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Application Note

MCF5272 Interrupt Service Routine
for the Physical Layer Interface Controller

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Part I Summary and Scope

1.1 Overview

The physical layer interface controller (PLIC) is a peripheral module of the ColdFire® MCF5272 intended to support ISDN applications such as CODECs, ISDN transceivers, and other peripherals. The PLIC supports two modes of operation: IDL and GCI physical layer protocols. It also has four dedicated TDM ports for connecting to external devices.

This document consists of four main parts:

1. A brief description of the inter digital link (IDL) mode of operation
2. The general circuit interface (GCI) explanation
3. A description of the interrupt service routine used to handle the data transfer for both modes of operation
4. Some examples of ColdFire microprocessor assembly code to perform quick evaluation of the MCF5272. See Part VIII, “Appendix A.”

The reader is strongly recommended to read the *MCF5272 User’s Manual* at www.mot.com/ColdFire before going through this document. The register and bit explanations therein help the reader to better understand the device’s internal architecture.

1.2 Contents

FIGURES and TABLES

Part II Interchip Digital Link Mode of Operation

2.1 Introduction

The IDL mode of operation is a four-wire interface used for full-duplex communication between ICs at the board level. This interface consists of a transmit path, a receive path, an associated clock, and a synchronization signal. These signals are known as Dout, Din, DCL, and FSC. The clock determines the rate of exchange of data in both transmit and receive directions and the sync controls when this exchange is to take place. Three channels of data are exchanged every 125 microseconds. These channels consist of two 64-kbps B channels and one 16-kbps D channel used for full-duplex communication. The waveform diagrams are shown in Figure 1 and Figure 2.

Two modes are available:

- The 10-bit mode:

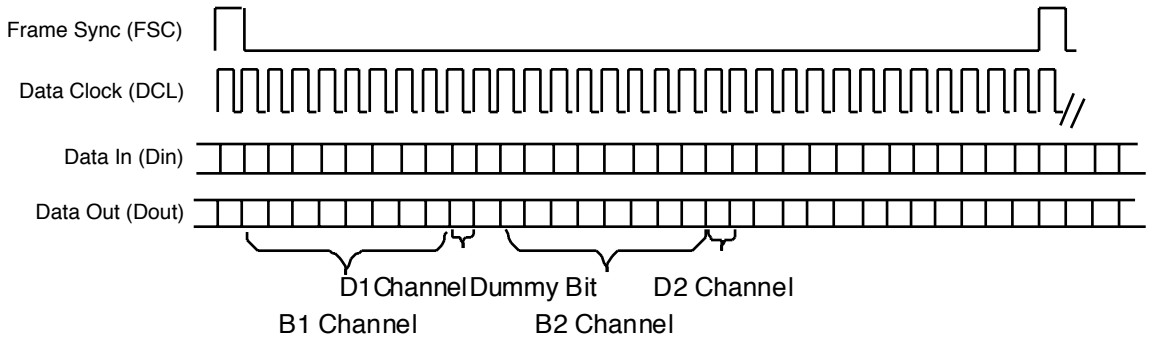


Figure 1. IDL 10-bit Mode

- The 8-bit mode:

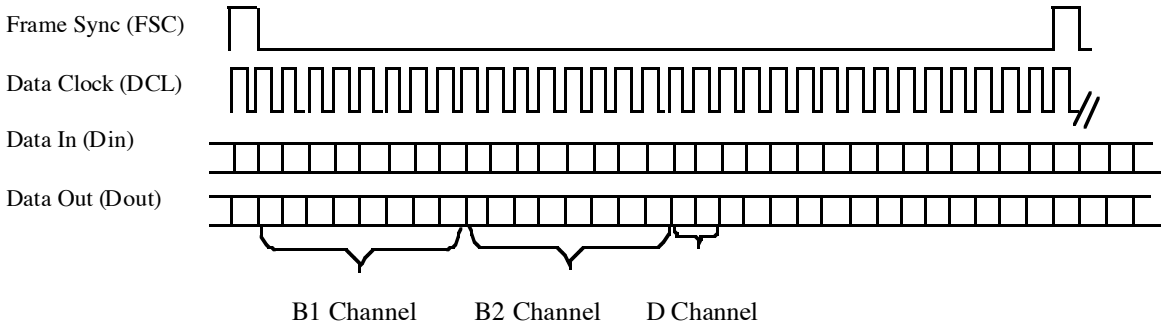


Figure 2. IDL 8-bit Mode

For more information about the different configurations of IDL, please refer to any ISDN product user's manual, such as the MC145574/572 or MC145576 at http://www.freescale.com.

Part III General Circuit Interface Mode of Operation

3.1 GCI History

The GCI mode was defined by European companies (Italtel, Siemens, Alcatel, and GPT). GCI is a time division multiplex (TDM) bus that combines the ISDN 2B+D data, control, and status information onto four signal pins. Some benefits of the GCI include the following:

- Operation and maintenance features
- Activation and deactivation facilities (via CI channel)
- Well-defined transmission protocols to ensure correct information transfer between GCI-compatible devices
- Point-to-point and multi-point communication links
- Multiplexed mode of operation where up to eight GCI channels can be combined to form a single data stream

Those four signals consist of the following:

- FSC, frame synchronization: 8-kHz frame pulse
- DCL, data, clock signal: two clocks per data bit
- Din, data in: the data in
- Dout, data out: This pin is an open-drain output and must be pulled to Vdd through a 1.2-kΩ resistor.

The GCI frame structure has the following format: two B channels, a monitor channel, the ISDN D channel, the command/indicate channel, and the A and E bits. The frame is shown in Figure 3.

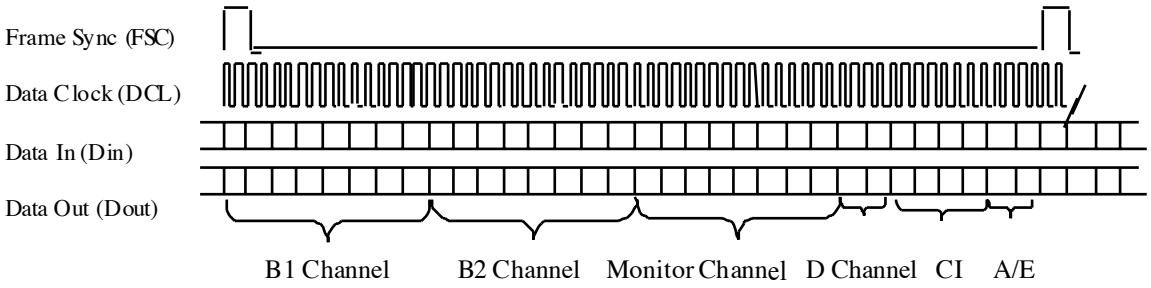


Figure 3. GCI Frame

3.2 Monitor Channel Operation

This feature is available only in GCI mode. The monitor channel is used to access the internal registers of any GCI device in order to support maintenance channel operations. All monitor channel messages are two bytes in length. Each byte is sent twice to permit the receiving GCI device to verify data integrity. In ISDN applications, the monitor channel is used for access to the maintenance messages. The A and E bits in the GCI channel are used to control and acknowledge monitor channel transfers between the MCF5272 and another GCI device.

Figure 4 shows the monitor channel protocol used. When the monitor channel is inactive, the A and E bits are both high. The A and E bits are active when they are driven low during their respective bit times. (Note that pull-up resistors are required on Din and Dout.) The E bit represents the transmission of a new monitor channel byte. The A bit from the opposite direction is used to acknowledge the monitor channel byte transfer. An idle monitor channel is indicated by both A and E bits being inactive for two GCI frames. The monitor channel data is 0xFF when inactive. The originating GCI device transmits a byte onto the monitor channel after receiving the A and E bits equal to 1 for at least two consecutive GCI frames. The originating GCI device also clears its outgoing E bit in the same GCI frame as the byte that is transmitted. The transmitted byte is repeated for at least two GCI frames, or is repeated in subsequent GCI frames, until the MCF5272 acknowledges receiving two consecutive GCI frames containing the same monitor byte.

Once the MCF5272 acknowledges the first byte, the sending device sets E high and transmits the first frame of the second byte. Then, the second byte is repeated with the E bit low until it is acknowledged. The destination GCI device verifies that it has received the first byte by clearing the A bit towards the originating GCI device for at least two GCI frames. Successive bytes are acknowledged by the receiving device setting A high on the first instance of the next byte, followed by A being cleared when the second instance of the byte is received. If the receiving GCI device does not receive the same monitor channel byte in two consecutive GCI frames, it indicates this by leaving A = 0 until two consecutive identical bytes are received. The last byte of the sequence is indicated by the originating GCI device when it sets its E bit for two successive GCI frames. The procedure is summarized in Figure 4.

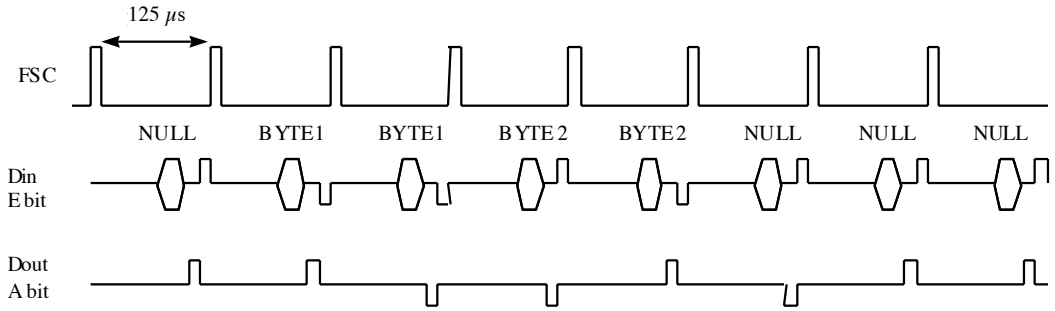


Figure 4. Monitor Channel Protocol

3.3 Command Indicate Operation

The command/indicate, or C/I channel, is used to activate and deactivate any GCI devices. Some control functions (such as loopbacks) are also supported over the C/I channel. C/I codes are four bits in length and must be received for two consecutive GCI frames before they are acted on. C/I channel bits are numbered bit 3 through 0, with bit 3 being the most significant. The C/I/ channel bits are transmitted starting with bit 3.

Part IV GCI/IDL and the MCF5272

This section gives a brief description of the internal registers in the PLIC.

4.1 Data Registers

For both GCI and IDL modes of operation, the maximum data rate transmitted for each digital port is 144 kbps (two 64-kbps B channels and one 16-kbps D channel). Frames of B1, B2, and D channels are packed together in P*n*RB*x*/P*n*TB*x* registers (with x = 1, 2, 3, 4) for receive and transmit direction respectively. Since the reception and transmission of information on the GCI/IDL interface is deterministic, a common interrupt is generated at 2 kHz. It is expected that a common interrupt service routine will be programmed to service the transmit and receive registers. After reset, the B and D channel shift registers and shadow registers are initialized to all 1's. For more information about the data registers, please refer to the *MCF5272 User's Manual*.

4.2 Monitor Channel Registers

This section describes receive and transmit channels.

4.2.1 Monitor Channel Receive

The P*n*GMR registers are 16-bit registers containing the received monitor channel bits for each of the four receive ports on the MCF5272. A byte of monitor channel data received on a certain port is put into an associated register using the format shown in Figure 5 and described in Table 1. A maskable interrupt is generated when a byte is written into any of the four available MCF5272 ports.

	15 — 11	10	9	8	7 — 0
Field	—	EOM	AB	MC	M
Reset	0000_0000_1111_1111				
R/W	Read Only				
Addr	MBAR + 0x360 (P0GMR); 0x362 (P1GMR); 0x364 (P2GMR); 0x366 (P3GMR)				

Figure 5. GCI Monitor Channel Receive Register (PnGMR)

Table 1. PnGMR Register Field Descriptions

Bits	Name	Description
15–11	—	Reserved, should be cleared.
10	EOM	End of message. 0 Default at reset. 1 Indicates to the CPU that an end-of-message condition has been recognized on the E bit. EOM is automatically cleared when the PnGMR register has been read by the CPU.
9	AB	Abort. 0 Default at reset. 1 Indicates that the GCI controller has recognized an abort condition and is acknowledging the abort. It is automatically cleared by the CPU when the PnGMR register has been read.
8	MC	Monitor change. 0 Default at reset. 1 Indicates to the CPU that the monitor channel data byte written to the respective PnGMR register has changed and that the data is available for processing. This bit is automatically cleared by the CPU when the PnGMR register has been read. Clearing this bit also clears the aperiodic GMR interrupt.
7–0	M	Monitor channel data byte. These bits are written by the monitor channel controller when valid monitor channel bytes are received.

4.2.2 Monitor Channel Transmit

The P*n*GMT registers are 16-bit registers containing the control and monitor channel bits to be transmitted for each of the four ports on the MCF5272. A byte of monitor channel data to be transmitted on a certain port is put into an associated register using the format shown in Figure 6 and described in Table 2. A maskable interrupt is generated when this byte of data has been successfully transmitted.

	15 — 10	9	8	7 — 0
Field	—	L	R	M
Reset	0000_0000_0000_0000			
R/W	Read/Write			
Addr	MBAR + 0x368 (P0GMT); 0x36A (P1GMT); 0x36C (P2GMT); 0x36E (P3GMT)			

Figure 6. GCI Monitor Channel Transmit Register (PnGMT)

Table 2. PnGMT Register Field Descriptions

Bits	Name	Description
15–10	—	Reserved, should be cleared.
9	L	Last. 0 Default reset value 1 Set by the CPU. Indicates to the monitor channel controller to transmit the end of message signal on the E bit. Both PnGMT[L] and PnGMT[R] must be set for the monitor channel controller to send the end of message signal. The L bit is automatically cleared by the GCI controller.

Table 2. PnGMT Register Field Descriptions

Bits	Name	Description
8	R	Ready. 0 Default reset value. 1 Set by the CPU. Indicate to the monitor channel controller that a byte of data is ready for transmission. Automatically cleared by the GCI controller when it generates a transmit acknowledge (ACK bit in P*n*GMTS register) or when the L bit is reset.
7–0	M	Monitor channel data byte. Written by the CPU when a byte is ready for transmission.

4.3 Command Indicate Registers

This section describes receive and transmit command registers.

4.3.1 Command Indicate Receive

The P*n*GCIR register is an 8-bit register containing the received C/I bits for one of each of the four ports on the MCF5272. The register is shown in Figure 7 and described in Table 3.

	7	5	4	3	2	1	0
Field	—		F	C3	C2	C1	C0
Read	R/W						
Reset	0000_0000						

Figure 7. PnGCIR Register

Table 3. PnGCIR Register Field Descriptions

Bits	Name	Description
7–5	—	Reserved, should be cleared.
4	F	Full. This bit is set by the C/I channel controller to indicate to the CPU that new C/I channel data has been received and is available for processing. It is automatically cleared by a CPU read. The clearing of this bit by reading this register also clears the aperiodic GCR interrupt.
3–0	C3–C0	C/I bits. These four bits are received on the GCI or SCIT channel 0. When a change in the C/I data value is received in two successive frames, it is interpreted as being valid and is passed on to the CPU via this register. A maskable interrupt is generated when data is written into any of the four available positions.

4.3.2 Command Indicate Transmit

The P*n*GCIT registers are 8-bit registers containing the monitor channel bits to be transmitted for each of the four ports on the MCF5272. The register is shown in Figure 8 and described in Table 4.

	7	5	4	3	2	1	0
Field	—		F	C3	C2	C1	C0
Read	R/W						
Reset	0000_0000						

Figure 8. PnGCIT Register

Table 4. PnGCIT Register Field Descriptions

Bits	Name	Description
7–5	—	Reserved, should be cleared.
4	R	Ready. This bit is set by the CPU to indicate to the C/I channel controller that data is ready for transmission. Setting this bit starts the C/I state machine, which responds with the transmit acknowledge (ACK bit in the PnGCITS register) once transmission of two successive C/I words is complete. This bit is automatically cleared by the GCI controller when it generates an ACK. The clearing of this bit by reading this register also clears the aperiodic GCT interrupt.
3–0	C3–C0	C/I bits. The CPU writes C/I data to be transmitted, on the GCI or SCIT channel 0, into these positions. The CPU must ensure that this data is not overwritten before it has been transmitted the required minimum number of times, that is, before a change is detected and confirmed by a receiver. A maskable interrupt is generated when this data has been successfully transmitted.

Part V Periodic Interrupt Process

This document does not intend to define all the meanings of the P*n*PSR register. For more information, the user should read the *MCF5272 User's Manual*. This P*n*PSR register is involved in the data processing. All P*n*RB*x* and P*n*TB*x* registers, either in IDL or GCI modes of operation, will use these registers. There is no difference between those two modes as far as they are concerned. P*n*PSR register is updated every 500μs. As long as the interrupt enable (IE) bits are set to invoke the interrupt service routine, the B*x*RDF bits will be set every 500μs, and a register access will be achieved to clear this interrupt.

This section is explained in two parts:

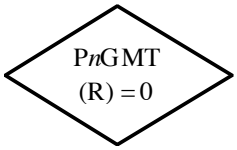
- One port only is enabled: description of how to handle all the bits involved in P*n*PSR
- Multiple ports are enabled: description of how to access the ports that created this interrupt

5.1 ISR Bubble Definitions

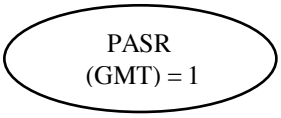
To assure that the following flow charts are well understood, this section defines the bubble shapes used in the illustrations:

- Start or End of the process

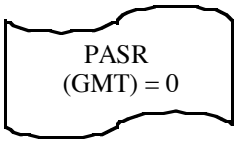
- Test Condition



- Interrupt creation



- Return from Interrupt



- Action taken

5.2 One-Port Processing

For this PLIC interrupt service routine, the channel priorities are fixed. In the periodic status registers, the B1RDF, B1TDE, and DRDF have top priority, then the B2RDF, B2TDE, and DTDE follow. The *x*TUE and *x*ROE should be given lowest priority because they should be cleared. This interrupt service routine implementation gives some flexibility by dynamically jumping between the action to take and the verification of the bit that creates the interrupt. Furthermore, the purpose of the code was to first evaluate the product after first silicon. The code and the ISR have been written with this objective in mind. In conclusion, all the actions are taken inside the ISR instead of raising a flag in order to perform it once the ISR has completed. The flow chart is shown in Figure 9.

Periodic Interrupt Process One-Port Processing

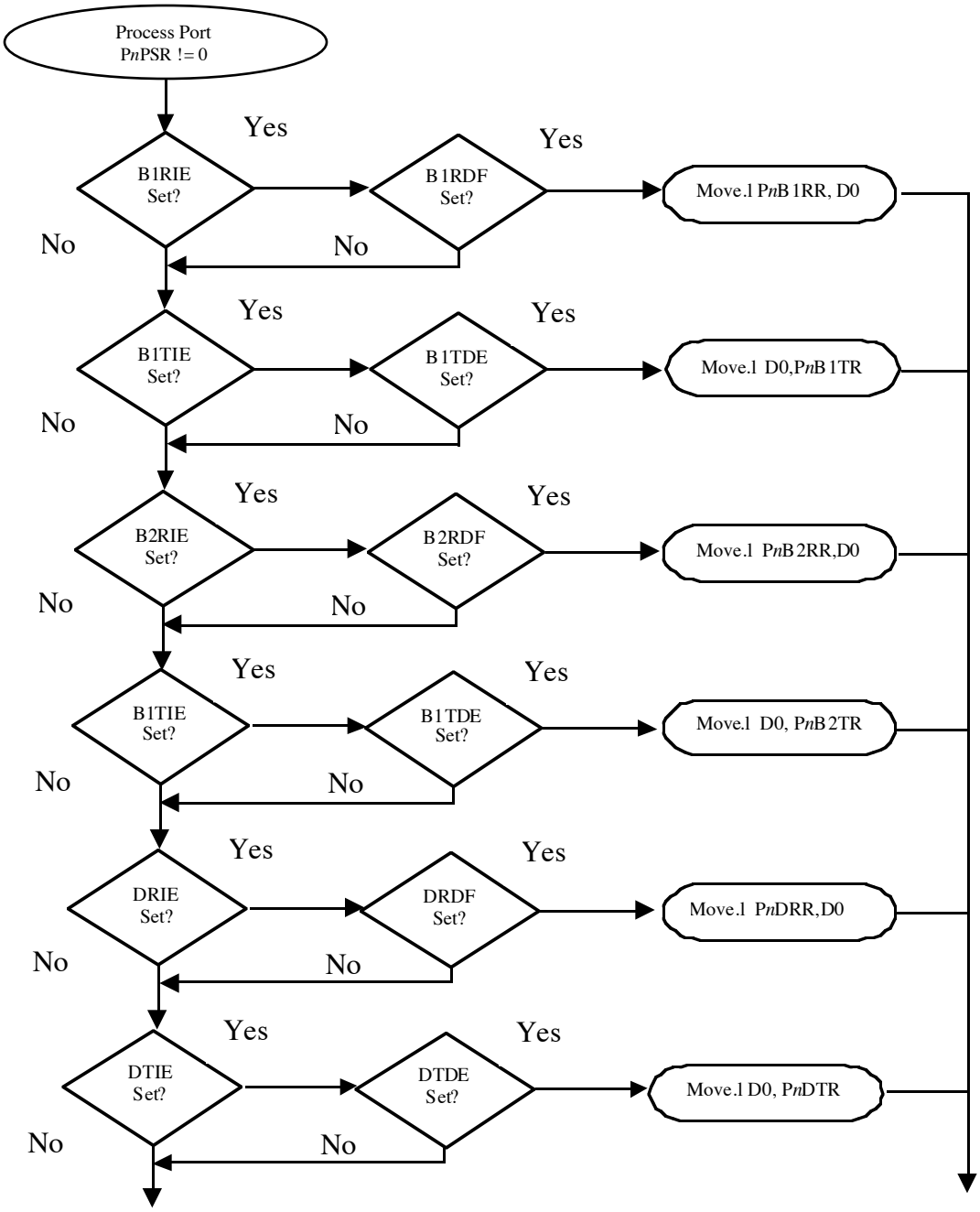


Figure 9. One-Port Processing Interrupt Service Routine Flow Diagram

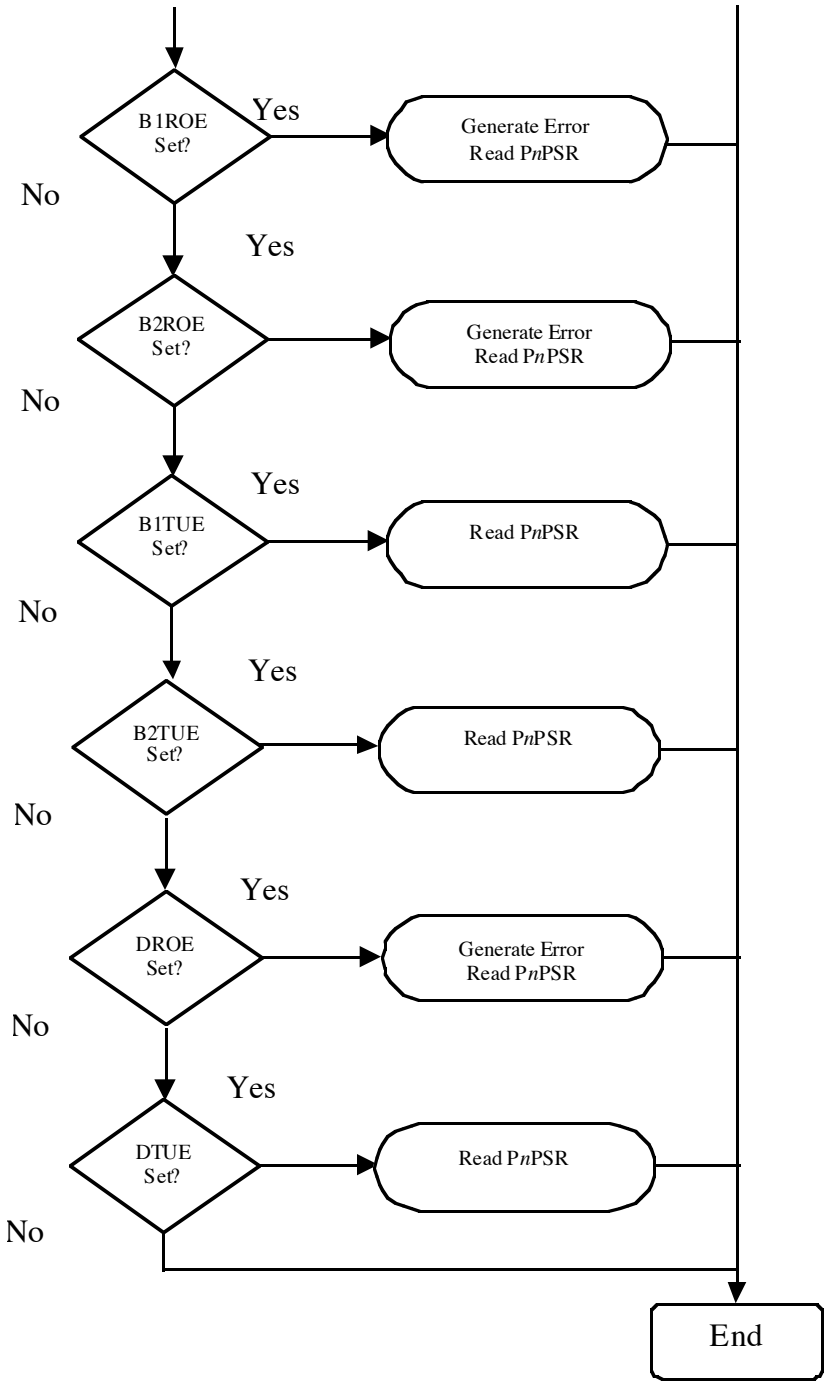


Figure 9. One-Port Processing Interrupt Service Routine Flow Diagram (Continued)

5.3 Multi-Ports Processing

Most of the time, more than one port will be enabled, and in order to make the ISR subroutine more efficient, several steps should be taken. When the periodic interrupt occurs, the user does not know yet which port has caused it. To find out, check the following registers:

1. P*n*ICR: PLIC Interrupt Configuration register
2. P*n*PSR: PLIC Periodic Status Register

In fact, even if the PLPSR has been updated, the corresponding bit in the P*n*ICR (IE) may not have been programmed; thus the ISR process cannot be called by this port. The flow chart is shown in Figure 10.

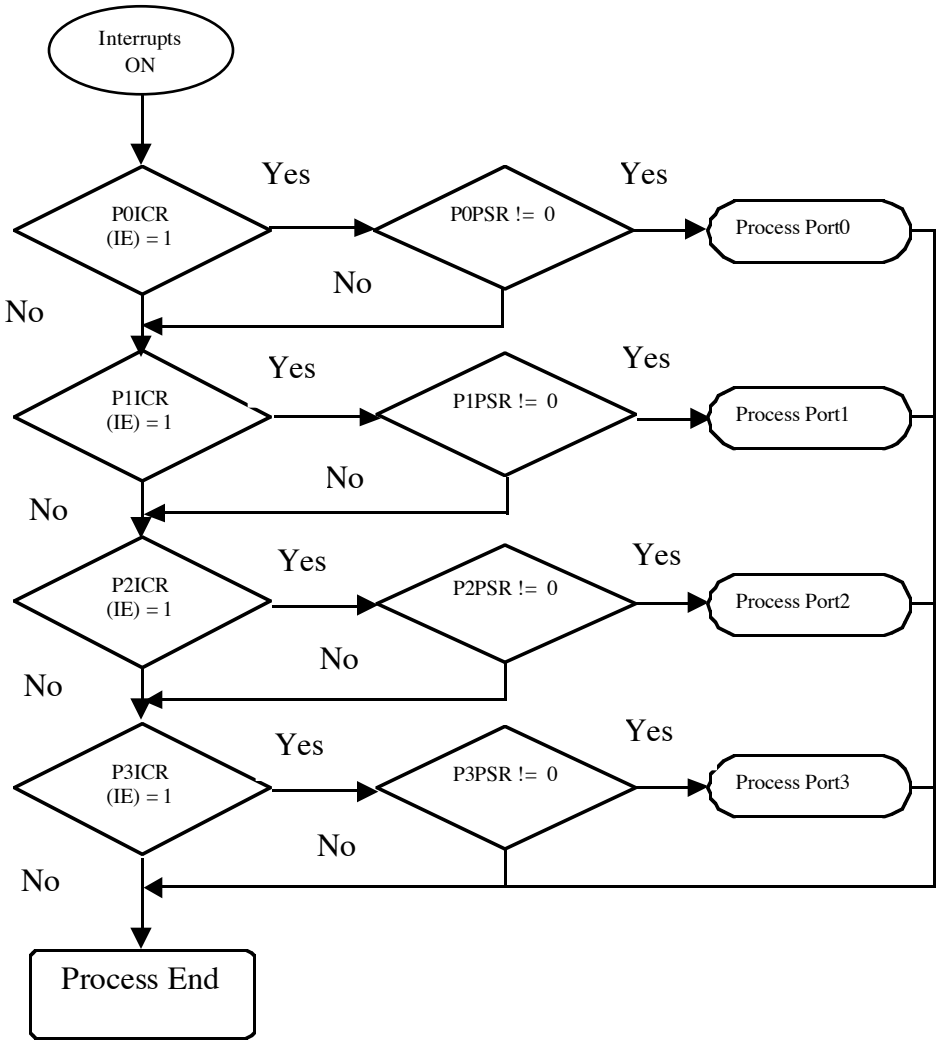


Figure 10. Multi-Port Processing Interrupt Service Routine Flow Diagram

Part VI Aperiodic Interrupt Process

This part describes port sequence, multi-port case, registers, channel sequence, abort condition, and the command indicate channel.

6.1 Aperiodic One-Port Sequence

This section explains how the aperiodic interrupt is used with one port enabled. The next section describes a multi-channel approach. When one port is enabled, a level of priority must be set up. For obvious reasons, the CI channel will be top priority because of its ability to activate and deactivate. As far the

monitor channel is concerned, the same philosophy will be applied, and the received path takes higher priority. The flow chart is shown in Figure 11.

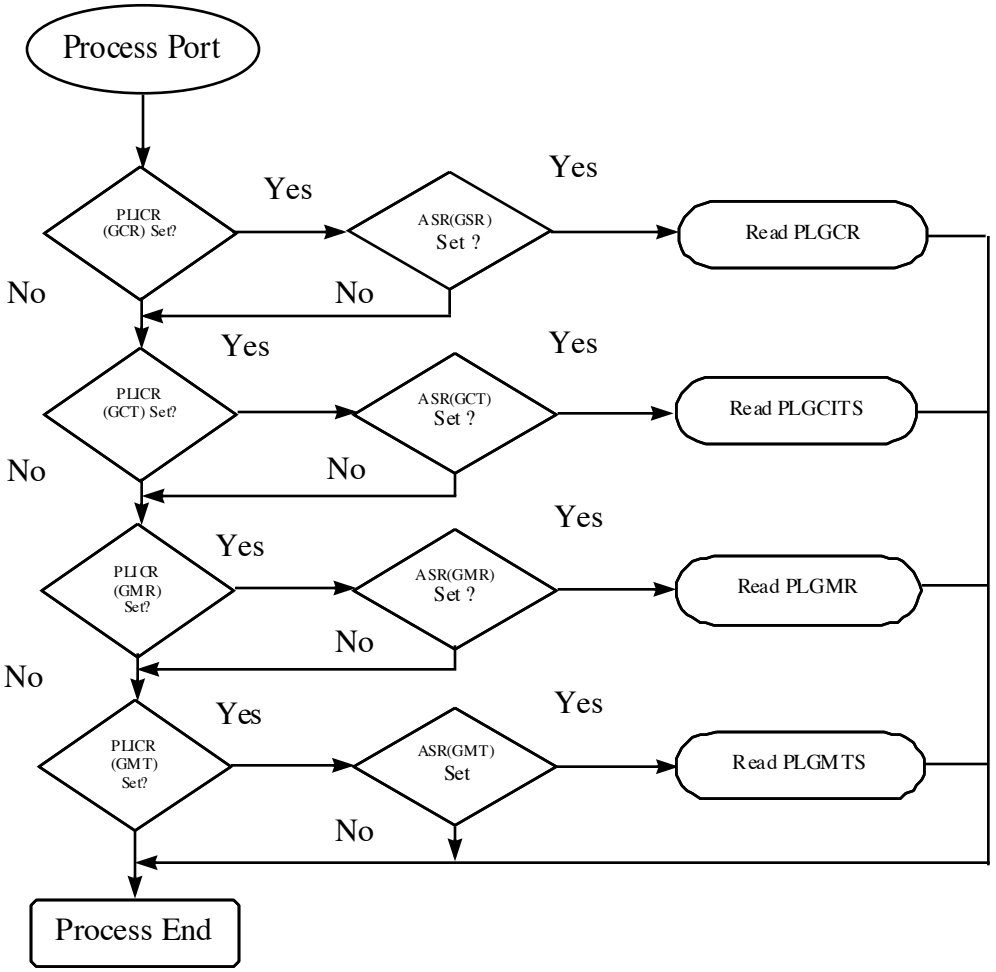


Figure 11. One-Port Processing Aperiodic Interrupt Service Routine Flow Diagram

6.2 Multi-Port Case

Once the PLIC has many GCI ports enabled, a generic aperiodic interrupt is required to handle all of the possibilities. As previously done in the periodic interrupt, the P*n*ICR will be read so it can save some MIPS in case the port is not enabled. The flow chart is shown in Figure 12.

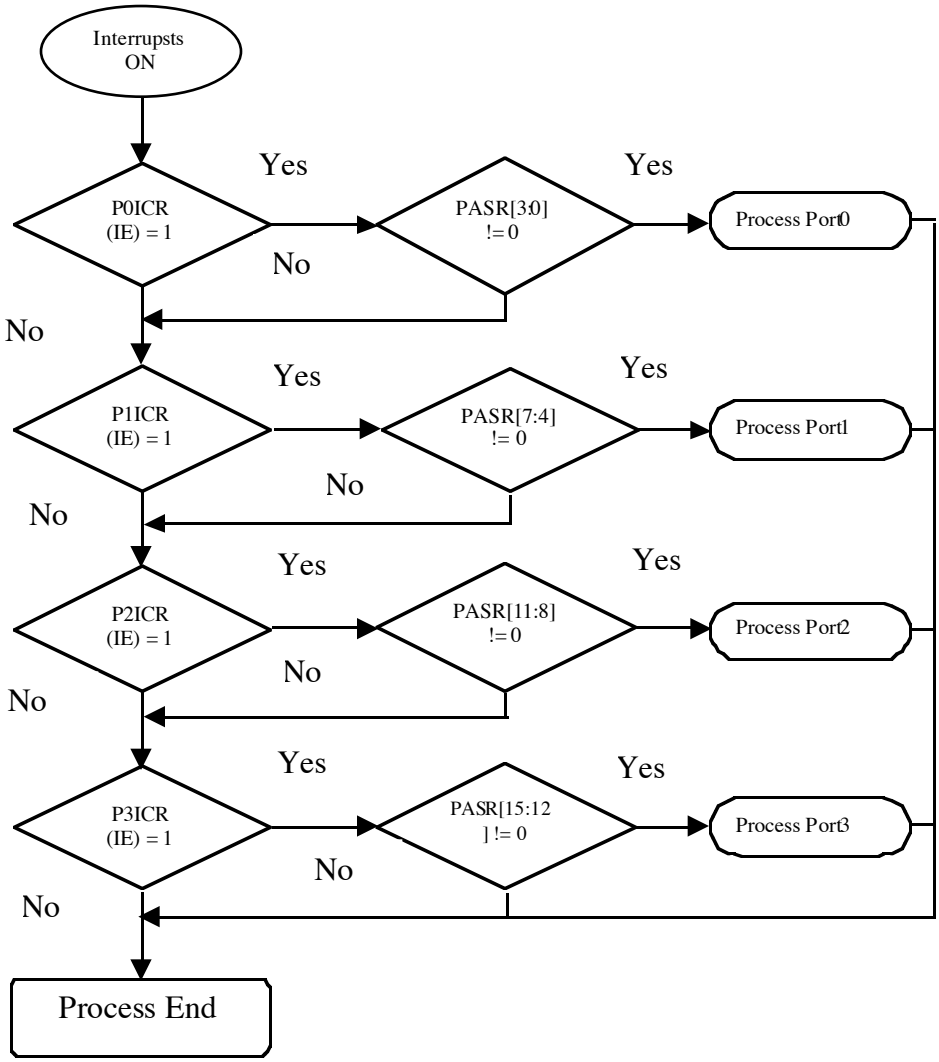


Figure 12. Multi-Processing Aperiodic Interrupt Service Routine Flow Diagram

6.3 Brief Register Explanation

This section describes the registers involved in the aperiodic interrupts service routine. The GCI oriented registers are P*n*GMR, P*n*GMT, P*n*GCIR, and P*n*GCIT. These are the only register that affect the PASR register. For more information about the definition of all those registers, please refer to the PLIC section in the *MCF5272 User's Manual* for a more detailed description.

6.4 Monitor Channel Sequence

This section details the manner in which GCI monitor channel data is handled. Based on the low-level protocol specification, the following information will help the user better understand the GCI monitor channel operation.

6.4.1 Transmit Sequence

Here is the transmit sequence of the GCI protocol using the GCI monitor channel transmit registers. The flow chart is shown in Figure 13.

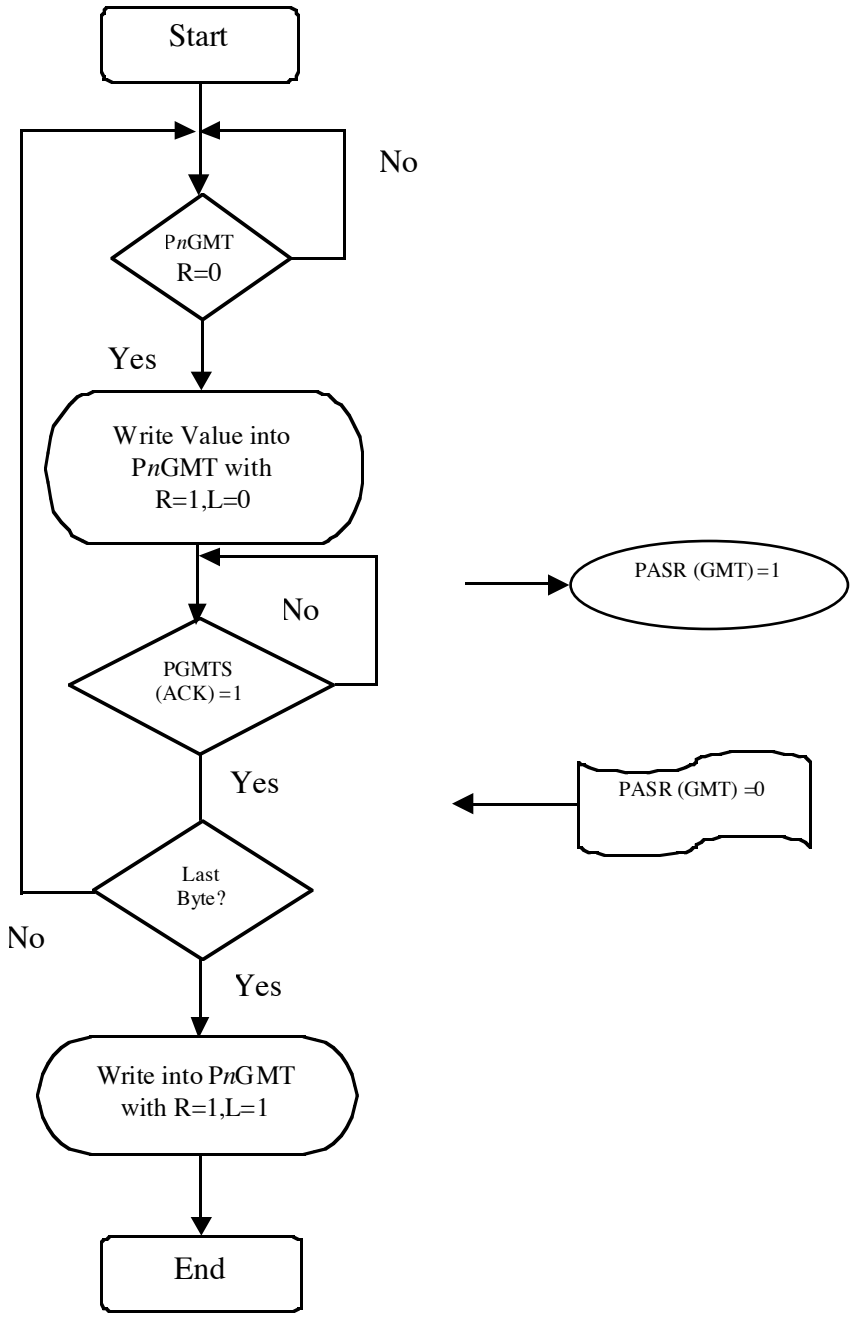


Figure 13. Monitor Channel Transmit Sequence Flow Diagram

6.4.2 Receive Sequence

This section describes with the receive sequence of the GCI protocol. The flow chart is shown in Figure 14.

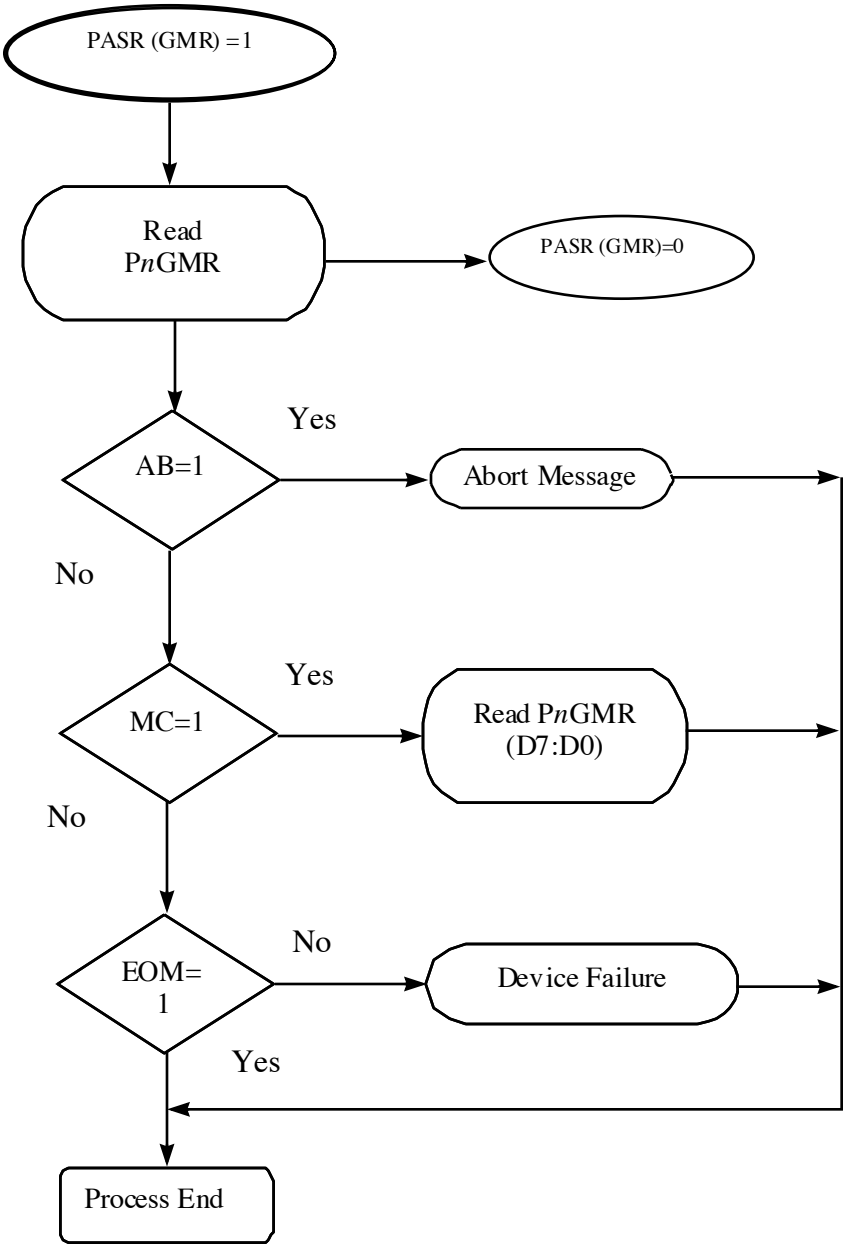


Figure 14. Monitor Channel Receive Sequence Flow Diagram

6.5 Transmit Abort Condition

One register is used to indicate an abort condition. The flow chart is shown in Figure 15.

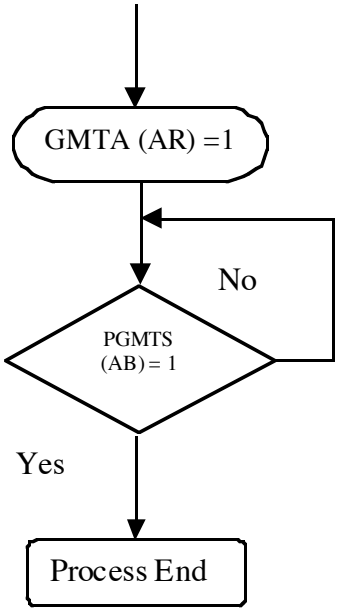


Figure 15. Transmit Abort Condition Flow Diagram

6.6 Command Indicate Channel

This section details the channel for command indication.

6.6.1 Transmit Sequence

Figure 16 explains CI channel operation.

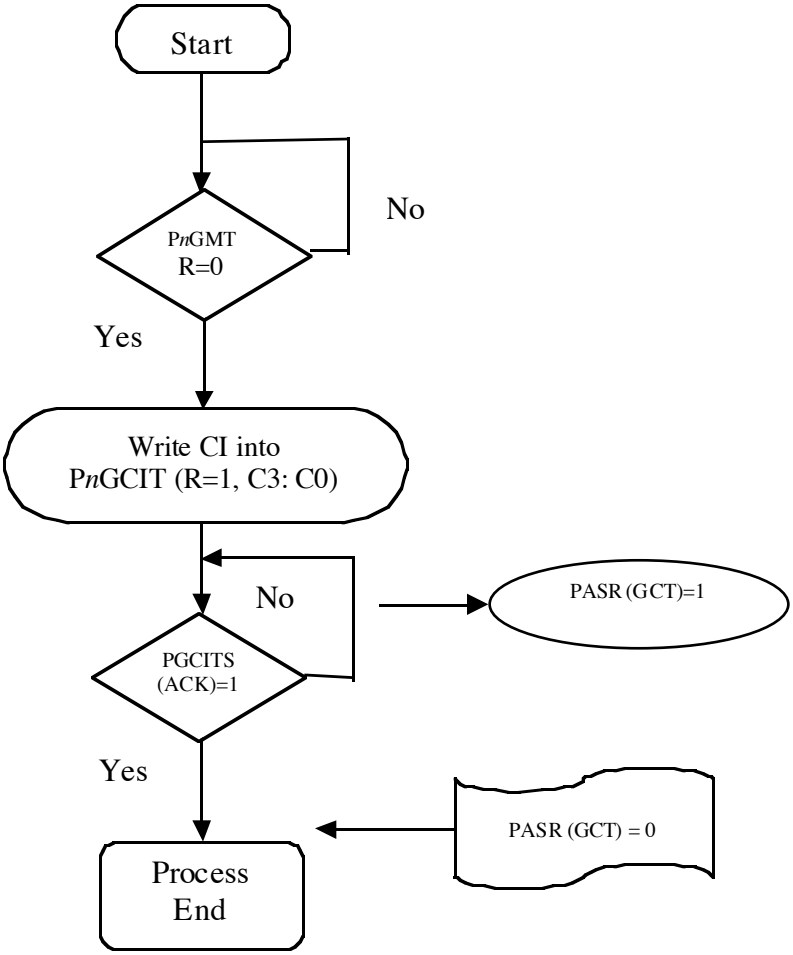


Figure 16. CI Transmit Sequence Flow Diagram

6.6.2 Receive Sequence

The flow chart for the receive sequence is shown in Figure 17.

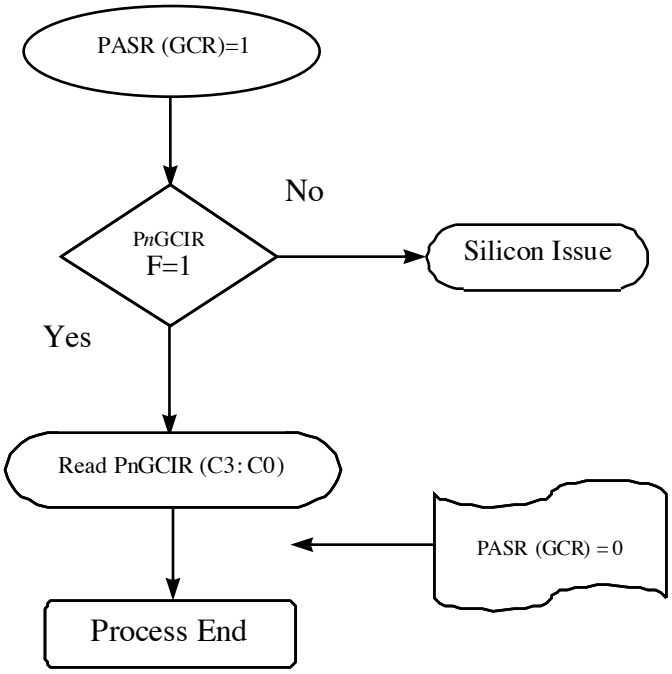


Figure 17. CI Receive Sequence Flow Diagram

Part VII Assembly Code

This section outlines how the ColdFire core will handle the PLIC. Some assembly code will be shown to better describe the sequence flow of the interrupt service routine. An interrupt occurs every 500 microseconds; therefore, all the actions must be performed within this time.

7.1 Interrupt Controller

The MCF5272 microprocessor device has some registers that set the interrupt prioritization levels for each interrupt source.

The on-chip system integration module contains an interrupt controller that is capable of providing up to 32 interrupt sources.

These sources include the following:

- External interrupt signals INT[6:1]
- Software watchdog timer
- Four general-purpose timers
- Two USARTs
- Ethernet controller
- PLIC controller
- DMA controller
- QSPI
- USB module

All external interrupt inputs are edge-sensitive where the active edge is programmable. The active edge is programmable. An interrupt request must be held valid for at least three consecutive CPU clock cycles to be considered a valid input. Each interrupt input can have its priority programmed by programming the xIPL(2-0) bits in the interrupt control registers. When the ColdFire core responds to a request with an interrupt acknowledge cycle, as is standard in MC52xx implementations, the interrupt controller logic will forward the correct vector depending on the original source of the interrupt. Software can clear pending interrupts from any source via the registers in the interrupt controller logic, and can program the location of the block of vectors used for interrupt sources via the programmable interrupt vector register. For an interrupt to be successfully processed, RAM must be available for the stack, and often this RAM will be selected by one of the programmable chip selects. So upon system startup there is a brief period where RAM is not available for the stack. To ensure no problems resulting from interrupts (particularly of priority level 7) during this period, there is an interlock which prevents any interrupt from reaching the ColdFire core until the first write cycle to the programmable interrupt vector register (PIVR). The user should ensure that both RAM chip selects and the system stack are set up prior to this write operation.

The interrupt controller includes daisy-chaining functions in order to avoid contention when the ColdFire core issues an interrupt acknowledge cycle. So if more than one interrupt source has the same interrupt priority level (IPL), they are daisy chained with INT1 being the highest priority. There are four interrupt control registers which control the interrupt priorities for the external general purpose latched interrupt input signals and the internal I/O modules' signals. These registers allow software to reset any pending interrupts from these external interrupt lines or internal modules. There are up to 32 interrupt inputs, each of which has four bits assigned to it in these registers. The registers can be read or written at any time. When read, the data returned is the last value that was written to the register, with the exception of the reset bits, which are transitory functions. The registers can be accessed by either long word (32-bit), word (16-bit), or byte (8-bit) data transfer instructions. An 8-bit write to one-half of a register will leave the other half intact.

7.2 Interrupt Vector Generation

Pending interrupts are presented to the MCF52*xx* core in order of priority. The core responds to an interrupt request by initiating an interrupt acknowledge cycle to receive a vector number, which allows the core to locate the interrupt's service routine. The interrupt controller is able to identify the source of the interrupt, which is being acknowledged and indicates this to the interrupt module mapper. The mapper determines which slave bus module is to provide the interrupt vector for the identified interrupt source. In most instances it is the interrupt controller itself which will provide the interrupt vector in which case the following procedure is used. The three most significant bits of the interrupt vector are programmed by the user in the programmable interrupt vector register.

7.3 Prioritization Level: ICR2 Register

The interrupt control registers (ICR*x*) allow the user to define which interrupt priority level (IPL), each of these peripheral sources will use. For those modules whose interrupt sources are mapped to the interrupt controller for the vector source, the programmable interrupt vector register (PIVR) allows the user to define a particular vector number to be presented when the respective module receives an interrupt acknowledge from the MCF52*xx* core via the interrupt controller logic. The interrupt vector register is initialized upon system reset with the uninitialized interrupt vector (hexadecimal 0x0F), and must be programmed with the required vector number for normal operation. It is important not to use reserved interrupt vector locations for this purpose. The dedicated ICR*x* for the periodic and aperiodic interrupts is ICR2.

MBASE +0x24

	31	30	29	28	27	26	25	24
Write	UART1PIR	UART1PL2	UART1/PL1	UART1/PL0	UART2PIR	UART2/PL2	UART2/PL1	UART2PL0
Read	UART1	UART1PL2	UART1/PL1	UART1/PL0	UART2	UART2/PL2	UART2/PL1	UART2PL0
Reset	0000_0000							

	23	22	21	20	19	18	17	16
Write	PLIPIR	PLIIPL2	PLIIPL1	PLIPL0	PLIAPIR	PLIAIPL2	PLIAIPL1	PLIAIPL0
Read	PLIP	PLIIPL2	PLIIPL1	PLIPL0	PLIA	PLIAIPL2	PLIAIPL1	PLIAIPL0
Reset	0000_0000							

	15	14	13	12	11	10	9	8
Write	USB0PIR	USB0IPL2	ISB0IPL1	USB0IPL0	USB1PIR	USB1IPL2	USB1IPL1	USB0IPL0
Read	USB0	USB0IPL2	ISB0IPL1	USB0IPL0	USB1	USB1IPL2	USB1IPL1	USB0IPL0
Reset	0000_0000							

	7	6	5	4	3	2	1	0
Write	USB2PIR	USB2IPL2	USB2IPL1	USB2IPL0	USB3PIR	USB3IPL2	USB2IPL1	USB2IPL0
Read	ISB2	USB2IPL2	USB2IPL1	USB2IPL0	USB3	USB3IPL2	USB2IPL1	USB2IPL0
Reset	0000_0000							

Figure 18. Interrupt Controller Register 2

For more explanation about the meaning of those bits, the user should read the *MCF5272 User's Manual*. Here is a brief summary ICRx bits:

*x*PIR: When set to one, the new IPL value is stored. When set to zero, the corresponding INTx interrupt latch and IPL level is unaffected. Any pending interrupt on that line will remain pending.

*x*IPL(2:0): Interrupt Priority Level (1-7): When set to zero, the corresponding INTx interrupt line is inhibited and will not generate interrupts. Its state can still be read via the ISR1 register. Otherwise, the corresponding INT1x interrupt line is enabled, and will generate an interrupt to the MCF52*xx* core with the indicated priority level.

For more explanation about the meaning of these bits, see the *MCF5272 User's Manual*.

7.4 Programmable Interrupt Vector Register: PIVR

This register specifies the vector numbers which will be returned by the interrupt controller in response to interrupt acknowledge cycles for the various peripherals and discrete interrupt sources. The high three bits of the vector number are programmed in the PIVR. The low five bits are provided by the interrupt controller depending on the highest priority source which is currently active for the specific interrupt priority level (IPL) being responded to in the current acknowledge cycle.

MBASE+0x3C

	7	6	5	4	3	2	1	0
Write	IV7	IV6	IV5	—				
Read	IV7	IV6	IV5	0_1111				
Reset	0000_1111							

Figure 19. Programmable Interrupt Vector Register

Table 5. PIV Register Field Descriptions

Bits	Name	Description
7–5	IV7–IV5	Interrupt vectors 7–5. These bits provide the three MSB's of the interrupt vector for interrupt acknowledge cycles from all sources. To conform to ColdFire interrupt vector allocation these bits should be set equal to or greater than 010. This is the same as writing a value of 0x40 to the register.
4–0	—	Reserved, should be cleared.

7.5 MBAR Configuration

This is one of the first registers that should be written after reset. MBAR configuration is arbitrarily set by the user.

7.6 Hardware Configuration

The evaluation board that is used in this setup is the M5272C3. The four ports are available through PCI sockets on the evaluation board. Be sure that, in addition to supplying the evaluation board with power, the user supplies 5V to J7, which supplies power to the daughter cards connected into the PCI sockets. The wire connection between the PC and the board is a BDM wiggler cable. Depending on the tested registers, the external environment could be either MC145572EVK (U Transceiver-oriented board) or MC145574EVK (T transceiver-oriented board). Along with the M5272C3 board, daughter cards will be plugged into these PCI sockets. Most of the time, the T2 daughter boards will be plugged in to evaluate multi-port functionality, D channel access, and other features. The U2 daughter card will be used for IDL BER measurement. The BER tester is the HP1645A, which is directly connected to either the MC145572EVK or MC145574EVK. The hardware setup is as follows:

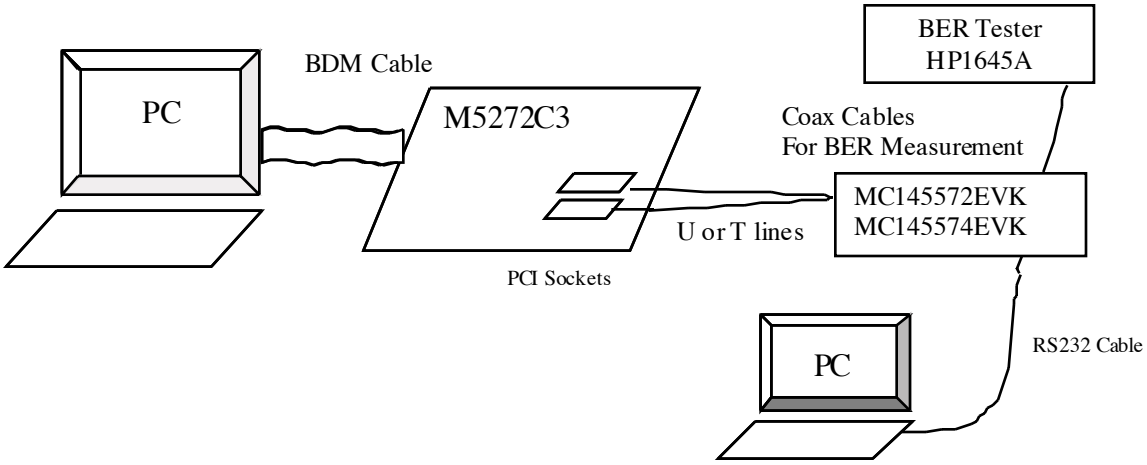


Figure 20. Hardware Configuration

7.7 Software Configuration

This section describes software configuration.

7.7.1 Customer Premises Equipment (CPE)

Depending on the CPE board used, the control software will run differently. This gives the user the ability to control the sourcing transceiver. If the MC145572EVK is used, the RS232 cable is connected and the embedded software will automatically come up with power-on reset. If the MC145574EVK is used, the scp.exe software must be run on a Windows-based PC. (Note: scp.exe software will not run on Windows NT.) Please refer to the specific EVK user's manual for more detailed information about the hardware and software for each.

7.7.2 ColdFire Port Configuration

Writing into the ColdFire core general purpose registers must configure the TDM pins of the MCF5272. With power-on reset, port1 will be automatically configured. Then port0 and some pins of port3 must be configured as a result of the GPIO register access. Table 6 shows the values.

Table 6. Port Pin Assignments

Port Pins	Configured by	Field in Control Register	Control Register Value (Binary)	Map BGA Pin
FSC0	PortA	PACNT8	01	J2
DCL0	PortD	PDCNT0	01	J4
Din0	PortD	PDCNT1	01	K1
Dout0	PortD	PDCNT4	01	K4
DREQ0	PortA	PACNT10	01	K5
DGRANT0	PortA	PACNT9	01	J3
FSC1	Reset	N/A		L4
DCL1 / DCL2	Reset	N/A		M1

Table 6. Port Pin Assignments

Port Pins	Configured by	Field in Control Register	Control Register Value (Binary)	Map BGA Pin
Din1 / Din2	Reset	N/A		N2
Dout1 / Dout2	Reset	N/A		N1
DREQ1	PortA	PACNT14	01	M2
DGRANT1	PortA	PACNT15	01	M3
FSC2	PortA	PACNT12	01	L2
FSC3	PortA	PACNT13	01	L3
Din3*	PortD / Reset	PDCNT5	10 / 00	P3 / N2
Dout3	PortA / Reset	PACNT 7	10 / 00	P1 / N1
Note: The user must keep in mind that ports 1, 2, and 3 share the same resource as long as DCL, Din, and Dout are concerned. This is called the indirect mode. Only the FSC pins are different. In some applications, Din3 and Dout3 might come from other resources, called the direct mode. In this case, PDCNT and PACNT values must be programmed as the above array shows. The MAP BGA pins will, of course, be different.				

As a summary, the port control registers values are:

Table 7. Port Control Register Values

Port Control Register	Indirect Mode (Hex)	Direct Mode (Hex)
PACNT (MBAR+0x80)	55150000	55158000
PDCNT (MBAR+0x98)	00000105	00000905

7.7.3 Debugger Configuration

Once the code has been compiled with the Diab compiler to the file **main.elf**, the user can download it to the M5272C3 evaluation board via the BDM cable. The configuration file is as follows:

```
set vectbase = 0x00000000
set vectaddr = 0x00000000


@ MBAR = 0x10000001
@ RAMBAR = 0x20000001



# 2MB FLASH on CS0 at 0xFFE00000
 write -l 0x10000040=0xFFE00201
 write -l 0x10000044=0xFFE00014


# Nothing on CS1 at 0x00000000
 write -l 0x10000048=0x00000000
 write -l 0x1000004C=0x00000000


# External FSRAM on CS2 at 0x30000000
 write -l 0x10000050=0x30000001
 write -l 0x10000054=0xFFF80008
```

```
# Nothing on CS3 at 0x00000000
# write -l 0x10000058=0x00000000
# write -l 0x1000005C=0x00000000


# CS7 from address 0x00000000 4M byte SDRAM
write -l 0x10000078 = 0x00000701
write -l 0x1000007C = 0xFFC0007c


# setup SDRAM Timing and Control Registers SDCTR then SDCCR
write -l 0x10000184 = 0x0000f415
write -l 0x10000180 = 0x00004211


# rem initialize SDRAM with a write
write -r 0x00040000=0x55555555 # STARTS SDRAM controller
```

Part VIII Appendix A

This appendix deals with an example of program that has been used to evaluate the MCF5272.

Scope of the program:

The purpose of that program was not to productize the MCF5272, but to simply evaluate the silicon. This is the reason why the internal architecture might not be optimized to the fullest. Some knowledge of Freescale ISDN products is required, in order to fully activate and send data over the data link. For more information, the user must refer to the MC145572 and MC145574 User's Manuals.

Once the hardware has been correctly set up (see Figure 20), the NT-configured MC145574 chip activates the (NR2 to 0x1) down to the TE-configured MC145574 device. When the link is up and running (NR1 to 0x9), the TE must have the B1 and B2 channels on (NR5 to 0xC). Once connected to the NT-configured T chip, the bit error rate tester (HP 1645A) sends data from the NT device through the link down to the TE device. The purpose of MCF5272 is to capture the received data and to perform a loopback in the ColdFire core via the interrupt service routine. The possible loopbacks that can be tested are all combinations of B channels or D channel by itself. Due to the internal architecture and the special processing of the D channel, the 2B+D loopback cannot be performed. The entire loopback process runs in the ISR. The flow diagram of the program (for both IDL and GCI modes, except that there is no aperiodic interrupt in IDL mode) is as follows:

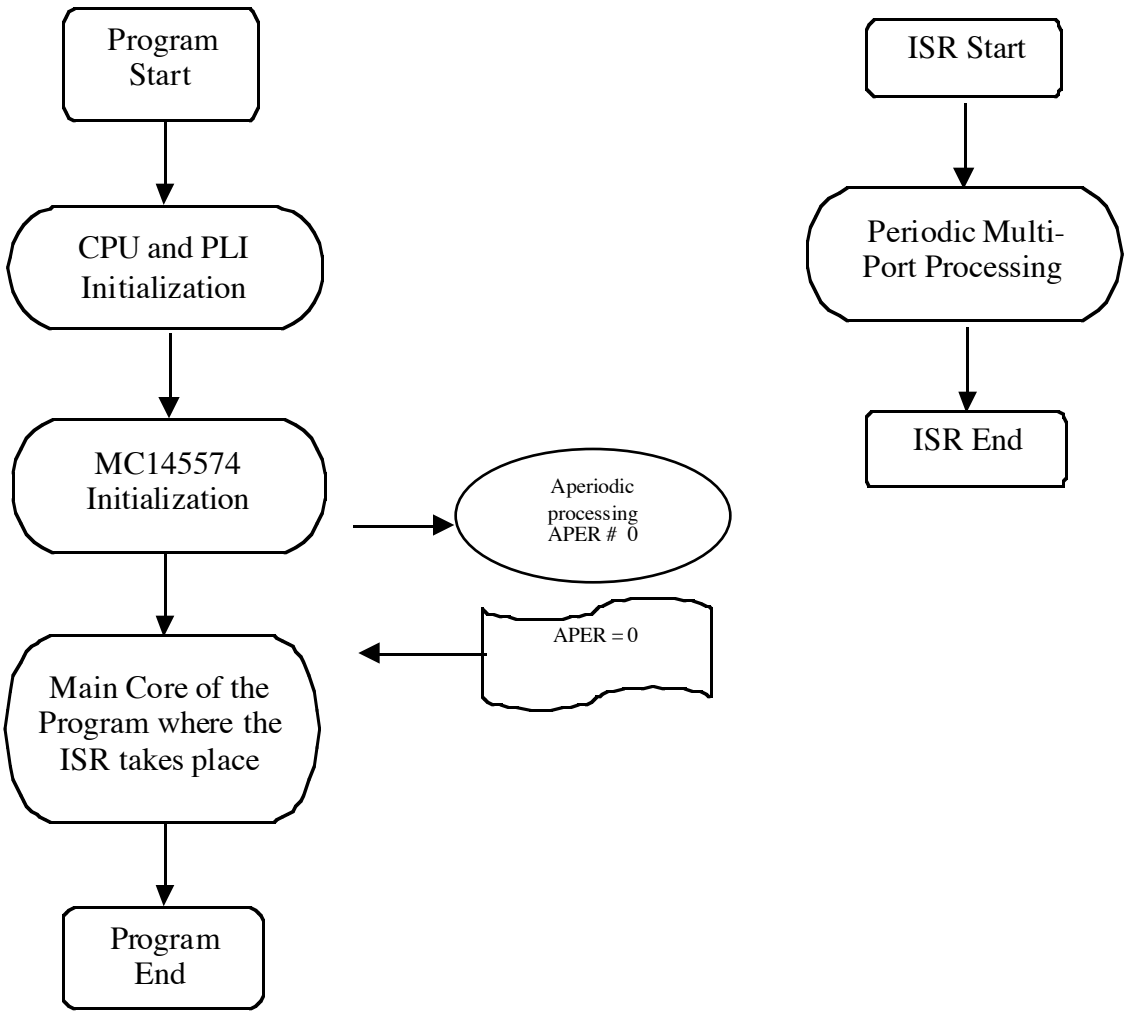


Figure 21. Main Program and ISR Flow Diagram

Here below is the MAIN file, with all the invoked files that are necessary

```
.include "configuration.h"                    ;Equates
.include "PLIInterupt.s"                      ;Interrupt Vectors
.include "PerIntVector.s"                     ;Periodic Interrupt
.include "AperIntVector.s"                    ;Aperiodic Interrupt
.include "CoreInit.s"                         ;Main file
.include "Init.s"                             ;Subroutine to init
.include "CPUInit.s"                          ;Linked to ColdFire Core
.include "Table.s"
```

Note: The user must add a space at each beginning of line to make sure the code will be correctly compiled.

This is the file that must be compiled with the following executable file **makeit**:

```
das -l -g -Xalign-value -tMCF5206eFN:simple -Xasm-debug-on -I@ -o
main.o target.s
dld -m2 -o main.elf main.o -lc > map
ddump -Rv -o try.mot main.elf
```

Once the main.elf file has been generated, it must be downloaded to the board via the BDM. Shown below are all the files included in main.s.

Configuration.h is the file used for all the definition of the equates. In order to save space, only the important and used equates are shown: i.e. the Initialization registers and the PLIC registers.

```
; Default initial register values

; Most of the values are not used for the PLIC evaluation


Module_Regs_Addr    EQU      $00300000              ;Addr. of on-chip reg
Init_MBAR           EQU      $10000001              ;MBAR value
Init_SCR            EQU      $0000
Init_PMR            EQU      $0                     ;Initial value of PMR
UserProgram         EQU      $00020000              ;Put program in SDRAM
Init_SPR            EQU      $00E8                  ;Initial value of SPR
Init_SCFR           EQU      $1211                  ;Initial value of SCFR
Init_PIVR           EQU      $40                    ;Initial value of PIVR
VBR_Init            EQU      $00000000
SRValue             EQU      $2500
LED                 EQU      $3
; ADDRESSES OF SYSTEM CONFIGURATION REGISTERS - These are absolute addresses


Sys_Config_Regs     EQU      $00000400             ;Absolute address of sers
MBAR                EQU      Sys_Config_Regs+0     ;Module Base Add Register
SCR                 EQU      Sys_Config_Regs+4     ;System Config Register
SPR                 EQU      Sys_Config_Regs+6     ;System Protection Register
PMR                 EQU      Sys_Config_Regs+8     ;Power Management Register
SCFR                EQU      Sys_Config_Regs+$C    ;Synthesized Clock Freq
DIR                 EQU      Sys_Config_Regs+$10   ;Device ID Register



; OFFSETS TO MODULES - Offsets w.r.t. contents of MBAR (don't use directly, use
register names below)


Intc_Reg_Offset     EQU         $000               ;Offset of SIM's IntC
Csel_Reg_Offset     EQU         $040               ;Offset of SIM's CSel
Port_Reg_Offset     EQU         $080               ;Offset of SIM's Ports
QSPI_Reg_Offset     EQU         $0A0               ;Offset of QSPI module
PWM_Reg_Offset      EQU         $0C0               ;Offset of PWM module
DMA_Reg_Offset      EQU         $0E0               ;Offset of DMA module
Uart1_Reg_Offset    EQU         $100               ;Offset of UART module
Uart2_Reg_Offset    EQU         $140               ;Offset of UART module
SDRAM_Reg_Offset    EQU         $180               ;Offset of SDRAM module
Timer_Reg_Offset    EQU         $200               ;Offset of Timer module
PLIC_Reg_Offset     EQU         $300               ;Offset of PLIC module
Ether_Reg_Offset    EQU         $800               ;Offset of Ethernet module
USB_Reg_Offset      EQU         $1000              ;Offset of USB module
```

```
; SIM INTERRUPT CONTROLLER REGISTERS


ICR1          EQU     Intc_Reg_Offset+$20          ;Int Control Register
ICR2          EQU     Intc_Reg_Offset+$24          ;Int Control Register
ICR3          EQU     Intc_Reg_Offset+$28          ;Int Control Register
ICR4          EQU     Intc_Reg_Offset+$2C          ;Int Control Register
ISR           EQU     Intc_Reg_Offset+$30          ;Interrupt Source Register
PITR          EQU     Intc_Reg_Offset+$34          ;Prog Interrupt Transition
PIWR          EQU     Intc_Reg_Offset+$38          ;Prog. Interrupt Wakeup
PIVR          EQU     Intc_Reg_Offset+$3F          ;Prog. Interrupt Vector

; SIM CHIP SELECT REGISTERS


BR0             EQU   Csel_Reg_Offset+$0           ;Chip Select Base Register
OR0             EQU   Csel_Reg_Offset+$4           ;CS Option Register
BR1             EQU   Csel_Reg_Offset+$8           ;Chip Select Base Register
OR1             EQU   Csel_Reg_Offset+$C           ;CS Option Register 1
BR2             EQU   Csel_Reg_Offset+$10          ;Chip Select Base Register
OR2             EQU   Csel_Reg_Offset+$14          ;CS Option Register
BR3             EQU   Csel_Reg_Offset+$18          ;Chip Select Base Register
OR3             EQU   Csel_Reg_Offset+$1C          ;CS Option Register 3
BR4             EQU   Csel_Reg_Offset+$20          ;CS Base Register 4
OR4             EQU   Csel_Reg_Offset+$24          ;CS Option Register 4
BR5             EQU   Csel_Reg_Offset+$28          ;CS Base Register 5
OR5             EQU   Csel_Reg_Offset+$2C          ;CS Option Register 5
BR6             EQU   Csel_Reg_Offset+$30          ;CS Base Register 6
OR6             EQU   Csel_Reg_Offset+$34          ;CS Option Register 6
BR7             EQU   Csel_Reg_Offset+$38          ;CS Base Register 7
OR7             EQU   Csel_Reg_Offset+$3C          ;CS Option Register 7


* SIM PORTS REGISTERS (PORT A and PORT B)


PACNT         EQU     Port_Reg_Offset+$00          ;Port A Control Reg
PADDR         EQU     Port_Reg_Offset+$04          ;Port A Data Direction
PADAT         EQU     Port_Reg_Offset+$06          ;Port A Data Register
PBCNT         EQU     Port_Reg_Offset+$08          ;Port B Control Register
PBDDR         EQU     Port_Reg_Offset+$0C          ;Port B Data Direction
PBDAT         EQU     Port_Reg_Offset+$0E          ;Port B Data Register

; Port C has no CNT register - pins controlled by data bus 16/32-bit mode

PCDDR         EQU     Port_Reg_Offset+$14          ;Port C Data Direction
PCDAT         EQU     Port_Reg_Offset+$16          ;Port C Data Register
PDCNT         EQU     Port_Reg_Offset+$18          ;Port C Control Register

; Port D has no DDR or DAT register - used for pin asignment only


; PLIC MODULE REGISTERS


P0B1RR          EQU   PLIC_Reg_Offset+$00          ;B1 Data Receive, Port0
P1B1RR          EQU   PLIC_Reg_Offset+$04          ;B1 Data Receive, Port1
P2B1RR          EQU   PLIC_Reg_Offset+$08          ;B1 Data Receive, Port2
P3B1RR          EQU   PLIC_Reg_Offset+$0C          ;B1 Data Receive, Port3
P0B2RR          EQU   PLIC_Reg_Offset+$10          ;B2 Data Receive, Port0
P1B2RR          EQU   PLIC_Reg_Offset+$14          ;B2 Data Receive, Port1
```

```
P2B2RR          EQU   PLIC_Reg_Offset+$18          ;B2 Data Receive, Port2
P3B2RR          EQU   PLIC_Reg_Offset+$1C          ;B2 Data Receive, Port3
P0DRR           EQU   PLIC_Reg_Offset+$20          ;D Data Receive, Port0
P1DRR           EQU   PLIC_Reg_Offset+$21          ;D Data Receive, Port1
P2DRR           EQU   PLIC_Reg_Offset+$22          ;D Data Receive, Port2
P3DRR           EQU   PLIC_Reg_Offset+$23          ;D Data Receive, Port3
P0B1TR          EQU   PLIC_Reg_Offset+$28          ;B1 Data Transmit, Port0
P1B1TR          EQU   PLIC_Reg_Offset+$2C          ;B1 Data Transmit, Port1
P2B1TR          EQU   PLIC_Reg_Offset+$30          ;B1 Data Transmit,Port2
P3B1TR          EQU   PLIC_Reg_Offset+$34          ;B1 Data Transmit, Port3
P0B2TR          EQU   PLIC_Reg_Offset+$38          ;B2 Data Transmit, Port0
P1B2TR          EQU   PLIC_Reg_Offset+$3C          ;B2 Data Transmit, Port1
P2B2TR          EQU   PLIC_Reg_Offset+$40          ;B2 Data Transmit, Port2
P3B2TR          EQU   PLIC_Reg_Offset+$44          ;B2 Data Transmit, Port3
P0DTR           EQU   PLIC_Reg_Offset+$48          ;D Data Transmit, Port0
P1DTR           EQU   PLIC_Reg_Offset+$49          ;D Data Transmit, Port1
P2DTR           EQU   PLIC_Reg_Offset+$4A          ;D Data Transmit, Port2
P3DTR           EQU   PLIC_Reg_Offset+$4B          ;D Data Transmit, Port3
PLCR0           EQU   PLIC_Reg_Offset+$50          ;GCI/IDL config, Port0
PLCR1           EQU   PLIC_Reg_Offset+$52          ;GCI/IDL config, Port1
PLCR2           EQU   PLIC_Reg_Offset+$54          ;GCI/IDL config, Port2
PLCR3           EQU   PLIC_Reg_Offset+$56          ;GCI/IDL config, Port3
P0ICR           EQU   PLIC_Reg_Offset+$58          ;GCI Int config, Port0
P1ICR           EQU   PLIC_Reg_Offset+$5A          ;GCI Int config, Port1
P2ICR           EQU   PLIC_Reg_Offset+$5C          ;GCI Int config, Port2
P3ICR           EQU   PLIC_Reg_Offset+$5E          ;GCI Int config, Port3
P0GMR           EQU   PLIC_Reg_Offset+$60          ;GCI Monitor RX, Port0
P1GMR           EQU   PLIC_Reg_Offset+$62          ;GCI Monitor RX, Port1
P2GMR           EQU   PLIC_Reg_Offset+$64          ;GCI Monitor RX, Port2
P3GMR           EQU   PLIC_Reg_Offset+$66          ;GCI Monitor RX, Port3
P0GMT           EQU   PLIC_Reg_Offset+$68          ;GCI Monitor TX, Port0
P1GMT           EQU   PLIC_Reg_Offset+$6A          ;GCI Monitor TX, Port1
P2GMT           EQU   PLIC_Reg_Offset+$6C          ;GCI Monitor TX, Port2
P3GMT           EQU   PLIC_Reg_Offset+$6E          ;GCI Monitor TX, Port3
PGMTS           EQU   PLIC_Reg_Offset+$71          ;GCI Monitor TX status
PGMTA           EQU   PLIC_Reg_Offset+$72          ;GCI Monitor TX abort
P0GCIR          EQU   PLIC_Reg_Offset+$74          ;GCI C/I RX, Port0
P1GCIR          EQU   PLIC_Reg_Offset+$75          ;GCI C/I RX, Port1
P2GCIR          EQU   PLIC_Reg_Offset+$76          ;GCI C/I RX, Port2
P3GCIR          EQU   PLIC_Reg_Offset+$77          ;GCI C/I RX, Port3
P0GCIT          EQU   PLIC_Reg_Offset+$78          ;GCI C/I TX, Port0
P1GCIT          EQU   PLIC_Reg_Offset+$79          ;GCI C/I TX, Port1
P2GCIT          EQU   PLIC_Reg_Offset+$7A          ;GCI C/I TX, Port2
P3GCIT          EQU   PLIC_Reg_Offset+$7B          ;GCI C/I TX, Port3
PGCITSR         EQU   PLIC_Reg_Offset+$7F          ;GCI C/I TX status
PDCSR           EQU   PLIC_Reg_Offset+$83          ;D Channel Status
P0PSR           EQU   PLIC_Reg_Offset+$84          ;Port Status, Port0
P1PSR           EQU   PLIC_Reg_Offset+$86          ;Port Status, Port1
P2PSR           EQU   PLIC_Reg_Offset+$88          ;Port Status, Port2
P3PSR           EQU   PLIC_Reg_Offset+$8A          ;Port Status, Port3
PASR            EQU   PLIC_Reg_Offset+$8C          ;Aperiodic Status Reg
PLCR            EQU   PLIC_Reg_Offset+$8F          ;Loopback Control
PDRQR           EQU   PLIC_Reg_Offset+$92          ;D Channel Request
P0SDR           EQU   PLIC_Reg_Offset+$94          ;Sync Delay, Port0
P1SDR           EQU   PLIC_Reg_Offset+$96          ;Sync Delay, Port1
P2SDR           EQU   PLIC_Reg_Offset+$98          ;Sync Delay, Port2
P3SDR           EQU   PLIC_Reg_Offset+$9A          ;Sync Delay, Port3
PCSR            EQU   PLIC_Reg_Offset+$9E          ;Clock Select
```

Shown below are the interrupt vector file. As long as the purpose of this evaluation is PLIC oriented, not all vectors need to correspond to a real ISR address:

```
                org     VBR_Init

reset_vec       DC.L    Init_SSP
                DC.L    Code_Start
berr_vec        DC.L    berr_handler
aerr_vec        DC.L    aerr_handler
illeg_vec       DC.L    illeg_handler
divz_vec        DC.L    divz_handler
chk_vec         DC.L    chk_handler
trapv_vec       DC.L    trapv_handler
privv_vec       DC.L    privv_handler
trace_vec       DC.L    trace_handler
aline_vec       DC.L    aline_handler
fline_vec       DC.L    fline_handler
res12_vec       DC.L    rsrv_handler
res13_vec       DC.L    rsrv_handler
res14_vec       DC.L    rsrv_handler
uninit_vec      DC.L    uninit_handler
res16_vec       DC.L    rsrv_handler
res17_vec       DC.L    rsrv_handler
res18_vec       DC.L    rsrv_handler
res19_vec       DC.L    rsrv_handler
res20_vec       DC.L    rsrv_handler
res21_vec       DC.L    rsrv_handler
res22_vec       DC.L    rsrv_handler
res23_vec       DC.L    rsrv_handler
spuri_vec       DC.L    spuri_handler
res25_vec       DC.L    rsrv_handler
res26_vec       DC.L    rsrv_handler
res27_vec       DC.L    rsrv_handler
res28_vec       DC.L    rsrv_handler
res29_vec       DC.L    rsrv_handler
res30_vec       DC.L    rsrv_handler
res31_vec       DC.L    rsrv_handler
trap0_vec       DC.L    trap0_handler
trap1_vec       DC.L    trap1_handler
trap2_vec       DC.L    trap2_handler
trap3_vec       DC.L    trap3_handler
trap4_vec       DC.L    trap4_handler
trap5_vec       DC.L    trap5_handler
trap6_vec       DC.L    trap6_handler
trap7_vec       DC.L    trap7_handler
trap8_vec       DC.L    trap8_handler
trap9_vec       DC.L    trap9_handler
trap10_vec      DC.L    trap10_handler
trap11_vec      DC.L    trap11_handler
trap12_vec      DC.L    trap12_handler
trap13_vec      DC.L    trap13_handler
trap14_vec      DC.L    trap14_handler
trap15_vec      DC.L    trap15_handler
res48_vec       DC.L    rsrv_handler
res49_vec       DC.L    rsrv_handler
res50_vec       DC.L    rsrv_handler
res51_vec       DC.L    rsrv_handler
res52_vec       DC.L    rsrv_handler
res53_vec       DC.L    rsrv_handler
res54_vec       DC.L    rsrv_handler
res55_vec       DC.L    rsrv_handler
res56_vec       DC.L    rsrv_handler
res57_vec       DC.L    rsrv_handler
res58_vec       DC.L    rsrv_handler
res59_vec       DC.L    rsrv_handler
res60_vec       DC.L    mbar_handler
res61_vec       DC.L    mbar_handler
```

```
res62_vec         DC.L     mbar_handler
res63_vec         DC.L     mbar_handler

i_spur_vec        DC.L     i_spur_handler
int1_vec          DC.L     int1_handler
int2_vec          DC.L     int2_handler
int3_vec          DC.L     int3_handler
int4_vec          DC.L     int4_handler
i_tim1_vec        DC.L     i_tim1_handler        ;Timer interrupt handler
i_tim2_vec        DC.L     i_tim2_handler        ;Timer interrupt handler
i_tim3_vec        DC.L     i_tim3_handler        ;Timer interrupt handler
i_tim4_vec        DC.L     i_tim4_handler        ;Timer interrupt handler
i_uart1_vec       DC.L     i_uart1_handler       ;UART interrupt handler
i_uart2_vec       DC.L     i_uart2_handler       ;UART interrupt handler
i_plic_per_vec    DC.L     i_PLIC_Periodic       ;PLIC periodic interrupt
i_plic_aper_vec   DC.L     i_PLIC_Aperiodic      ;PLIC Aperiodic interrupt
i_usb0_vec        DC.L     i_usb0_handler
i_usb1_vec        DC.L     i_usb1_handler
i_usb2_vec        DC.L     i_usb2_handler
i_usb3_vec        DC.L     i_usb3_handler
i_usb4_vec        DC.L     i_usb4_handler
i_usb5_vec        DC.L     i_usb5_handler
i_usb6_vec        DC.L     i_usb6_handler
i_usb7_vec        DC.L     i_usb7_handler
i_dma_vec         DC.L     i_dma_handler
i_ether_rx_vec    DC.L     i_ether_rx_handler
i_ether_tx_vec    DC.L     i_ether_tx_handler
i_ether_ntc_vec   DC.L     i_ether_ntc_handler
i_qspi_vec        DC.L     i_qspi_handler
int5_vec          DC.L     int5_handler
int6_vec          DC.L     int6_handler

berr_handler:
aerr_handler:
illeg_handler:
divz_handler:
chk_handler:
trapv_handler:
privv_handler:
trace_handler:
aline_handler:
fline_handler:
rsrv_handler:
uninit_handler:
spuri_handler:
trap0_handler:
trap1_handler:
trap2_handler:
trap3_handler:
trap4_handler:
trap5_handler:
trap6_handler:
trap7_handler:
trap8_handler:
trap9_handler:
trap10_handler:
trap11_handler:
trap12_handler:
trap13_handler:
trap14_handler:
trap15_handler:
mbar_handler:
i_spur_handler:
int1_handler:
```

```
int2_handler:
int3_handler:
int4_handler:
i_tim1_handler:
i_tim2_handler:
i_tim3_handler:
i_tim4_handler:
i_uart1_handler:
i_uart2_handler:
i_usb0_handler:
i_usb1_handler:
i_usb2_handler:
i_usb3_handler:
i_usb4_handler:
i_usb5_handler:
i_usb6_handler:
i_usb7_handler:
i_dma_handler:
i_ether_rx_handler:
i_ether_tx_handler:
i_ether_ntc_handler:
i_qspi_handler:
int5_handler:
int6_handler:
                nop
                stop    #$2700

                org     UserProgram

User_Ram:       ds.b    10                  ;Leave 1K for user variables
Stack:          ds.b    10                  ;Supervisor Stack 1Kbytes
Init_SSP                                    ;Initial SSP
```

The file below deals with the general periodic interrupt service routine including all of the bit handling. Not all of the overrun and underrun bits are implemented in this file. Nevertheless, those bits have been verified. Further more, this file has been written as dynamic as possible.

```
;*********************************************************************

; The program below has been written in the dynamic way. That means
; every time an Interrupt has been handled, the program counter exits
; In case that other bits are set, the program counter will enter the
; ISR again.

;*********************************************************************

; D0 is used for Data
; D1 is used for recovering the PnPSR
; D2 is used for checking the T/RIE bits by reading PnICR
; D3 is used for checking bits
; D4 is used for B2 Data in case of crossing the B1/B2 data
; D5 is used LED if necessary
; D6 is used for D channel
; D7 for comparing values


i_PLIC_Periodic:

Port0Test:move.w P0ICR(A5),D1; Interrupt Config Register

        andi.l          #$00008000,D1           ; Mask the IE bit
        cmp.l           #$00008000,D1           ; compare
        bne             Port1Test               ; Go to Port1
        move.w          P0PSR(A5),D1            ; Port0 is the cause
        move.l          D1,D7                   ; Save D1 into D7
```

```
        andi.l          #$0000003F,D7           ; mask with all Port0 bits
        cmp.l           #$0,D7                  ; compare to 0
        beq             Port1Test               ; go to Port1 if not equal

Port0Int:
        move.w          P0ICR(A5),D2            ; Read ICR0
        andi.l          #$00000001,D2           ; to make sure B1RIE is set
        cmp.l           #$00000001,D2
        bne             EndPort0RxB1            ; if not, go to next interrupt
        move.l          D1,D7                   ; P0PSR check
        andi.l          #$00000001,D7           ; D1 has the PLPSP0 value
        cmp.l           #$00000001,D7
        beq             Port0ReadB1             ; Go to read B1 if bit set

EndPort0RxB1:
        move.w          P0ICR(A5),D2            ; Read ICR0 to make sure B1TIE
        andi.l          #$00000008,D2           ; is set
        cmp.l           #$00000008,D2
        bne             EndPort0TxB1
        move.l          D1,D7                   ; B1TDE Test
        andi.l          #$00000008,D7
        cmp.l           #$00000008,D7
        beq             Port0TransmitB1         ; go to Transmit B1 if bit set

EndPort0TxB1:
        move.w          P0ICR(A5),D2            ; Read ICR0 to make sure B2RIE
        andi.l          #$00000002,D2           ; is set
        cmp.l           #$00000002,D2
        bne             EndPort0RxB2
        move.l          D1,D7                   ; R2RDF Test
        andi.l          #$00000002,D7
        cmp.l           #$00000002,D7
        beq             Port0ReadB2             ; Go to read B2 if bit set

EndPort0RxB2:
        move.w          P0ICR(A5),D2
        andi.l          #$00000010,D2
        cmp.l           #$00000010,D2
        bne             Port0D
        move.l          D1,D7                   ; B2TDE Test
        andi.l          #$00000010,D7
        cmp.l           #$00000010,D7
        beq             Port0TransmitB2         ; go to Transmit B2 if bit set

Port0D: move.w          P0ICR(A5),D2            ; Read ICR0 to make sure DRIE

        andi.l          #$00000004,D2           ; is set
        cmp.l           #$00000004,D2
        bne             EndPort0Rx              ; if not, go to next source
        move.l          D1,D7                   ; DRIE is set, needs to
        andi.l          #$00000004,D7           ; receive the D data
        cmp.l           #$00000004,D7
        beq             Port0RxD                ; Go to Read D if bit set

EndPort0Rx:
        move.w          P0ICR(A5),D2            ; Read ICR0(DTIE) to make
        andi.l          #$00000020,D2           ; sure the bit is set
        cmp.l           #$00000020,D2
        bne             Port1Test               ; go to next port
        move.l          D1,D7                   ; DTDE Test
        andi.l          #$00000020,D7
        cmp.l           #$00000020,D7
        beq             Port0TxD
Port1Test:
        move.w          P1ICR(A5),D1            ; IE Test on Port1
```

```
        andi.l          #$00008000,D1
        cmp.l           #$00008000,D1
        bne             Port2Test               ; go to Port2 if not equal

Port1Int:nop
        move.w          PnPSR1(A5),D1           ; Port1
        move.l          D1,D7
        andi.l          #$0000003F,D7
        cmp.l           #$0,D7
        beq             Port2Test               ; go to Port2 if not equal
        move.w          P1ICR(A5),D2
        andi.l          #$00000001,D2
        cmp.l           #$00000001,D2
        bne             EndPort1RxB1
        move.l          D1,D7                   ; B1RDF Test
        andi.l          #$00000001,D7
        cmp.l           #$00000001,D7
        beq             Port1ReadB1

EndPort1RxB1:
        move.w          P1ICR(A5),D2
        andi.l          #$00000008,D2
        cmp.l           #$00000008,D2
        bne             EndPort1TxB1
        move.l          D1,D7                   ; B1TDE Test
        andi.l          #$00000008,D7
        cmp.l           #$00000008,D7
        beq             Port1TransmitB1

EndPort1TxB1:
        move.w          P1ICR(A5),D2
        andi.l          #$00000002,D2
        cmp.l           #$00000002,D2
        bne             EndPort1RxB2
        move.l          D1,D7                   ; B2RDF Test
        andi.l          #$00000002,D7
        cmp.l           #$00000002,D7
        beq             Port1ReadB2

EndPort1RxB2:
        move.w          P1ICR(A5),D2
        andi.l          #$00000010,D2
        cmp.l           #$00000010,D2
        bne             Port1D
        move.l          D1,D7                   ; B2TDE Test
        andi.l          #$00000010,D7
        cmp.l           #$00000010,D7
        beq             Port1TransmitB2

Port1D: move.w          P1ICR(A5),D2
        andi.l          #$00000004,D2
        cmp.l           #$00000004,D2
        bne             EndPort1Rx
        move.l          D1,D7                   ; DRDF Test
        andi.l          #$00000004,D7
        cmp.l           #$00000004,D7
        beq             Port1RxD

EndPort1Rx:
        move.w          P1ICR(A5),D2
        andi.l          #$00000020,D2
        cmp.l           #$00000020,D2
        bne             Port2Test
        move.l          D1,D7                   ; DTDE Test
```

```
        andi.l          #$00000020,D7
        cmp.l           #$00000020,D7
        beq             Port1TxD

Port2Test:
        move.w          P2ICR(A5),D1            ; IE Test on Port2
        andi.l          #$00008000,D1
        cmp.l           #$00008000,D1
        bne             Port3Test

Port2Int:nop
        move.w          P2PSR(A5),D1            ; Port2
        move.l          D1,D7
        andi.l          #$0000003F,D7
        cmp.l           #$0,D7
        beq             Port3Test
        move.w          P2ICR(A5),D2
        andi.l          #$00000001,D2
        cmp.l           #$00000001,D2
        bne             EndPort2RxB1
        move.l          D1,D7                   ; B1RDF Test
        andi.l          #$00000001,D7
        cmp.l           #$00000001,D7
        beq             Port2ReadB1

EndPort2RxB1:
        move.w          P2ICR(A5),D2
        andi.l          #$00000008,D2
        cmp.l           #$00000008,D2
        bne             EndPort2TxB1
        move.l          D1,D7                   ; B1TDE Test
        andi.l          #$00000008,D7
        cmp.l           #$00000008,D7
        beq             Port2TransmitB1

EndPort2TxB1:
        move.w          P2ICR(A5),D2
        andi.l          #$00000002,D2
        cmp.l           #$00000002,D2
        bne             EndPort2RxB2
        move.l          D1,D7                   ; B2RDF Test
        andi.l          #$00000002,D7
        cmp.l           #$00000002,D7
        beq             Port2ReadB2

EndPort2RxB2:
        move.w          P2ICR(A5),D2
        andi.l          #$00000010,D2
        cmp.l           #$00000010,D2
        bne             Port2D
        move.l          D1,D7                   ; B2TDE Test
        andi.l          #$00000010,D7
        cmp.l           #$00000010,D7
        beq             Port2TransmitB2

Port2D:  move.w         P2ICR(A5),D2
        andi.l          #$00000004,D2
        cmp.l           #$00000004,D2
        bne             EndPort2Rx
        move.l          D1,D7                   ; DRDF Test
        andi.l          #$00000004,D7
        cmp.l           #$00000004,D7
        beq             Port2RxD
```

```
EndPort2Rx:
        move.w          P2ICR(A5),D2
        andi.l          #$00000020,D2
        cmp.l           #$00000020,D2
        bne             Port3Test
        move.l          D1,D7                   ; DTDE Test
        andi.l          #$00000020,D7
        cmp.l           #$00000020,D7
        beq             Port2TxD

Port3Test:
        move.w          P3ICR(A5),D1            ;Port3 IE Test
        andi.l          #$00008000,D1
        cmp.l           #$00008000,D1
        bne             EndSR

Port3Int:move.w         P3PSR(A5),D1
        move.l          D1,D7
        andi.l          #$0000003F,D7
        cmp.l           #$0,D7
        beq             EndSR
        move.w          P3ICR(A5),D2
        andi.l          #$00000001,D2
        cmp.l           #$00000001,D2
        bne             EndPort3RxB1
        move.l          D1,D7                   ; B1RDF Test
        andi.l          #$00000001,D7
        cmp.l           #$00000001,D7
        beq             Port3ReadB1

EndPort3RxB1:
        move.w          P3ICR(A5),D2
        andi.l          #$00000008,D2
        cmp.l           #$00000008,D2
        bne             EndPort3TxB1
        move.l          D1,D7                   ; B1TDE Test
        andi.l          #$00000008,D7
        cmp.l           #$00000008,D7
        beq             Port3TransmitB1

EndPort3TxB1:
        move.w          P3ICR(A5),D2
        andi.l          #$00000002,D2
        cmp.l           #$00000002,D2
        bne             EndPort3RxB2
        move.l          D1,D7                   ; B2RDF Test
        andi.l          #$00000002,D7
        cmp.l           #$00000002,D7
        beq             Port3ReadB2

EndPort3RxB2:
        move.w          P3ICR(A5),D2
        andi.l          #$00000010,D2
        cmp.l           #$00000010,D2
        bne             Port3D
        move.l          D1,D7                   ; B2TDE test
        andi.l          #$00000010,D7
        cmp.l           #$00000010,D7
        beq             Port3TransmitB2

Port3D:  nop
        move.w          P3ICR(A5),D2
        andi.l          #$00000004,D2
        cmp.l           #$00000004,D2
        bne             EndPort3Rx
        move.l          D1,D7                   ; DRDF Test
```

```
        andi.l          #$00000004,D7
        cmp.l           #$00000004,D7
        beq             Port3RxD

EndPort3Rx:
        move.w          P3ICR(A5),D2
        andi.l          #$00000020,D2
        cmp.l           #$00000020,D2
        bne             EndSR
        move.l          D1,D7                   ; DTDE Test
        andi.l          #$00000020,D7
        cmp.l           #$00000020,D7
        beq             Port3TxD

EndSR:  rte

;*********************************************************
;                End of Interrupt Procedure              *
;*********************************************************
;                 Read Procedure  for each port          *
;*********************************************************

Port0ReadB1:
        move.l  P0B1RR(A5),D0; Read B1 on Port0
        jsr     Port0B1RDFReset; test if RDF is reset
        bra     EndSR    ; go to ISR end

Port0ReadB2:
        move.l  P0B2RR(A5),D0; Read B2 on Port0
        jsr     Port0B2RDFReset; test if RDF is reset
        bra     EndSR    ; go to ISR end

Port0RxD:
        move.b  P0DRR(A5),D6
        jsr     Port0DRDFReset
        bra     EndSR

Port1ReadB1:
        move.l  P1B1RR(A5),D0
        jsr     Port1B1RDFReset
        bra     EndSR

Port1ReadB2:
        move.l  P1B2RR(A5),D0
        jsr     Port1B2RDFReset
        bra     EndSR

Port1RxD:
        move.b  P1DRR(A5),D6
        jsr     Port1DRDFReset
        bra     EndSR

Port2ReadB1:
        move.l  P2B1RR(A5),D0
        jsr     Port2B1RDFReset
        bra     EndSR

Port2ReadB2:
        move.l  P2B2RR(A5),D0
        jsr     Port2B2RDFReset
        bra     EndSR

Port2RxD:
        move.b  P2DRR(A5),D6
        jsr     Port2DRDFReset
        bra     EndSR
```

```
Port3ReadB1:
        move.l   P3B1RR(A5),D0
        jsr      Port3B1RDFReset
        bra      EndSR

Port3ReadB2:
        move.l   P3B2RR(A5),D0
        jsr      Port3B2RDFReset
        bra      EndSR

Port3RxD:
        move.b   P3DRR(A5),D6
        jsr      Port3DRDFReset
        bra      EndSR

;*************************************************************
;              Transmit Procedure                            *
;*************************************************************

Port0TransmitB1:
        jsr              Port0B1TDESet            ; Make sure CPU can write
        move.l           D0,P0B1TR(A5)            ; move to the register
        jsr              Port0B1TDEReset          ; Make sure the bit is reset
        bra              EndSR                    ; go to ISR end

Port0TransmitB2:
        jsr              Port0B2TDESet            ; Make sure CPU can write
        move.l           D0,P0B2TR(A5)            ; move to the register
        jsr              Port0B2TDEReset          ; Make sure the bit is reset
        bra              EndSR                    ; go to ISR end

Port0TxD:jsr             Port0DTDESet
        move.b           D6,P0DTR(A5)
        jsr              Port0DTDEReset
        bra              EndSR

Port1TransmitB1:
        jsr              Port1B1TDESet
        move.l           D0,P1B1TR(A5)
        jsr              Port1B1TDEReset
        bra              EndSR

Port1TransmitB2:
        jsr              Port1B2TDESet
        move.l           D0,P1B2TR(A5)
        jsr              Port1B2TDEReset
        bra              EndSR

Port1TxD:jsr             Port1DTDESet
        move.b           D6,P1DTR(A5)
        jsr              Port1DTDEReset
        bra              EndSR

Port2TransmitB1:
        jsr              Port2B1TDESet
        move.l           D0,P2B1TR(A5)
        jsr              Port2B1TDEReset
        bra              EndSR

Port2TransmitB2:
        jsr              Port2B2TDESet
        move.l           D0,P2B2TR(A5)
        jsr              Port2B2TDEReset
        bra              EndSR
```

```
Port2TxD:jsr            Port2DTDESet
         move.b         D6,P2DTR(A5)
         jsr            Port2DTDEReset
         bra            EndSR

Port3TransmitB1:
         jsr            Port3B1TDESet
         move.l         D0,P3B1TR(A5)
         jsr            Port3B1TDEReset
         bra            EndSR

Port3TransmitB2:
         jsr            Port3B2TDESet
         move.l         D0,P3B2TR(A5)
         jsr            Port3B2TDEReset
         bra            EndSR

Port3TxD:jsr            Port3DTDESet
         move.b         D6,P3DTR(A5)
         jsr            Port3DTDEReset
         bra            EndSR

;*********************************************************
;            End of Transmit Bx                          *
;*********************************************************
;               Bx RDF reset                             *
;*********************************************************

Port0B1RDFReset:
         nop
         move.w         P0PSR(A5),D3            ; To make sure B1RDF is reset
         andi.l         #$00000001,D3
         cmp.l          #$00000000,D3
         bne            Port0B1RDFReset
         rts

Port0B2RDFReset:
         nop
         move.w         P0PSR(A5),D3            ; To make sure B2RDF is reset
         andi.l         #$00000002,D3
         cmp.l          #$00000000,D3
         bne            Port0B2RDFReset
         rts

Port0DRDFReset
:        nop
         move.w         P0PSR(A5),D3
         andi.l         #$00000004,D3
         cmp.l          #$00000000,D3
         bne            Port0DRDFReset
         rts

Port1B1RDFReset:
         nop
         move.w         PnPSR1(A5),D3
         andi.l         #$00000001,D3
         cmp.l          #$00000000,D3
         bne            Port1B1RDFReset
         rts

Port1B2RDFReset:
         nop
         move.w         PnPSR1(A5),D3
         andi.l         #$00000002,D3
```

```
        cmp.l           #$00000000,D3
        bne             Port1B2RDFReset
        rts

Port2B1RDFReset:
        nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000001,D3
        cmp.l           #$00000000,D3
        bne             Port2B1RDFReset
        rts

Port2B2RDFReset:
        nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000002,D3
        cmp.l           #$00000000,D3
        bne             Port2B2RDFReset
        rts

Port2DRDFReset:
        nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000004,D3
        cmp.l           #$00000000,D3
        bne             Port2DRDFReset
        rts

Port3B1RDFReset:
        nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000001,D3
        cmp.l           #$00000000,D3
        bne             Port3B1RDFReset
        rts

Port3B2RDFReset:
        nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000002,D3
        cmp.l           #$00000000,D3
        bne             Port3B2RDFReset
        rts

Port3DRDFReset:
        nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000004,D3
        cmp.l           #$00000000,D3
        bne             Port3DRDFReset
        rts
;*************************************************
;*          End of Bx RDF Procedures             *
;*************************************************
;*          Bx TDE Set                           *
;*************************************************
Port0B1TDESet:nop
        move.w          P0PSR(A5),D3            ; to make sure B1TDE is set
        andi.l          #$00000008,D3
        cmp.l           #$00000008,D3
        bne             Port0B1TDESet
        rts
Port0B2TDESet:nop
        move.w          P0PSR(A5),D3            ; to make sure B2TDE is set
        andi.l          #$00000010,D3
        cmp.l           #$00000010,D3
```

```
        bne             Port0B2TDESet
        rts
Port0DTDESet:nop
        move.w          P0PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000020,D3
        bne             Port0DTDESet
        rts
Port1B1TDESet:nop
        move.w          P1PSR(A5),D3
        andi.l          #$00000008,D3
        cmp.l           #$00000008,D3
        bne             Port1B1TDESet
        rts
Port1B2TDESet:nop
        move.w          P1PSR(A5),D3
        andi.l          #$00000010,D3
        cmp.l           #$00000010,D3
        bne             Port1B2TDESet
        rts
Port1DTDESet:nop
        move.w          P1PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000020,D3
        bne             Port1DTDESet
        rts
Port2B1TDESet:nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000008,D3
        cmp.l           #$00000008,D3
        bne             Port2B1TDESet
        rts
Port2B2TDESet:nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000010,D3
        cmp.l           #$00000010,D3
        bne             Port2B2TDESet
        rts
Port2DTDESet:nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000020,D3
        bne             Port2DTDESet
        rts
Port3B1TDESet:nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000008,D3
        cmp.l           #$00000008,D3
        bne             Port3B1TDESet
        rts
Port3B2TDESet:nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000010,D3
        cmp.l           #$00000010,D3
        bne             Port3B2TDESet
        rts
Port3DTDESet:nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000020,D3
        bne             Port3DTDESet
        rts
;*****************************************
;       End of Bx TDE Set procedures          *
```

```
;*****************************************
;*       Bx TDE Reset                    *
;*****************************************
Port0B1TDEReset:nop
        move.w          P0PSR(A5),D3            ; to make sure B1TDE is Reset
        andi.l          #$00000008,D3
        cmp.l           #$00000000,D3
        bne             Port0B1TDEReset
        rts

Port0B2TDEReset:nop
        move.w          P0PSR(A5),D3            ; to make sure B2TDE is Reset
        andi.l          #$00000010,D3
        cmp.l           #$00000000,D3
        bne             Port0B2TDEReset
        rts
Port0DTDEReset:nop
        move.w          P0PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000000,D3
        bne             Port0DTDEReset
        rts
Port1B1TDEReset:nop
        move.w          P1PSR(A5),D3
        andi.l          #$00000008,D3
        cmp.l           #$00000000,D3
        bne             Port1B1TDEReset
        rts
Port1B2TDEReset:nop
        move.w          P1PSR(A5),D3
        andi.l          #$00000010,D3
        cmp.l           #$00000000,D3
        bne             Port1B2TDEReset
        rts
Port1DTDEReset:nop
        move.w          P1PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000000,D3
        bne             Port1DTDEReset
        rts
Port2B1TDEReset:nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000008,D3
        cmp.l           #$00000000,D3
        bne             Port2B1TDEReset
        rts
Port2B2TDEReset:nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000010,D3
        cmp.l           #$00000000,D3
        bne             Port2B2TDEReset
        rts
Port2DTDEReset:nop
        move.w          P2PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000000,D3
        bne             Port2DTDEReset
        rts
Port3B1TDEReset:nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000008,D3
        cmp.l           #$00000000,D3
        bne             Port3B1TDEReset
        rts
```

```
Port3B2TDEReset:nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000010,D3
        cmp.l           #$00000000,D3
        bne             Port3B2TDEReset
        rts
Port3DTDEReset:nop
        move.w          P3PSR(A5),D3
        andi.l          #$00000020,D3
        cmp.l           #$00000000,D3
        bne             Port3DTDEReset
        rts
```

The following file describes all the aperiodic interrupts that only occur in GCI mode of operation. Given that the ports are supposed to work in conjunction with periodic process, this example below does not show IE tests. The file is as follows:

```
; PLIC Aperiodic Interrupt Subroutine
; Can handle up to 4 GCI Ports in a dynamic way
; As soon as the action has been taken, the program counter quits
; the interrupt. In case of many interrupts at the same time, the
; program counter will re-enter the Aperiodic Interrupt.
; All the comments will be written for the Port0. For the other Ports, the
; same comments apply.
; Use of register
; D1: PASR Value
; D2: No use
; D3: Monitor Channel Receive or Transmit register
; D4: Monitor Channel Receive or Transmit Buffer of D3
; D5: First Byte of the Received Monitor Channel Register
; D6: Second Byte of the Received Monitor Channel Register
; D7: Buffer of D1


i_PLIC_Aperiodic:
        move.w          PASR(A5),D1         ; Store PASR into D1
        move.w          D1,D7               ; Buffering D1 into D7
        andi.l          #$0000000F,D7       ; mask D7
        cmp.l           #$0,D7              ; compare with 0
        bne             AperPort0           ; go to AperPort0 otherwise
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$000000F0,D7       ; mask D7
        cmp.l           #$0,D7              ; compare with 0
        bne             AperPort1           ; go to AperPoprt1 otherwise
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000F00,D7       ; mask D7
        cmp.l           #$0,D7              ; compare with 0
        bne             AperPort2           ; go to AperPort2 otherwise
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$0000F000,D7       ; mask D7
        cmp.l           #$0,D7              ; compare with 0
        bne             AperPort3           ; go to AperPort3 otherwise
        bra             EndASR              ; exit w/o taking action

AperPort0:
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$0000008,D7        ; mask D7
        cmp.l           #$00000008,D7       ; compare with $8
        beq             Port0CommandIndRx   ; if equal, go to CI Receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000004,D7       ; mask D7
```

```
        cmp.l           #$00000004,D7       ; compare with $4
        beq             Port0CommandIndTx   ; if equal, go to CI Transmit
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000002,D7       ; mask D7
        cmp.l           #$00000002,D7       ; compare with $2
        beq             Port0MonitorChanRx  ; if equal, go to MC receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000001,D7       ; mask D7
        cmp.l           #$00000001,D7       ; compare with $1
        beq             Port0MonitorChanTx  ; if equal, go to MC Transmit

AperPort1:
        move.w          PASR(A5),D1
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000080,D7       ; mask D7
        cmp.l           #$00000080,D7       ; compare with $8
        beq             Port1CommandIndRx   ; if equal, go to CI Receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000040,D7       ; mask D7
        cmp.l           #$00000040,D7       ; compare with $4
        beq             Port1CommandIndTx   ; if equal, go to CI Transmit
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000020,D7       ; mask D7
        cmp.l           #$00000020,D7       ; compare with $2
        beq             Port1MonitorChanRx  ; if equal, go to MC receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000010,D7       ; mask D7
        cmp.l           #$00000010,D7       ; compare with $1
        beq             Port1MonitorChanTx  ; if equal, go to MC Transmit
AperPort2:
        move.w          PASR(A5),D1
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000800,D7       ; mask D7
        cmp.l           #$00000800,D7       ; compare with $8
        beq             Port2CommandIndRx   ; if equal, go to CI Receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000400,D7       ; mask D7
        cmp.l           #$00000400,D7       ; compare with $4
        beq             Port2CommandIndTx   ; if equal, go to CI Transmit
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000200,D7       ; mask D7
        cmp.l           #$00000200,D7       ; compare with $2
        beq             Port2MonitorChanRx  ; if equal, go to MC receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00000100,D7       ; mask D7
        cmp.l           #$00000100,D7       ; compare with $1
        beq             Port2MonitorChanTx  ; if equal, go to MC Transmit
AperPort3:
        move.w          PASR(A5),D1
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00008000,D7       ; mask D7
        cmp.l           #$00008000,D7       ; compare with $8
        beq             Port3CommandIndRx   ; if equal, go to CI Receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00004000,D7       ; mask D7
        cmp.l           #$00004000,D7       ; compare with $4
        beq             Port3CommandIndTx   ; if equal, go to CI Transmit
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00002000,D7       ; mask D7
        cmp.l           #$00002000,D7       ; compare with $2
        beq             Port3MonitorChanRx  ; if equal, go to MC receive
        move.w          D1,D7               ; Store PASR into D7
        andi.l          #$00001000,D7       ; mask D7
        cmp.l           #$00001000,D7       ; compare with $1
        beq             Port3MonitorChanTx  ; if equal, go to MC Transmit
```

```
EndASR   nop
         move.l          #$0,D1              ; clear all registers
         move.l          #$0,D2
         move.l          #$0,D3
         move.b          #$0,D4
         move.b          #$0,D5
         move.b          #$0,D6
         move.l          #$0,D7
         rte                                 ; End of ISR
;*************************************************************
;*           Port0 Subroutines                                *
;*************************************************************
;*          Monitor Channel Subroutine                       *
;*************************************************************
Port0MonitorChanTx:
         move.b          PGMTS(A5),D3        ; read PGMTS to clear the bit
         jsr             Port0GMTCheck       ; to make sure GMT=0
         bra             EndASR              ; ends the CI Tx
Port0MonitorChanRx:
         move.w          P0GMR(A5),D3        ; read GMR
         jsr             Port0GMRCheck       ; to make sure R=0
         move.w          D3,D4               ; Save D3 into D4
         andi.l          #$000000FF,D4
         cmp.l           #$00000035,D4       ; to access to NR5 (MC145574)
         beq             FirstByte           ; if equal go to FirstByte
         move.w          D3,D4               ; otherwise continue
         andi.l          #$000000FF,D4
         cmp.l           #$000000CF,D4       ; $CF is NR5 Value of MC145574
         beq             SecondByte          ; if equal go to SecondByte
         bra             EndASR              ; ends the ISR
FirstByte:
         move.w          D3,D5               ; move D3 into D5 to check
         bra             EndASR
SecondByte:
         move.w          D3,D6               ; move D3 into D6 to check
         bra             EndASR
;*************************************************************
;*                  Command Indicate Subroutine              *
;*************************************************************

Port0CommandIndTx:
         move.l          PGCITSR(A5),D3      ; clear the bit
         jsr             Port0Rcheck         ; to make sure R=0
         bra             EndASR
Port0CommandIndRx:
         move.l          #0,D3
         move.b          P0GCIR(A5),D3       ; Move GCR0 into D3
         andi.l          #$000000FF,D3
         cmp.l           #$00000010,D3       ; Deactivation Request
         beq             Port0DeacReq
         cmp.l           #$00000018,D3       ; Activation Indication Value
         beq             Port0ActInd
         cmp.l           #$0000001C,D3       ; Activation Confirmed
         beq             EndASR              ; nothing to do
         cmp.l           #$0000001F,D3       ; Deactivation Indication
         beq             Port0DeacInd
         bra             EndASR
Port0DeacReq:
         move.b          #$1F,D0             ; Send Deactivation Indication
         move.b          D0,P0GCIT(A5)       ; in response of dea Request
         jsr             Port0Rcheck         ; to make sure R=0
         bra             EndASR
Port0DeacConf:
         nop                                 ; nothing else to do
```

```
        bra             EndASR
Port0ActInd:
        move.b          #$1C,D0             ; Send Activation Indication
        move.b          d0,P0GCIT(A5)
        jsr             Port0RCheck
        bra             EndASR
Port0DeacInd:
        move.b          #$1F,D0             ; Send Deactivation Indication
        move.b          D0,P0GCIT(A5)
        jsr             Port0RCheck
        bra             EndASR
;*****************************************************************
;*              Checking Procedure                               *
;*****************************************************************

Port0GMTCheck:
        move.w          PASR(A5),D3         ; to make sure GMT=0
        andi.l          #$00000001,D3
        cmp.l           #$0,D3
        bne             Port0GMTCheck
        rts
Port0GMRCheck:
        move.w          PASR(A5),D4         ; to make sure GMR=0
        andi.l          #$00000002,D4
        cmp.l           #$0,D4
        bne             Port0GMRCheck
        rts
Port0LCheck:
        move.w          P0GMT(A5),D3        ; to make sure L=0
        andi.l          #$00000200,D3
        cmp.l           #$0,D3
        bne             Port0RTxCheck
        rts
Port0RTxCheck:
        move.w          P0GMT(A5),D3        ; to make sure R=0
        andi.l          #$00000100,D3
        cmp.l           #$0,D3
        bne             Port0RTxCheck
        rts
Port0RCheck:
        move.b          P0GCIT(A5),D3       ; to make sure R=0
        andi.l          #$00000010,D3
        cmp.l           #$0,D3
        bne             Port0RCheck
        rts
;*************************************************************
;*          Port1 Subroutines                                *
;*************************************************************
Port1MonitorChanTx:
        move.b          PGMTS(A5),D3
        jsr             Port1GMTCheck       ;to make sure GMT=0
        bra             EndASR
Port1MonitorChanRx:
        move.w          P1GMR(A5),D3
        jsr             Port1GMRCheck       ; to make sure GMR=0
        move.w          D3,D4
        andi.l          #$000000FF,D4
        cmp.l           #$00000035,D4
        beq             FirstByte1
        move.w          D3,D4
        andi.l          #$000000FF,D4
        cmp.l           #$000000CF,D4
        beq             SecondByte1
        bra             EndASR
```

```
FirstByte1:
        move.w          D3,D5
        bra             EndASR
SecondByte1:
        move.w          D3,D6
        bra             EndASR
Port1CommandIndTx:
        move.b          PGCITSR(A5),D3
        jsr             Port1RCheck
        bra             EndASR
;*****************************************************************
;*            Command Indicate Subroutine                        *
;*****************************************************************
Port1CommandIndRx:
        move.l          #0,D3
        move.b          P1GCIR(A5),D3
        andi.l          #$000000FF,D3
        cmp.l           #$00000010,D3
        beq             Port1DeacReq
        cmp.l           #$00000018,D3
        beq             Port1ActInd
        cmp.l           #$0000001C,D3
        beq             EndASR
        cmp.l           #$0000001F,D3
        beq             Port1DeacInd
        bra             EndASR
Port1DeacReq:
        move.b          #$1F,D0
        move.b          D0,P1GCIT(A5)
        jsr             Port1RCheck
        bra             EndASR
Port1DeacConf:
        nop
        bra             EndASR
Port1ActInd:
        move.b          #$1C,D0
        move.b          d0,P1GCIT(A5)
        jsr             Port1RCheck
        bra             EndASR
Port1DeacInd:
        move.b          #$1F,D0
        move.b          D0,P1GCIT(A5)
        jsr             Port1RCheck
        bra             EndASR
;*************************************************************
;*                  Checking Procedures                      *
;*************************************************************

Port1GMTCheck:
        move.w          PASR(A5),D4         ; to make sure GMT=0
        andi.l          #$00000010,D4
        cmp.l           #$0,D4
        bne             Port1GMTCheck
        rts
Port1GMRCheck:
        move.w          PASR(A5),D4         ; to make sure GMR=0
        andi.l          #$00000020,D4
        cmp.l           #$0,D4
        bne             Port1GMRCheck
        rts
Port1LCheck:
        move.w          P1GMT(A5),D4        ; to make sure L=0
        andi.l          #$00000200,D4
        cmp.l           #$0,D4
```

```
        bne             Port1LCheck
        rts
Port1RTxCheck:
        move.w          P1GMT(A5),D4        ; to make sure R=0
        andi.l          #$00000100,D4
        cmp.l           #$0,D4
        bne             Port1RTxCheck
        rts
Port1RCheck:
        move.b          P1GCIT(A5),D4       ; to make sure R=0
        andi.l          #$00000010,D4
        cmp.l           #$0,D4
        bne             Port1RCheck
        rts
;*************************************************************
;*          Port2 Subroutines                                *
;*************************************************************
;            Monitor Channel Subroutines                     *
;*************************************************************

Port2MonitorChanTx:
        move.b          PGMTS(A5),D3
        jsr             Port2GMTCheck       ; to make sure GMT=0
        bra             EndASR
Port2MonitorChanRx:
        move.w          P2GMR(A5),D3
        jsr             Port2GMRCheck       ; to make sure GMR=0
        move.w          D3,D4
        andi.l          #$000000FF,D4
        cmp.l           #$00000035,D4
        beq             FirstByte2
        move.w          D3,D4
        andi.l          #$000000FF,D4
        cmp.l           #$000000CF,D4
        beq             SecondByte2
        bra             EndASR
FirstByte2:
        move.w          D3,D5
        bra             EndASR
SecondByte2:
        move.w          D3,D6
        bra             EndASR
;*****************************************************************
;*            Command Indicate Subroutine                        *
;*****************************************************************

Port2CommandIndTx:
        move.b          PGCITSR(A5),D3
        jsr             Port2RCheck
        bra             EndASR

Port2CommandIndRx:
        move.l          #0,D3
        move.b          P2GCIR(A5),D3
        andi.l          #$000000FF,D3
        cmp.l           #$00000010,D3
        beq             Port2DeacReq
        cmp.l           #$00000018,D3
        beq             Port2ActInd
        cmp.l           #$0000001C,D3
        beq             EndASR
        cmp.l           #$0000001F,D3
        beq             Port2DeacInd
        bra             EndASR
```

```
Port2DeacReq:
        move.b          #$1F,D0
        move.b          D0,P2GCIT(A5)
        jsr             Port2RCheck
        bra             EndASR
Port2DeacConf:
        bra             EndASR
Port2ActInd:
        move.b          #$1C,D0
        move.b          d0,P2GCIT(A5)
        jsr             Port2RCheck
        bra             EndASR
Port2DeacInd:
        move.b          #$1F,D0
        move.b          D0,P2GCIT(A5)
        jsr             Port2RCheck
        bra             EndASR
;*********************************************************************
;*             Checking Subroutines                                  *
;*********************************************************************

Port2GMTCheck:
        move.w          PASR(A5),D4         ; to make sure GMT=0
        andi.l          #$00000100,D4
        cmp.l           #$0,D4
        bne             Port2GMTCheck
        rts
Port2GMRCheck:
        move.w          PASR(A5),D4         ; to make sure GMR=0
        andi.l          #$00000200,D4
        cmp.l           #$0,D4
        bne             Port2GMRCheck
        rts
Port2LCheck:
        move.w          P2GMT(A5),D4        ; to make sure L=0
        andi.l          #$00000200,D4
        cmp.l           #$0,D4
        bne             Port2LCheck
        rts
Port2RTxCheck:
        move.w          P2GMT(A5),D4        ; to make sure R=0
        andi.l          #$00000100,D4
        cmp.l           #$0,D4
        bne             Port2RTxCheck
        rts
Port2RCheck:
        move.b          P2GCIT(A5),D4       ; to make sure R=0
        andi.l          #$00000010,D4
        cmp.l           #$0,D4
        bne             Port2RCheck
        rts
;*********************************************************
;*          Port3 Subroutines                            *
;*********************************************************
;*          Monitor Channel Subroutines                  *
;*********************************************************
Port3MonitorChanTx:
        move.b          PGMTS(A5),D3
        jsr             Port3GMTCheck       ; to make sure GMT=0
        bra             EndASR
Port3MonitorChanRx:
        move.w          P3GMR(A5),D3
        jsr             Port3GMRCheck       ; to make sure GMR=0
        move.w          D3,D4
```

```
        andi.l          #$000000FF,D4
        cmp.l           #$00000035,D4
        beq             FirstByte3
        move.w          D3,D4
        andi.l          #$000000FF,D4
        cmp.l           #$000000CF,D4
        beq             SecondByte3
        bra             EndASR
FirstByte3:
        move.w          D3,D5
        bra             EndASR
SecondByte3:
        move.w          D3,D6
        bra             EndASR
;*************************************************************
;*          Command Indicate Subroutine                      *
;*************************************************************

Port3CommandIndTx:
        move.b          PGCITSR(A5),D3
        jsr             Port3RCheck
        bra             EndASR

Port3CommandIndRx:
        move.l          #0,D3
        move.b          P3GCIR(A5),D3
        andi.l          #$000000FF,D3
        cmp.l           #$00000010,D3
        beq             Port3DeacReq
        cmp.l           #$00000018,D3
        beq             Port3ActInd
        cmp.l           #$0000001C,D3
        beq             EndASR
        cmp.l           #$0000001F,D3
        beq             Port3DeacInd
        bra             EndASR
Port3DeacReq:
        move.b          #$1F,D0
        move.b          D0,P3GCIT(A5)
        jsr             Port3RCheck
        bra             EndASR
Port3DeacConf:
        nop
        bra             EndASR
Port3ActInd:
        move.b          #$1C,D0
        move.b          d0,P3GCIT(A5)
        jsr             Port3RCheck
        bra             EndASR
Port3DeacInd:
        move.b          #$1F,D0
        move.b          D0,P3GCIT(A5)
        jsr             Port3RCheck
        bra             EndASR
;*************************************************************
;*          Checking Subroutines                             *
;*************************************************************

Port3GMTCheck:
        move.w          PASR(A5),D4         ; to make sure GMT=0
        andi.l          #$00001000,D4
        cmp.l           #$0,D4
        bne             Port3GMTCheck
        rts
```

```
Port3GMRCheck:
        move.w          PASR(A5),D4         ; to make sure GMR=0
        andi.l          #$00002000,D4
        cmp.l           #$0,D4
        bne             Port3GMRCheck
        rts
Port3LCheck:
        move.w          P3GMT(A5),D4        ; to make sure L=0
        andi.l          #$00000200,D4
        cmp.l           #$0,D4
        bne             Port3LCheck
        rts
Port3RTxCheck:
        move.w          P3GMT(A5),D4        ; to make sure R=0
        andi.l          #$00000100,D4
        cmp.l           #$0,D4
        bne             Port3RTxCheck
        rts
Port3RCheck:
        move.b          P3GCIT(A5),D4       ; to make sure R=0
        andi.l          #$00000010,D4
        cmp.l           #$0,D4
        bne             Port3RCheck
        rts
```

The following file is called CoreInit.s. It is the core of the program with the program counter starting at the address defined by the user. Obviously, this program will require modifications depending on the evaluation the user wants to perform. This example shows a very generic flow. Users are welcome to make further modifications, which should not affect the core of the program itself.

```
Code_Start:
        nop
        move.l          #$40000000,A3    ; address allocation
        move.l          #$10000000,A6
        move.l          #$10000000,A5
        move.l          #$20001000,A7
        jsr             IntInit          ; Interrupt Initialization
        jsr             RegisterInit     ; Register Initialization
        jsr             GCIInit          ; if used, GCI mode on
        jsr             GCIIntEnable     ; GCI Interrupt on
        jsr             WaitLoop         ; loop to configure in GCI
        jsr             CI2F             ;
        jsr             MonitorAbort     ; Monitor initialization
        jsr             CICommand        ; to Initialization CI
        jsr             ST1BchannelEn    ; to Send Value to MC
        jsr             ReadPort0MC
        rts
```

The file shown below is the initialization file configuring some registers in order to perform the right tests. Before performing any tests, the user definitely needs to know the PLIC registers set to make sure the PLIC configuration will match the test requirements. The following example tests Port1 in GCI Slave Mode. Some monitor channel information is sent and the 2kHz rate works. The other ports are off.

```
;*********************************************************************
;* Different Subroutine used for init and checking GCI/IDL  *
;*********************************************************************
GCIInit:
```

```
        move.w          #$0003,d0       ; port0 off, GCI, B1,B2 on
        move.w          d0,PLCR0(A5)    ;
        move.w          #$A203,D0       ;port1 on,S, FSM, GCI,B1,B2 on
        move.w          D0,PLCR1(A5)    ;
        move.w          #$0003,D0       ; port3 off,Slave,GCI, B1,B2 on
        move.w          D0,PLCR3(A5)    ;
        move.w          #$0003,D0       ; port2 off,Slave,GCI, B1,B2 on
        move.w          D0,PLCR2(A5)    ;
        move.b          PGMTS(A5),D0
        move.b          PGCITSR(A5),D0
        move.b          P0GCIR(A5),D0
        move.w          #$0000,D0       ; NPM disabled
        move.w          D0,PCSR(A5)     ; DCL=512kHz, MULT=64, MUX=FSC
        move.w          #$0000,D0
        move.w          D0,P0SDR(A5)
        move.w          #$0000,D0
        move.w          D0,P1SDR(A5)    ; $1E delay,Max delay at 512kHz
        move.w          #$0000,D0       ; $40
        move.w          D0,P2SDR(A5)    ; Total delay=$20 but not used
        move.w          #$0000,D0
        move.w          D0,P3SDR(A5)    ; Total delay=$20 but not used
        move.w          #$0000,D0       ; D channel off
        move.w          D0,PDRQR(A5)
        rts

GCIIntEnable:
        move.w          #$0F000,D0      ; IE=0, GCI Interrupt Off
        move.w          D0,P0ICR(A5)    ; B1,B2, D Interrupt Off
        move.w          #$001B,D0       ; Interrupt off on Port2
        move.w          D0,P2ICR(A5)
        move.w          #$0000,D0       ; Interrupt off on Port3
        move.w          D0,P3ICR(A5)
        move.w          #$8F1B,D0       ; IE=1, GCI Interrupts On,
        move.w          D0,P1ICR(A5)    ; B1,B2 Interrupts On
        rts


MonitorAbort:
        move.b          #$20,D2
        move.b          D2,PGMTA(A5)    ; Abort previous Port1 GCI MC
        rts

CI2F:   move.b          #$1F,D0         ; Port1 Deactivation Request
        move.b          D0,P1GCIT(A5)
        rts

ST1BChannelEn:
                                        ; Send Monitor Channel
        lea.l           B1B2En,A2
Loop0:  nop
        move.w          (A2)+,D0
        jsr             RTxCheck1
        move.w          D0,P1GMT(A5)
        and.l           #$000000AA,D0
        cmp.l           #$000000AA,D0
        beq             EndLoop2
        bra             Loop0
EndLoop2:
        nop
        rts

RTxCheck1:
        move.w          P1GMT(A5),D2
        andi.l          #$00000100,D2
```

```
        cmp.l           #$0,D2
        bne             RTxCheck1
        rts

CICommand:nop
        lea.l           CICom,A2
        jsr             RCheck
LoopCI: move.b          (A2)+,D0
        andi.l          #$000000FF,D0
        jsr             RCheck
        move.b          D0,P1GCIT(A5)
        cmp.l           #$1C,D0
        bne             LoopCI
        rts

CheckACK:nop
        move.b          PGCITSR(A5),D1
        andi.l          #$02,D1
        cmp.l           #$02,D1
        bne             CheckACK
        rts

RCheck: nop
        move.b          P1GCIT(A5),D2
        andi.l          #$00000010,D2
        cmp.l           #$00000010,D2
        beq             RCheck
        rts

WaitLoop:
        nop
        Move.l          #$FFF,D0
LoopGCI: sub.l          #1,D0
        cmp.l           #0,D0
        bne             LoopGCI
        rts
```

The following file is used to configure the ColdFire® CPU core. Before using this file, the user must check to make sure the configuration matches his requirements. The file is as follows:

```
RegisterInit:; to initialize the registers
        clr.l           D0
        clr.l           D1
        clr.l           D2
        clr.l           D3
        clr.l           D4
        clr.l           D5
        clr.l           D6
        clr.l           D7
        rts
IntInit:
        move.l          #VBR_Init,D0            ; to set the vector base reg.
        movec           D0,VBR
        move.w          #$2400,D0               ; to set the status register
        move.w          D0,SR
        move.b          #$40,D0                 ; to point the interrupts
        move.b          D0,PIVR(A6)
        move.l          #$88888888,D0           ; Disable all type of ISR
        move.l          D0,ICR1(A6)
        move.l          D0,ICR3(A6)
        move.l          D0,ICR4(A6)             ; reset all types of interrupt
        move.l          #$88EF8888,D0           ; PLIC APer Interrupt on, level 7
        move.l          D0,ICR2(A6)             ; PLIC Per Interrupt on level 6
```

```
        move.l          #$0,D0                  ; this case.
        move.l          D0,PIWR(A6)             ; No wake up process yet
        move.l          #i_PLIC_Periodic,D0     ; Point to the address vector
        move.l          D0,i_plic_per_vec
        move.l          #i_PLIC_Aperiodic,D0    ; Point to the address vector
        move.l          D0,i_plic_aper_vec
        rts
```

The final file represents the table allocation of configuration data that can be sent to the peripheral to control various funcions:

```
B1B2En:
        DC.W            $0125               ; MC145574 NR5 access
        DC.W            $01C0               ; Enabling the B1/B2 Channels
        DC.W            $03AA               ; End of sending (should see $FF)
        DC.W            $0126               ; MC145574 NR5 access
        DC.W            $0180               ; Enabling Loopabck
        DC.W            $03FF               ; End of sending
        DC.W            $0105               ; Access to BR5
        DC.W            $01EE               ; Send $EE
        DC.W            $03FF               ; End of sending

B1B2Read:
        DC.W            $0135               ; Read NR5
        DC.W            $03FF               ; End of Process
B1Send:
        DC.L            $00112233           ; Value written to TBx
        DC.L            $A00A5FF5           ; Value written to TBx
        DC.L            $F708D728           ; Value written to TBx
        DC.L            $FFFFFFFF           ; Value written to TBx
CICom:  DC.B            $18                 ; Command Indicate Activation Request
        DC.B            $1C                 ; Command Indicate Activation Confirmed
TxData:
        DC.B            $95
        DC.B            $A5
        DC.B            $AA
;       DC.W            $03FF               ; End of sending

B1B2Read:
        DC.W            $0135               ; Read NR5
        DC.W            $03FF               ; End of Process
B1Send:
        DC.L            $00112233           ; Value written to TBx
        DC.L            $A00A5FF5           ; Value written to TBx
        DC.L            $F708D728           ; Value written to TBx
        DC.L            $FFFFFFFF           ; Value written to TBx
CICom:
        DC.B            $18                 ; Command Indicate Activation Request
        DC.B            $1C                 ; Command Indicate Activation Confirmed
TxData:
        DC.B            $95
        DC.B            $A5
        DC.B            $AA
```

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