XPress™ Crypto Module User's Manual

FIPS 140-2 Security Module

90033945_D
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About This Guide

Thank you for your purchase of the XPress™ Crypto Module, also known as the AW140 FIPS 140-2 Security Module.

This module from Digi International is a multi-chip embedded security module that performs AES 128/192/256 bit encryption. It meets the FIPS 140-2 Security Standard and is approved by CMVP (the Cryptographic Module Validation Program), a joint effort of NIST (The National Institute of Standards and Technology) and CESC (Communications Security Establishment Canada). This approval indicates acceptance by the Federal Agencies of both countries for the protection of sensitive information.

The module has a tamper-evident coating and two separate interfaces:

- A Serial Peripheral Interface (SPI) that is used to connect to a host microcontroller and transfers encrypted an non-encrypted data.
- A USB interface that is used to establish login credentials, configure the encryption method and set the key.

If you have any questions when configuring your Digi product, please visit www.digi.com/support. If further assistance is needed, send an e-mail to support@digi.com. To speak to a live technician, please call technical support at the number listed below, during normal business hours.

Digi Contact Information

To contact Digi International for more information about your Digi products, or for customer service and technical support, use the following contact information:

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Features and Specifications

- Government approved FIPS 140-2 Security
- Fast realtime AES encryption at 5 Mbps
- Easily integrated SPI (Serial Peripheral Interface)
- Security key managed with a terminal interface via a USB port
- Tamper-evident conformal coating
- Small physical size
- Low power consumption

Characteristic	Specification
Encryption Throughput	5 Mbps
Certifications	NIST FIPS 140-2, NIST FIPS 197
SPI Data Interface	2 x 5 pin header, 0.1" spacing plus 3 pin support
Command Interface	Mini USB Socket
Size	30mm wide, 50mm long, 15mm deep including connector pins
Voltage Range	3.1 to 3.6 VDC
Power Consumption	45 ma at 3.3 VDC (150 mW)
Operating Temperature Range	-70° C to +80° C

Secure Setup and Initialization

If you have a Digi radio with FIPS 140-2 Security, this supplement to the User Manual provides instructions for setting up the encryption. Please disregard the AES Encryption instructions in the regular manual: this supersedes them. A feature of the level of security provided is that there is no way to change the encryption method or key through the radio's interface. A separate port must be used.

The XPress™ Crypto Module is programmed and queried through a terminal interface. To use the terminal interface, you must install the following two pieces of software:

1. A driver that provides a virtual COM port through the USB connection. This driver can be downloaded from the Future Technology Devices International website, http://www.ftdichip.com. Follow their menu to the webpage for VCP drivers and choose the one that matches your operating system. Installation guides are also available in the documents section of the website.
2. A terminal emulator that will provide the user interface to the XPress™ Crypto Module. Options include Hyper-Terminal (available automatically in Windows XP and earlier operating systems) or Digi's XCTU available at www.digi.com/xctu. Customers using non-Windows OS can use tools such as minicom for Linux Ubuntu or ZTerm for Mac.

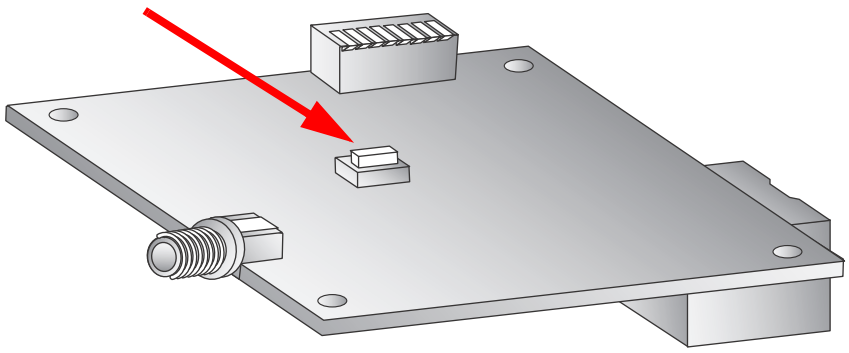
There are two roles defined for those having access to the programming interface, Crypto Officer and User. Each has a different password. Only the Crypto Officer is allowed to set the encryption method and encryption key. The user may examine self test results and firmware version only.

Step by step programming procedure:

1. Connect your hardware.

If your module is connected to a development board or is a standalone module, make sure the main power for the radio is off, and connect the XPress™ Crypto Module's USB port to your computer using a USB mini B cable.

If you have purchased an XPress™ Crypto Module as part of an XPress™ Ethernet Bridge, remove the cover of the XPress™ Ethernet Bridge using a Phillips screwdriver. The USB cable coiled inside the XPress™ Ethernet Bridge should be plugged into your PC's USB port. Power your XPress™ Ethernet Bridge using Power over Ethernet. Then press the reset button located in the middle of the XPress™ Ethernet Bridge PCB as shown in the image below.

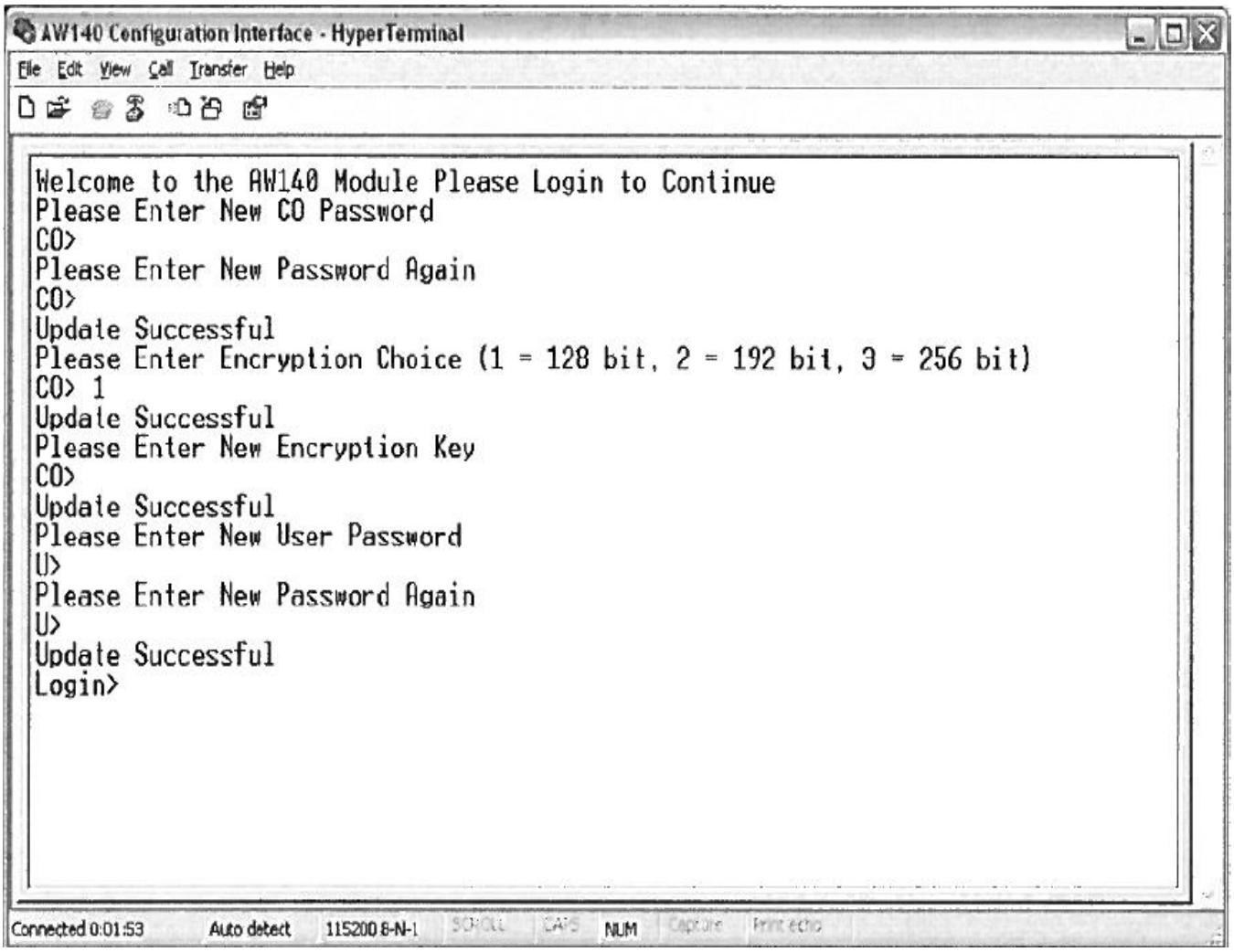


2. Open your terminal emulator program and set the COM port settings as follows:

Data bits:	8
Baud rate:	115200
Parity:	none
Stop bits:	1
Flow control:	none

3. Press any key to activate the XPress™ Crypto Module. If the module has never been programmed, setup prompts will occur as shown in the example screen shot below. If you see only a login prompt, then the module has previously been initialized. If you know the password, enter it. If not, type "init" to erase all keys and passwords and return the module to its uninitalized state.

4. Initial Setup.

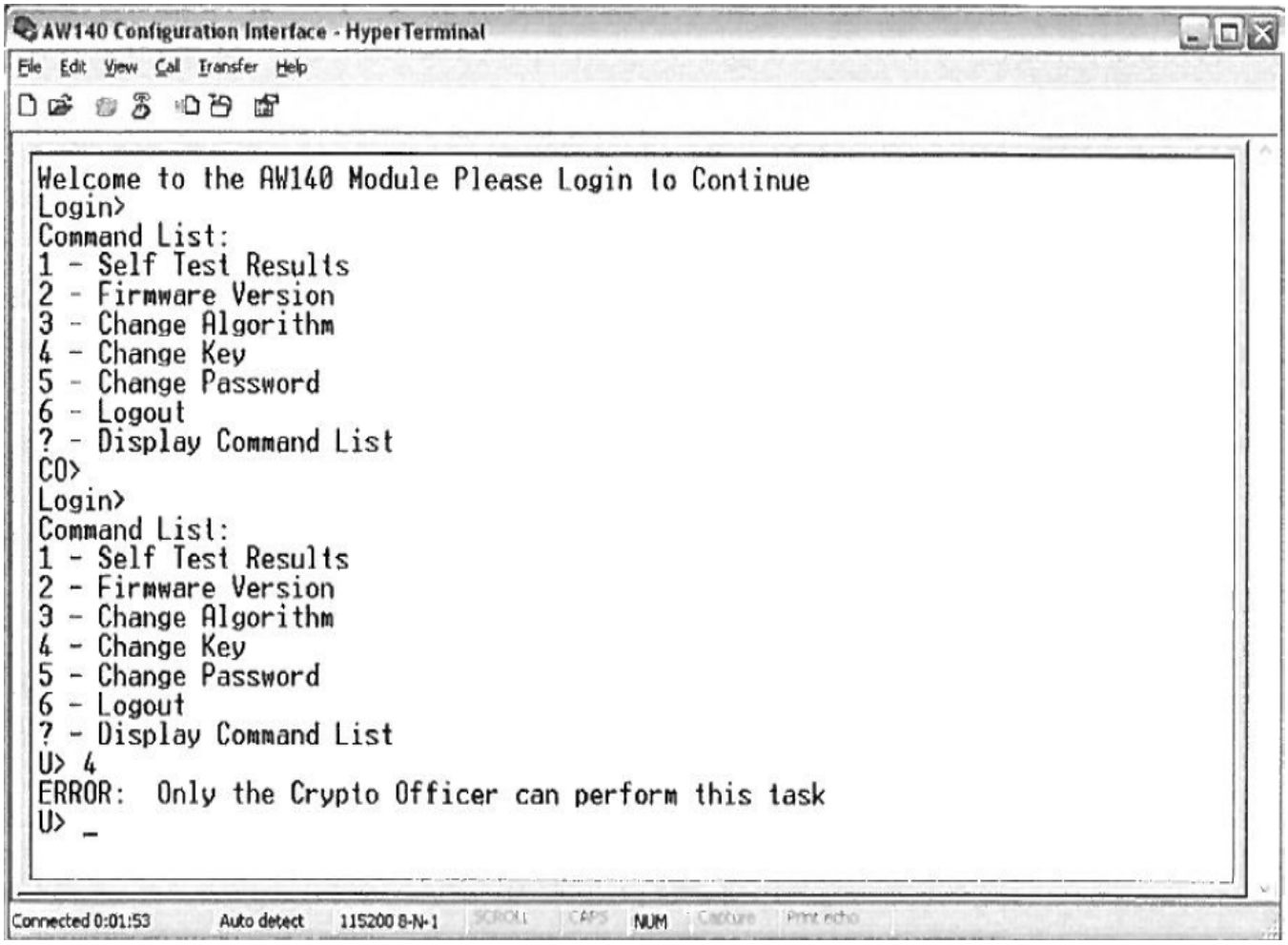


Passwords must be between 8 and 32 characters. Passwords are case-sensitive and any ASCII characters may be used.

You may select a 128, 192, or 256 bit encryption key. The encryption key must be entered as a 32, 48, or 64 digit hexadecimal number (0-9, a-f), corresponding to the length of the encryption key selected. If you enter less than the full number of digits, the XPress™ Crypto Module will pad your key with zeros.

5. After completing the initial setup, disconnect the USB cable. If you are using the XPress™ Crypto Module as part of an XPress™ Ethernet Bridge, replace the ESD cap on the USB connector to ensure the USB connector will not cause damage inside the unit, recoil the USB cable inside the XPress™ Ethernet Bridge using the reusable cable tie, and replace the enclosure cover. Next, power up the Digi radio to resume normal cryptographic operation.

6. It may become necessary to change the programming or test the module at some later time. Connect your hardware as shown in step 1 then set up the COM port parameters and terminal emulator program as described in step 2. A screen similar to the one below will display:



Self Test Results displays the results of the power up self test. At power up, the XPress™ Crypto Module runs a known answer test for all encryption/decryption
algorithms.

Firmware Version displays the revision number of the firmware running in the XPress™ Crypto Module.

Change Algorithm and **Change Key** can only be used by the Crypto Officer Role. If the User Role attempts to run these commands, an error occurs as shown in the above screen shot.

Change Password allows a new choice for the Crypto Officer or User password, depending on which Role is logged in.

Display Command List will display the list of available commands.

Logout will log you out of the XPress™ Crypto Module.

Note: If an incorrect password is entered at the login prompt, two more tries are allowed and then the XPress™ Crypto Module enters a lockout state for 5 minutes.

7. After completing the setup or testing, log out and disconnect the USB cable. If you are using the XPress™ Crypto Module as part of an XPress™ Ethernet Bridge, replace the ESD cap on the USB connector to ensure the USB connector will not cause damage inside the unit, recoil the USB cable inside the XPress™ Ethernet Bridge using the reusable cable tie, and replace the enclosure cover. Next, power up the Digi radio to resume normal cryptographic operation.

Module Physical Interface

Signal definitions for the XPress™ Crypto Module SPI interface:

Pin Number	Name	Description
1	Vcc	3.3 VDC power for module
2	SCK	Serial clock
3	MOSI	Serial data input to module
4	MISO	Serial data output from module
5	GND	Module ground
6	#RESET	Active low reset
7	FIFO Full Flag	0 = FIFO empty 1 = FIFO full, don't send any more data
8	Data Ready	0 = no data 1 = data packet available
9	Error	1 = Error occurred To clear flag, de-assert Chip Select
10	#CS	Active Low Chip Select

Module SPI Interface

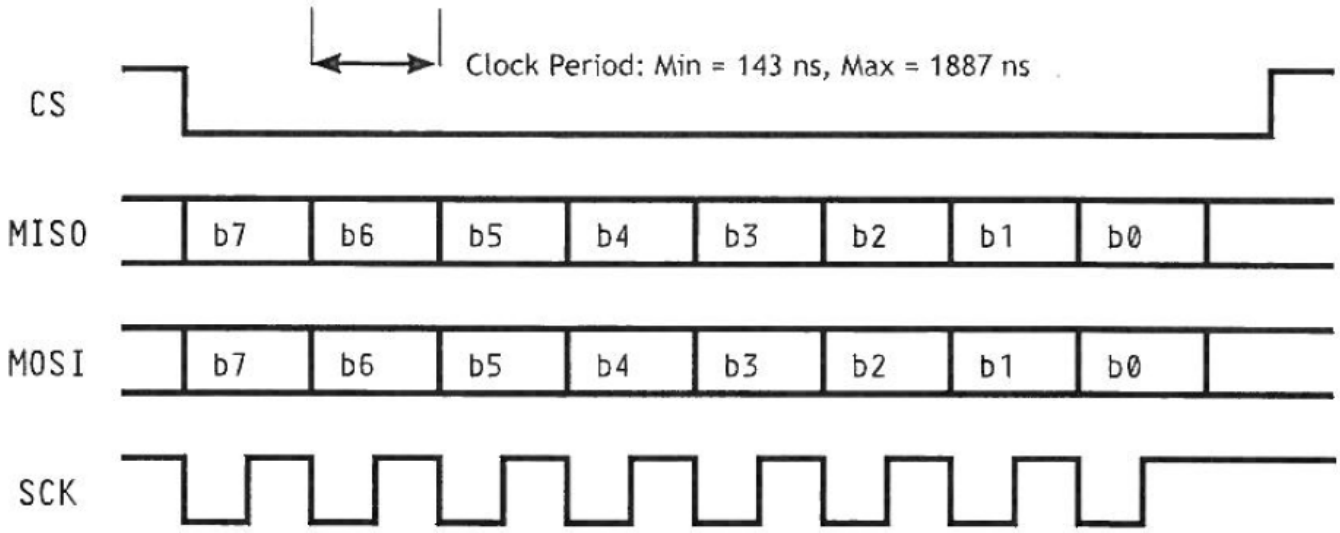
Serial Peripheral Interface (SPI) is a full duplex synchronous serial interface that allows data to be shifted in and out of the XPress™ Crypto Module 8 bits at a time (most significant bit first).

The SPI requires 4 pins to be physically connected:

- SCK - Serial Bit Shift Clock (provided by master SPI)
- MISO - Master In Slave Out
- MOSI - Master Out Slave In
- CS - Active Low Chip Select

The SPI on the XPress™ Crypto Module is a slave SPI and uses mode (1, 1) for clock phase and polarity. This means that the SCK line idles high and data is setup on the falling edge of the clock and latched on the rising edge.

The maximum clock rate for the SPI is 7MHz and the minimum clock rate its 530kHz.



The SPI operates in slave mode, meaning SCK is supplied by an external source. This interface is used to transfer data to and from the module and to read status information.

The first byte on the MOSI line after the #CS line goes low is the Command Byte. This byte tells the XPress™ Crypto Module what command is to be executed.

Command Byte:

b7	b6	b5	b4	b3	b2	b1	b0
get/set	-	-	-	-	-	CMD1	CMD0

When the get/set bit is set, information will be sent to the XPress™ Crypto Module on MOSI and MISO will be high impedance. When clear, a get transaction will take place and information will be sent from the XPress™ Crypto Module on MISO.

After the command byte is issued the master microcontroller must delay to allow the XPress™ Crypto Module enough time to prepare for the transaction. See the timing diagrams with each command for the delay times to use.

When a data transaction is complete and the #CS line is high, the master microcontroller must delay to allow the XPress™ Crypto Module to finish processing the transaction.

CMD1 and CMD0 are used to tell the XPress™ Crypto Module what command is to be executed according to this table:

Command Byte - HEX	Command
0x00	getSTATUS
0x01	getPlainText
0x02	getCipherText
0x03	getVersion
0x80	INVALID
0x81	setPlainText
0x82	setCipherText
0x83	setReset

Status and Reset Commands

`getStatus:`

The getStatus command is used to find out the current status of the module.

0x00	getStatus							
	b7	b6	b5	b4	b3	b2	b1	b0
Byte1	ST	DFIFO	EFIFO	DDATA	EDATA	CODE2	CODE1	CODE0

ST: When set, this bit indicates that the XPress™ Crypto Module is performing power up self test.

DFIFO: When set, this bit indicates that the Decipher FIFO is full; no more ciphertext can be transferred to the module until some plaintext is read out.

EFIFO: When set, this bit indicates that the Encipher FIFO is full; no more plaintext can be transferred to the module until some ciphertext is read out.

DDATA: When set, this bit indicates that plaintext is ready to be read out of the XPress™ Crypto Module.

EDATA: When set, this bit indicates that ciphertext is ready to be read out of the XPress™ Crypto Module.

CODE2...0: If an error occurs (error line asserted) there will be a condition code here. The error must be cleared by de-asserting the #CS line before operation can be resumed.

Error Code	Error
0x00	Null/No code
0x01	Self test in progress
0x02	Last command not understood
0x03	Data size invalid
0x04	No code
0x05	Self test failed

getVersion:

The getVersion command is used to determine the firmware version running in the XPress™ Crypto Module.

0x03	getVersion							
	b7	b6	b5	b4	b3	b2	b1	b0
Byte1	Ma3	Ma2	Ma1	Ma0	Mi3	Mi2	Mi1	Mi0
Byte2	BN15	BN14	BN13	BN12	BN11	BN10	BN9	BN8
Byte3	BN7	BN6	BN5	BN4	BN3	BN2	BN1	BN0

Ma3...0: Major Version Number

Mi3...0: Minor Version Number

BM15...0: Build Number

setReset:XPress™ Crypto Module

The setReset command is used to reset the XPress™ Crypto Module and can be issued at any time during normal operation. After a reset has been issued the XPress™ Crypto Module takes approximately 300ms to restart.

There are no other bytes required to reset the device. The host microcontroller simply needs to send the 0x83 Command Byte.

Plain Data Commands

The Plain Data Commands are used to transfer plaintext between XPress™ Crypto Module and the host microcontroller.

getPlainText:

The getPlainText command is used to read deciphered plaintext data from the XPress™ Crypto Module. The Data Ready line will be asserted and the EDATA bit of the status register will be set when data is present in the decipher FIFO and will remain asserted until all data is read. There is protection for data in the decipher FIFO; the data will remain present until it has been read out.

0x01	getPlainText							
	b7	b6	b5	b4	b3	b2	b1	b0
Byte1	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0

ID7...0: A packet identifier, the same one associated with the packet when it was sent to the XPress™ Crypto Module using the setCipherText command.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte2	-	-	-	-	-	S10	S9	S8
Byte3	S7	S6	S5	S4	S3	S2	S1	S0

S10...0: Data packet size in bytes.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte4	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
...	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
ByteN	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0

DATA7...0: Data bytes.

Timing requirements for getPlainText:

1. Between the Command Byte and Byte1, at least 4.0 µs.
2. Between Byte1 and Byte2, Byte2 and Byte3, at least 0.5 µs.
3. Between each data byte, at least 1.0 µs.
4. After the last data byte and before de-asserting #CS, at least 2.0 µs.

setPlainText:

The setPlainText command is used to submit data for encryption. The FIFO Full line will be asserted if the transmit FIFO cannot accept any more data. If the host microcontroller attempts to submit data while the FIFO Full line is asserted then the Error line will also become asserted and the data being submitted will not be entered into the FIFO.

Once the data has been fully transferred to the XPress™ Crypto Module, it is queued up for enciphering.

0x81	setPlainText							
	b7	b6	b5	b4	b3	b2	b1	b0
Byte1	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0

ID7...0: A packet identifier, this value is associated with the data packet and will be sent back to the host microcontroller when the enciphered data is read back out using the getCipherText command.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte2	-	-	-	-	-	S10	S9	S8
Byte3	S7	S6	S5	S4	S3	S2	S1	S0

S10...0: Data packet size in bytes. The number of bytes must be between 1 and 2047.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte4	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
...	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
ByteN	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0

DATA7...0: Data bytes.

Timing requirements for setPlainText:

1. Between the Command Byte and Byte1, at least 1.8 µs.
2. Between Byte1 and Byte2, Byte2 and Byte3, at least 0.5 µs.
3. Between Byte3 and the first data byte, at least 2.0 µs.
4. Between each data byte, at least 1.1 µs.
5. After the last data byte and before de-asserting #CS, at least 4.5 µs.

Cipher Data Commands

The Cipher Data commands are used to transfer ciphertext between XPress™ Crypto Module and the host microcontroller. They behave in a very similar manner to the Plain Data Commands just described.

getCipherText:

The getCipherText command is used to read ciphered data from the XPress™ Crypto Module. The Data Ready line will be asserted and the DDATA bit of the status register will be set when data is present in the encipher FIFO and will remain asserted until all data is read. There is protection for data in the encipher FIFO; the data will remain present until it has been read out.

0x02	getCipherText							
	b7	b6	b5	b4	b3	b2	b1	b0
Byte1	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0

ID7...0: A packet identifier, the same one associated with the packet when it was sent to the XPress™ Crypto Module using the setPlainText command.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte2	-	-	-	-	-	S10	S9	S8
Byte3	S7	S6	S5	S4	S3	S2	S1	S0

S10...0: Data packet size in bytes.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte4	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
...	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
ByteN	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0

DATA7...0: Data bytes.

Timing requirements for getCipherText:

1. Between the Command Byte and Byte1, at least 4.0 µs.
2. Between Byte1 and Byte2, Byte2 and Byte3, at least 0.5 µs.
3. Between each data byte, at least 1.0 µs.
4. After the last data byte and before de-asserting #CS, at least 2.0 µs.