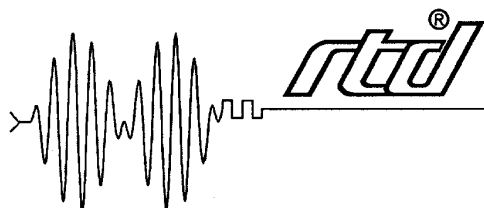


ECAN527DHR Isolated 1 Mb/s CAN interface board User's Manual

Hardware Release 1.2 – 1.3



Real Time Devices, Inc.

"Accessing the Analog World"®

ECAN527DHR ISOLATED 1 MB/S CAN INTERFACE BOARD USER'S MANUAL

Declaration of conformity of the ECAN527DHR to the following Directives:

EU EMC directive 89/336/EEC

EU Low Voltage directive 73/23/EEC

using the relevant section of the following EU standards and other normative documents:

EN50081-2: 1995 Emissions, generic requirements

-EN55022 Measurement of radio interference characteristics of information technology equipment

EN50082-2: 1995 Immunity, generic requirements

-EN61000-4-3 Radio-frequency electromagnetic field, AM modulated

-EN61000-4-6 Radio-frequency common mode, AM modulated

-EN61000-4-2 Electrostatic discharge

-EN61000-4-4 Fast transients

Relevant documents are available upon request from RTD.

Tomi Hänninen
Managing Director
RTD Finland Oy

REAL TIME DEVICES FINLAND OY
LEPOLANTIE 14
FIN-00660 HELSINKI
FINLAND

Phone: (+358) 9 346 4538
FAX: (+358) 9 346 4539

E-Mail
sales@rtdfinland.fi

Website
www.rtdfinland.fi

Revision History

20/05/1998	Release 2.0
21/09/1998	Hardware release 1.1 changes: - No interrupt sharing - EEPROM pullup resistors - CE information
02/02/1999	Updated CE information Corrected diagram of interrupt jumpers
03/01/2001	Small changes in driver section
11/07/2001	Name of company changed, formatted pages

Notice: We have attempted to verify all information in this manual as of the publication date. Information in this manual may change without prior notice from RTD Finland Oy.

Published by
Real Time Devices Finland Oy
Lepolantie 14
FIN-00660 Helsinki
Finland

Copyright 1997-2001 Real Time Devices Finland Oy
All rights reserved
Printed in Finland

PC/XT, PC/AT are registered trademarks of IBM Corporation.
PC/104 is a registered trademark of PC/104 Consortium.
The Real Time Devices Logo is a registered trademark of Real Time Devices.
utilityModule is a trademark of Real Time Devices.
All other trademarks appearing in this document are the property of their respective owners.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS AND TABLES	6
CHAPTER 1 - INTRODUCTION.....	7
Features	7
CAN bus controller.....	7
Physical interface	7
Mechanical description	7
Connector description	8
What comes with your board	8
Board accessories	8
- Application software and drivers	
- Hardware accessories	
Using this manual	8
When you need help.....	8
CHAPTER 2 - BOARD SETTINGS	9
Factory-Configured Jumper Settings.....	10
Base Address Jumpers	11
Interrupt channels.....	13
CHAPTER 3 - BOARD INSTALLATION	14
Board installation	14
External I/O connections.....	16
- General purpose digital I/O connector	
- Galvanically isolated CAN bus connectors	
- Galvanically isolated CAN bus Termination Jumpers	
CHAPTER 4 - HARDWARE DESCRIPTION.....	18
82527 CAN bus controller.....	19
Galvanic Isolation of the CAN bus	19
Configuration EEPROM.....	20
Digital I/O	20

CHAPTER 5 - BOARD OPERATION AND PROGRAMMING	21
Defining the memory map	21
- 82527 Data sheet reprint from Intel	
Interrupts	22
What is an interrupt?	22
Interrupt request lines	22
8259 Programmable interrupt controller	22
Interrupt mask register (IMR)	22
End-Of-Interrupt (EOI) Command.....	23
What exactly happens when an interrupt occurs?	23
Using interrupts in your program	23
Writing an interrupt service routine (ISR)	23
Saving the startup IMR and interrupt vector	25
Common Interrupt mistakes.....	26
 CHAPTER 6 - ECAN527DHR SPECIFICATIONS.....	27
 CHAPTER 7 - RETURN POLICY & WARRANTY	28

LIST OF ILLUSTRATIONS AND TABLES

ILLUSTRATIONS

- Fig. 2-1: Board layout showing jumper locations
- Fig. 2-2: Base address jumpers
- Fig. 2-3: Interrupt jumpers
- Fig. 3-1: ECAN527DHR integrated with a PC/104 cpuModule stack
- Fig. 3-2: 19" Eurocard rack installation with an integrated PC/104 data Module and EUROCARD cpuModule computer system
- Fig. 4-1: ECAN527DHR Block diagram

TABLES

- Table 2-1: Factory configured jumper settings
- Table 2-2: Base Address Jumper settings
- Table 3-1a: Digital I/O Connector J28 of ECAN527DHR
- Table 3-1b: Digital I/O Connector J49 of ECAN527DHR
- Table 3-2: Physical Interface connector J35/J45 pin outs of ECAN527DHR
- Table 4-1a: Digital I/O configuration of port P2 of the 82527 chip 1
- Table 4-1b: Digital I/O configuration of port P2 of the 82527 chip 2

Chapter 1 INTRODUCTION

This user's manual describes the operation of the ECAN527DHR CAN-bus Interface board.

Features

Some of the key features of the ECAN527DHR include:

- Two independent CAN-network controllers
- 1 Mb/s maximum data rate (fully programmable)
- Full CAN-functionality 2.0 B
- 2 Independent Intel 82527 CAN-bus controllers
- 256 bytes of configuration EEPROM
- Galvanically isolated physical interfaces
- 14 user accessible bit programmable bi-directional digital I/O
- 4 status LED's (2 for each channel)
- +5V only operation
- PC/104 compliant

The following paragraphs briefly describe the major features of the ECAN527DHR. A more detailed discussion is included in chapter 4 (Hardware description) and in Chapter 5 (Board operation and programming). The board setup is described in Chapter 2 (Board Settings). A full description of the Intel 82527 CAN-controllers is included in Chapter 5 (Board operation and programming).

CAN-bus controller

The ECAN527DHR CAN-bus interface is implemented using the Intel 82527 chips. This controller supports CAN Specification 2.0. This versatile chip supports standard and extended Data and Remote frames; a Programmable Global Message Identifier Mask; 15 message objects of 8-byte Data Length and a Programmable Bit Rate. This fully integrated chip supports all the functionality of the CAN-bus protocol.

Physical Interface

Industrial environments require galvanic isolation and bus filtering to provide reliable data communication and safety. The *galvanically isolated physical interface* is implemented using high-speed optocouplers and a DC/DC converter. To protect the input from radiated bus noise a specially balanced bus filter is used. The bus connectors conform to the ISO11898/2 specification. (For more information on CAN bus please visit the CAN in Automation Website at: <http://www.can-cia.de>.)

Mechanical description

The ECAN527DHR is designed on a PC/104 form factor. An easy mechanical interface to both PC/104 and EUROCARD systems can be achieved. Stack your ECAN527DHR directly on a PC/104 compatible computer using the onboard mounting holes.

Connector description

There are two 10-pin interface header connectors on the ECAN527DHR to directly interface to the galvanically isolated CAN-networks. The general-purpose digital outputs and inputs are connected to the ECAN527DHR by using a 20-pin header connector.

What comes with your board

Your ECAN527DHR package contains the following items:

- ECAN527DHR CAN-bus interface module
- User's manual

Note: Software and driver can be downloaded from our website

If any item is missing or damaged, please call Real Time Devices Finland customer service department at the following number: (+358) 9 346 4538.

Board accessories

In addition to the items included in your ECAN527DHR delivery, several software and hardware accessories are available. Contact your distributor for more information and for advice on selecting the most appropriate accessories to support your instrumentation system.

- **Application software and drivers for QNX including CANOpen protocol drivers**
- **Hardware accessories including IDAN solid aluminum mounting frames for PC/104 Computers**

For more information on IDAN, please visit our website at the following address: www.rtdfinland.fi or www.rtdusa.com.

Using this manual

This manual is intended to help you install your new ECAN527DHR card and get it working quickly, whilst also providing enough detail about the board and its functions so that you can obtain maximum use of its features even in the most demanding applications. The scope of this manual does not cover CAN-bus network programming and system design.

When you need help

This manual and all the example programs will provide you with enough information to fully utilize all the features on this board. If you have any problems with installation or use of the board, contact our Technical Support Department (+358) 9 346 4538 during European business hours. Alternatively, send a FAX to (+358) 9 346 4539, or Email to: sales@rtdfinland.fi. When sending a FAX or Email request, please include the following information: Your company's name and address, your name, your telephone number, and a brief description of the problem.

Chapter 2 **BOARD SETTINGS**

The ECAN527DHR CAN bus interface board has jumper settings which can be changed to suit your application and host computer memory configuration. The factory settings are listed and shown in the diagram at the beginning of this chapter.

Factory-Configured Jumper Settings

Table 2-1 below illustrates the factory jumper setting for the ECAN527DHR. Figure 2-1 shows the board layout of the ECAN527DHR and the locations of the jumpers. The following paragraphs explain how to change the factory jumper settings to suit your specific application.

Table 2-1: Factory configured jumper settings (Please refer to figure 2-1 below for detailed locations)

JUMPER NAME	DESCRIPTION	NUMBER OF JUMPERS	FACTORY SETTING
ADDR	Base Addresses	10	D0000
IRQ'S	Host interrupts	10 + 10	5/11
J34/J52	Can-bus termination	1+1	Closed

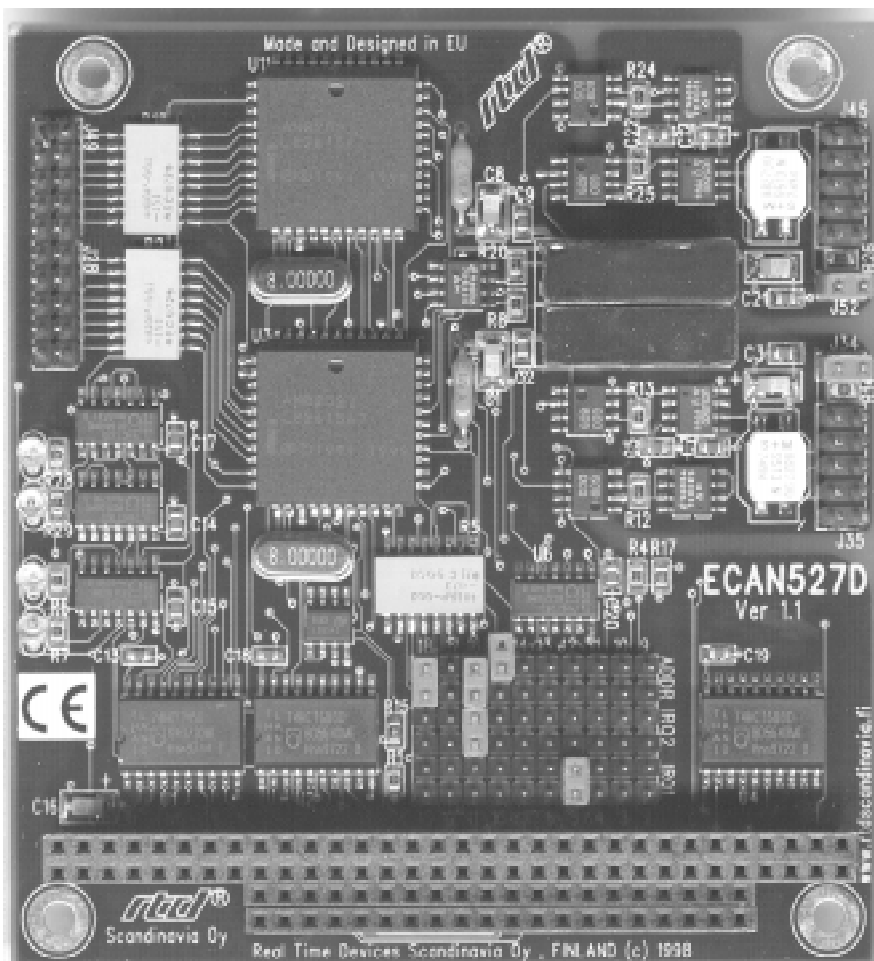


Figure 2-1: ECAN527DHR Board layout showing jumper locations

Base address Jumpers (Factory setting: D0000h)

The ECAN527DHR is memory mapped into the low memory of your host XT/AT. The board occupies a consecutive memory window of 512 bytes starting from the base address.

The most common cause of failure when you are first setting up your module is address contention: Some of your computer's I/O space is already occupied by other devices and memory resident programs. When the ECAN527DHR attempts to use its own reserved memory addresses (which are being already used by another peripheral device) erratic performance may occur and the data read from the board may be corrupted.

To avoid this problem make sure you set up the base address by using the ten jumpers marked "ADDR". This allows you to choose from a number of different addresses in your host computer's memory map. Should the factory installed setting of D0000h be incompatible to your system configuration, you may change this setting to another using the options illustrated in Table 2-2 (overleaf). The table shows the jumper settings and their corresponding values in hexadecimal form. Ensure that you verify the correct location of the base address jumpers. When the jumper is removed it corresponds to a logical "0", connecting the jumper to a "1". When you set the base address of the module, record the setting inside the back cover of this manual

Note: If you are using a memory manager such as QEMM, make sure that you exclude the memory section occupied by the ECAN527DHR. For example, this may be X= D0000-D00FF

BASE ADDRESS JUMPER SETTINGS ECAN527DHR

Base address Hex	Jumper Settings 18 17 16 15
80XXX	0 0 0 0
88XXX	0 0 0 1
90XXX	0 0 1 0
98XXX	0 0 1 1
A0XXX	0 1 0 0
A8XXX	0 1 0 1
B0XXX	0 1 1 0
B8XXX	0 1 1 1
C0XXX	1 0 0 0
C8XXX	1 0 0 1
D0XXX	1 0 1 0
D8XXX	1 0 1 1
E0XXX	1 1 0 0
E8XXX	1 1 0 1
F0XXX	1 1 1 0
F8XXX	1 1 1 1

0 = JUMPER OFF

1 = JUMPER CLOSED

Table 2-2: Base Address Jumper settings ECAN527DHR

Note: The above table only illustrates the settings for the high address bits A18-A15. If you for instance want to configure address D8E00 - D8EFF for your ECAN527DHR you must set the jumpers as: 1 0 1 _ 1 0 0 0 _ 1 1 1 0! Address line A19 is always decoded as "1".

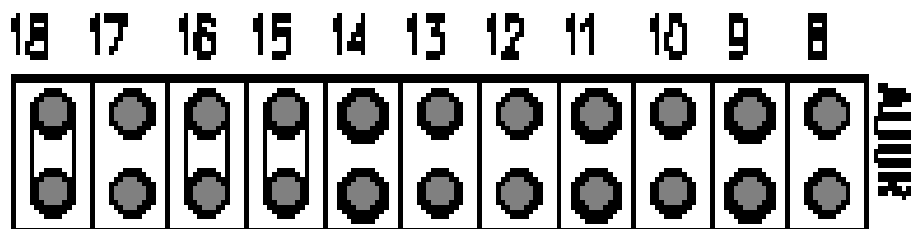


Fig. 2-2: Base address jumpers illustrating address D8000

Interrupt Channels (Factory setting: IRQ5 / IRQ11)

The header connector, shown in Figure 2-3 below, lets you connect the onboard 82527 CAN controllers interrupt outputs to one of the interrupt channels available on the host XT/AT bus. If your board has no AT extension interrupts then IRQ 10-15 are not available. Both CAN-controllers must use different interrupts and therefore two headers are available. IRQ1 marks the Channel 1 interrupt and IRQ2 marks the interrupt for Channel 2.

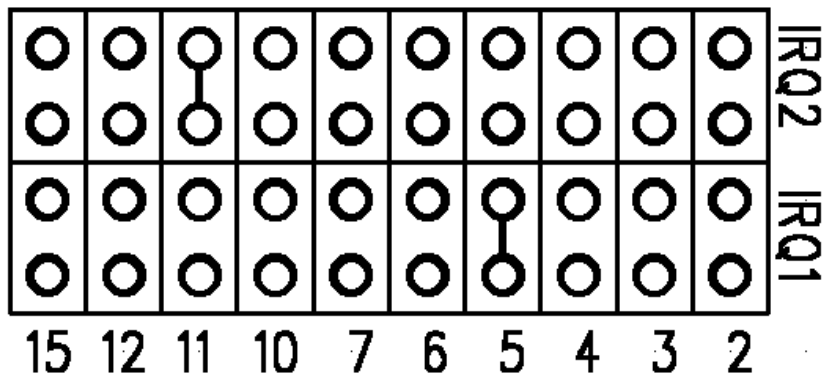


Fig. 2-3: Interrupt jumpers

Note: The ECAN527C Hardware release 1.1 onward does not support interrupt sharing! This feature is sometimes regarded as a part of the PC/104 special features. After extensive software and hardware tests we have found that errorfree interrupt performance can not be guaranteed when sharing interrupts.

Chapter 3 BOARD INSTALLATION

The ECAN527DHR CAN-bus interface board is very easy to connect to your industrial distributed control system. Direct interface to PC/104 systems as well as EUROCARD boards is possible. This chapter gives step by step instructions on how to install the ECAN527DHR into your system.

After completing the installation it is recommended that you use the diagnostic and test software to fully verify that your board is working.

Board Installation

Keep your board in the antistatic bag until you are ready to install it to your system! When removing it from the bag, hold the board at the edges and do not touch the components or connectors. Please handle the board in an antistatic environment and use a **grounded** workbench for testing and handling of your hardware. Before installing the board in your computer, check the jumper settings. Chapter 2 reviews the factory settings and how to alter them. If any alterations are needed, please refer to the appropriate instructions in this chapter. Do however note that incompatible settings can result in unpredictable board operation and erratic response.

General installation guidelines:

- ***Turn OFF the power to your computer and all devices connected to the ECAN527DHR.***
- Touch the grounded metal housing of your computer to discharge any antistatic build-up and then remove the board from its antistatic bag.
- Hold the board by the edges and install it in an enclosure or place it on the table on an antistatic surface.
- Connect the board to the CAN field-bus using the two field-bus interface header connectors. Make sure that the orientation of the cables is correct and the same.

Installation integrated with a PC/104 module stack

- Secure the four PC/104 installation holes with standoffs.
- Connect the board to the CAN bus using the two field-bus interface header connectors.

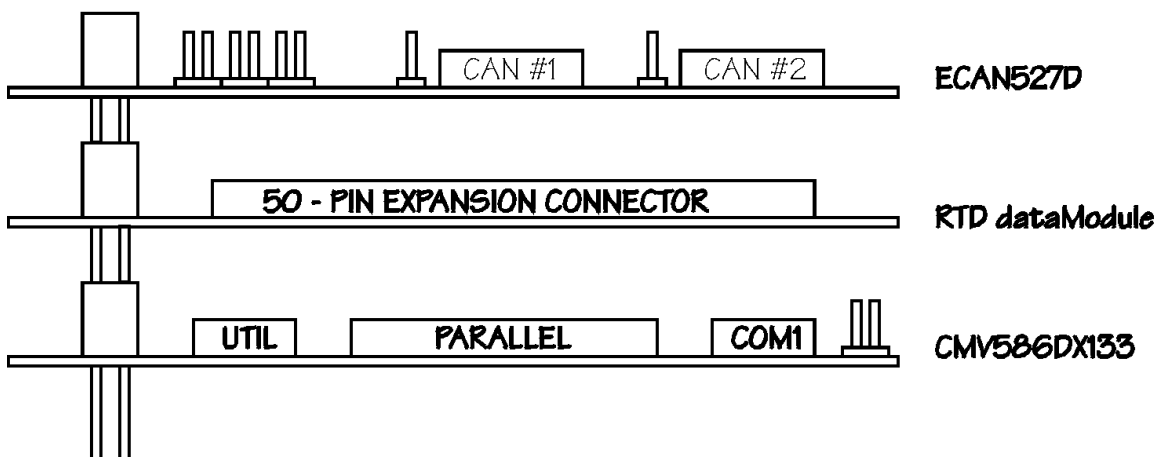


Fig. 3-1: ECAN527DHR integrated in a PC/104 RTD cpuModule stack

3U rack or enclosure installation with a EUROCARD CPU containing an ECAN527DHR

The PC/104 system can be easily inserted into a 19" rack installation using the CPU as a "form factor adapter". Assemble your PC/104 data modules on an RTD single board EUROCARD computer and install the system in a 19" enclosure. Multiple ECAN527DHR boards can be easily connected to this system. See figure 3-2 below.

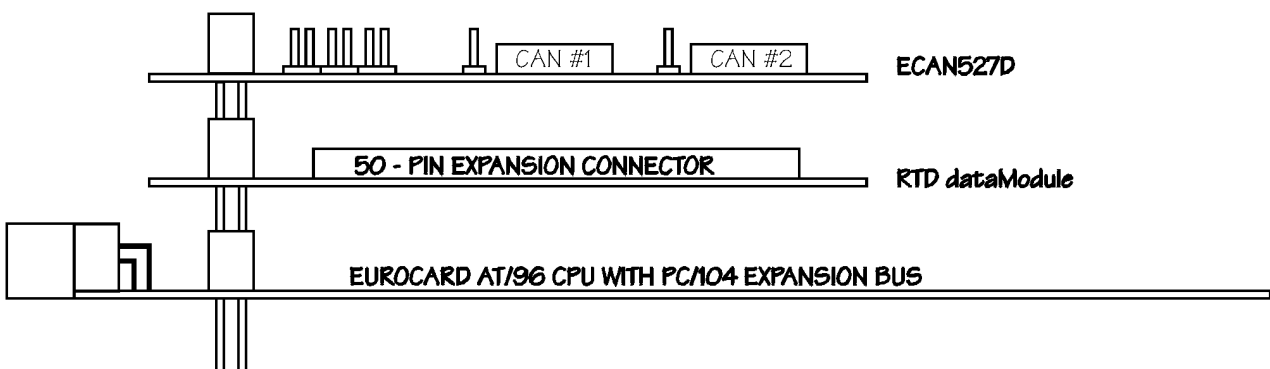


Fig 3-2: 19" Eurocard rack installation with an integrated PC/104 dataModule and EUROCARD cpuModule computer system

External I/O Connections

General purpose digital I/O connector

Table 3-1 below shows the connector layout of the ECAN527DHR digital I/O connectors J28 and J49. These connectors are located towards the left of the board. Refer to this diagram when making signal connections.

PIN number	Function (Channel 1)
1	P2.0 / LED1
2	P2.1 / LED2
3	P2.2 EEPROM Clock
4	P2.3 EEPROM Data
5	P2.4
6	P2.5
7	P2.6
8	P2.7
9	+5V
10	GND

Table 3-1a: Digital I/O connector J28 of the ECAN527DHR

Note: I/O signals 3 and 4 are reserved for the use of the non-volatile EEPROM.
In this case these pins are not available for user I/O

PIN number	Function (Channel 2)
1	P2.0 / LED1
2	P2.1 / LED2
3	P2.2
4	P2.3
5	P2.4
6	P2.5
7	P2.6
8	P2.7
9	+5V
10	GND

Table 3-1b: Digital I/O connector J49 of the ECAN527DHR

Galvanically isolated CAN bus connectors

Table 3-2 below shows the identical CAN physical interface connectors. These connectors are to the right hand side of your board. The pin-outs conform to the ISO 11898 standard specification.

PIN number	Function
1	N.C.
2	GND_isolated
3	BUS_L
4	BUS_H
5	GND_isolated
6	N.C.
7	N.C.
8	+5V-isolated
9	GND-isolated
10	N.C.

	9	7	5	3	1
	I_GND	N.C.	I_GND	BUS_L	N.C.
	N.C.	I_+5V	N.C.	BUS_H	I_GND
	10	8	6	4	2

Table 3-2: Physical interface connector J35 / J45 pin-outs of the ECAN527DHR

Galvanically isolated CAN bus Termination Jumpers

The jumpers marked as J34 and J53 are CAN bus termination jumpers. Only two termination jumpers should be closed at the endpoints of the CAN bus. Failure to do so may degrade the performance of the bus or even cause permanent damage to the driver chips. The typical drive capability of the transceiver is 32 nodes.

Chapter 4 - HARDWARE DESCRIPTION

This chapter describes in detail the major features of the ECAN527DHR:

- The Intel 82527 CAN bus controller
- Galvanic isolation of the CAN bus
- The onboard configuration EEPROM
- Digital I/O

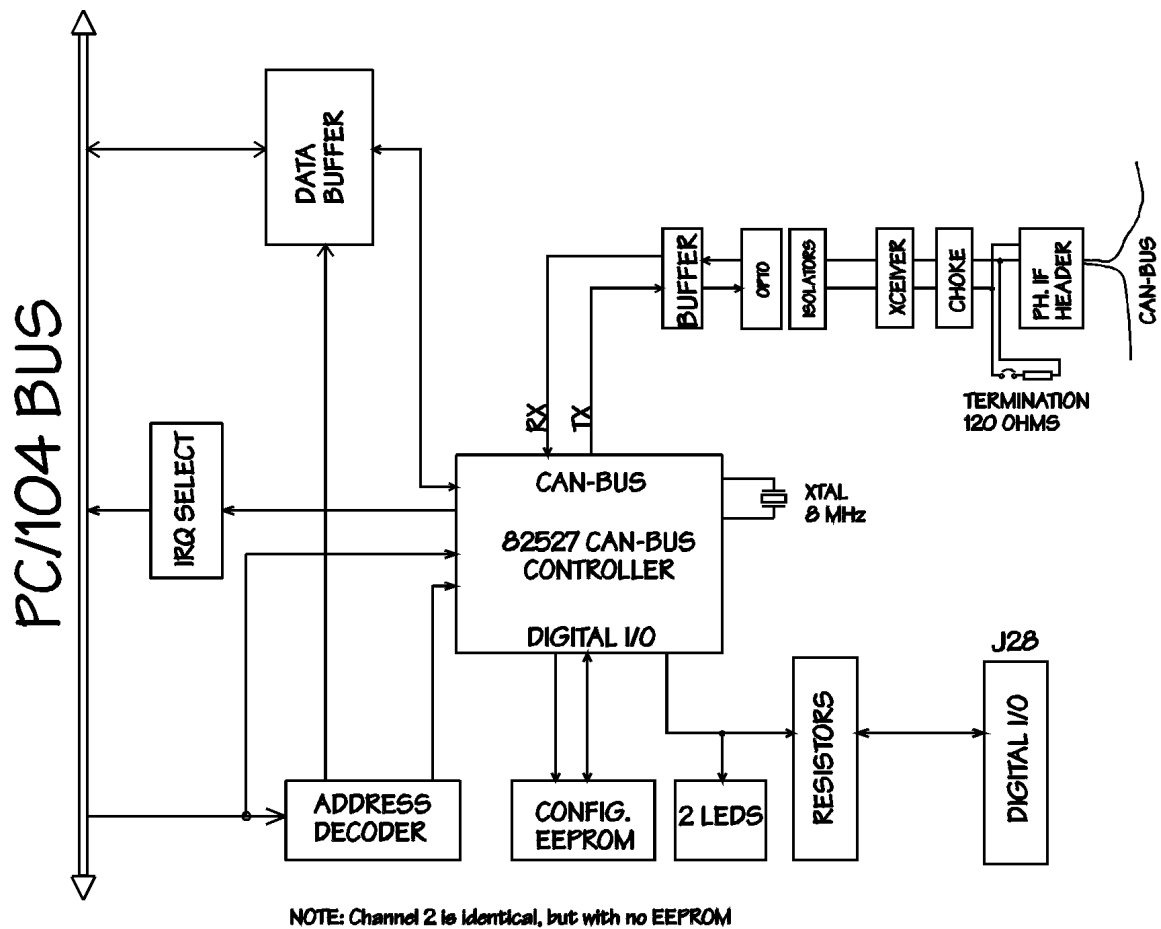


Fig 4-1: ECAN527DHR Block diagram

82527 CAN bus controller

Reference note: (Intel publication CAN Architectural Overview, Automotive Products Data book)

The 82527 CAN controller consists of six functional blocks. The function of the CPU interface logic is to manage the communication to the host computer. The CAN controller interfaces to the CAN bus and implements the rules of the CAN protocol for the transmission and reception of messages. The RAM is the physical interface layer between the host CPU and the CAN bus. One eight-bit I/O port provides low speed I/O capabilities.

The 82527 RAM provides storage for 15 message objects of 8-byte length. Each message object has a unique identifier and can be configured to either transmit or to receive except for the last message object. The last message object is a receive-only buffer with a special mask design to allow selected groups of different message identifiers to be received.

Each message identifier contains control and status bits. A message object with a direction set for receive will send a remote frame by requesting a message transmission. A message set as transmit will be configured to automatically send a data frame whenever a remote frame with a matching identifier is received over the CAN bus. All message objects have separate transmit and receive interrupts and status bits, allowing the CPU full flexibility in detecting when a remote frame has been sent or received.

The 82527 chip also supports a global masking feature for acceptance filtering. This feature allows the user to globally mask, or "don't care", any identifier bits of the incoming message. This mask is programmable to allow the user to design application specific message identification strategies. There are separate global masks for standard and extended frames.

The incoming message first passes through the global mask and is then matched to the identifiers in the message objects 1-14. If there is no identifier match then the message passes through the local mask in message object 15. The local mask allows a large number of infrequent messages to be received by the 82527. Message object 15 is also buffered to allow the CPU time to service a message received.

Galvanic isolation of the CAN-bus

The galvanic isolation of the ECAN527DHR is implemented using the following:

- Optocouplers for data transmission
- DC/DC converter to supply power to the CAN bus and the physical interface circuitry.

The high-speed optocouplers are directly connected to the 82527. The optocouplers drive the CAN bus transceiver. A special balanced CAN bus choke is used not only to improve immunity to bus noise, but also to protect the bus transceiver. This choke also reduces the radiated emissions in the range of 30-200Mhz. A 1W DC/DC converter may be used to power other remote devices on the CAN bus. The output power of this converter is isolated up to 1,5 kV peak. 125mA fuses (green) are used to protect the DC/DC converters.

The jumpers marked as J34 and J53 are CAN bus termination jumpers. Only two termination jumpers should be closed at the endpoints of the CAN bus. Failure to do so may degrade the performance of the bus or even cause permanent damage to the driver chips. The maximum drive of the transceiver is 32 nodes.

Configuration EEPROM

An onboard configuration EEPROM may store up to 256 bytes of user data. This memory may be used to store CAN bus parameters or other identifier codes required by the system.

CAN controller 1. Data is read and written by clocking these lines to provide the serial interface required by the EEPROM device. See ECAN527DHR Specifications (Chapter 6) for more exact descriptions on EEPROM interfacing. The EEPROM used the I2C interface scheme with the device address set to 000.

Digital I/O

The tables 4-1a and 4-1b below show the functionality of the 82527 port P2 bits. Bits 0 and 1 have two functions. They may either drive the two onboard status-LED's or operate as user TTL-level I/O. The output impedance of this port is 100 Ohms. This series resistor on every I/O line provides protection against short circuits and transient voltages.

P2.0	P2.1	P2.2	P2.3	P2.4	P2.5	P2.6	P2.7
LED1	LED2	CLK	DATA	DIO3	DIO4	DIO5	DIO6

Table 4-1a: Digital I/O configuration of port P2 of the 82527 chip number 1

P2.0	P2.1	P2.2	P2.3	P2.4	P2.5	P2.6	P2.7
LED1	LED2	DIO3	DIO4	DIO5	DIO6	DIO7	DIO8

Table 4-1b: Digital I/O configuration of port P2 of the 82527 chip number 2

Chapter 5 - **BOARD OPERATION AND PROGRAMMING**

This chapter shows you how to program and use your ECAN527DHR. It provides a complete detailed description of the memory map and a detailed discussion of programming operations to aid you in programming. The full functionality of the ECAN527DHR is described in the attached data sheet reprint from Intel on the 82527 CAN controller chip.

Defining the Memory Map

The memory map of the ECAN527DHR occupies 512 bytes of host PC low memory space. CAN controller number 1 occupies addresses BASE to BASE+FFh, whilst CAN controller number 2 occupies addresses BASE+100h to BASE+1FFh. This window is freely selectable by the user as described in *Chapter 2, Table 2-2*. After setting the base address you have access to the internal resources of the 82527 CAN controller chips. These resources are described in the next sections reprinted from the Intel 82527 manual.

INTERRUPTS

What is an interrupt?

An interrupt is an event that causes the processor in your computer to temporarily halt its current process and execute another routine. Upon completion of the new routine, control is returned to the original routine at the point where its execution was interrupted.

Interrupts are a very flexible way of dealing with asynchronous events. Keyboard activity is a good example; your computer cannot predict when you might press a key and it would be a waste of processor time to do nothing whilst waiting for a keystroke to occur. Thus the interrupt scheme is used and the processor proceeds with other tasks. When a keystroke finally occurs, the keyboard then 'interrupts' the processor so that it can get the keyboard data. It then places it into the memory, and then returns to what it was doing before the interrupt occurred. Other common devices that use interrupts are A/D boards, network boards, serial ports etc.

Your ECAN527DHR can interrupt the main processor when a message is received or transmitted if interrupts are enabled on the ECAN527DHR board. By using interrupts you can write powerful code to interface to your CAN network.

Interrupt request lines

To allow different peripheral devices to generate interrupts on the same computer, the PC AT bus has interrupt request channels (IRQ's). A rising edge transition on one of these lines will be latched into the interrupt controller. The interrupt controller checks to see if the interrupts are to be acknowledged from that IRQ and, if another interrupt is being processed, it decides if the new request should supercede the one in progress or if it has to wait until the one in progress has been completed. The priority level of the interrupt is determined by the number of the IRQ as follows; IRQ0 has the highest priority whilst IRQ15 has the lowest. Many of the IRQ's are used by standard system resources, IRQ0 is dedicated to the internal timer, IRQ1 is dedicated to the keyboard input, IRQ3 for the serial port COM2, and IRQ4 for the serial port COM1. Often interrupts 5,7,11,15 are often free.

8259 Programmable Interrupt Controller

The chip responsible for handling interrupt requests in a PC is the 8259 Interrupt Controller. To use interrupts you will need to know how to read and set the 8259's internal interrupt mask register (IMR) and how to send the end-of-interrupt (EOI) command to acknowledge the 8259 interrupt controller.

Interrupt Mask Register (IMR)

Each bit in the interrupt mask register (IMR) contains the mask status of the interrupt line. If a bit is set (equal to 1), then the corresponding IRQ is masked, and it will not generate an interrupt. If a bit is cleared (equal to 0), then the corresponding IRQ is not masked, and it can then generate an interrupt. The interrupt mask register is programmed through **port 21h**.

End-of-Interrupt (EOI) Command

After an interrupt service routine is complete, the 8259 Interrupt Controller must be acknowledged by writing the value 20h to port 20h.

What exactly happens when an interrupt occurs?

Understanding the sequence of events when an interrupt is triggered is necessary to correctly write interrupt handlers. When an interrupt request line is driven high by a peripheral device (such as the ECAN527DHR), the interrupt controller checks to see if interrupts are enabled for that IRQ. It then checks to see if other interrupts are active or requested and determines which interrupt has priority. The interrupt controller then interrupts the processor. The current code segment (CS), instruction pointer (IP), and flags are pushed onto the system stack, and a new set of CS and IP are loaded from the lowest 1024 bytes of memory.

This table is referred to as the interrupt vector table and each entry to this table is called an interrupt vector. Once the new CS and IP are loaded from the interrupt vector table, the processor starts to execute code from the new Code Segment (CS) and from the new Instruction Pointer (IP). When the interrupt routine is completed the old CS and IP are popped from the system stack and the program execution continues from the point where interruption occurred.

Using Interrupts in your Program

Adding interrupt support to your program is not as difficult as it may seem especially when programming under DOS. The following discussion will cover programming under DOS. Note that even the smallest mistake in your interrupt program may cause the computer to hang up and will only restart after a reboot. This can be frustrating and time-consuming.

Writing an Interrupt Service Routine (ISR)

The first step in adding interrupts to your software is to write an interrupt service routine (ISR). This is the routine that will be executed automatically each time an interrupt request occurs for the specified IRQ. An ISR is different from other sub-routines or procedures. First, on entrance the processor registers must be pushed onto the stack before anything else! Second, just before exiting the routine, you must clear the interrupt on the ECAN527DHR by writing to the 82527 CAN controller, and write the EOI command to the interrupt controller. Finally, when exiting the interrupt routine the processor registers must be popped from the system stack and you must execute the IRET assembly instruction. This instruction pops the CS, IP and processor flags from the system stack. These were pushed onto the stack when entering the ISR.

Most compilers allow you to identify a function as an interrupt type and will automatically add these instructions to your ISR with one exception: most compilers do not automatically add the EOI command to the function, you must do it yourself. Other than this and a few exceptions discussed below, you can write your ISR as any code routine. It can call other functions and procedures in your program and it can access global data. If you are writing your first ISR, we recommend you stick to the basics; just something that enables you to verify you have entered the ISR and executed it successfully. For example: set a flag in your ISR and in your main program check for the flag.

Note: If you choose to write your ISR in in-line Assembly, you must push and pop registers correctly and exit the routine with the IRET instruction instead of the RET instruction.

There are a few precautions you must consider when writing ISR's. The most important is, **do not use any DOS functions or functions that call DOS functions from an interrupt routine**. DOS is not re-entrant; that is, a DOS function cannot call itself. In typical programming, this will not happen because of the way DOS is written. But what about using interrupts? Consider then the following situation in your program: If DOS function X is being executed when an interrupt occurs and the interrupt routine makes a call to the same DOS function X, then function X is essentially being called while active. Such cases will cause the computer to crash. DOS does not support such operations. The general rule is that do not call any functions that use the screen, read keyboard input or any file I/O routines. These should not be used in ISR's.

The same problem of re-entrancy also exists for many floating-point emulators. This effectively means that you should also avoid floating point mathematical operations in your ISR.

Note that the problem of reentrancy exists, no matter what programming language you use. Even, if you are writing your ISR in Assembly language, DOS and many floating point emulators are not re-entrant. Of course there are ways to avoid this problem, such as those which activate when your ISR is called. Such solutions are, however, beyond the scope of this manual.

The second major concern when writing ISR's is to make them as short as possible in term of execution time. Spending long times in interrupt service routines may mean that other important interrupts are not serviced. Also, if you spend too long in your ISR, it may be called again before you have exited. This will lead to your computer hanging up and will require a reboot.

Your ISR should have the following structure:

- Push any processor registers used in your ISR. Most C compiler do this automatically
- Put the body of your routine here
- Read interrupt status register of the 82527 chip on your ECAN527DHR board
- Clear the interrupt bit by writing to the 82527 CAN controller
- Issue the EOI command to the 8259 by writing 20h to address 20h
- Pop all registers. Most C compilers do this automatically

The following C example shows what the shell of your ISR should be like:

```

/*-----
| Function:    new_IRQ_handler
| Inputs: Nothing
| Returns:    Nothing - Sets the interrupt flag for the EVENT.
|-----*/
void interrupt far new_IRQ_handler(void)
{
    IRQ_flag = 1;          // Indicate to main process interrupt has occurred
    {
        // Your program code should be here
    }
    // Read interrupt status registers
    // Clear the interrupt on ECAN527DHR
    outp(0x20, 0x20);     /* Acknowledge the interrupt controller. */
}

```

Saving the Startup Interrupt Mask Register (IMR) and interrupt vector

The next step after writing the ISR is to save the start-up state of the interrupt mask register (IMR) and the original interrupt vector you are using. The IMR is located in address **21h**. The interrupt vector you will be using is located in the interrupt vector table which is an array of pointers (addresses) and it is located in the first 1024 bytes of the memory (Segment 0 offset 0). You can read this value directly, but it is better practice to use DOS function 35h (get interrupt vector) to do this. Most C compilers have a special function available for doing this. The vectors for the hardware interrupts on the XT - bus are vectors 8-15, where IRQ0 uses vector 8 and IRQ7 uses vector 15. Thus if your ECAN527DHR is using IRQ5 it corresponds to vector number 13.

Before you install your ISR, temporarily mask out the IRQ you will be using. This prevents the IRQ from requesting an interrupt while you are installing and initializing your ISR. To mask the IRQ, read the current IMR at I/O port 21h, and set the bit that corresponds to IRQ. The IMR is arranged so that bit 0 is for IRQ0 and bit 7 is for IRQ7. See the paragraph entitled *Interrupt Mask Register (IMR)* earlier in this discussion for help in determining your IRQ's bit. After setting the bit, write the new value to I/O port 21h.

With the startup IMR saved and the interrupts temporarily disabled, you can assign the interrupt vector to point to your ISR. Again you can overwrite the appropriate entry in the vector table with a direct memory write, but this is not recommended. Instead use the DOS function 25h (Set Interrupt Vector) or, if your compiler provides it, the library routine for setting up interrupt vectors. Remember, that interrupt vector 8 corresponds to IRQ0, vector 9 for IRQ1 etc.

If you need to program the source of your interrupts, do that next. For example, if you are using transmitted or received messages as an interrupt source, program it to do that. Finally, clear the mask bit for your IRQ in the IMR. This will enable your IRQ.

Common Interrupt mistakes

Remember that hardware interrupts are from 8-15, XT IRQ's are numbered 0-7. Forgetting to clear the IRQ mask bit in the IMR. Forgetting to send the EOI command after ISR code. Disables further interrupts.

Example on Interrupt vector table setup in C-code:

```
void far _interrupt new_IRQ1_handler(void);          /* ISR function prototype */
#define IRQ1_VECTOR3                               /* Name for IRQ */
void (interrupt far *old_IRQ1_dispatcher)
    (es,ds,di,si,bp,sp,bx,dx,cx,ax,ip,cs,flags);    /* Variable to store old IRQ_Vector */
void far _interrupt new_IRQ1_handler(void);

/*-----
| Function:    init_irq_handlers
| Inputs: Nothing
| Returns:    Nothing
| Purpose:    Set the pointers in the interrupt table to point to
|             our funtions ie. setup for ISR's.
|-----*/
void init_irq_handlers(void)
{
    _disable();
    old_IRQ1_handler = _dos_getvect(IRQ1_VECTOR + 8);
    _dos_setvect(IRQ1_VECTOR + 8, new_IRQ1_handler);
    Gi_old_mask = inp(0x21);
    outp(0x21,Gi_old_mask & ~(1 << IRQ1_VECTOR));
    _enable();
}

/*-----
| Function:    restore do this before exiting program
| Inputs: Nothing
| Returns:    Nothing
| Purpose:    Restore interrupt vector table.
|-----*/
void restore(void)
{
    /* Restore the old vectors */

    _disable();

    _dos_setvect(IRQ1_VECTOR + 8, old_IRQ1_handler);
    outp(0x21,Gi_old_mask);

    _enable();
}
```

Chapter 6 ECAN527DHR SPECIFICATIONS

Host Interface

Memory mapped into low memory, occupies 512 bytes
 Jumper-selectable base address
 8-bit data bus, 16-bit AT bus connector
 Jumper selectable interrupts XT and AT

CAN Interfaces

Galvanically isolated transceiver 1 Mb/s data-rate
 Timing parameters and speed of bus programmable
 Balanced CAN-bus Choke
 Jumper selectable 120 Ohm termination resistors
 Transceiver drive: 32 nodes
 0.8W 5V isolated output power for other field devices

Digital I/O (non isolated)

Number of lines	14
LED's	4
Series resistor	100 Ohms
Pull-up / Pull-down	Bits 1,2 ,9,10 have a 10K pull-down

Connectors

Galvanically isolated CAN bus	Two 10-pin headers
Non Isolated I/O's	10-pin header connectors
Host bus	XT/AT PC/104 bus

Electrical

Operating temperature range	-40 to +85 C
Supply voltage	+5V, +-8%
Power consumption	1,2W typical

CE

The ECAN527DHR is CE certified in the IDAN Enclosure System.
 Please consult the factory for more system information

Chapter 7 RETURN POLICY AND WARRANTY

If the module requires repair, you may return it to us by following the procedure listed below:

Caution: Failure to follow this return procedure will *almost always* delay repair! Please help us expedite your repair by following this procedure.

- 1) Read the limited warranty, which follows.
- 2) Contact the factory and request a Returned Merchandise Authorization (RMA) number.
- 3) On a sheet of paper, write the name, phone number, and fax number of a technically competent person who can answer questions about the problem.
- 4) On the paper, write a detailed description of the problem with the product. Answer the following questions:
 - Did the product ever work in your application?
 - What other devices were connected to the product?
 - How was power supplied to the product?
 - What features did and did not work?
 - What was being done when the product failed?
 - What were environmental conditions when the product failed?
- 5) Indicate the method we should use to ship the product back to you.
 - We will return warranty repairs by UPS Ground at our expense.
 - Warranty repairs may be returned by a faster service at your expense.
 - Non-warranty repairs will be returned by UPS Ground or the method you select, and will be billed to you.
- 6) Clearly specify the address to which we should return the product when repaired.
- 7) Enclose the paper with the product being returned.
- 8) Carefully package the product to be returned *using anti-static packaging!* We will not be responsible for products damaged in transit for repair.
- 7) Write the RMA number on the outside of the package.
- 8) Ship the package to:

Real Time Devices Finland Oy

Lepolantie 14

FIN-00660 Helsinki

FINLAND

Limited Warranty

Real Time Devices warrants the hardware and software products it manufactures and produces to be free from defects in materials and workmanship for one year following the date of shipment from REAL TIME DEVICES. This warranty is limited to the original purchaser of product and is not transferable.

During the one year warranty period, REAL TIME DEVICES will repair or replace, at its option, any defective products or parts at no additional charge, provided that the product is returned, shipping prepaid, to REAL TIME DEVICES. All replaced parts and products become the property of REAL TIME DEVICES. Before returning any product for repair, customers are required to contact the factory for an RMA number.

THIS LIMITED WARRANTY DOES NOT EXTEND TO ANY PRODUCTS WHICH HAVE BEEN DAMAGED AS A RESULT OF ACCIDENT, MISUSE, ABUSE (such as: use of incorrect input voltages, improper or insufficient ventilation, failure to follow the operating instructions that are provided by REAL TIME DEVICES, "acts of God" or other contingencies beyond the control of REAL TIME DEVICES), OR AS A RESULT OF SERVICE OR MODIFICATION BY ANYONE OTHER THAN REAL TIME DEVICES. EXCEPT AS EXPRESSLY SET FORTH ABOVE, NO OTHER WARRANTIES ARE EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND REAL TIME DEVICES EXPRESSLY DISCLAIMS ALL WARRANTIES NOT STATED HEREIN. ALL IMPLIED WARRANTIES, INCLUDING IMPLIED WARRANTIES FOR MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE DURATION OF THIS WARRANTY. IN THE EVENT THE PRODUCT IS NOT FREE FROM DEFECTS AS WARRANTED ABOVE, THE PURCHASER'S SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS PROVIDED ABOVE. UNDER NO CIRCUMSTANCES WILL REAL TIME DEVICES BE LIABLE TO THE PURCHASER OR ANY USER FOR ANY DAMAGES, INCLUDING ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES, EXPENSES, LOST PROFITS, LOST SAVINGS, OR OTHER DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PRODUCT.

SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES FOR CONSUMER PRODUCTS, AND SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, SO THE ABOVE LIMITATIONS OR EXCLUSIONS MAY NOT APPLY TO YOU.

THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS, AND YOU MAY ALSO HAVE OTHER RIGHTS, WHICH VARY FROM STATE TO STATE.