



APPLICATION NOTE 3579

# In-Application Programming (IAP) of the MAXQ7665C Page-Erasable (PE) Flash with One-Word-Erase Data Flash

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*Abstract: This application note describes the program flash, the page-erasable (PE) data flash, and in-application programming (IAP) using the built-in Utility ROM on the MAXQ7665C microcontroller ( $\mu$ C). The information applies only to the MAXQ7665C flash-based microcontroller with PE flash configured as one-word-erase data flash.*

## Introduction

This application note describes how to manage the internal data and program flash in the [MAXQ7665C](#) flash-based microcontroller ( $\mu$ C) with page-erasable (PE) flash memory and single-word-erase data flash. General instruction for performing in-application programming (IAP) of the program flash is presented.

## Memory Maps

This section details the general flash information and memory organization for the MAXQ7665C microcontroller. There are three types of flash memory available on the MAX7665 devices: sector flash, single-word erase, and two-page erase. This document *only* covers MAXQ7665C devices that have PE flash with single-word-erase data flash; the article does not apply to the sector-erase-only devices or devices with two-page-erase data flash. For information on MAXQ7665 sector-erasable (SE) devices, please refer to application note 3575, "[In-Application Programming \(IAP\) of the MAXQ7665 Sector-Erasable Program and Data Flash](#)". For information on MAXQ7665 page-erasable (PE) devices with two-page-erase data flash, please refer to application note 3576, "[In-Application Programming \(IAP\) of the MAXQ7665 Page-Erasable \(PE\) Program and Data Flash](#)".

**Table 1** through **Table 3** show the memory maps for the 16KB MAXQ7665C device when executing code from program flash, Utility ROM, and data SRAM respectively. **Figures 1** and **2** chart the sector and page structure for the 16KB and 128B data flash. Other flash options are available, so please consult the MAXQ7665C data sheet for a complete list.

**Table 1. 16KB Memory Space—Executing from Program Flash**

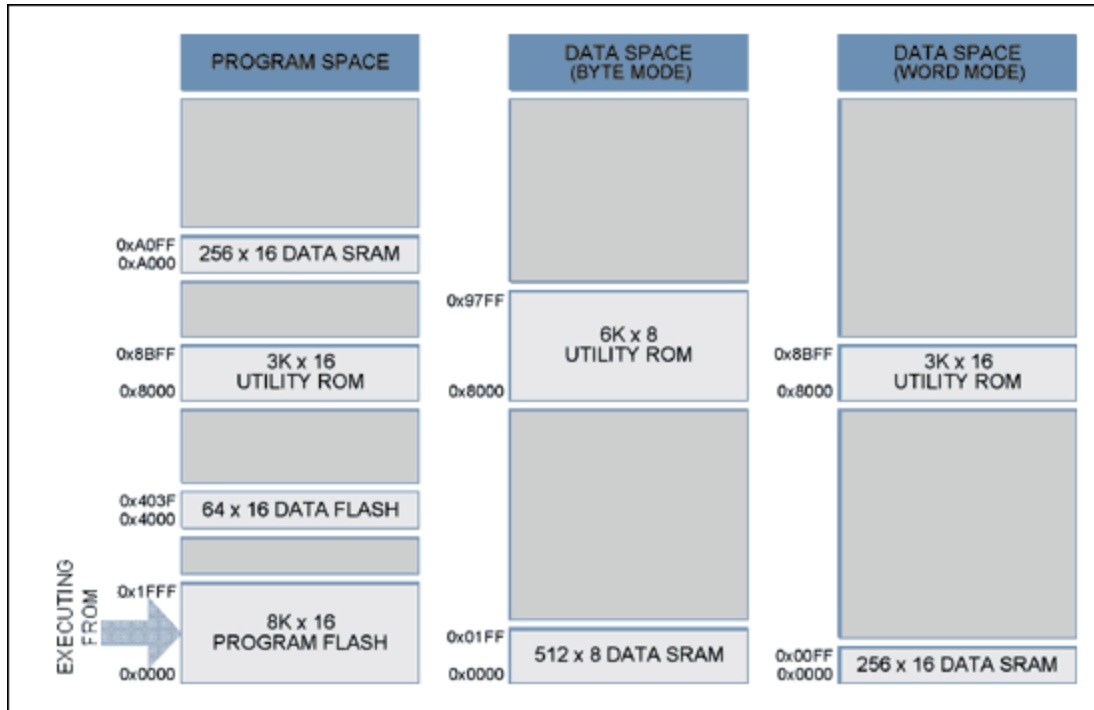


Table 2. 16KB Memory Space—Executing from Utility ROM

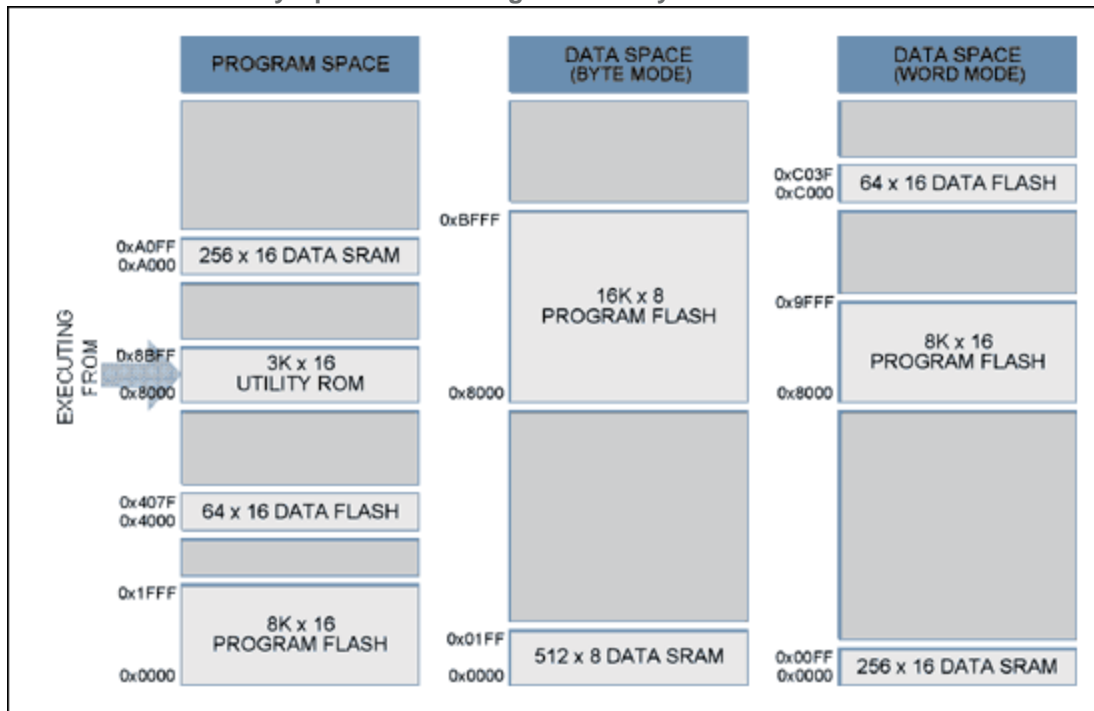


Table 3. 16KB Memory Space—Executing from Data SRAM

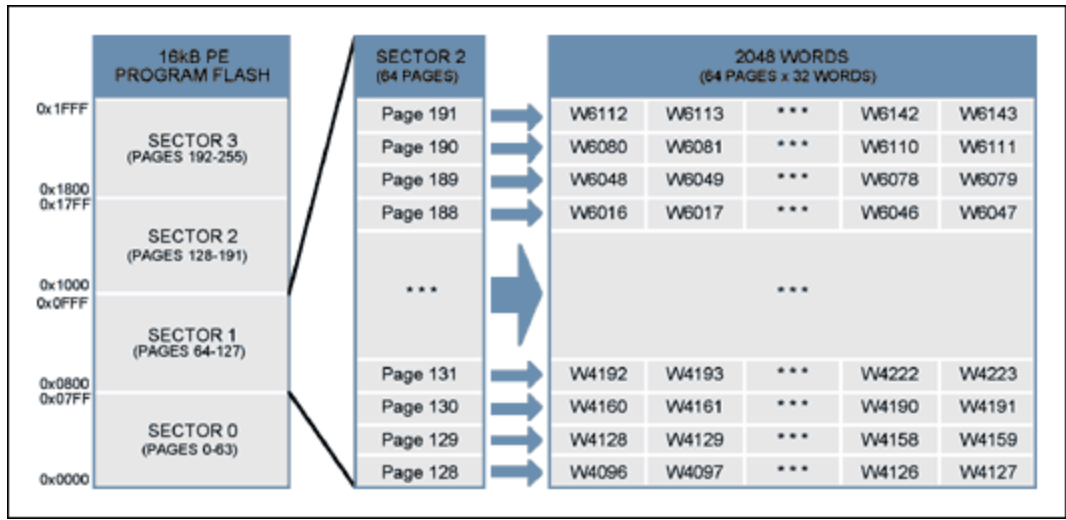
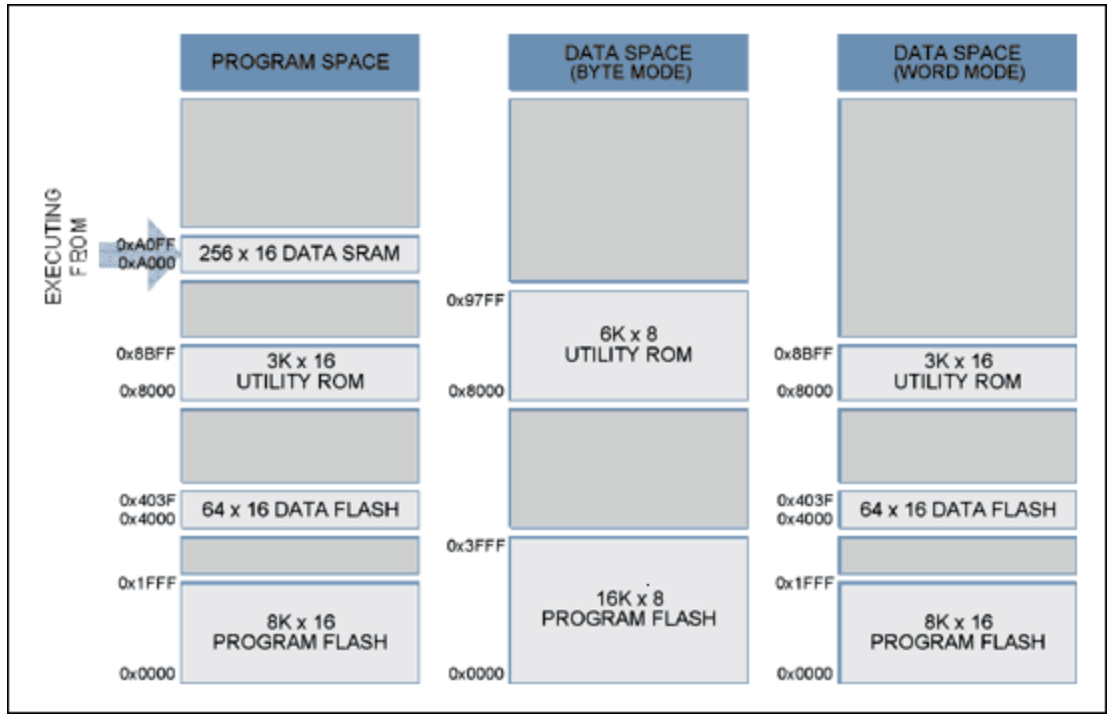


Figure 1. Sector/page structure for 16KB program flash.

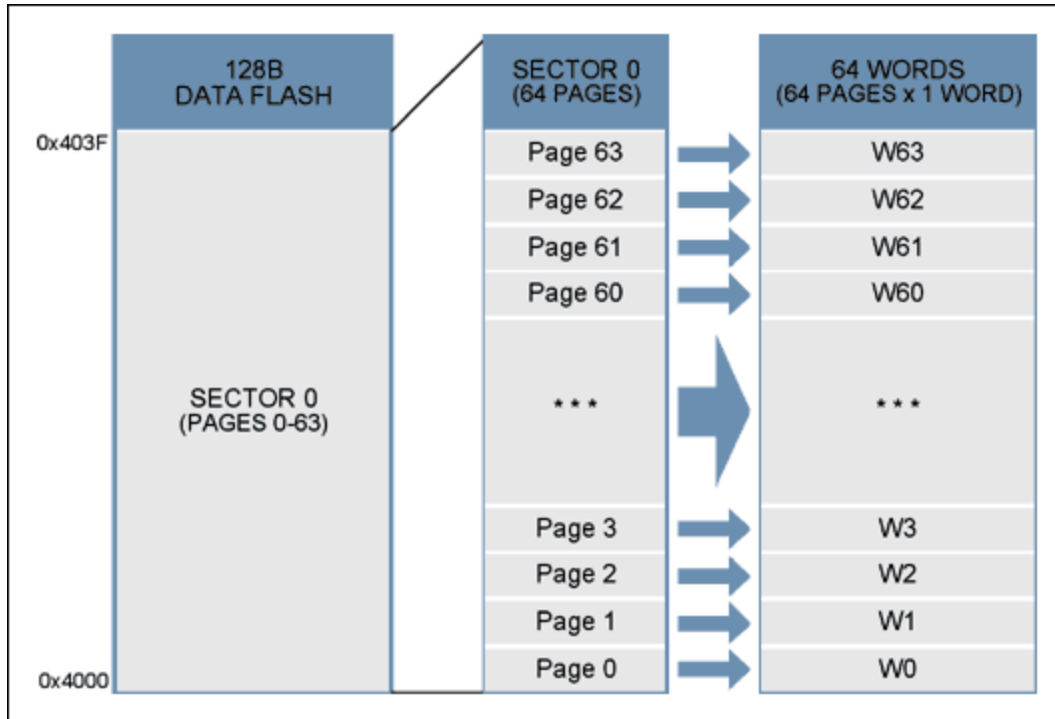


Figure 2. Sector/page structure for 128B data flash.

## Using Data Flash to Store Data

The flash can reliably store system data that needs to be programmed once or periodically during system operation. Like EEPROM, flash on the MAXQ7665C can be word-erased. This erasure typically takes 10ms, but can take longer under worst-case conditions. During this time the user code is stalled so no other processing can occur.

There are multiple techniques for storing data to flash, and several factors to consider when choosing the appropriate method for an application. Does the application need to ensure that the current data remains intact until the new data is completely written? If the answer is yes, then some form of bank-switching technique is necessary. How many erase/write cycles will occur during the life of the product? If the number of erase/write cycles will exceed the maximum specified in the data sheet, then using a bounded-queue technique can substantially increase the total erase/write cycles by spreading these cycles over multiple pages of the data flash. For most periodic data-storage needs, bank switching and/or a bounded-queue approach meet the reliability requirements and needs of the system. Simple examples of each technique follow below.

### Bank Switching

Bank switching is an effective method of preventing data loss or corruption during an erase/write cycle. This method works well by always maintaining at least one copy of the data. The drawback to bank switching is that it requires double the amount of data flash than a bounded queue. Bank switching is, in fact, nothing more than the bounded-queue method with a queue size of 2. For this reason, please refer to the next section for details on how to implement a bounded queue.

### Bounded Queue

A bounded queue is a queue limited by a fixed number of items. This method is commonly used for processing periodic data.

A bounded queue is formed by creating a fixed-length queue of "entries" equal to the desired data-block size. The entry size is application specific, and must be rounded up to the nearest page-erase boundary. Note that the minimum size that can be erased is two pages/words. While the data flash can be partitioned many ways based on application requirements, entries are limited to multiples of two pages due to the two-page-erase restriction imposed by the data flash. A 64 x 16 data flash, for example, can be divided into eight 8-word entries, which would result in the memory map of **Table 4**.

Upon initialization, a startup routine scans the queue entries to determine the next available entry in the queue. Once the queue is full, it can be made to wrap back to the beginning. Once the data flash entry is erased, the new entry can be written. **Figure 3** illustrates the flow of entries into a bounded queue.

See **Appendix A** for a simple C source-code example.

**Table 4. Example of a Bounded-Queue Memory Map**

FLASHQueue[ ]	
Queue Index	Data Flash Address
7	0xC038-0xC03F
6	0xC030-0xC037
5	0xC028-0xC02F
4	0xC020-0xC027
3	0xC018-0xC01F
2	0xC010-0xC017
1	0xC008-0xC00F
0	0xC000-0xC007

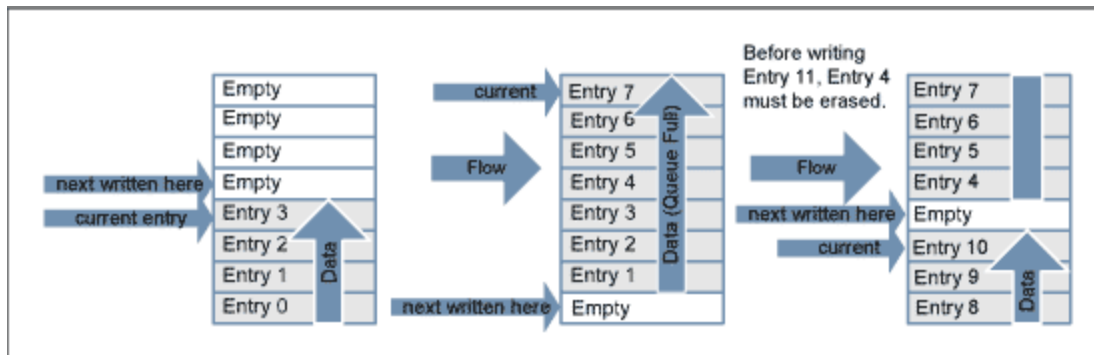


Figure 3. Diagram of a bounded-queue flow.

## Utility ROM Flash Routines

To program, erase, and verify flash, the MAXQ7665C microcontroller has on-chip flash support routines residing in ROM (read-only memory). There are two ways to access these routines: direct access and indirect access through a lookup table. Direct access, the fastest method, directly calls the routine. To do this, provide a header file with the following lines:

```

u16 flashErasePage(void *);
u16 flashEraseSector(void *);
u16 flashEraseAll(void);

u16 dataFlashWriteE(u16 *pAddress, u16 iData);
u16 dataFlashErasePage(void *);
u16 dataFlashEraseSector(void *);
u16 dataFlashEraseAll(void);
u16 dataFlashReadE(u16 *pAddress, u16 iData);

```

Next, add linker defines to assign the appropriate address for each routine. For the IAR linker file, the added lines would look like this:

```

-DflashEraseSector=0x8XXX
-DflashErasePage=0x8XXX
-DflashEraseAll=0x8XXX
. . .

```

Replace **0x8XXX** with the appropriate memory address for each routine. Other compilers may use a different method for adding such references.

The **flashWrite()** utility routine cannot be called directly from C due to argument passing incompatibility with the C language. A small assembly routine such as the one below must be written to call this function.

**Note:** The direct-access method does not provide forward compatibility with future ROM versions.

The second method to access the flash support routines is indirect access through a table lookup. This method provides greater compatibility with future ROM versions, but consumes greater execution time. After each routine described below, an assembly routine uses the table-lookup method to obtain the address of the Utility ROM routine. **Table 5** shows the flash routines supplied by the Utility ROM. For a complete listing of Utility ROM routines, please refer to the [MAXQ7665C User's Guide](#).

**Table 5. Flash Utility ROM Routines**

Routine Number	Routine Name	Entry Point ROMTable = ROM[800Dh]	Entry Point Physical Address
1	flashWrite	ROM[ROMTable]	0x8XXX
2	flashErasePage	ROM[ROMTable + 1]	0x8XXX
3	flashEraseAll	ROM[ROMTable + 2]	0x8XXX
4	moveDP0	ROM[ROMTable + 3]	0x8XXX
16	flashEraseSector	ROM[ROMTable + 15]	0x8XXX
18	dataFlashWriteE	ROM[ROMTable + 17]	0x8XXX
19	dataFlashErasePage	ROM[ROMTable + 18]	0x8XXX
20	dataFlashEraseSector	ROM[ROMTable + 19]	0x8XXX
21	dataFlashEraseAll	ROM[ROMTable + 20]	0x8XXX
22	dataFlashReadE	ROM[ROMTable + 21]	0x8XXX

#### flashWrite()

<b>Routine:</b>	u16 flashWrite(u16 *pDest, u16 *pSrc)
<b>Summary:</b>	Programs a single page (32 words) of program-flash memory.
	DP[0]—Destination address in flash memory.

<b>Inputs:</b>	DP[1]—Source address in SRAM holding 32 words of data to write.
<b>Outputs:</b>	Carry: Set on error and cleared on success. If set, then A[0] contains one of the following error codes: 1: failure due to software timeout 2: failure reported by hardware (DQ5/FERR) 4: command not supported SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

The following example of assembly code calls the **flashWrite()** utility routine using the indirect-addressing method (lookup table). This routine is callable by C code.

```
; This routine is callable by C code using the following prototype
; u16 flashWrite(u16 *pDest, u16 *pSrc);
;
flashWrite:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #2           ; Set ACC to A[2].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
    move ACC, @DP[0]      ; Get the location of the routine table.
    add #14               ; Add the index to the flashWrite routine.
    move DP[0], ACC
    move ACC, @DP[0]      ; Retrieve the address of the routine.
    push DP[1]           ; Save Frame Pointer on the stack.
    move DP[0], A[0]      ; Move argument 0(dest address) to DP[0].
    move DP[1], A[1]      ; Move argument 1(src address) to DP[1].
    call ACC              ; Execute the routine.
    pop DP[1]            ; Restore Frame Pointer.
    ret                  ; Status returned in A[0].
```

### flashErasePage()

<b>Routine:</b>	u16 flashErasePage(void *pAddress)
<b>Summary:</b>	Erases a two-page block of program-flash memory.
<b>Inputs:</b>	A[0]—Address located in the two page block to erase, i.e., to erase pages 0 and 1, A[0] can contain any address from 0x0000 to 0x001F.
<b>Outputs:</b>	Carry: Set on error and cleared on success. If set, then A[0] contains one of the following error codes: 1: failure due to software timeout 2: failure reported by hardware (DQ5/FERR) 4: command not supported SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

```
; This routine is callable by C code using the following prototype
; u16 flashErasePage(void *pAddress);
;
flashErasePage:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #1           ; Set ACC to A[1].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
```

```

move ACC, @DP[0]      ; Get the location of the routine table.
add #1                ; Add the index to the flashEraseSector routine.
move DP[0], ACC
move ACC, @DP[0]     ; Retrieve the address of the routine.
call ACC              ; Execute the routine.
ret                   ; Status returned in A[0].

```

### flashEraseAll()

<b>Routine:</b>	Void flashEraseAll(void)
<b>Summary:</b>	Erases the entire program and data-flash memory. This routine can only be called from RAM.
<b>Inputs:</b>	None
<b>Outputs:</b>	Carry: Set on error and cleared on success. SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

```

; This routine is callable by C code using the following prototype
; void flashEraseAll(void);
;
flashEraseAll:
    move APC, #0      ; No auto inc/dec of accumulator.
    move AP, #0       ; Set ACC to A[0].
    move DP[0], #0800Dh ; This is where the address of the table is
stored.
    move ACC, @DP[0]  ; Get the location of the routine table.
    add #2            ; Add the index to the flashEraseAll routine.
    move DP[0], ACC
    move ACC, @DP[0]  ; Retrieve the address of the routine.
    call ACC          ; Execute the routine.
    ret

```

### moveDP0

<b>Routine:</b>	moveDP0
<b>Summary:</b>	Reads a single word of program-flash memory.
<b>Inputs:</b>	DP[0]—Source address in flash memory. Add 0x8000 to read program flash.
<b>Outputs:</b>	GR will contain the data at specified address.
<b>Notes:</b>	This function cannot be called directly from C because argument and return register are not compatible with C-calling conventions.

The following example of assembly code converts **moveDP0** into a C-callable routine. If speed is essential to the application, then a custom assembly-language routine should be written for a specific task. There are several Utility ROM routines like this one that will aid in writing an efficient data transfer from flash.

```

; This routine is callable by C code using the following prototype
; u16 flashRead(u16 *pAddress);
;
flashRead:
    move APC, #0      ; No auto inc/dec of accumulator.
    move AP, #1       ; Set ACC to A[1].
    move DP[0], #0800Dh ; This is where the address of the table is
stored.
    move ACC, @DP[0]  ; Get the location of the routine table.
    add #3            ; Add the index to the moveDP0 routine.

```



```

move DP[0], ACC
move ACC, @DP[0] ; Retrieve the address of the routine.
push DP[1] ; Save Frame Pointer on the stack.
move DP[0],A[0] ; Move argument 0(src address) to DP[0].
call ACC ; Execute the routine.
pop DP[1] ; Restore Frame Pointer.
move A[0],GR
ret ; Data word returned in A[0].

```

### flashEraseSector()

<b>Routine:</b>	u16 flashEraseSector(void *pAddress)
<b>Summary:</b>	Erases a single sector of program-flash memory.
<b>Inputs:</b>	A[0]—Address located in the sector to erase.
<b>Outputs:</b>	Carry: Set on error and cleared on success. If set, then A[0] contains one of the following error codes: 1: failure due to software timeout 2: failure reported by hardware (DQ5/FERR) 4: command not supported SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

```

; This routine is callable by C code using the following prototype
; u16 flashEraseSector(void *pAddress);
;
flashEraseSector:
    move APC, #0 ; No auto inc/dec of accumulator.
    move AP, #1 ; Set ACC to A[1].
    move DP[0], #0800Dh ; This is where the address of the table is
stored.
    move ACC, @DP[0] ; Get the location of the routine table.
    add #15 ; Add the index to the flashEraseSector routine.
    move DP[0], ACC
    move ACC, @DP[0] ; Retrieve the address of the routine.
    call ACC ; Execute the routine.
    ret ; Status returned in A[0].

```

### dataFlashWriteE()

<b>Routine:</b>	u16 dataFlashWriteE(void *pAddress, u16 *pData)
<b>Summary:</b>	Programs a single word of data-flash memory.
<b>Inputs:</b>	A[0]—Word address in flash memory to which to write. A[1]—Word value to write to flash memory.
<b>Outputs:</b>	Carry: Set on error and cleared on success. If set, then A[0] contains one of the following error codes: 1: failure due to software timeout 2: failure reported by hardware (DQ5/FERR) 4: command not supported SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset. This routine is the companion routine to <b>dataFlashReadE()</b> .

The following example assembly code calls the **dataFlashWriteE()** utility routine using the indirect-addressing method (lookup table). This routine is callable by C code.

```

; This routine is callable by C code using the following prototype
; u16 dataFlashWriteE(void *pAddress, u16 iData);
;
dataFlashWriteE:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #2           ; Set ACC to A[2].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
    move ACC, @DP[0]      ; Get the location of the routine table.
    add #16               ; Add the index to the flashWrite routine.
    move DP[0], ACC
    move ACC, @DP[0]      ; Retrieve the address of the routine.
    call ACC              ; Execute the routine.
    ret                  ; Status returned in A[0].

```

### dataFlashErasePage()

<b>Routine:</b>	u16 dataFlashErasePage(void *pAddress)
<b>Summary:</b>	Erases two pages of data-flash memory.
<b>Inputs:</b>	A[0]—Address located in the two-page block to erase, i.e., to erase pages 0 and 1, A[0] can contain address 0x4000 or 0x4001.
<b>Outputs:</b>	Carry: Set on error and cleared on success. If set, then A[0] contains one of the following error codes: 1: failure due to software timeout 2: failure reported by hardware (DQ5/FERR) 4: command not supported SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

```

; This routine is callable by C code using the following prototype
; u16 dataFlashErasePage(void *pAddress);
;
dataFlashErasePage:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #1           ; Set ACC to A[1].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
    move ACC, @DP[0]      ; Get the location of the routine table.
    add #18               ; Add the index to the dataFlashErasePage routine.
    move DP[0], ACC
    move ACC, @DP[0]      ; Retrieve the address of the routine.
    call ACC              ; Execute the routine.
    ret                  ; Status returned in A[0].

```

### dataFlashEraseSector()

<b>Routine:</b>	u16 dataFlashEraseSector(void *pAddress)
<b>Summary:</b>	Erases a single sector of data-flash memory.
<b>Inputs:</b>	A[0]—Address located in the sector to erase.
<b>Outputs:</b>	Carry: Set on error and cleared on success. If set, then A[0] contains one of the following error codes: 1: failure due to software timeout 2: failure reported by hardware (DQ5/FERR) 4: command not supported SW_FERR—Set on error, cleared on success.

**Notes:**

The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

```
; This routine is callable by C code using the following prototype
; ul6 dataFlashEraseSector(void *pAddress);
;
dataFlashEraseSector:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #1           ; Set ACC to A[1].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
    move ACC, @DP[0]      ; Get the location of the routine table.
    add #19               ; Add the index to the dataFlashEraseSector
routine.
    move DP[0], ACC
    move ACC, @DP[0]      ; Retrieve the address of the routine.
    call ACC             ; Execute the routine.
    ret                 ; Status returned in A[0].
```

**dataFlashEraseAll()**

<b>Routine:</b>	void dataFlashEraseAll(void)
<b>Summary:</b>	Erases the entire data-flash memory.
<b>Inputs:</b>	None
<b>Outputs:</b>	Carry: Set on error and cleared on success. SW_FERR—Set on error, cleared on success.
<b>Notes:</b>	The watchdog must not be active, or the watchdog timeout must be set long enough to complete this routine without triggering a reset.

```
; This routine is callable by C code using the following prototype
; void dataFlashEraseAll(void);
;
dataFlashEraseAll:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #0           ; Set ACC to A[0].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
    move ACC, @DP[0]      ; Get the location of the routine table.
    add #20               ; Add the index to the flashEraseAll routine.
    move DP[0], ACC
    move ACC, @DP[0]      ; Retrieve the address of the routine.
    call ACC             ; Execute the routine.
    ret
```

**dataFlashReadE**

<b>Routine:</b>	dataFlashReadE
<b>Summary:</b>	Reads a single word of flash memory.
<b>Inputs:</b>	A[0]—Source address in flash memory.
<b>Outputs:</b>	A[0]—Contains the data at specified address.
<b>Notes:</b>	Companion routine to <b>dataFlashWriteE()</b> .

The following example assembly code calls the **dataFlashReadE()** utility routine using the indirect-addressing method (lookup table). This routine is callable by C code.

```
; This routine is callable by C code using the following prototype
```

```

; u16 flashReadE(u16 *pAddress);
;
dataFlashReadE:
    move APC, #0           ; No auto inc/dec of accumulator.
    move AP, #1           ; Set ACC to A[1].
    move DP[0], #0800Dh   ; This is where the address of the table is
stored.
    move ACC, @DP[0]      ; Get the location of the routine table.
    add #21               ; Add the index to the dataFlashReadE routine.
    move DP[0], ACC
    move ACC, @DP[0]      ; Retrieve the address of the routine.
    call ACC              ; Execute the routine.
    ret                  ; Data word returned in A[0].

```

## In-Application Programming

An important requirement for most flash-based systems is the ability to update firmware while the system is installed in the end product. This is referred to as In-Application Programming (IAP). This section presents general guidelines for creating an IAP application.

The Utility ROM flash routines outlined in the previous section perform all the actions necessary to erase and write the flash ROM. Thus it is possible for an end-user application to perform operations on the flash memory. Like any other subroutine call, control will return to the end-user's code after completion of the routine.

For a reliable IAP, the boot-loader application must be separate from the main application. This separation ensures that the reprogramming procedure can be retried even after an incomplete reprogramming sequence occurred.

## Boot Loader

The ROM jumps to address `0x0000` after initialization. The entry point of the boot-loader application must, therefore, be placed at `0x0000`. The boot-loader application can extend into as many flash sectors/pages as needed. Any page used for the boot-loader application will not be available for the user-application code. The specific requirements that must be met when erasing and writing flash are listed in **Table 6**.

**Table 6. Requirements for Calling Flash Utility ROM Routines**

You cannot erase or program from the same flash page from which you are executing code. This is not normally a problem since the flash boot-loader application should never be erased during IAP.

The watchdog must not be enabled or the watchdog timeout must be set long enough to complete this routine without triggering a reset before calling the **flashEraseSector()** or **flashErasePage()** routine. If the watchdog timeout occurs before the erase is complete, it will reset the part.

Since the System Control Register bit, SC.UPA, must be set to 0 to access the Utility ROM, a Utility ROM routine cannot be called directly from program memory addresses  $\geq 0x8000$ . If access to a Utility ROM routine is required from a program in upper memory ( $\geq 0x8000$ ), then the program must indirectly call the ROM routine through a routine residing in lower memory ( $< 0x8000$ ). This effectively limits the boot loader to  $\leq 64\text{KB}$  ( $32\text{KB} \times 16$ ).

The flowchart in **Figure 4** shows what the MAXQ7665 does when exiting the reset state. After a diagnostic of the ROM itself and verification that the flash is ready, the ROM initialization code jumps directly to address `0x0000`.

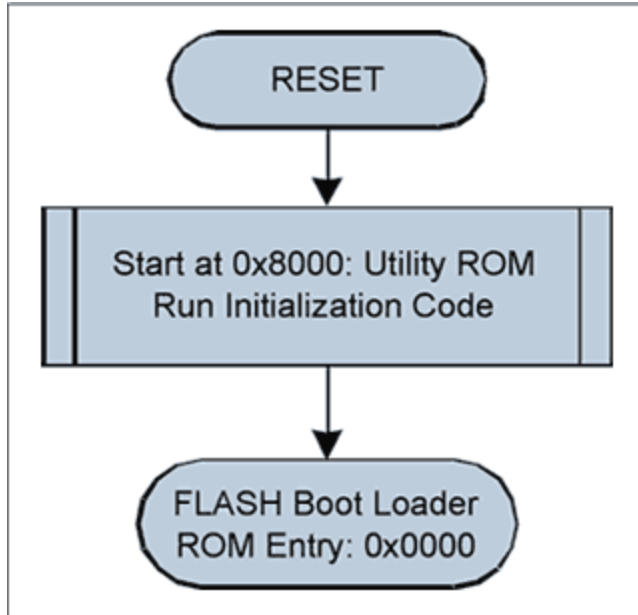


Figure 4. Flowchart of a simplified ROM initialization.

The **Figure 5** flowchart shows how a simple boot-loader application can appear. A simple application header looks something like:

```

typedef struct {
    u16 iSize; // The size of the application in words
    u32 iCRC; // The CRC of the application
    u8 ID[8]; // ID string for current application
} APPLICATION_HEADER;
  
```

Using the information from this header, the boot loader can check the validity of the main application program and report the version identification if requested.

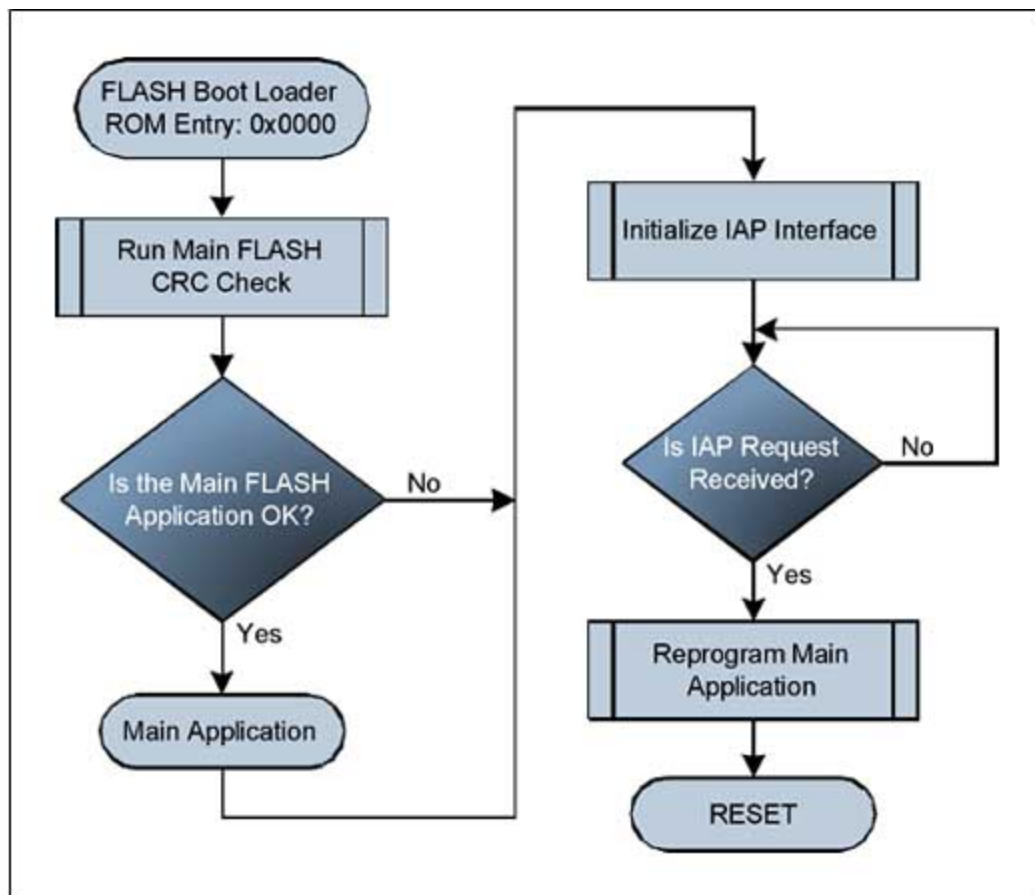


Figure 5. Flowchart for a simplified flash boot loader.

The programming sequence itself is quite simple. Erase each sector/page containing the main application code through a call to **flashEraseSector()** and/or **flashErasePage()**. Then write one page at a time by calling **flashWrite()** for every 32 words that need to be programmed. We advise you to erase the page containing the application header first and program the CRC data last to minimize the possibility of an errant CRC match. A very simple routine to reflash the microcontroller that gets data through the serial port looks like the following:

```

/*
// VerySimpleReFlash()
//   As simple as it gets.
//   Step 1. Wait for erase command, then erase flash.
//   Step 2. Wait for program command, then program flash one word
//           at a time.
*/
void VerySimpleReFlash()
{
ul6 iStatus;           // The status returned from flash utility ROM calls
s32 iSize;             // The size of the main code to program
ul6 *pAddress = 0x2000; // The starting address of the main application
ul6 i;

    InitializeCOMM(); // Can be CAN or UART.
    WaitForEraseCommand();

    // Assume that application starts at the beginning of a sector.
    for (i=C_START_SECTOR;i<C_SECTOR_END;++i) {

```

```

        iStatus = flashEraseSector(C_ADDRESS_SECTOR_1);
        if (iStatus != 0)
            break;
    }

    SlowDownWatchdogUpdate(); // If watchdog enabled slow down to prevent
    timeout

    SendFlashErasedResponse(iStatus);

    UpdateWatchdog(); // Prevent timeout.

    if (iStatus)
        ResetMicro();

    iSize = WaitForProgramCommand();
    while (iSize > 0)
    {
        u16 iData[32];
        Get32WordsFromCOMM(iData);
        iStatus = flashWrite(pAddress, iData);
        if (iStatus)
            break;
        pAddress += 32;
        iSize -= 32;
        UpdateWatchdog(); // Prevent timeout.
    }

    SendFlashWriteResponse(iStatus);
    ResetMicro();
}

```

## Appendix A. Code Examples

**Appendix A. Code Examples**

**Example Code for a Bounded Queue**

**Variables and Constants**

```

// These just make life easier
typedef unsigned char  u8;
typedef unsigned short u16;
typedef unsigned int   u32;
typedef signed char    s8;
typedef signed short  s16;
typedef signed int    s32;

#define C_0_X00      ( 0 )
#define C_0_X00_ID  ( C_0_X00 * 2 )
#define C_0_X00_IDI ( 0 )
#define C_0_FILL    (-1)
#define C_0_EMPTY   (-2)
#define C_0_IDI     ( 0xFF )

```

*// Note of this constant should be divisible by 4 for the code to work properly*

```

typedef struct {
    u16 iData[C_0_X00];
} QUEUE;

extern bool CheckValid(QUEUE *pQueue);
extern u16 dataFlashRead(u16 *pAddress);
extern u16 dataFlashWrite(u16 *pAddress, u16 iData);
extern QUEUE FlashQueue(C_0_X00); // Mapped into Data Flash
extern u8 iQueue;

```

**Initialization Code**

```

//
// queueInitQueue()
// This routine returns the current valid entry in the queue and
// sets the global variable iQueue to the ID of the current valid entry.
//
u8 queueInitQueue(u16 i)
{
    u16 iQueue;
    iQueue = 0;
    // Find the last valid entry
    for (iQueue = C_0_X00-1; iQueue >= 0; iQueue--)
    {
        // If empty then return the previous entry
        if (FlashQueue[iQueue].iID == C_0_EMPTY)
        {
            iQueue = iQueue + C_0_X00 - 1; // C_0_X00;
            iQueue = FlashQueue[iQueue].iID & C_0_X00_ID;
            return iQueue;
        }
    }
    // Should never get here. The queue is full, return error
    return C_0_FILL;
}

```

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