

## ADuC702x Serial Download Protocol

by Aude Richard

### INTRODUCTION

One of the many features of the MicroConverter® product family is the ability of the device to download code to its on-chip Flash/EE program memory while in-circuit. This in-circuit code download feature is conducted over the device UART serial port, and is thus commonly referred to as serial download. Serial download capability allows developers to reprogram the part while it is soldered directly onto the target system, avoiding the need for an external device programmer. Serial download also opens up the possibility of system upgrades in the field; all that is required is serial port access to the MicroConverter. This means manufacturers can upgrade system firmware in the field without having to swap out the device.

Any MicroConverter device can be configured for serial download mode via a specific pin configuration at power-on or during application of the external reset signal. For the ADuC702x family of MicroConverters, the P0.0 input pin is pulled low through a resistor (1 kΩ). If this condition is detected by the part at power-on or during application of a hard reset input, the part will enter serial download mode. In this

mode, an on-chip resident loader routine is initiated. The on-chip loader configures the device UART and, via a specific serial download protocol, communicates with any host machine to manage the download of data into its Flash/EE memory spaces. The format of the program data to download must be little-endian.

It should be noted that serial download mode operates within the standard supply rating of the part (2.7 V to 3.6 V). Therefore, there is no requirement for a specific high programming voltage since it's generated on-chip. Figure 1 shows how to enter serial download mode on an evaluation board.

As part of Analog Devices' QuickStart™ Development Tools, a Windows®-executable program is provided (C:\ADuC702x\Download\ARMWSD.exe) that allows the user to download code from the PC (PC serial ports COM1, 2, 3, or 4) to the MicroConverter. However, it should be emphasized that any master host machine (PC, microcontroller, or DSP) can download to the MicroConverter once the host machine adheres to the serial download protocols detailed in this application note.

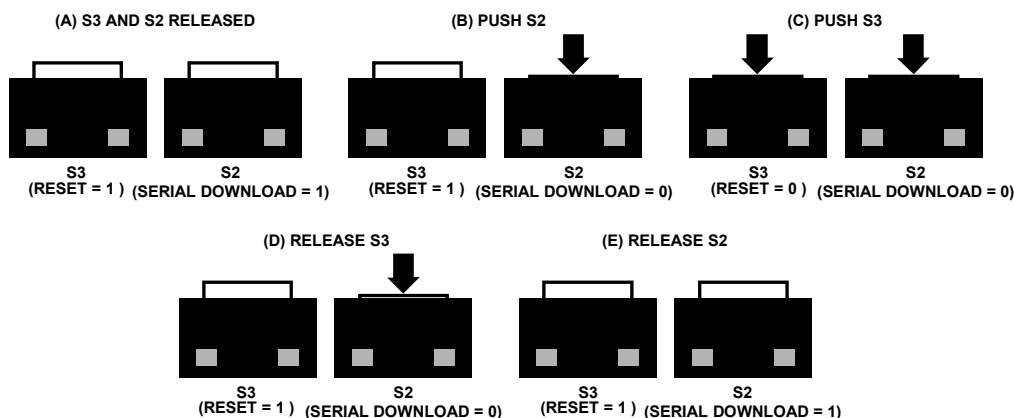


Figure 1. MicroConverter in Serial Download Mode

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This application note outlines in detail the MicroConverter serial download protocol, allowing end users to both fully understand the protocol and, if required, to successfully implement this protocol (embedded host to embedded MicroConverter) in an end-target system.

For the purposes of clarity, the term “host” refers to the host machine (PC, microcontroller, or DSP) attempting to download data to the MicroConverter. The term “loader” refers specifically to the on-chip serial download firmware on the MicroConverter.

## RUNNING THE MICROCONVERTER LOADER

The loader on the ADuC702x MicroConverter is run by pulling the P0.0 pin (serial download) low through a resistor (typically 1 kΩ pull-down) and resetting the part (toggling the RST input pin on the part itself, or a power cycle will reset the part).

## THE PHYSICAL INTERFACE

Once triggered, the loader waits for the host to send a backspace (BS = 0x08) character to synchronize. The loader measures the timing of this character and accordingly configures the MicroConverter UART serial port to transmit/receive at the host’s baud rate with 8 data bits and no parity. The baud rate must be between 600 bps and 115200 bps included. On receiving the backspace, the loader will immediately send the following 24-byte ID data packet:

15 bytes = product identifier

3 bytes = hardware and firmware version number

4 bytes = reserved for future use

2 bytes = line feed and carriage return

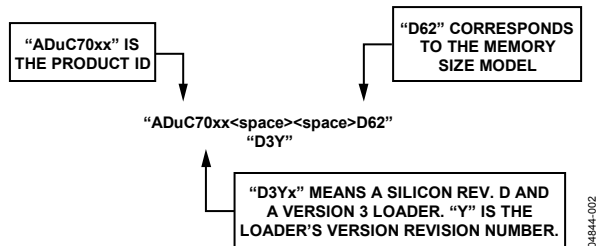


Figure 2. ID Data Packet

## DEFINING THE DATA TRANSPORT PACKET FORMAT

Once the UART has been configured, the transfer of data can begin. The general communications data transport packet format is shown in Table 1.

### Packet Start ID Field

The first field is the Packet Start ID field and contains two start characters (0x07 and 0x0E). These bytes are constant and are used by the loader to detect a valid data packet start.

### Number of Data Bytes Field

The next field is the total number of data bytes, including Data 1 (Command Function). The minimum number of data bytes is five, which corresponds to the command function and the address. The maximum number of data bytes allowed is 255: command function, 4-byte address, and 250 bytes of data.

### Command Function Field (Data 1)

The command function field describes the function of the data packet. One of five valid command functions is allowed. The five command functions are described by one of five ASCII characters: 'E,' 'W,' 'V,' 'P' or 'R.'

### Address Field (Data 2 → 5)

The address field contains a 32-bit address, h, u, m, l, with MSB in h and LSB in l.

### Data Byte Fields 6 → 255

User code is downloaded/verified by bytes. The data byte field contains a maximum of 250 data bytes. The data is normally stripped out of the Intel® Extended Hex 16-byte record format and reassembled by the host as part of the above data form before transmission to the loader (see the Intel Extended Hex Format section at the end of this application note).

### Checksum Field

The data packet checksum is written into this field. The twos complement checksum is calculated from the summation of the hex values in the number of bytes field and the hex values in the Data 1 to 255 fields (as many as exist). The checksum is the twos complement value of this summation. Thus the LSB of the sum of all the bytes from number of data bytes to the checksum inclusive should be 0. This can also be expressed mathematically as

$$CS = 0x00 - (\text{No. Data Bytes} + \sum_{N=1}^{255} \text{Data Byte}_N)$$

### Acknowledge of Command

The loader routine will respond with a BEL (0x07) as a negative response or an ACK (0x06) as a positive response to each data packet.

A BEL is transmitted by the loader if it receives an incorrect checksum or an invalid address. The loader does not give a warning if data is downloaded over old (unerased) data. The PC interface must ensure that any location where code will be downloaded is erased.

The full set of data packet command functions is shown in Table 2.

**Table 1. Data Transport Packet Format**

Start ID	No. of Data Bytes	Data 1 CMD	Data 2 → 5 (Address: h, u, m, l)	Data x (x = 6 → 255)	Checksum	
0x07	0x0E	5 → 255	E, W, V, P or R	h, u, m, l	xx	CS

**Table 2. Data Packet Command Functions**

Command Functions	Command Byte in Data 1 Field	Loader Positive Response	Loader Negative Response
Erase Page	E (0x45)	ACK (0x06)	BEL (0x07)
Write	W (0x57)	ACK (0x06)	BEL (0x07)
Verify	V (0x56)	ACK (0x06)	BEL (0x07)
Protect	P (0x50)	ACK (0x06)	BEL (0x07)
Run (Jump to User Code)	R (0x52)	ACK (0x06)	BEL (0x07)

**Table 3. Erase Flash/EE Memory Command**

Start ID	No. of Data Bytes	Data 1 CMD	Data 2 → 5 (Address: h, u, m, l)	Data 6 (pages)	Checksum	
0x07	0x0E	6	E (0x45)	h, u, m, l	X pages (1–124)	CS

**Table 4. Program Flash/EE Memory Command**

Start ID	No. of Data Bytes	Data 1 CMD	Data 2 → 5 (Address: h, u, m, l)	Data x (x = 1 → 250)	Checksum	
0x07	0x0E	5 + x (6 → 255)	W (0x57)	h, u, m, l	Data Bytes	CS

### **Erase Command**

The erase command allows the user to erase Flash/EE from a specific page determined by data 2 → 5. The address is rounded down to the page start. This command also requires the number of pages to erase. If the address is 0x00000000 and the number of pages is 0x00, the loader will interpret it as a mass erase command, erasing the entire user code space and the Flash/EE protection.

The data packet for the erase command is shown in Table 3.

### **Write Command**

The write command requires the number of data bytes (5 + x), the command, the address of the first data byte to program, and the data bytes to program. The bytes will be programmed into Flash/EE as they arrive. The loader will send a BEL if the checksum is incorrect or if the address received is out of range. If the host receives a BEL from the loader, the download process should be aborted and the entire download sequence started again.

### **Verify Command**

The verify command is almost identical to the write command, as shown in Table 5. The command field is V (0x56), but to improve the chance of detecting errors the data bytes are modified: the low 5 bits are shifted to the high 5 bits, and the high 3 bits are shifted to the low 3 bits.

**Table 5. Verify Command, Bit Modifications**

Original Bits	Transmitted Bits	Restored Bits
7	4	7
6	3	6
5	2	5
4	1	4
3	0	3
2	7	2
1	6	1
0	5	0

The loader restores the correct bit sequence and compares it to the flash contents. If it is correct and the checksum is correct, ACK (0x06) is returned; otherwise BEL (0x07) is returned.

**Table 6. Verify Flash/EE Memory Command**

Start ID	No. of Data Bytes	Data 1 CMD	Data 2 → 5 (Address: h, u, m, l)	Data x (x = 1 → 250)	Checksum
0x07	0x0E 5 + x (6 → 255)	V (0x56)	h, u, m, l	Modified Data Bytes	CS

**Table 7. Flash/EE Memory Protection Command**

Start ID	No. of Data Bytes	Data 1 CMD	Data 2 → 5 (Address: h, u, m, l)	Data 6	Checksum
0x07	0x0E 0x06	P (0x50)	h, u, m, l	Type	CS

**Table 8. Jump to User Code (Remote RUN) Command**

Packet ID	No. of Data Bytes	Data 1 CMD	Data 2 → 5 (Address: h, u, m, l)	Checksum
0x07	0x0E 0x05	R (0x52)	h, u, m, l = 0x80000	0xA1

### Flash/EE Memory Protection Command

To use this command a three-step sequence must be followed:

1. Initiation of the command: type must be 0x00 and “huml” can be any value.
2. Send the address of the group of page to protect. This step must be repeated for each group of page to protect and type must be 0x0F
3. Send the key in “huml”, type must be 0x01. FEEADR will take the value of “hu” and FEEDAT will take the value of “ml”. If no keys are required, “huml” must be 0xFFFFFFFF.

For example, to protect page 0 to 7 against writing, set the read protection and use key 0x12345678, the following commands must be sent.

1. start sequence:  
0x07 0x0E 0x06 0x50 0xFFFFFFFF 0x00 CS
2. protection:  
0x07 0x0E 0x06 0x50 0x00000000 0x0F CS (pages 0 to 3)  
0x07 0x0E 0x06 0x50 0x00000200 0x0F CS (pages 4 to 7)  
0x07 0x0E 0x06 0x50 0x0008F800 0x0F CS (read protection)
3. key and end of sequence :  
0x07 0x0E 0x06 0x50 0x12345678 0x01 CS

Note:

The protection command is only available rev O and later revision of the loader. On rev O, FEEADR = ‘ml’ and FEEDAT = ‘ml’. On later revision of the loader FEEADR = ‘hu’.

This protocol doesn’t allow to unprotect the Flash/EE memory. To remove the protection, a mass erase command can be used.

### Jump to User Code (Remote Run) Command

Once the host has transmitted all data packets to the loader, the host can send a final packet instructing the loader to force the MicroConverter program counter to a given address, and thus begin executing the code that has just been downloaded. Table 8 shows an example of a Remote RUN or “jump to user code” from address 0x00.

Only run from start of the Flash/EE (h, u, m, l = 0x80000) is supported at present.

### INTEL EXTENDED HEX FORMAT

Intel Extended Hexadecimal format or Intel Extended Hex format is a standard for storing machine language in displayable ASCII or printable format. It is similar to the Hex 8 format except that the Intel extended linear address record is output to also establish the upper 16 bits of the data address. Each data record begins with a colon followed by an 8-character prefix, and ends with a 2-character checksum. Each record has the following format:

:BBAAAATTHHHH...HHHCC

where:

BB is a 2-digit hexadecimal byte count representing the number of data bytes that will appear on the line.

AAAA is a 4-digit hexadecimal address representing the starting address of the data record.

TT is a 2-digit record type:

- 00–Data record
- 01–End of file record
- 02–Extended segment address record
- 03–Start segment address record
- 04–Extended linear address record
- 05–Start linear address record

HH is a 2-digit hexadecimal data byte.

CC is a 2-digit hexadecimal checksum that is the twos complement of the sum of all preceding bytes in the record, including the prefix (sum of all bytes + checksum = 00).

## RECORD TYPES

### **Data Record**

Record type 00, the data record, is the record that contains the data of the file. The data record begins with the colon start character (":") followed by the byte count, the address of the first byte, and the record type ("00"). The data bytes follow the record type. The checksum follows the data bytes and is the twos complement of the preceding bytes in the record, excluding the start character. The following are examples of data records (spaces are included for clarity only and should not be found in a real object file).

```
:10 0000 00 FFFDFDFCFBFAF9F8F7F6F5F4F3F2F1F0 FF
```

```
:05 0010 00 0102030405 AA
```

### **End Record**

Record type 01, the end record, signals the end of the data file. The end record starts with the colon start character (":") followed by the byte count ("00"), the address ("0000"), the record type ("01"), and the checksum ("FF").

```
:00 0000 01 FF
```

### **Extended Segment Address Record**

Record type 02, the extended segment address record, defines Bits 4 through 19 of the segment base address. It can appear anywhere within the object file and it affects the absolute memory address of all subsequent data records in the file until it is changed. The extended segment address record starts with the colon start character (":") followed by the byte count ("02"), the address ("0000"), the record type ("02"), the 4-character hexadecimal number represented by Bits 4 through 19 of the segment base address, and the 2-character checksum.

```
:02 0000 02 1000 55
```

### **Start Segment Address Record**

Record type 03, the start segment address record, defines Bits 4 through 19 of the execution start segment base address for the object file.

```
:02 0000 03 0000 55
```

### **Extended Linear Address Record**

Record type 04, the extended linear address record, defines Bits 16 through 31 of the destination address. It can appear anywhere within the object file and it affects the absolute memory address of all subsequent data records in the file until it is changed. The extended linear address record starts with the colon start character (":") followed by the byte count ("02"), the address ("0000"), the record type ("04"), the 4-character

hexadecimal number represented by Bits 16 through 31 of the destination address, and the 2-character checksum.

```
:02 0000 04 FFFF 55
```

### **Start Linear Address Record**

Record type 05, the start linear address record, defines Bits 16 through 31 of the execution start address for the object file.

```
:02 0000 05 0000 55
```

The following is an example of an Intel Hexadecimal Object File that contains the following records: extended linear address, extended segment address, data, and end.

```
:020000040108EA
```

```
:0200000212FFBD
```

```
:0401000090FFAA5502
```

```
:00000001FF
```

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1. Determine the extended linear address offset for the data record (0108 in this example).

:02 0000 04 0108 EA

2. Determine the extended segment address for the data record (12FF in this example).

:02 0000 02 12FF BD

3. Determine the address offset for the data in the data record (0100 in this example).

:04 0100 00 90FFAA55 02

4. Calculate the absolute address for the first byte of the data record.

+ 0108 0000 linear address offset shifted left 16 bits

+ 0001 2FF0 segment address offset shifted left 4 bits

+ 0000 0100 address offset from data record  
= 0109 30F0 32 bit address for first data byte

5. Calculations

010930F0 90

010930F1 FF

010930F2 AA

010930F3 55

## LIMITATIONS

Record types 02, 03, 04, and 05 are not implemented. Unsupported records are ignored. Only the low 16 address bits are significant to access internal Flash, therefore it is safe to ignore these record types that change the high 16 bits.

**NOTES**

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