Storage & DMA Integration - 8086 Microprocessor Project

Giovanny Garcia

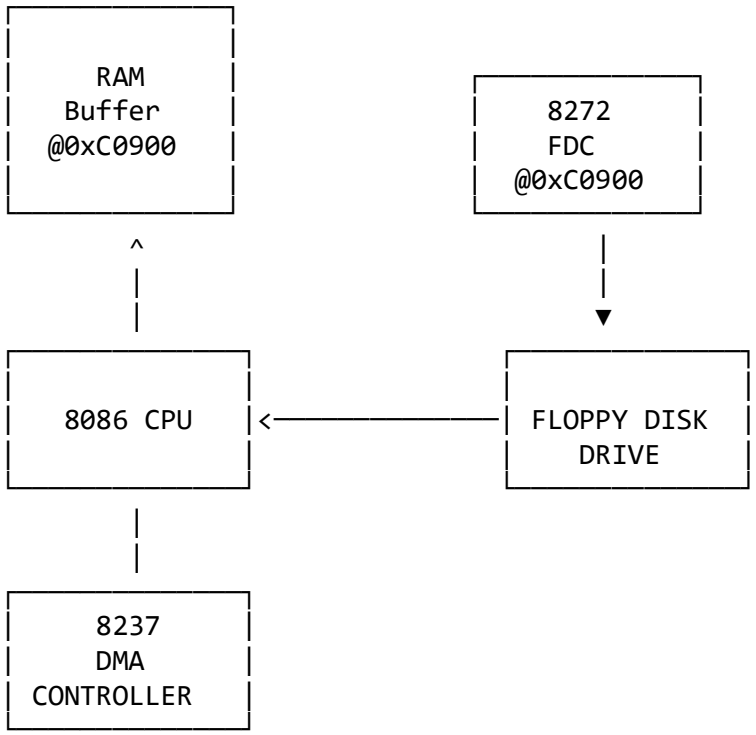
This document outlines the implementation of the 8272 floppy disk controller, DMA-based high-speed data transfer using the 8237 controller, USB transfers via DMA, and system integration for the 8086 microprocessor project.

1. 8272 Floppy Disk Controller

Components used:

- 8272 Floppy Disk Controller (FDC)
- Floppy disk drive interface
- DMA integration for high-speed transfers

Block Diagram:



Description:

8272 Floppy Disk Controller

- Manages read/write operations to floppy disks (360KB/720KB/1.44MB formats).
- Handles sector formatting, track positioning, and data transfer.
- Supports multiple drives (up to 4 drives).

- Uses DMA for high-speed data transfer to minimize CPU overhead.
- Provides status monitoring for drive ready, write protect, and track positioning.

Address Mapping:

Register	Address
Status Register	0xC0900
Command Register	0xC0901
Data Register	0xC0902
Control Register	0xC0903

PSEUDOCODE

```
FUNCTION Initialize8272FDC()
BEGIN
    // Reset the 8272 controller
    WritePort(0xC0903, 0x00)         // Reset control register
    Wait(10 milliseconds)
    WritePort(0xC0903, 0x0C)         // Enable controller

    // Wait for controller ready
    WAIT_FDC_READY:
    status = ReadPort(0xC0900)
    IF (status AND 0x80 == 0) THEN
        GOTO WAIT_FDC_READY
    EndIF

    // Configure drive parameters
    WritePort(0xC0901, 0x03)         // Specify command
    WritePort(0xC0902, 0xCF)         // Step rate=3ms, head unload=240ms
    WritePort(0xC0902, 0x02)         // Head load=4ms, DMA mode

    // Recalibrate drive 0
    WritePort(0xC0901, 0x07)         // Recalibrate command
    WritePort(0xC0902, 0x00)         // Drive 0

    // Wait for recalibration complete
    WAIT_RECALIBRATE:
    status = ReadPort(0xC0900)
    IF (status AND 0x20 == 0) THEN
        GOTO WAIT_RECALIBRATE
    EndIF

    SHOW "8272 FDC initialized successfully"
    RETURN SUCCESS
END

FUNCTION ReadSector(drive, track, head, sector, buffer)
BEGIN
```

```
    // Setup DMA for read operation
    CallFunction ConfigureDMAForRead(buffer, 512)

    // Send read command to 8272
    WritePort(0xC0901, 0x46)         // Read data command
    WritePort(0xC0902, (head << 2) | drive)  // Head and drive
    WritePort(0xC0902, track)        // Track number
    WritePort(0xC0902, head)         // Head number
    WritePort(0xC0902, sector)       // Sector number
    WritePort(0xC0902, 0x02)         // 512 bytes per sector
    WritePort(0xC0902, sector)       // End of track
    WritePort(0xC0902, 0x1B)         // Gap length
    WritePort(0xC0902, 0xFF)         // Data length

    // Wait for operation completion
    WAIT_READ_COMPLETE:
    status = ReadPort(0xC0900)
    IF (status AND 0x10 == 0) THEN
        GOTO WAIT_READ_COMPLETE
    EndIF

    // Read result bytes
    result1 = ReadPort(0xC0902)      // ST0
    result2 = ReadPort(0xC0902)      // ST1
    result3 = ReadPort(0xC0902)      // ST2

    IF (result1 AND 0xC0 == 0x00) THEN
        RETURN SUCCESS
    ELSE
        RETURN ERROR
    EndIF
END

FUNCTION WriteSector(drive, track, head, sector, buffer)
BEGIN
    // Setup DMA for write operation
    CallFunction ConfigureDMAForWrite(buffer, 512)

    // Send write command to 8272
    WritePort(0xC0901, 0x45)         // Write data command
    WritePort(0xC0902, (head << 2) | drive)  // Head and drive
    WritePort(0xC0902, track)        // Track number
    WritePort(0xC0902, head)         // Head number
    WritePort(0xC0902, sector)       // Sector number
    WritePort(0xC0902, 0x02)         // 512 bytes per sector
    WritePort(0xC0902, sector)       // End of track
    WritePort(0xC0902, 0x1B)         // Gap length
    WritePort(0xC0902, 0xFF)         // Data length
```

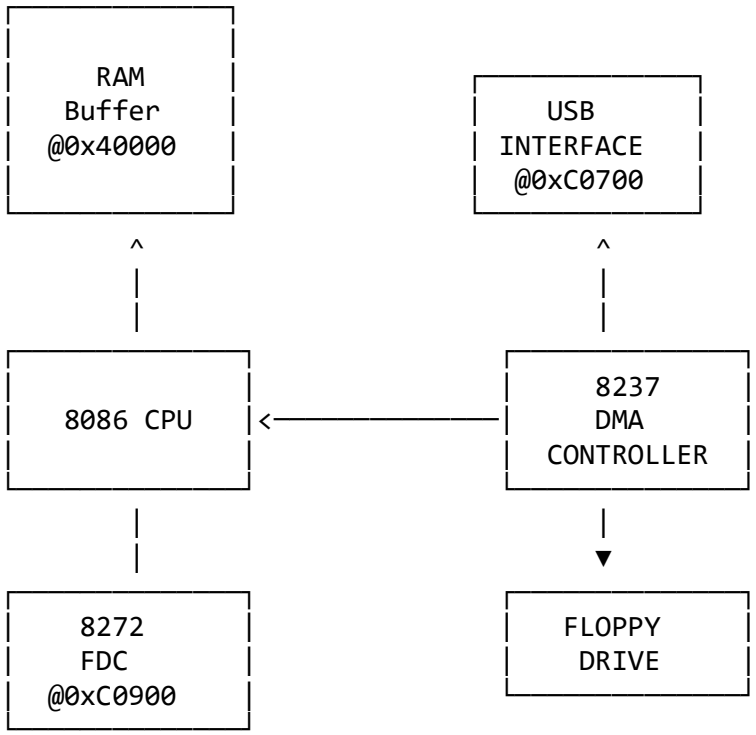
```
    // Wait for operation completion
    WAIT_WRITE_COMPLETE:
    status = ReadPort(0xC0900)
    IF (status AND 0x10 == 0) THEN
        GOTO WAIT_WRITE_COMPLETE
    EndIF

    // Read result bytes
    result1 = ReadPort(0xC0902)      // ST0
    result2 = ReadPort(0xC0902)      // ST1
    result3 = ReadPort(0xC0902)      // ST2

    IF (result1 AND 0xC0 == 0x00) THEN
        RETURN SUCCESS
    ELSE
        RETURN ERROR
    EndIF
END
```

2. 8237 DMA Controller for High-Speed Data

Components used:

- 8237 DMA Controller
- Multiple DMA channels for different operations
- Memory buffers for data transfer

Block Diagram:



Description:

8237 DMA Controller

- Provides high-speed data transfer between memory and peripherals.
- Supports 4 DMA channels (0-3) for concurrent operations.
- Reduces CPU overhead during data transfer operations.
- Handles memory-to-peripheral and peripheral-to-memory transfers.

Address Mapping:

Component	Address Range
DMA Controller	0x0000-0x000F
DMA Page Registers	0x0080-0x008F
DMA Buffer	0x40000-0x4FFFF

PSEUDOCODE

```
FUNCTION Initialize8237DMA()
BEGIN
    // Reset DMA controller
    WritePort(0x000D, 0x00)          // Master clear
    WritePort(0x000C, 0x00)          // Clear byte pointer

    // Configure DMA channels
    CallFunction ConfigureDMAChannel0()  // Reserved
    CallFunction ConfigureDMAChannel1()  // Floppy disk
    CallFunction ConfigureDMAChannel2()  // USB transfers
    CallFunction ConfigureDMAChannel3()  // System integration

    SHOW "8237 DMA Controller initialized"
    RETURN SUCCESS
END

FUNCTION ConfigureDMAForRead(buffer, size)
BEGIN
    // Configure DMA Channel 1 for floppy read
    WritePort(0x000A, 0x05)          // Mask channel 1
    WritePort(0x000C, 0x00)          // Clear byte pointer
    WritePort(0x000B, 0x46)          // Single mode, read, channel 1

    // Set buffer address
    address = buffer
    WritePort(0x0002, address AND 0xFF)      // Address low byte
    WritePort(0x0002, (address >> 8) AND 0xFF)  // Address high byte
    WritePort(0x0083, (address >> 16) AND 0xFF) // Page register

    // Set transfer count
    count = size - 1
    WritePort(0x0003, count AND 0xFF)        // Count low byte
```

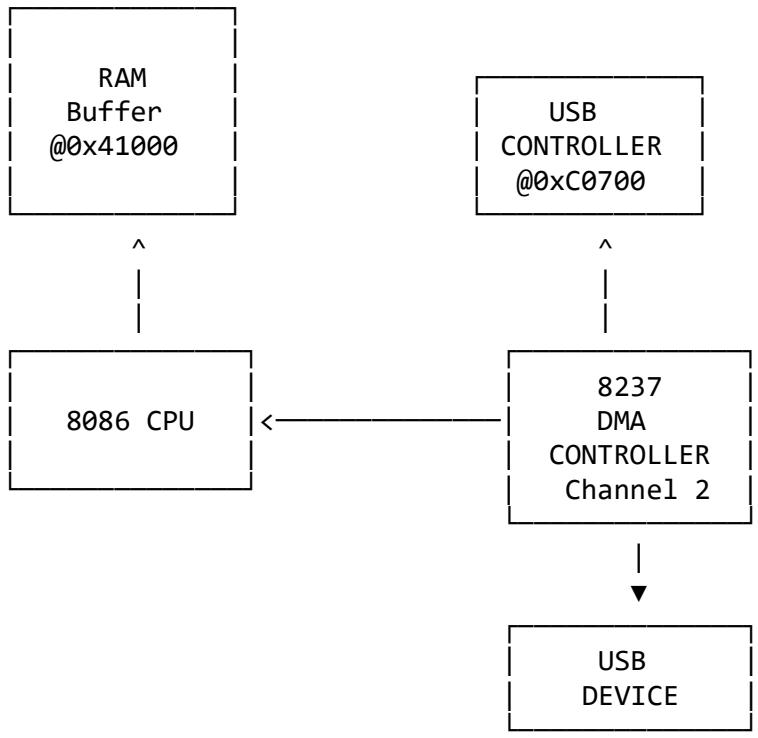
```
    WritePort(0x0003, (count >> 8) AND 0xFF) // Count high byte

    // Enable DMA channel
    WritePort(0x000A, 0x01)          // Unmask channel 1

    RETURN SUCCESS
END

FUNCTION ConfigureDMAForWrite(buffer, size)
BEGIN
    // Configure DMA Channel 1 for floppy write
    WritePort(0x000A, 0x05)          // Mask channel 1
    WritePort(0x000C, 0x00)          // Clear byte pointer
    WritePort(0x000B, 0x4A)          // Single mode, write, channel 1

    // Set buffer address
    address = buffer
    WritePort(0x0002, address AND 0xFF)      // Address low byte
    WritePort(0x0002, (address >> 8) AND 0xFF)  // Address high byte
    WritePort(0x0083, (address >> 16) AND 0xFF) // Page register

    // Set transfer count
    count = size - 1
    WritePort(0x0003, count AND 0xFF)        // Count low byte
    WritePort(0x0003, (count >> 8) AND 0xFF) // Count high byte

    // Enable DMA channel
    WritePort(0x000A, 0x01)          // Unmask channel 1

    RETURN SUCCESS
END
```

3. USB Transfers Using DMA

Components used:

- USB interface (external controller)
- 8237 DMA Controller
- Memory buffers for USB data

Block Diagram:



Description:

USB Interface via DMA

- Handles USB data transfers using DMA Channel 2.
- Supports bulk data transfer for high-speed USB operations.
- Manages USB protocol through external USB controller.
- Provides efficient data movement between USB devices and system memory.

Address Mapping:

Component	Address Range
USB Controller	0xC0700-0xC07FF
USB Buffer	0x41000-0x41FFF

PSEUDOCODE

```
FUNCTION InitializeUSBDMA()
BEGIN
    // Configure DMA Channel 2 for USB operations
    WritePort(0x000A, 0x06)          // Mask channel 2
    WritePort(0x000C, 0x00)          // Clear byte pointer

    // Set USB buffer address
    address = 0x41000
    WritePort(0x0004, address AND 0xFF)      // Address low byte
    WritePort(0x0004, (address >> 8) AND 0xFF)  // Address high byte
```

```
    WritePort(0x0081, (address >> 16) AND 0xFF) // Page register

    SHOW "USB DMA initialized"
    RETURN SUCCESS
END

FUNCTION USBTransferToMemory(size)
BEGIN
    // Configure DMA for USB read operation
    WritePort(0x000A, 0x06)          // Mask channel 2
    WritePort(0x000B, 0x42)          // Single mode, read, channel 2

    // Set transfer count
    count = size - 1
    WritePort(0x0005, count AND 0xFF)        // Count low byte
    WritePort(0x0005, (count >> 8) AND 0xFF) // Count high byte

    // Enable DMA channel
    WritePort(0x000A, 0x02)          // Unmask channel 2

    // Start USB transfer
    WritePort(0xC0700, 0x01)         // Start USB read

    // Wait for DMA completion
    WAIT_USB_DMA:
    status = ReadPort(0x0008)
    IF (status AND 0x04 == 0) THEN
        GOTO WAIT_USB_DMA
    EndIF

    RETURN SUCCESS
END

FUNCTION USBTransferFromMemory(size)
BEGIN
    // Configure DMA for USB write operation
    WritePort(0x000A, 0x06)          // Mask channel 2
    WritePort(0x000B, 0x46)          // Single mode, write, channel 2

    // Set transfer count
    count = size - 1
    WritePort(0x0005, count AND 0xFF)        // Count low byte
    WritePort(0x0005, (count >> 8) AND 0xFF) // Count high byte

    // Enable DMA channel
    WritePort(0x000A, 0x02)          // Unmask channel 2

    // Start USB transfer
    WritePort(0xC0700, 0x02)         // Start USB write
```

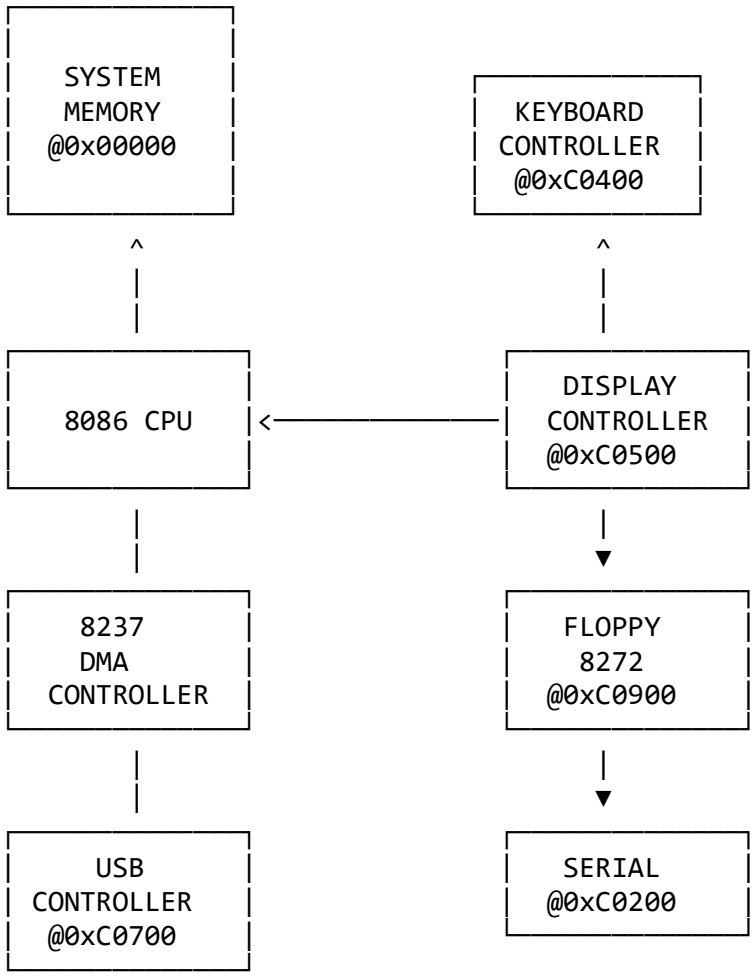
```
    // Wait for DMA completion
    WAIT_USB_DMA:
    status = ReadPort(0x0008)
    IF (status AND 0x04 == 0) THEN
        GOTO WAIT_USB_DMA
    EndIF

    RETURN SUCCESS
END
```

4. System Integration

Components used:

- All I/O controllers and interfaces
- Unified memory management
- Interrupt coordination

Block Diagram:



Description:

System Integration

- Coordinates all I/O operations through unified addressing.
- Manages data flow between different subsystems.
- Provides high-level functions for complex operations.
- Handles error conditions and system recovery.

PSEUDOCODE

```
FUNCTION IntegrateAllSystems()
BEGIN
    // Initialize all controllers
    CallFunction Initialize8272FDC()
    CallFunction Initialize8237DMA()
    CallFunction InitializeUSBDMA()

    // Configure system memory buffers
    CallFunction ConfigureSystemBuffers()

    // Setup interrupt handlers
    CallFunction SetupSystemInterrupts()

    SHOW "All systems integrated successfully"
    RETURN SUCCESS
END

FUNCTION ConfigureSystemBuffers()
BEGIN
    // Assign memory buffers for different operations
    // Floppy buffer: 0x40000-0x407FF (2KB)
    // USB buffer: 0x41000-0x417FF (2KB)
    // System buffer: 0x42000-0x427FF (2KB)

    // Clear all buffers
    CallFunction FillMemory(0x40000, 0x800, 0x00)   // Floppy buffer
    CallFunction FillMemory(0x41000, 0x800, 0x00)   // USB buffer
    CallFunction FillMemory(0x42000, 0x800, 0x00)   // System buffer

    RETURN SUCCESS
END

FUNCTION DataFlowOperation(source, destination, size)
BEGIN
    // High-level data flow between different systems

    IF (source == "FLOPPY" AND destination == "USB") THEN
        // Read from floppy to memory
        CallFunction ReadSector(0, 0, 0, 1, 0x40000)
```

```
        // Transfer from memory to USB
        CallFunction CopyBlock(0x40000, 0x41000, size)
        CallFunction USBTransferFromMemory(size)

    ELSE IF (source == "USB" AND destination == "FLOPPY") THEN
        // Read from USB to memory
        CallFunction USBTransferToMemory(size)

        // Transfer from memory to floppy
        CallFunction CopyBlock(0x41000, 0x40000, size)
        CallFunction WriteSector(0, 0, 0, 1, 0x40000)

    EndIF

    RETURN SUCCESS
END

FUNCTION SystemHealthCheck()
BEGIN
    // Check all system components
    floppyStatus = CallFunction CheckFloppyStatus()
    usbStatus = CallFunction CheckUSBStatus()
    dmaStatus = CallFunction CheckDMAStatus()

    IF (floppyStatus == SUCCESS AND usbStatus == SUCCESS AND dmaStatus ==
SUCCESS) THEN
        SHOW "All systems operational"
        RETURN SUCCESS
    ELSE
        SHOW "System component failure detected"
        RETURN ERROR
    EndIF
END
```

5. Integration Notes

Memory Buffer Assignment:

- Floppy Data Buffer: 0x40000-0x407FF (2KB)
- USB Transfer Buffer: 0x41000-0x417FF (2KB)
- System Integration Buffer: 0x42000-0x427FF (2KB)

DMA Channel Assignment:

- Channel 0: Reserved for system use
- Channel 1: Floppy disk operations (8272)
- Channel 2: USB transfers
- Channel 3: System integration and bulk transfers

Address Coordination:

- Floppy Controller: 0xC0900-0xC09FF
- USB Controller: 0xC0700-0xC07FF
- All addresses coordinated with team assignments
- No conflicts with other subsystems

Interrupt Integration:

- Floppy operations use IRQ6 (managed by 8259A)
- USB operations use IRQ5 (managed by 8259A)
- DMA completion signals handled through polling and interrupts

Conclusion:

This document provides a complete implementation of storage and DMA integration systems for the 8086 microprocessor. The implementation focuses on efficient data transfer using DMA controllers, reliable floppy disk operations, and seamless USB integration. All components are designed to work together as part of the larger system architecture while maintaining compatibility with othe