRF7970A evaluation modules, they should be arranged in a parallel orientation relative to each other for the best coupling/best performance (see Figure 32).

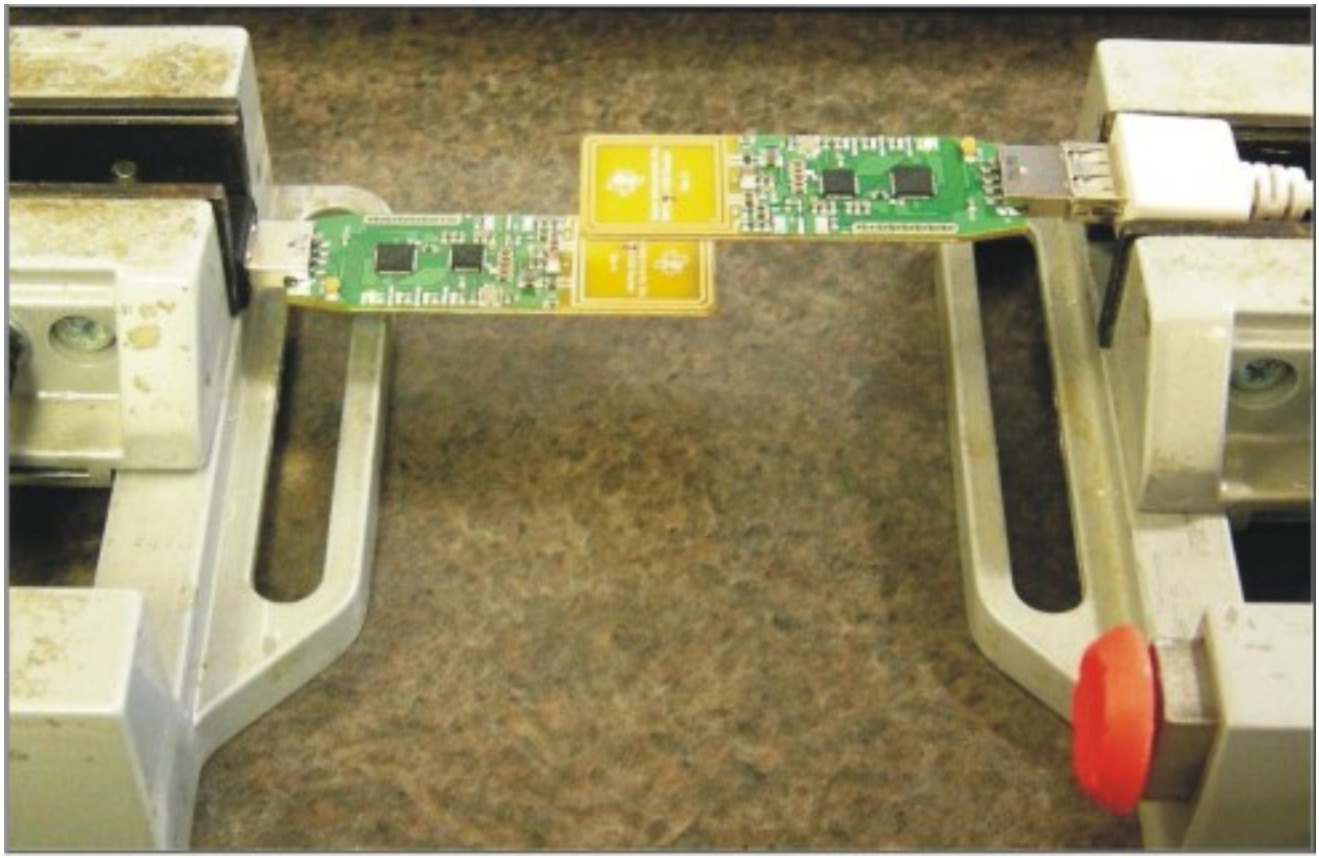
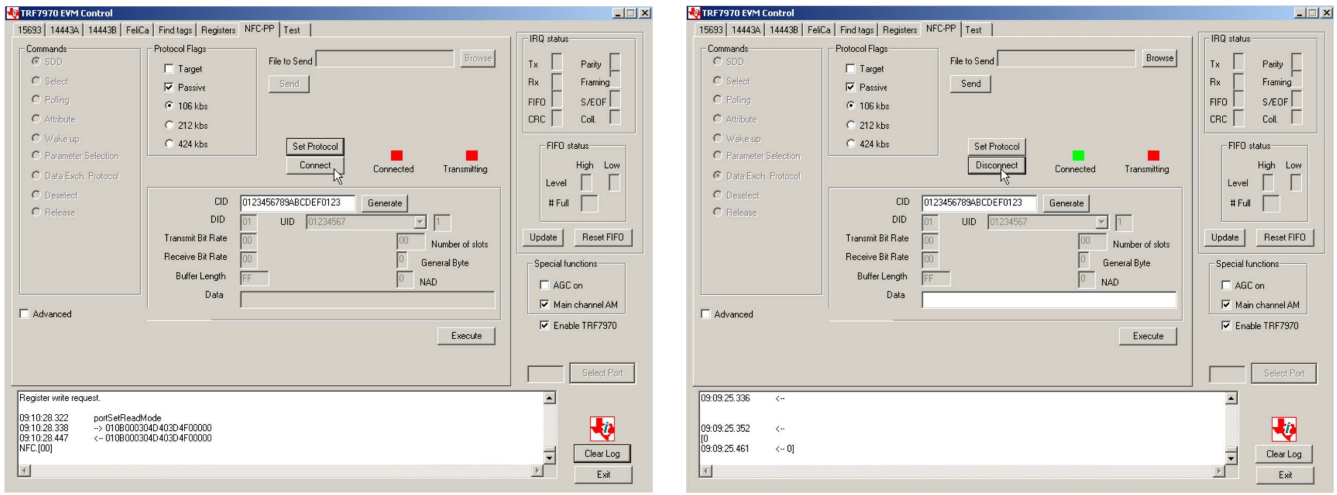


Figure 32. Demonstration Hardware Configuration Example

2.9.3 Peer-to-Peer Connection Step

To connect the two TRF7970A evaluation modules (see Figure 33):

1. In the GUI for the Initiator, click Connect (the button then changes to Disconnect).
2. The Initiator and Target GUI indicators turn green when connection is successful.



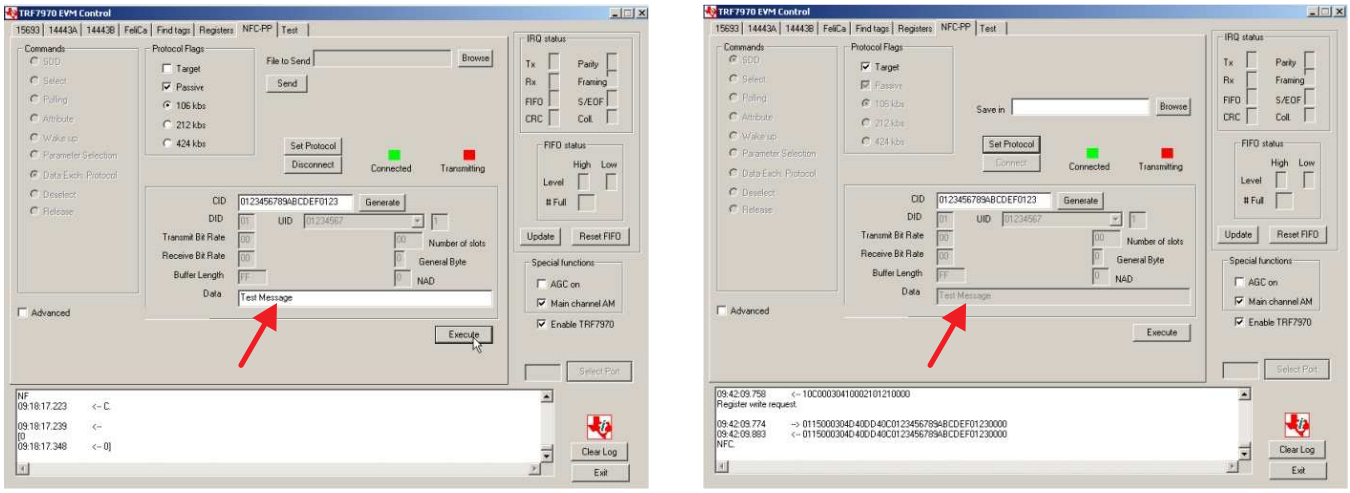
Not Connected (Initiator GUI) **Connected (Initiator GUI)**

Figure 33. Peer-to-Peer Connection Step

2.9.4 NFC Text Message Transfer

To transfer a text message from the Initiator hardware to the Target hardware for display in the Target GUI:

1. Perform peer-to-peer connection as described in Section 2.9.3.
2. Type in text to be sent into the Data entry text box.
3. Click Execute.
4. Look at the Target GUI window and observe text message that was sent (see red arrows in Figure 34).



Initiator GUI Window (Message Being Sent) **Target GUI Window (Message Received)**

Figure 34. NFC Text Message Transfer

2.9.5 NFC File Transfer

While still in Initiator and Target modes as described in Section 2.9.3, files can also be transferred. This is done by selecting a file to be sent from the Initiator side and also a location (a file folder or directory) to store the file on the Target. Any file format can be transferred (for example, .doc, .xls, .jpg, or .zip). In this example, a firmware image file (.d43) is used.

1. Select file using the Browse button in the Initiator GUI.
2. Click Open (see Figure 35).

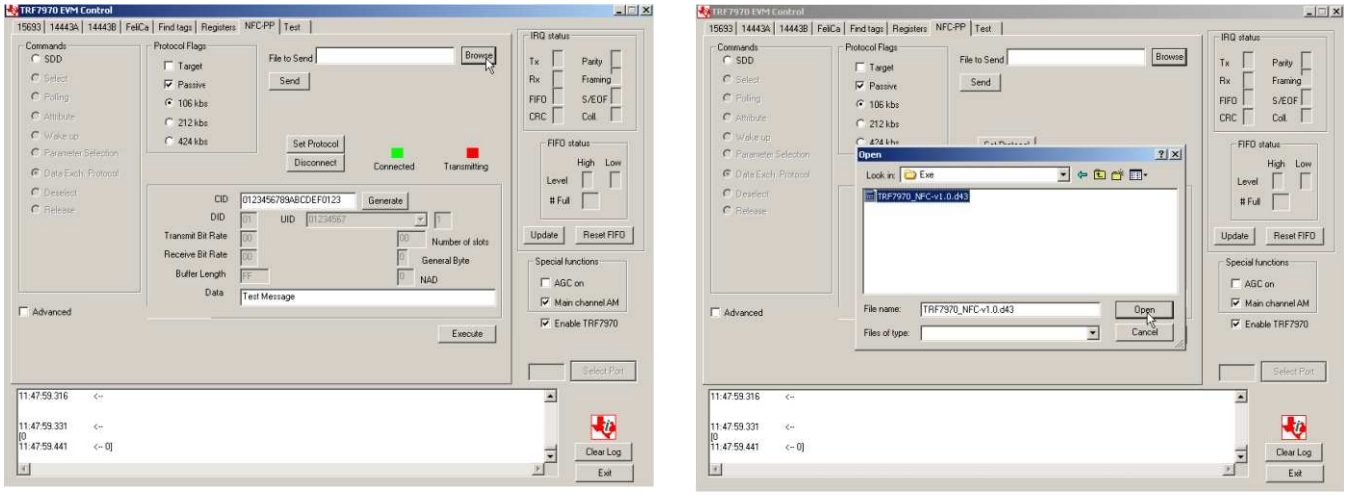


Figure 35. NFC File Transfer, Select File on Initiator

3. Select file folder or directory using the Browse button in the Target GUI (in this case, a folder called NFC_File_Transfers was created for the demonstration).
4. Click Open (see Figure 36).

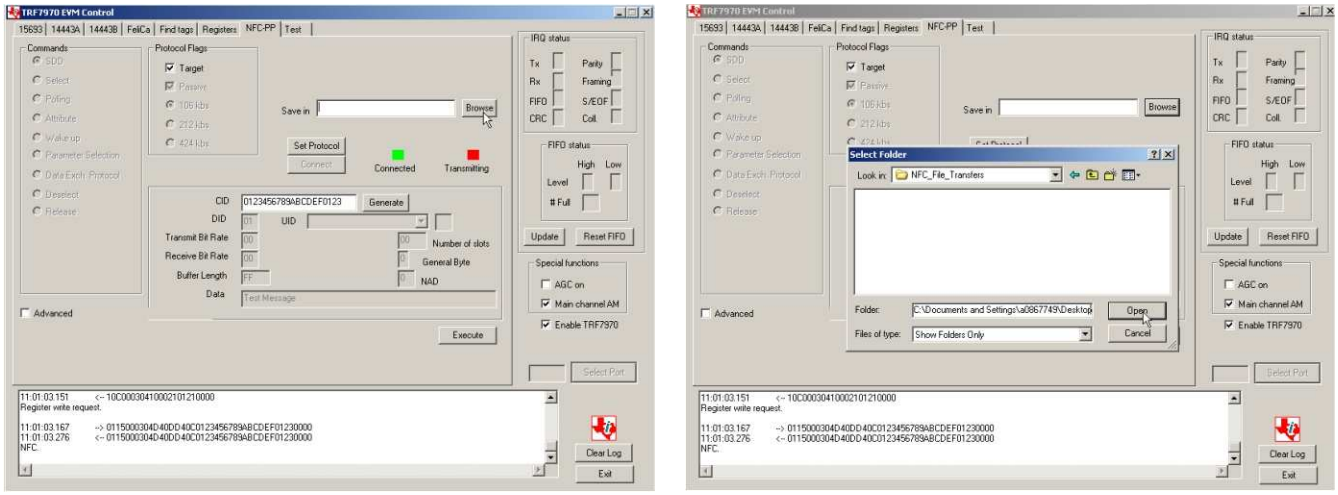
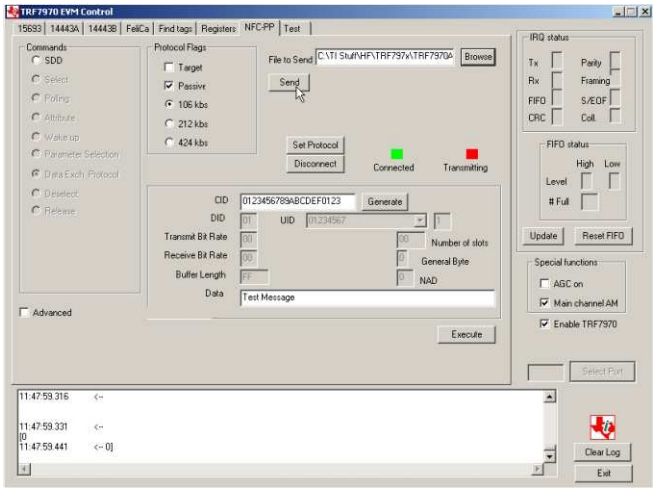
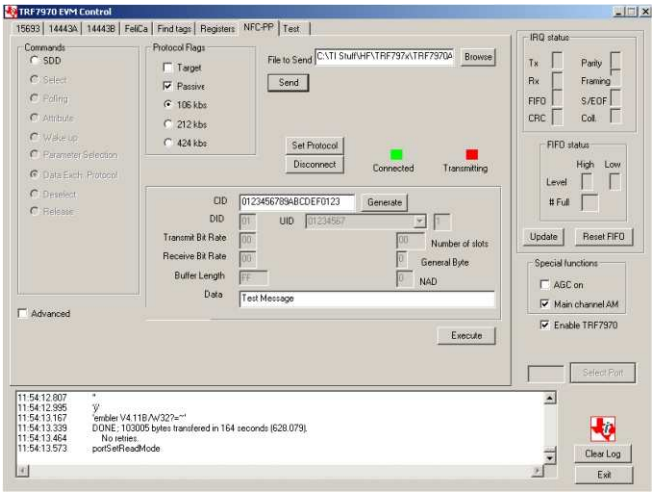


Figure 36. NFC File Transfer, Save File on Target

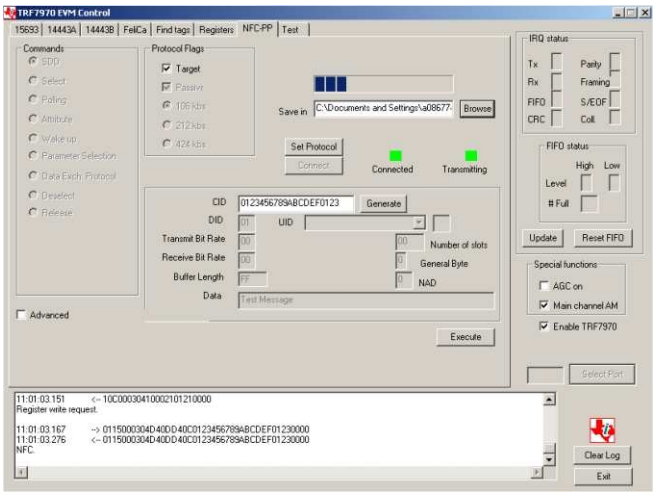
5. Click Send in the Initiator GUI (a status bar indicates activity) (see Figure 37).
6. When file transfer is complete, the status is reported in the Initiator protocol log window and the file is available on the Target PC. The Target GUI also indicates activity.



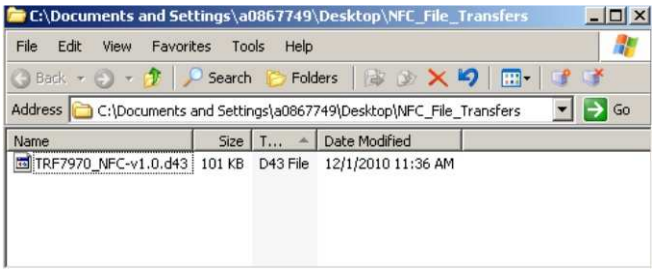
Initiator GUI File Transfer Being Started



Initiator GUI File Transfer Complete



Target GUI File Transfer in Progress



Target File Folder Contents After
File Transfer is Complete (File Received)

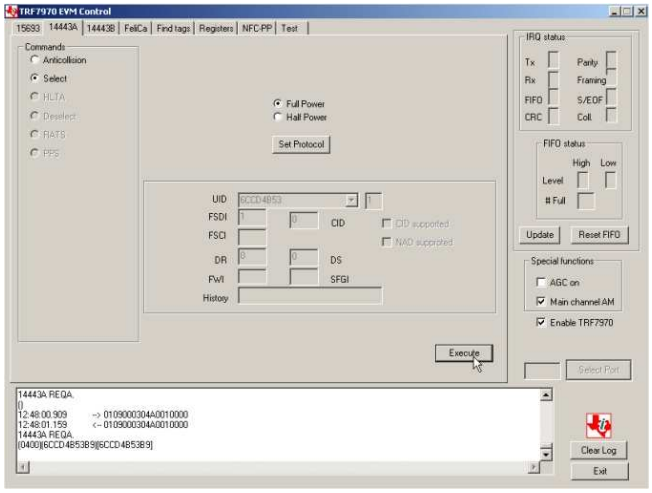
Figure 37. NFC File Transfer Progress

2.9.6 Card Emulation Mode

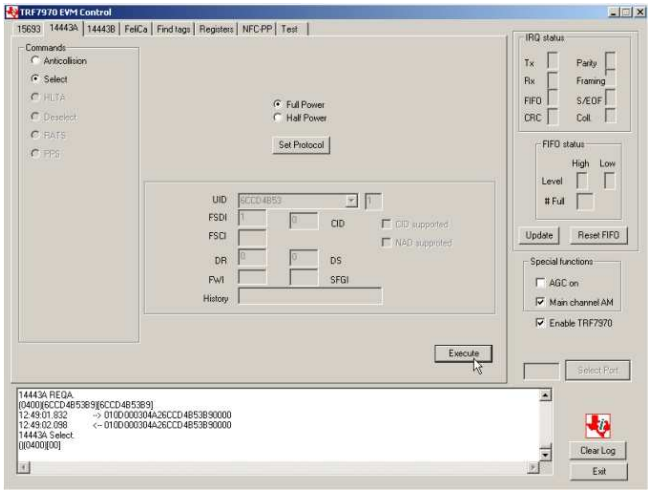
For card emulation mode, one TRF7970A EVM should be set up as a Target (see Section 2.9.2). Another TRF7970A EVM can be used as an RFID reader (in this example, the device is set up and used as an ISO14443A reader; see Section 2.4).

To use card emulation mode (see Figure 38):

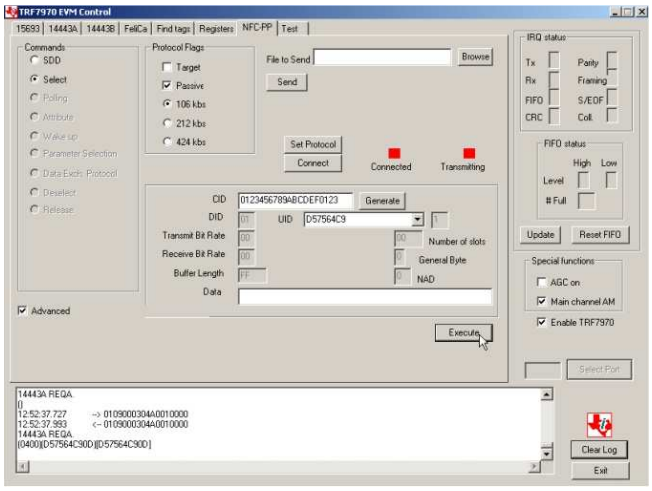
1. On the Initiator reader side, go to the NFC-PP tab.
2. Select the Advanced check box.
3. Click Set Protocol.
4. Click Execute.
5. The SDD and Select commands can now be used.



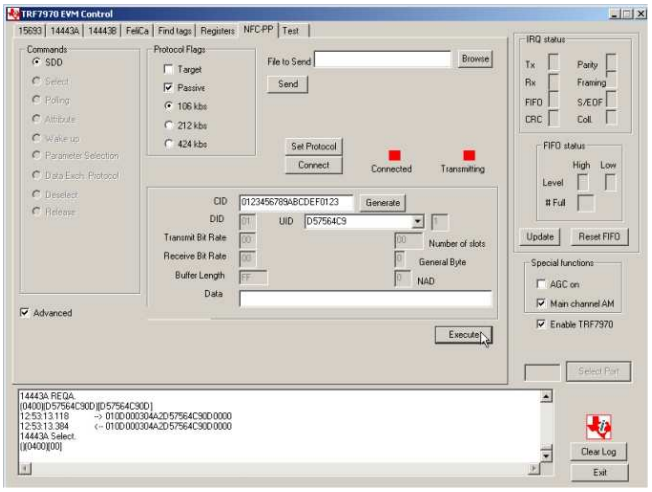
ISO14443A UID Read
From TRF7970A in Card Emulation Mode



ISO14443A Select Command Response
From TRF7970A in Card Emulation Mode



ISO14443A UID Read
From TRF7970A in Card Emulation Mode



ISO14443A Select Command Response
From TRF7970A in Card Emulation Mode

Figure 38. Card Emulation Mode

2.10 Test Tab

The TRF7970A EVM GUI Test Tab is used to send specific command strings that the firmware supports but that are not built into the specific protocol tabs in the GUI and to assist in understanding the finer details of the TRF7970A EVM operations. This tab also allows retrieval of the version number of the firmware loaded in the MSP430F2370 on the EVM. The following example show how and why test strings might be used.

Two buttons are available for sending strings: Send and Send Raw. The Send button is used to send complete strings (including SOF, length, etc.). The Send Raw button prepends and appends those byte required by the MSP4340F2370 host.c file for a properly concatenated string.

A few examples of when a user would need to utilize these features would be:

1. For observing a read or write continuous to the registers of the TRF7970A during code development with a logic analyzer. These examples are using the Send button which adds on the necessary bytes before and after data to send strings are entered. This example is setting up the TRF7970A for full power out and ISO15693 operation (see Figure 39 and Figure 40).

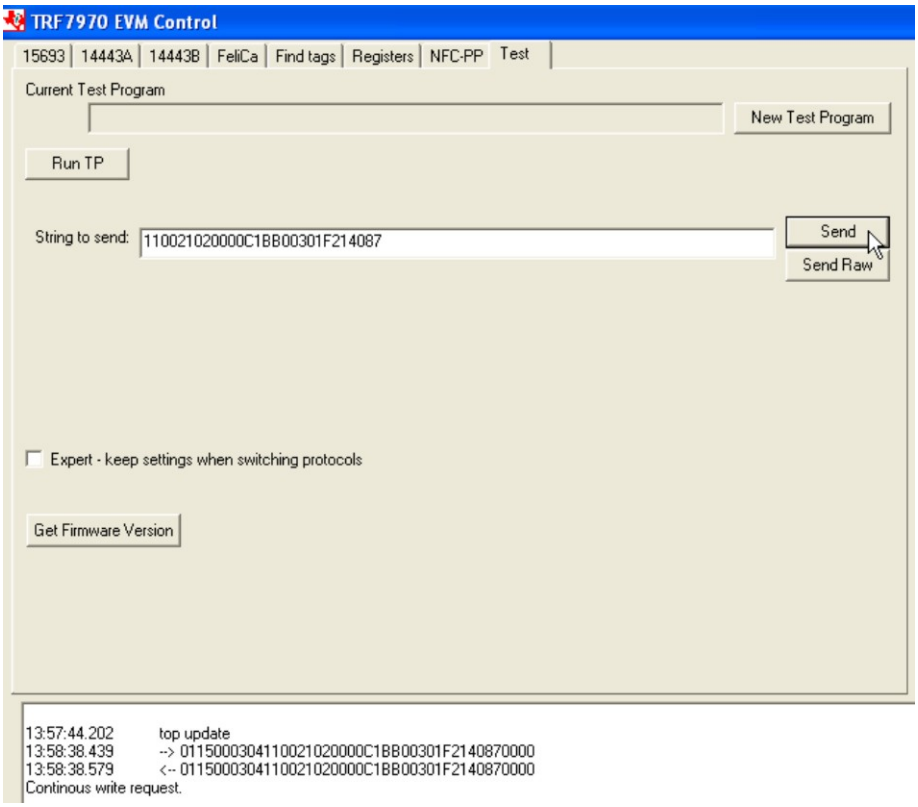


Figure 39. Continuous Write to Registers 0x00 to 0x0B Example

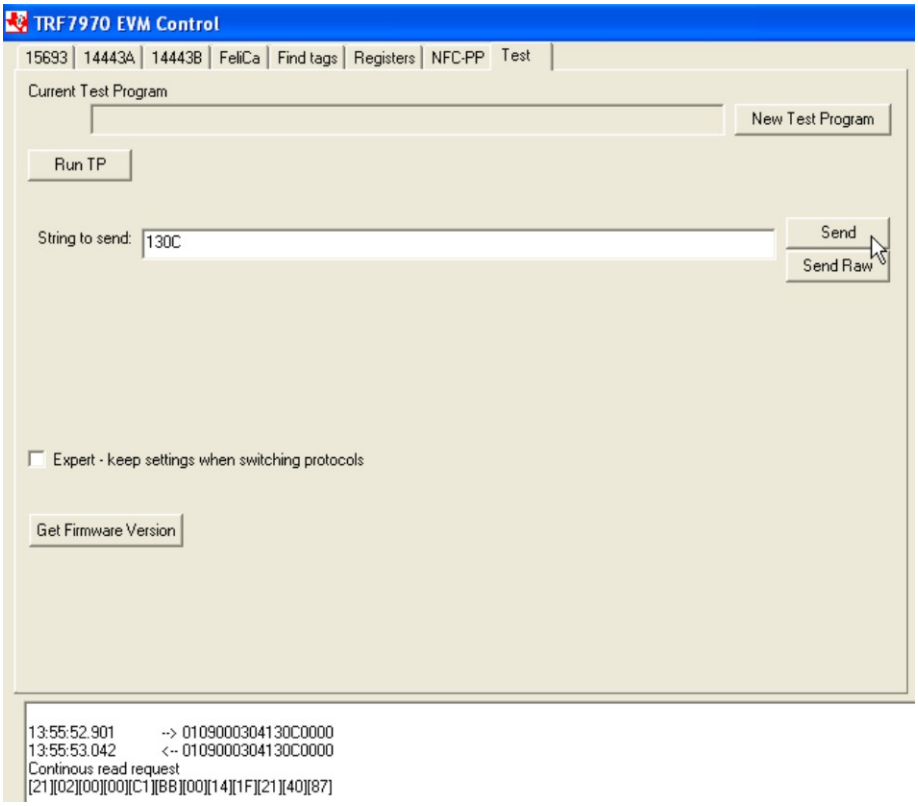


Figure 40. Continuous Read from Registers 0x00 to 0x0B Example

2. To turn on or off the MSP430F2370 GPIO-controlled LEDs on the EVM. These could also be used in the development environment for other functions such as turning on or off other peripherals, for digital control of reed relays and switches, etc. (see Table 8 and Figure 41).

Table 8. Command Codes for GPI/O Controlled Outputs on EVM

LED Number	Command Code to be Sent (Using Send Button in GUI)	State
2	FB	ON
2	FC	OFF
3	F9	ON
3	FA	OFF
4	F7	ON
4	F8	OFF
5	F5	ON
5	F6	OFF
6	F3	ON
6	F4	OFF

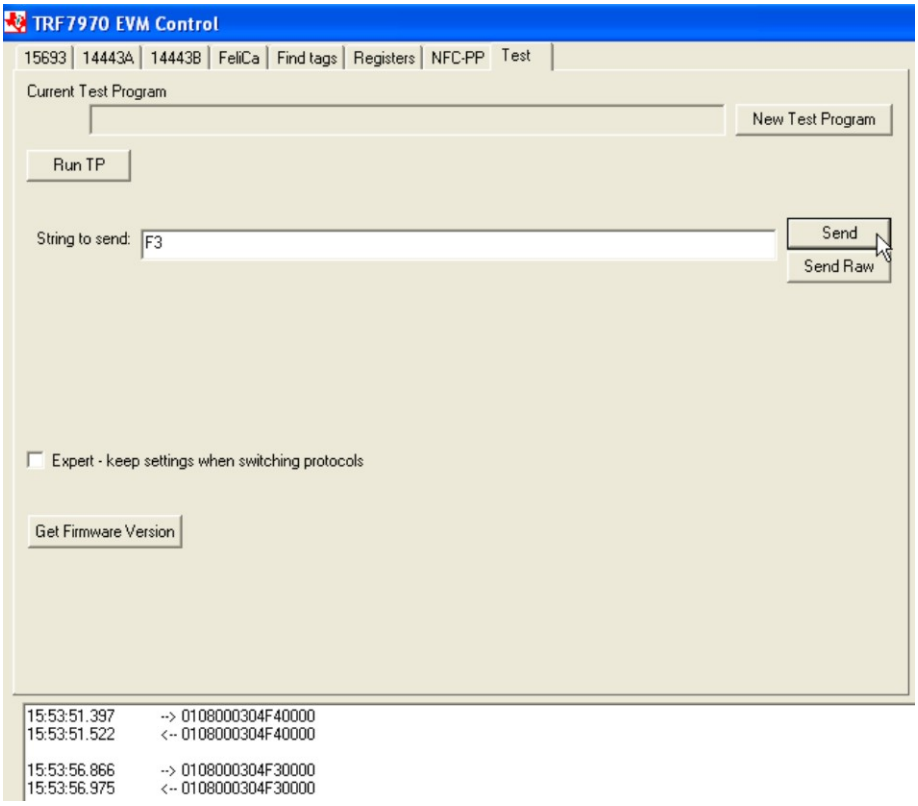


Figure 41. Sending GPIO Control Command

3. To retrieve the PUPI from an ISO14443B tag on which anticollision has been disabled (this is most often the instance for ISO14443B cards that are being used for payment applications), thus requiring a single slot REQB to be sent. Notice in Figure 42 that the Send Raw button is used. This could have also been sent using the Send button with only *B000* as the String to send.

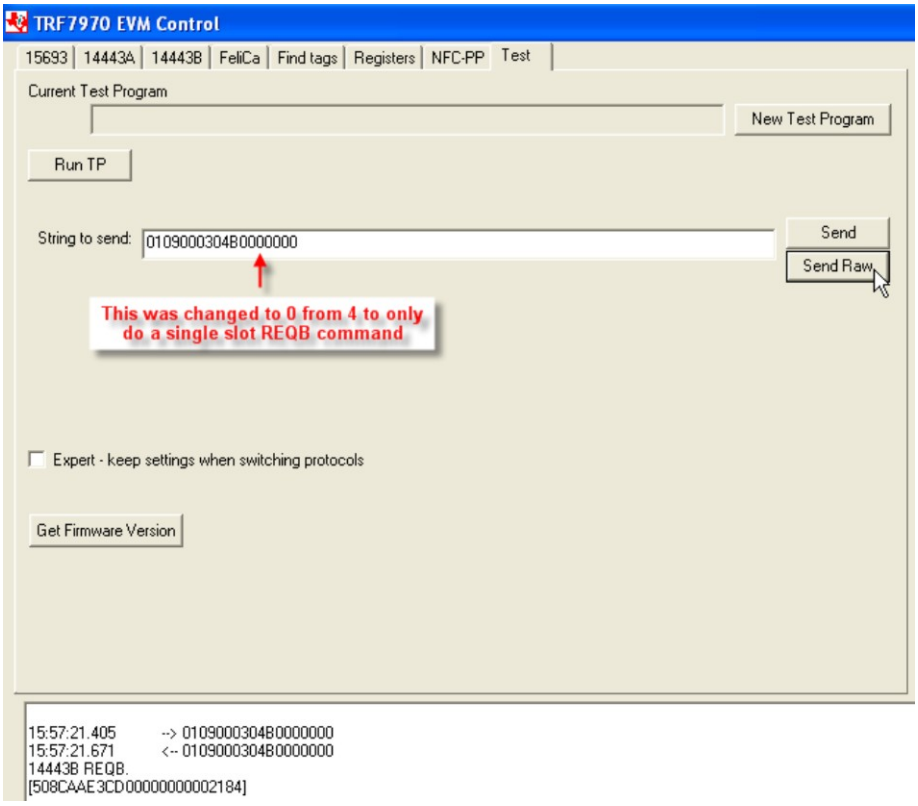


Figure 42. Sending Single Slot REQB

3 Abbreviations

AFI	Application Family Identifier
BCC	Block Check Character
CRC	Cyclic Redundancy Check
DSFID	Data Storage Format Identifier
EOF	End of Frame
LSB	Least Significant Byte
MSB	Most Significant Byte
RFU	Reserved for Future Use
SOF	Start of Frame
UID	Unique Identifier
PCD	Proximity Coupling Device
PICC	Proximity Integrated Circuit Card
PUPI	Pseudo Unique PICC Identifier
VCD	Vicinity Coupling Device
VICC	Vicinity Integrated Circuit Card

4 References

1. TRF7970A Data Sheet (SLOS743)
2. TRF7970A Firmware Description (SLOA157)
3. TRF7970A Firmware Design Hints (SLOA159)
4. TRF7970A NFC BSL Application Note (SLOA160)
5. ISO/IEC 15693 (http://www.iso.org)
6. ISO/IEC 14443 (http://www.iso.org)
7. ISO/IEC18092 (http://www.iso.org)
8. ISO/IEC 21481 (http://www.iso.org)
9. FeliCa™ (http://www.sony.net/Products/felica/)
10. MIFARE™ (http://www.mifare.net/)