nanoMODUL-164

Hardware Manual

Edition May 2005

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Preface

This nanoMODUL-164 Hardware Manual describes the board's design and functions. Precise specifications for the C164 microcontroller can be found in the enclosed microcontroller Data-Sheet/User's Manual. If software is included please also refer to additional documentation for this software.

In this hardware manual and in the attached schematics, low active signals are denoted by a "/" in front of the signal name (i.e.: /RD). A "0" indicates a logic-zero or low-level signal, while a "1" represents a logic-one or high-level signal.

Declaration of Electro Magnetic Conformity of the PHYTEC nanoMODUL-164

PHYTEC Single Board Computers (henceforth products) are designed for installation in electrical appliances or as dedicated Evaluation Boards (i.e.: for use as a test and prototype platform for hardware/software development) in laboratory environments.

Caution:
PHYTEC products lacking protective enclosures are subject to damage by ESD and, hence, may only be unpacked, handled or operated in environments in which sufficient precautionary measures have been taken in respect to ESD-dangers. It is also necessary that only appropriately trained personnel (such as electricians, technicians and engineers) handle and/or operate these products. Moreover, PHYTEC products should not be operated without protection circuitry if connections to the product's pin header rows are longer than 3 m.

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The nanoMODUL-164 is one of a series of PHYTEC nano/micro/miniMODULs which can be fitted with different controllers and, hence, offers various functions and configurations. PHYTEC supports all common 8- and 16-bit controllers in two ways:

(1) as the basis for Starter Kits in which user-designed hardware can be implemented on a wrap-field around the controller and

(2) as insert-ready, fully functional micro- and miniMODULes which can be embedded directly into the user's peripheral hardware design.

PHYTEC's microcontroller modules allow engineers to shorten development horizons, reduce design costs and speed project concepts from design to market.

1 Introduction to the nanoMODUL-164

The nanoMODUL-164 is a matchbox-size (47 x 38 mm) Single Board Computer based on the Infineon C164x microcontroller of the C16x-microcontroller family. Its universal design allows its insertion in a wide range of embedded applications. All controller signals and ports extend from the controller to dual-row pin header receptacles (X1 and X2, with 1.27 mm spacing), allowing it to be plugged into a target application like a "big chip". The nanoMODUL-164 is preconfigured and equipped with all necessary connectors required for immediate start-up (*refer to Figure 2 and Figure 4*).

This Hardware Manual describes the features and functions of the nanoMODUL-164 with the PCB revision #1134.2.

The nanoMODUL-164 offers the following features:

- SBC in matchbox-size dimensions (47.1 x 38.3 mm) achieved through advanced SMD
- improved interference safety through multi-layer technology
- controller signals and ports extend to dual-row pin header receptacles (1.27 mm spacing) aligning board edges, allowing the board to be plugged into any target application like a “big chip”
- requires a single low power supply 5 V/typ. < 120 mA
- 16-bit external data bus
- 20 MHz CPU speed (100 ns / instruction cycle)
- 4 MByte address space
- 256 kByte Flash on-board (opt. expandable to up to 2 MByte)[1]
- on-board Flash-programming
- no dedicated Flash programming voltage required through use of 5 V Flash devices
- 256 kByte SRAM on-board (optionally up to 1 MByte)[1]
- on-chip bootstrap loader
- RS-232 serial interface

[1]: Please contact PHYTEC for more information about additional module configurations.

- CAN interface
- battery buffered RTC-8564
- up to 32 kByte E²PROM or 8 kByte FRAM
- four free Chip-Select signals for easy connection of peripheral devices
- provision for operating the board with an ICE/connect-16x for easy emulation of the controller

1.1 Block Diagram

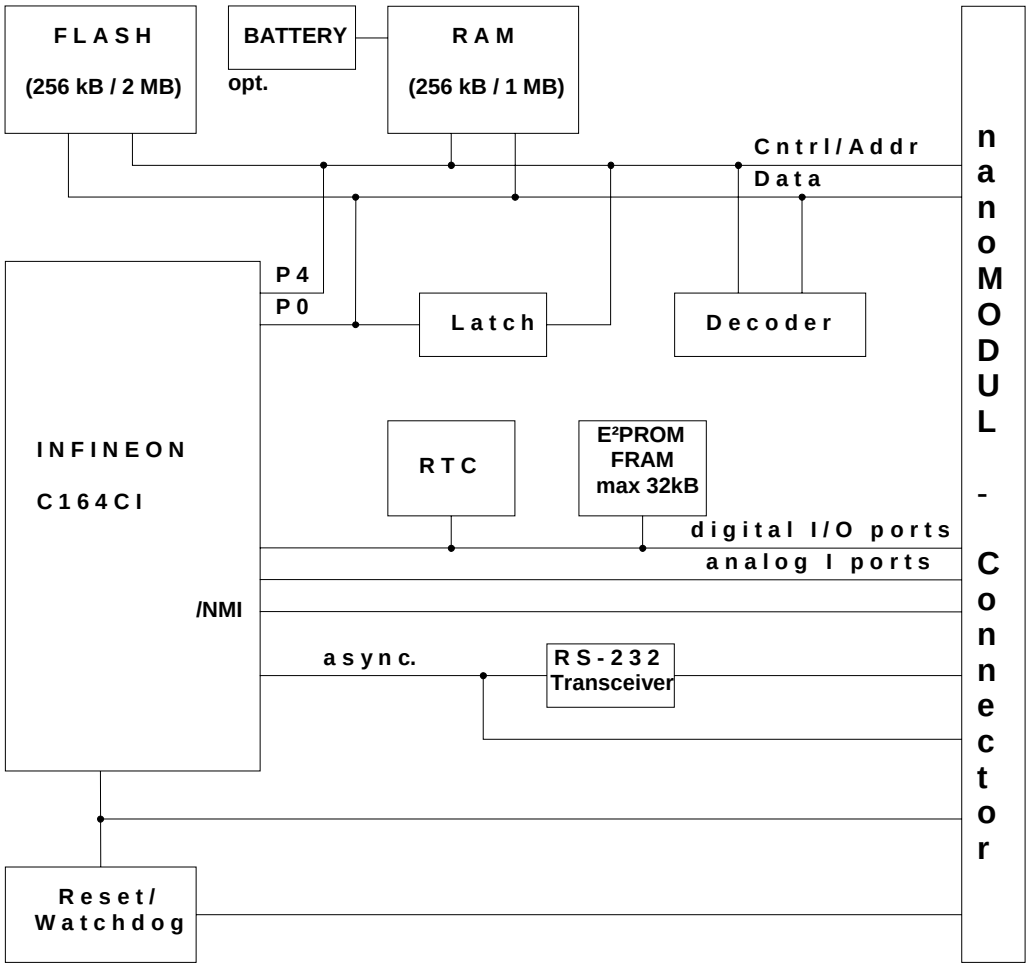

Figure 1: Block Diagram

1: Please contact PHYTEC for more information about additional module configurations.

1.2 Overview of the nanoMODUL-164

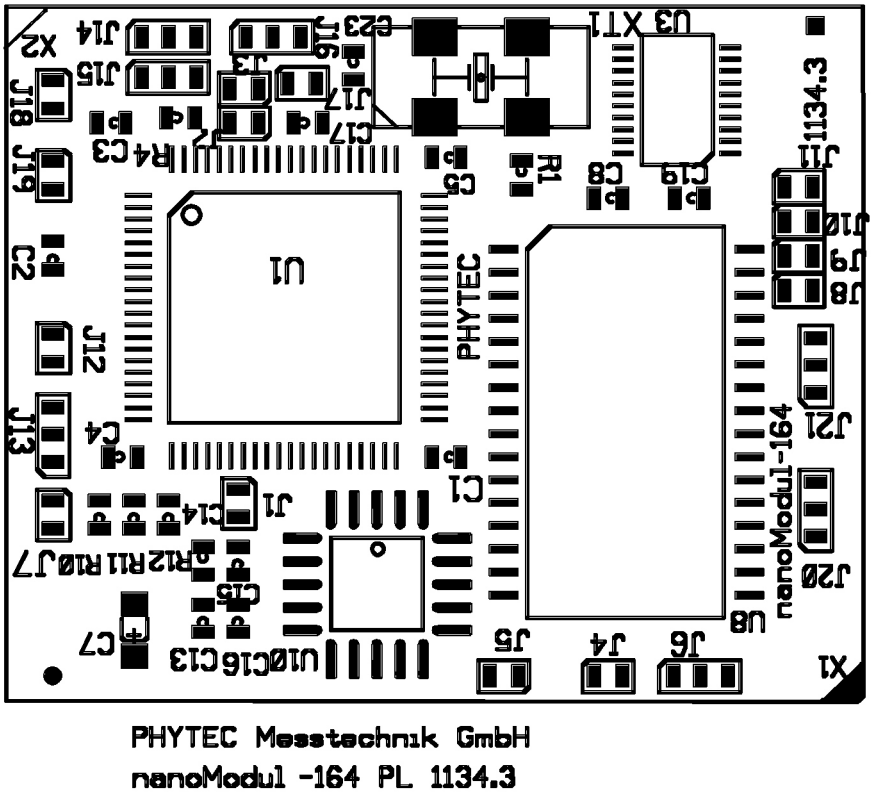

Figure 2: View of the nanoMODUL-164 (Controller Side)

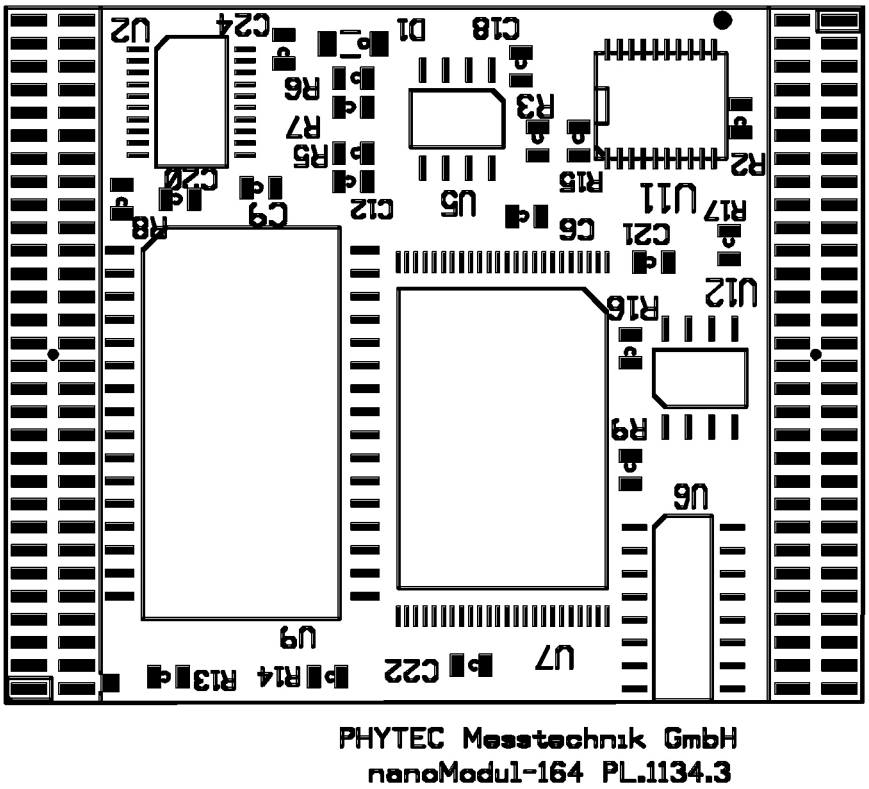

Figure 3: View of the nanoMODUL-164 (Connector Side)

2 Pinout

Please note that all module connections are not to exceed their expressed maximum voltage or current. Maximum input values are indicated in the corresponding controller manuals/data sheets. As damage from improper connections varies according to use and application, it is the user's responsibility to take appropriate safety measures to ensure that the module connections are protected from overloading through connected peripherals.

As *Figure 4* indicates, all controller signals extend to dual-row pin header receptacles (X1 and X2, with 1.27 mm spacing) lining two edges of the board (referred to as nanoMODUL-Connector). This allows the board to be plugged into any target application like a "big chip". An external circuitry can be attached to the nanoMODUL-164 to enable use of an ICE/connect-16x for easy emulation of the controller. In order to plug the nanoMODUL-164 into target hardware, we suggest use of the pin header connector mate manufactured by SAMTEC[1] (FTSH Series Micro Header).

Many of the controller port pins accessible at the edges of the board have been assigned alternate functions that can be activated via software. *Table 1* provides an overview of the pinout of the nanoMODUL-Connector. *Please refer to the C164Cx User Manual for further details about additional functions of some of the port pins.*

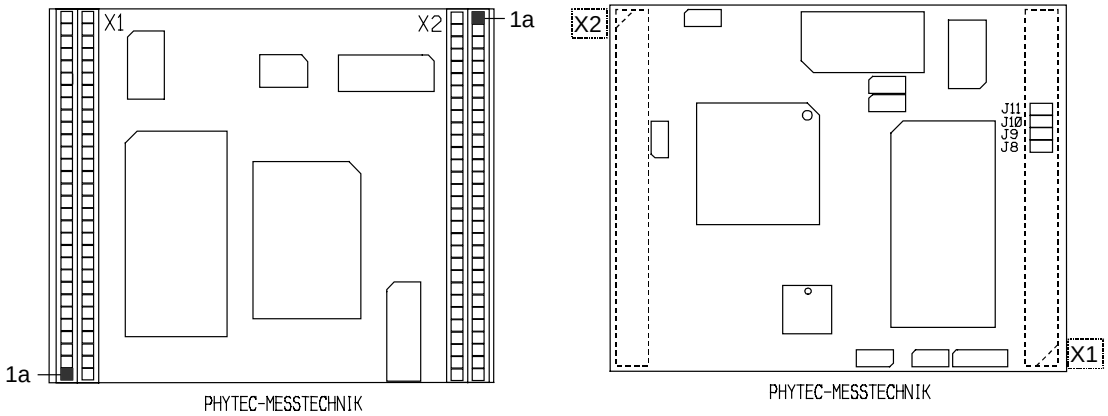

Figure 4: Position of the Connectors

[1] : These can also be ordered directly from PHYTEC (Ordering Code: VL074)

2.1 Pinout of the Pin Header Receptacles X1 and X2 (nanoMODUL-Connector)

X1 Pin # / Signal Name			
1a	A0	1b	A1
2a	A2	2b	A3
3a	A4	3b	A5
4a	A6	4b	A7
5a	A8	5b	A9
6a	A10	6b	A11
7a	A12	7b	A13
8a	A14	8b	A15
9a	A16	9b	A17
10a	A18	10b	A19
11a	A20/CRX	11b	A21/CTX
12a	N.C.	12b	N.C.
13a	/IO1	13b	/IO2
14a	/IO3	14b	/IO4
15a	GND	15b	VPP/EA
16a	VCC	16b	VPP/EA
17a	XTO	17b	ALE
18a	/WRL	18b	/WRH
19a	/NMI-P	19b	/NMI-U
20a	/RD-P	20b	/RD-U
21a	/RESO-P	21b	/RESO-U
22a	/RES-P	22b	/RES-U
23a	D0	23b	D1
24a	D2	24b	D3
25a	D4	25b	D5
26a	D6	26b	D7
27a	D8	27b	D9
28a	D10	28b	D11
29a	D12	29b	D13
30a	D14	30b	D15

X2 Pin # / Signal Name			
1a	VREF	1b	VGND
2a	P5.0	2b	P5.1
3a	P5.2	3b	P5.3
4a	P5.4	4b	P5.5
5a	P5.6	5b	P5.7
6a	P3.4	6b	P3.6
7a	P3.8	7b	P3.9
8a	P3.10	8b	P3.11
9a	P3.13	9b	P3.15
10a	N.C.	10b	N.C.
11a	N.C.	11b	N.C.
12a	N.C.	12b	SCL_X2
13a	SDA_X2	13b	RTC_INT
14a	/PFO	14b	WDI
15a	GND	15b	VPD
16a	VCC	16b	VBAT
17a	/MODE0	17b	/MODE1
18a	P8.0	18b	P8.1
19a	P8.2	19b	P8.3
20a	P1.0	20b	P1.1
21a	P1.2	21b	P1.3
22a	P1.4	22b	P1.5
23a	P1.6	23b	P1.7
24a	P1.8	24b	P1.9
25a	P1.10	25b	P1.11
26a	P1.12	26b	P1.13
27a	P1.14	27b	P1.15
28a	T2I	28b	R2O
29a	T2O	29b	R2I
30a	T1O	30b	R1I

Table 1: Pinout of the nanoMODUL-Connector

2.2 ICE/Connect-16x

The ICE/connect-16x provides an easy possibility for connecting a standard emulator, which uses the controller on-board, to the nanoMODUL-164. It carries all data- and address signals. The ICE/connect-16X adapter can be mounted on an expansion board to which the nanoMODUL-164 is connected via pin header receptacle X1. The control signals coming from the controller are extended via pre-connections at the X1 to the peripheral devices. When using an emulator the control signals are generated by the emulator. In this case the connections must be opened.

Table 2 shows the pinout of the ICE/connect-16x.

Caution:
Please note, pins 19a+19b, 20a+20b, 21a+21b and 22a+22b are pre-connected with Jumpers J8 – J11 on the top side of the nanoMODUL-Connector X1 (*refer to section 3.7*). When using an ICE/connect-16x these connections must be opened by cutting the signal traces.

Pin	Description	Description	Pin
1a	A0	A1	1b
2a	A2	A3	2b
3a	A4	A5	3b
4a	A6	A7	4b
5a	A8	A9	5b
6a	A10	A11	6b
7a	A12	A13	7b
8a	A14	A15	8b
9a	A16	A17	9b
10a	A18	A19	10b
11a	A20/CAN	A21/CAN	11b
12a	-	-	12b
13a	-	-	13b
14a	-	-	14b
15a	-	-	15b
16a	-	-	16b
17a	-	ALE	17b
18a	/WRL	/WRH	18b
19a	/NMI-P	/NMI-U	19b
20a	/RD-P	/RD-U	20b
21a	/RESO-P	/RESO-U	21b
22a	/RES-P	/RES-U	22b
23a	D0	D1	23b
24a	D2	D3	24b
25a	D4	D5	25b
26a	D6	D7	26b
27a	D8	D9	27b
28a	D10	D11	28b
29a	D12	D13	29b
30a	D14	D15	30b

Table 2: Pinout of the ICE/Connect-16x at X1

2.3 /MODE1, WDI and PFO Signals

The pin header receptacle X2 provides the signals /MODE1, WDI and PFO.

Pin 14b (WDI) extends directly to the watchdog input of the watchdog device MAX694 (U5). The watchdog input controls the watchdog timer. As long as this pin is left open (i.e. the WDI pin is floating) the watchdog timer is disabled. If WDI is driven to either high or low level the watchdog timer is started. After the time-out period a reset is executed, if there is no further transition at this pin (*see the MAX694 data sheet for further information on the exact timing of the watchdog timer).*

Pin 14a (/PFO) extends directly to the power failure output of the watchdog device MAX694. /PFO can be used to monitor the condition of the supporting battery or to indicate a power failure at VCC (i.e. VCC is below the battery voltage) (*see the MAX694 data sheet for further information on the exact functioning of /PFO and the trigger levels*).

/MODE1 connects to pin 11 of the address decoder, enabling all Chip Select signals to be pulled high. This can be usefull when the controller is switched into power down mode. A port pin can connect to /MODE1 in this power down mode. This means that, before the processor is switched into power down mode, /MODE1 can be pulled to GND. Once in power down mode, all address lines maintain their last active status. Consequently, all logic devices that were last selected remain active.

3 Jumper

For configuration purposes, the nanoModul-164 has 21 solder jumpers and 3 configuration resistors. In order to ensure immediate use of the module the jumpers have been configured prior to delivery. *Figure 5* illustrates the numbering of the solder jumpers, while Figure 6 indicates the location of the jumper on the board.

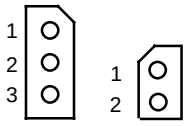

Figure 5: Numbering of the Jumper

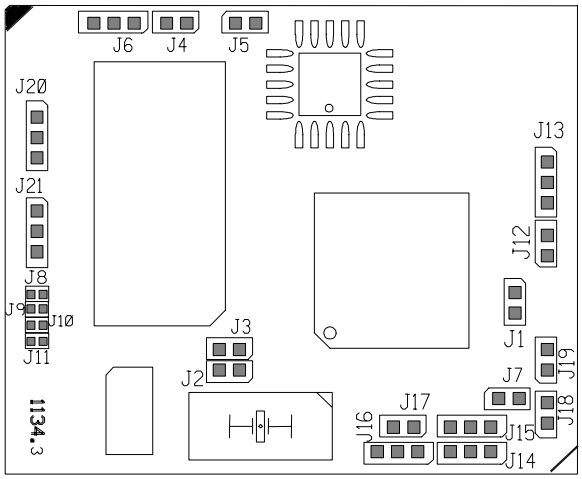

Figure 6: Position of the Jumper (Controller Side)

The jumpers (J = solder jumper) have the following functions:

	Default Setting[1]		**Alternative Setting**	
J1	(closed)	external ROM/ Flash active	(open)	Pin VPP/EA of the C164 connected to X1 pins15b and 16a (for on-chip ROM programming and program execution)
J2	(closed)	VAREF derived from supply voltage VCC	(open)	VAREF from external voltage source via X2 pin 1a
J3	(closed)	VAGND derived from digital ground GND	(open)	VAREF from external ground via Xa pin 1b
J4	(open)	memory model Mode 1 (normal mode)	(1 + 2)	memory model Mode 0 (Monitor mode)
J5	(open)	memory model configuration via Jumper J4	(1 + 2)	/Mode1 input connected to GND
J6	(2 + 3)	RAM memory at U8/9 up to max. 256 kByte	(1 + 2)	RAM memory at U8/9 larger than 256 kByte
J7	(open)	RTC interrupt output is only connected with X2 pin 13b	(closed)	RTC interrupt output is connected with X2 Pin 13b and port 1.8
J8-J11	(closed)	without ICE/connect	(open)	with ICE/connect
J12	(open)	deactivates write protection of the E²PROM/FRAM memory device	(closed)	optional write protection of the E²PROM/FRAM memory device is activated (*see Data Sheet*)
J13	(1 + 2)	VCC E²PROM derived from supply voltage VCC	(2 + 3)	VCC E²PROM derived from battery supply connected to X2 pin 15b
J14	(2 + 3)	E²PROM address line A1 = low	(1 + 2)	E²PROM address line A1 = high
J15	(2 + 3)	E²PROM address line A2 = high	(1 + 2)	E²PROM address line A2 = low

[1]: Applies to standard modules without optional features.

	Default Setting		Alternative Setting	
J16	(2 + 3)	SDA connected to port P8.2	(1 + 2) (open)	SDA connected with port P8.0 Port P8.0 and P8.2 available as port pins at X2
J17	(closed)	SCL connected to port P8.1	(open)	Port 8.1 available as port pins at X2
J18	(open)	SDA not available at X2	(closed)	SDA available as SDA_X2 at X2
J19	(open)	SCL not available at X2	(closed)	SCL available as SCL_X2 at X2
J20	(2 + 3)	A20/CAN connected to X2 as CAN_RxD	(1 + 2)	Port P8.2 connected to X2 as CAN_RxD
J21	(2 + 3)	A21/CAN connected to X2 as CAN_TxD	(1 + 2)	Port P8.3 connected to X2 as CAN_TxD

Table 3: Jumper Setting

3.1 J1 Internal or External Program Memory

At the time of delivery, Jumper J1 is closed. This default configuration means that the program stored in the external program memory is executed after a hardware reset. In order to allow the execution of a specific controller's internal program memory, Jumper J1 must be opened.

The following configurations are possible:

Code Fetch Selection	J1
Execution from external program memory	closed*
Execution from internal program memory	open

* = Default setting

Table 4: J1 Code Fetch Selection

3.2 J2, J3 A/D Reference Voltage

The A/D converter of the controller requires a reference voltage (V_{AREF}, V_{AGND}) applied at pins 1 and 80 of the C164. This reference voltage can be derived either from an external source connected to pins 1a and 1b of the pin header receptacle X2 or from the supply voltage of the nanoMODUL-164. The source of the reference voltage can be selected with Jumper J2 and J3.

The following configurations are possible:

Reference voltage of the A/D converter	**J2 (V_{AREF})**	**J3 (V_{AGND})**
V_{AREF} derived from the supply voltage V_{CC} of the nanoMODUL-164	closed*	closed*
V_{AREF} derived from external source at Pin 1a and 1b of X2	open	open

* = Default setting

Table 5: J2, J3 A/D Converter Reference Voltage

3.3 J4 Memory Models

Jumper J4 configures the memory model used on the nanoMODUL-164. If Jumper J4 is closed, then RAM is mapped into the lower address space and Flash memory in the upper address space (*refer to section 5,"Memory Models").*

The following configurations are possible:

For modules with 1 MByte address space (P474, P658 at U10):

Memory Model	J4
0:0000h – 7:FFFFh Flash 8:0000h – F:7FFFh RAM (e.g. for FlashTools)	open*
0:0000h – 7:FFFFh RAM 8:0000h – F:7FFFh Flash (e.g. for Monitor)	closed

For modules with 2 MByte address space (P533, P659 at U10):

Memory Model	J4
0:0000h – F:FFFFh Flash 10:0000h – 1F:7FFFh RAM (e.g. for FlashTools)	open*
0:0000 – F:FFFFh RAM 10:0000h – 1F:7FFFh Flash (e.g. for Monitor)	closed

For modules with 4 MByte address space (P667 at U10):

Memory Model	J4
0:0000h – 1F:FFFFh Flash 20:0000h – 3F:7FFFh RAM (e.g. for FlashTools)	open*
0:0000h – 1F:FFFFh RAM 20:0000h – 3F:7FFFh Flash (e.g. for Monitor)	closed

* = Default setting

Table 6: J4 Memory Model Selection

3.4 J5 /CS Generation

Jumper J5 enables connection of the /Mode1 signal (pin 11 of the address decoder at U10) to GND or VCC. If Jumper J5 is closed, generation of /CS signals is disabled. This can be useful if the Controller is switched into power down mode. Once in power down mode, all address lines maintain their last active status. Consequently, all logic devices that were last selected remain active.

It is not advisable to permanently close this jumper. This jumper can be of particular value for user-specific configuration of the address decoder.

3.5 J6 RAM Memory Size

Jumper J6configures the memory size for devices mounted on U8/U9. The standard memory configuration of the nanoMODUL-164 offers 256 kByte RAM[1] mounted on U8 and U9.

The following configurations are possible:

Memory Size of U8/U9	J6
512 kByte RAM devices	1 + 2
256 kByte RAM devices	2 + 3*

* = Default setting (depends on order option)

Table 7: J6 RAM Memory Size Selection

[1]: Please contact PHYTEC for more information about additional module configurations.

3.6 J7 RTC Interrupt Output

Jumper J7 determines, if the interrupt output of the RTC extends to pin 13b of pin header receptacle X2 and port P1.8 or to pin 13b only.

The following configurations are possible:

RTC Interrupt Output	J7
Interrupt output is connected with both X2 Pin 13b and Port 1.8	closed
Interrupt output is connected with X2 Pin 13b only	open*

* = Default-Setting

Table 8: J7 RTC Interrupt Output

3.7 J8, J9, J10, J11 Using the ICE/Connect

Pins 19a+19b, 20a+20b, 21a+21b and 22a+22b at X1 on the nanoMODUL-164 are connected via Jumpers J8 - J11. These connections must be opened in case the user wants use an ICE/connect-16x (*refer to section 2.2*).

3.8 J12 Write Protection of E²PROM/FRAM

Various types of E²PROM/FRAM can populate space U12. Some of these devices provide a write protection function[1]. Closing Jumper J12 connects pin 7 of the serial E²PROM/FRAM with VCC and thus activates write protection.

[1]: *Refer to the corresponding E²PROM/FRAM Data Sheet for more information on the write protection function.*

The following configurations are possible:

Write Protection E²PROM/FRAM	**J12**
Write protection of E²PROM/FRAM deactivated	open*
Write protection of E²PROM/FRAM activated	closed

* = Default setting

Table 9: J12 Write Protection of E²PROM/FRAM

3.9 J13 E²PROM/FRAM Supply Voltage

The device at U12 can be connected to VCC or VPD using Jumper J13. As default, U12 is populated with a serial E²PROM with voltage supply pins connected to VCC. Alternatively, a serial FRAM device can also populate U12, in order to support frequent write cycles, for instance. If mounted with an FRAM device, the circuit supply pins can be applied to the battery voltage VPD for purposes of data buffering.

The following configurations are possible:

Supply Voltage for U12	J13
E²PROM/FRAM at U12 supplied with VCC	1 + 2*
E²PROM/FRAM at U12 supplied with VPD	2 + 3

*= Default setting

Table 10: J13 E²PROM/FRAM Supply Voltage Configuration

3.10 J14, J15 Address of the Serial E²PROM/ FRAM

Jumper J14 and J15 configure the serial E²PROM/FRAM address. The default configuration sets the address to 0xA8.

The following configurations are possible:

Address E²PROM/FRAM	J14	J15
0xA0	2 + 3	1 + 2
0xA4	1 + 2	1 + 2
0xA8	2 + 3*	2 + 3*
0xAC	1 + 2	2 + 3

* = Default setting

Table 11: J14, J15 E²PROM/FRAM Address Configuration

3.11 J16, J17 Configuration of P8.0, P8.1 and P8.2 for I²C Bus

The nanoMODUL-164 is equipped with a Real-Time Clock at U11 and a serial E²PROM/FRAM at U12. Both the Real-Time Clock and the serial E²PROM/FRAM are accessed by means of an I²C interface. With Jumpers J16 and J17, this interface can be connected to port pins P8.1 and P8.2 or P8.0. Use of these pins as standard I/O lines at X2-18a (P8.0), X2-18b (P8.1) and X2-19a (P8.2) requires opening of the corresponding jumpers.

The following configurations are possible:

Port P8.0, P8.1 and P8.2 Configuration	J16	J17
Port P8.0 and P8.2 as I/O pin at X2-18a and X2-19a	open	
Port P8.2 as I²C SDA	2 + 3*	
Port P8.0 as I²C SDA	1 + 2	
Port P8.1 as I/O pin at X2-18b		open
Port P8.1 as I²C SCL		closed*

* = Default setting

Table 12: J16, J17 I²C Bus Configuration

3.12 J18, J19 Configuration of SDA and SCL for External I²C Bus

The signals of the nanoMODUL-164's I²C interface can be extended out to nanoMODUL-connector X2 (pins X2-13a and X2-12b) with the help of Jumpers J18 and J19. This enables easy connection of an external I²C device to the nanoMODUL-164. In order to maintain compatibility to the older revisions of the module, it is possible to interrupt the signal by opening both jumpers.

The following configurations are possible:

SDA and SCL Configuration	J18	J19
SDA routed to X2_13A	closed	
SDA disconnected from X2_13A	open*	
SCL routed to X2_12B		closed
SCL disconnected from X2_12B		open*

* = Default setting

Table 13: J18, J19 External I²C Bus Configuration

3.13 J20, J21 CAN Interface

In order to utilize the full 4 MByte linear address space of the microcontroller, the CAN interface signals can be optionally routed to port 8[1]. In this case Jumpers J20 and J21 must be set at positions 1+2. *Please refer to the Infineon C164 User's Manual/Data Sheet for details on the functions and features of controller signals and port pins.*

The following configurations are possible:

CAN Port	J20	J21
CAN_RxD at P4.5 / A20	2 + 3*	
CAN_TxD at P4.6 / A21		2 + 3*
CAN_RxD at P8.2	1 + 2	
CAN_TxD at P8.3		1 + 2

* = Default setting

Table 14: J20, J21 CAN Interface Configuration

1: The feature of rerouting CAN signals to port P8 is only available with Infineon's C164CI controller with step DA and higher

4 Configuration During System Reset

Although most of the programmable features of the C164 are either selected during the initialization phase or repeatedly during program execution, there are some features that must be selected earlier, because they are used for the first access of the program execution. These selections are made during reset via the pins of Port P0, which are read at the end of the internal reset sequence. During reset internal pullup devices are active at Port P0 meaning that high levels are the default configuration on Port P0. To change the configuration external pull-down devices have to be connected to the respective port pin. (*for more information about the configuration during system reset refer also to the C164 User's manual, chapter "System Reset")*. Some configurations which are usually done only once can be changed by mounting optional 0 Ω resistors.

Some of the configurations are fix and must not be changed. The following figure shows Port P0, the function of the pins during reset and how they can be changed (either with solder jumpers or with optional resistors).

Function of Port P0 during System Reset (High-Byte)							
Bit H7	H6	H5	H4	H3	H2	H1	Bit H0
CLKCFG			SALSEL *R11 + R12 (4k7)*		CSSEL		WRC *0*

Function of Port P0 during System Reset (Low-Byte)							
Bit L7	L6	L5	L4	L3	L2	L1	Bit L0
BUSTYP *1*	*1*	**R**	BSL	**R**	**R**	ADP	EMU

Reserved pins must remain high in order to ensure proper operation
The configuration of these pins must not be changed
These pins are preconfigured and can only be changed with external Pull-Down resistors

The following sections contain a more detailed description of the available configuration options.

4.1 Bootstrap Loader

The C164 features an on-chip Bootstrap Loader which can be activated with a 4.7 kΩ pull-down resistor. To enter the Bootstrap mode the resistor must be attached to pin 25a of the pin header receptacle X1 (D4).

4.1.1 Segment Address Lines (R11 + R12)

The C164 controller family allows user configuration of the number of address lines available for segment addressing at port P4. By means of configuring port P0.11 and P0.12 during system reset the number of active address lines is specified. This configuration can be done with pull-down resistors R11 and R12.

Segment Adress Lines	R11	R12
only A16 and A17 are active	open	open
four address lines A16 - A19 are active	closed*	closed*
all address lines A16 - A21 are active	closed	open
none are active	open	closed

* = Default setting

Table 15: R11, R12 Segment Address Line Configuration

4.1.2 Clock MODE (Pin 29b – 30b at X1)

The CPU clock can be derived either directly from the oscillator clock or from the on-chip PLL which allows definition of a prescaler. To determin the clock source and the prescaler port P0.13 -P0.15 have to be configured with pull-down resistors (pins 29b –30b at X1) during system reset. The standard version of the nanoMODUL-164 is equipped with a 5 MHz quartz meaning that the frequency of the CPU clock is 20 MHz with the default jumper setting.

Clock - Mode	P0.13 (D13)	P0.14 (D14)	P0.15 (D15)
XT1 x 4 (2.5 - 6.25 MHz)	open*	open*	open*
XT1 x 3 (3 - 8.3 MHz)	pull-down	open	open
XT1 x 2 (5 - 12,5 MHz)	open	pull-down	open
XT1 x5 (2 - 5 MHz)	pull-down	pull-down	open
OSC1 x 1 (1 - 25 MHz)	open	open	pull-down

* = Default setting

Table 16: System Clock Configuration

5 Memory Models

Address decoding on the nanoMODUL-164 is done with the help of one GAL device at U10. Configuring the Mode Jumper J4 allows one of two memory models to be selected (Mode 1: J4 open; Mode 0: J4 closed). The first two figures illustrate the memory models given when the CAN interface is used. Due to the alternate functions of address lines A20 and A21 the address space is limited to max. 1 MByte. Hence a maximum of 512 kByte Flash and 512 kByte SRAM can be utilized.

Figure 10 shows the memory model without using of the CAN interface. This model covers the complete 4 MByte address space of the controller.

Note:
Starting at step DA of the C164CI microcontroller the CAN signals can be rerouted to Port 8. This new feature resolves the memory size limitation. *Please refer to the Infineon C164 User's Manual/Data Sheet for details on this function.*

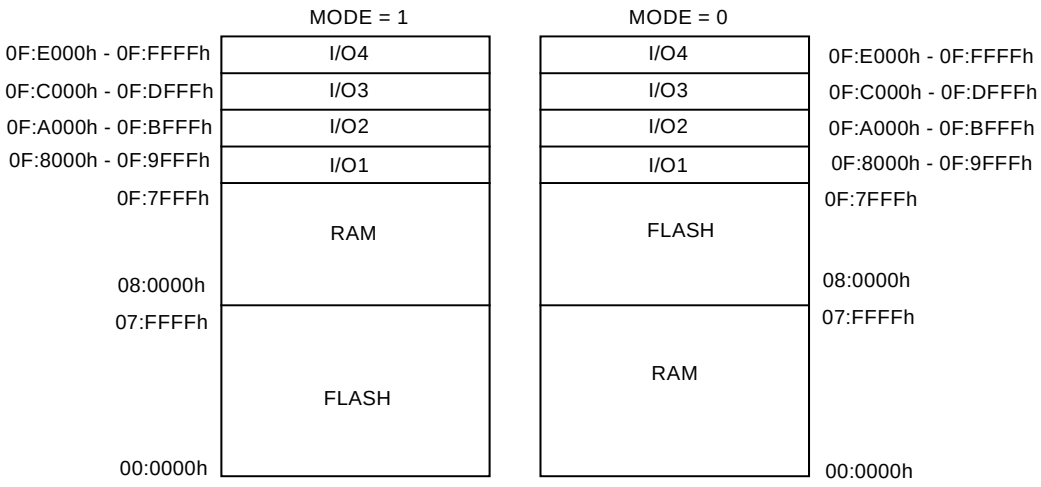

Figure 7: Memory Model at Maximum Memory with Usage of the CAN Interface (512 kByte Flash, 512 kByte SRAM)

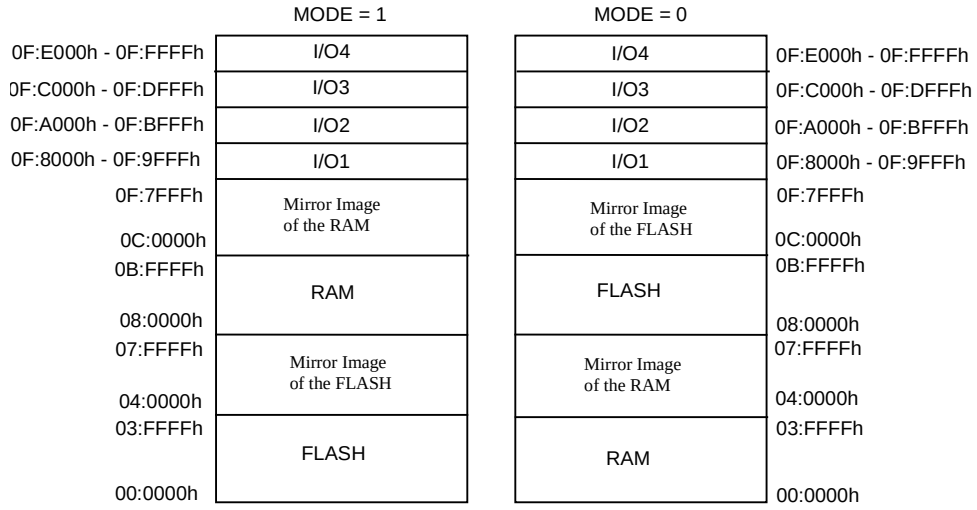

Figure 8: Memory Model at Standard Memory (256 kByte SRAM, 256 kByte Flash)

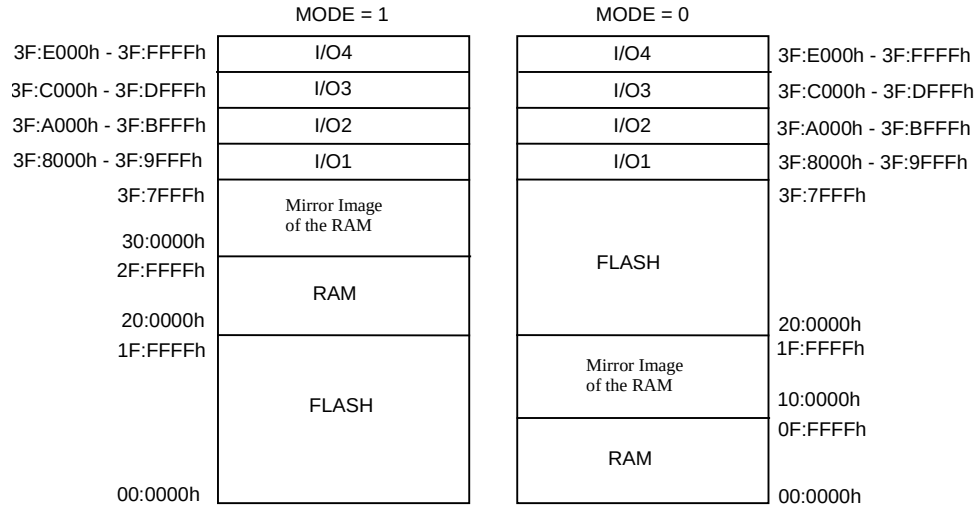

Figure 9: Memory Model at Maximum Memory (1 MByte SRAM, 2 MByte Flash)

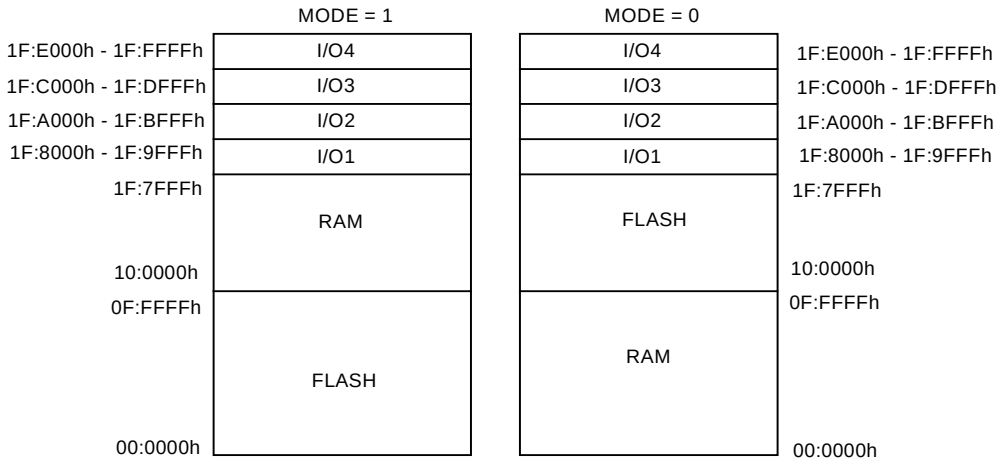

Figure 10: Memory Model at Maximum Memory (1 MByte Flash, 1 MByte SRAM)

Note:
Two changes have to be made when utilizing the memory model shown above. First J6 must be connected at 1+2, whereas resistor R12 must be removed. Second inductors L5 and L6 on the Development Board must be removed.

Mode 1 (J4 open) represents the mode for normal program execution out of the ROM/Flash memory, as well as for programming/download of user code into the Flash. If pin 25a of the pin header receptacle X1 is left open during the reset (i.e. D4 is at high level), the user application in the Flash will be executed starting at address 00:0000h.

If a pull-down resistor (4,7 kΩ) is connected to pin 25a of the pin header receptacle X1 (i.e. D4 is at low level), the bootstrap loader will start. It will load, and subsequently execute, any application in the external RAM. The application can be user code, or any other program or utility of choice. When using the PHYTEC FlashTools (a proprietary software from PHYTEC) will be loaded for purposes of downloading user code into the Flash.

Mode 0 (J4 closed) represents the mode for starting a program out of external memory. This is required, for example, when a monitor program is used. If pin 25a of the pin header receptacle X1 is left open during the reset (i.e. D4 is at high level), the user application in the external RAM will be executed starting at address 00:0000h.

If a pull-down resistor (4,7 kΩ) is connected to pin 25a of the pin header receptacle X1 (i.e. D4 is at low level), the bootstrap loader is started. It loads, and subsequently executes, any application in the external RAM. The application can be user code, or any other program or utility of choice. If the terminal program ***MON166.EXE*** is used, a monitor program from KEIL Software will be loaded and executed.

In both modes four 8 kByte I/O areas are available in addition to RAM and ROM.

Note that a total of 256 kByte Flash memory is mirrored in the ROM memory area. A special address decoder is required if the board is populated with 1 MByte of RAM and/or Flash. Extended memory boards use the address line A20 for Chip Select signal generation. As lines A20/A21 are normally used for the CAN interface, the on-chip CAN function cannot be used if the board is populated with 1 MByte of Flash and/or RAM. Use of CAN requires a maximum of 512 kByte SRAM and/or Flash on the board.

Note:
Starting at step DA of the C164CI microcontroller the CAN signals can be rerouted to Port 8. This new feature resolves the memory size limitation. *Please refer to the Infineon C164 User's Manual/Data Sheet for details on this function.*

6 Flash Memory (U7)

Flash is a highly functional means of storing non-volatile data. Having the nanoMODUL-164 equipped with Flash devices this modern technique is at your disposal. The nanoMODUL-164 can house a Flash device of either type 29F200 (256 kByte), type 29F400 (512 kByte), type 29F800 (1 Mbyte) or type 29F160 (2 MByte). These Flash devices are programmable with 5 VDC. Consequently, no dedicated programming voltage is required.

On-board programming is done with the utility program PHYTEC FlashTools (*refer to "QuickStart Instructions"*).

Use of a Flash device as the only code memory results in no or only a limited usability of the Flash memory as non-volatile memory for data. This is due to the internal structure of the Flash device as, during the Flash-internal programming process, the reading of data from Flash is not possible. Hence, for Flash programming, program execution must be transferred out of Flash (such as into von Neumann RAM). This usually equals the interruption of a "normal" program execution cycle.

As of the printing of this manual, Flash devices generally have a life expectancy of at least 100.000 erase/program cycles.

7 CAN Interface

The nanoMODUL-164 is populated by an Infineon C164CI controller. One of the special features of this controller is the on-chip Full-CAN controller which enables the nanoMODUL-164 to be run within a CAN network. Running the C164CI controller with 20 MHz CPU clock, a CAN bit rate of up to 1 MBit/s can be achieved.

The CAN interface signals are available at port pins P4.5 (A20/RxDC) and P4.6 (A21/TxDC) or, if the rerouting feature is used[1], at P8.2 (RxDC) and P8.3 (TxDC). The CAN signals of the controller extend via Jumpers J20 and J21 (*refer to section 3.13*) to pins 11a and 11b of the pin header receptacle X1. In order to connect the nanoMODUL-164 to a CAN bus an external CAN transceiver (e.g. SI9200 or 82C250) must be connected directly to these pins.

Note:
Due to space limitations the nanoMODUL-164 does not feature an on-board CAN transceiver. When used with the nanoMODUL-specific Development Board - a CAN transceiver on the Development Board delivers physical CAN signals. If the nanoMODUL-164 is used with other carrier/bread boards, the user must provide for an appropriate CAN transceiver in the target hardware.

The programming of the CAN controller is done by means of control-registers, which are mapped into segment 0 of the normal memory area of the controller at the addresses 00:EF00h through 00:EFFFh.

The exact meaning of the registers and how to program the controller can be read in the controller manual of the C164CI.

1: The feature of rerouting CAN signals to port P8 is only available with Infineon's C164CI controller with step DA and higher.

8 Battery Buffer

The battery that buffers the memory is not essential to the functioning of the nanoMODUL-164. However, this battery buffer embodies an economical and practical means of storing non-volatile data. It is necessary to preserve data from the Real-Time Clock in case of a power failure.

As of the printing of this manual, a lithium battery is recommended as it offers relatively high capacity at low discharge. In the event of a power failure at VCC, the RAM memory and the RTC will be buffered by a connected battery via VBAT (pin 16b of the pin header receptacle X2). The RTC and the SRAM devices are generally supplied via VPD in order to preserve data by means of the battery back-up in the absence of a power supply via VCC.

The power consumption depends on the components used and memory size. For the standard devices used on the board the current draw is typically 1 µA (max. 100 µA) per RAM device. The power consumption of the Real-Time Cock is 50 µA.

Note:
Be advised that despite the battery buffer, changes in the data content within the RAM can occur. The battery buffer does not completely remove the danger of data destruction. Please note that utilizing the battery buffer for the RAMs and the Real-Time Clock the storage temperature for the module is only 0°C to +70°C.

9 Real-Time Clock RTC-8564 (U11)

For real-time or time-driven applications, the nanoMODUL-164 is equipped with an RTC-8564 Real-Time Clock at U11. This RTC device provides the following features:

- Serial input/output bus (I^2C)
- Power consumption

  Bus active: max. 50 mA
  Bus inactive, CLKOUT = 32 kHz : max. 1.7 µA
  Bus inactive, CLKOUT = 0 kHz : max. 0.75 µA
- Clock function with four year calendar
- Century bit for year 2000-compliance
- Universal timer with alarm and overflow indication
- 24-hour format
- Automatic word address incrementing
- Programmable alarm, timer and interrupt functions

If the nanoMODUL-164 is equipped with a battery, the Real-Time Clock runs independently of the board.

Programming the Real-Time Clock is done via the I^2C bus (address 0 x A2 = 1010001), which is connected to port P8.1 (SCL) and port P8.2 (SDA). The Real-Time Clock also provides an interrupt output that extends to port P1.8 via Jumper J7 and to pin 13b pin at header receptacle X2. An interrupt occurs in case of a clock alarm, timer alarm, timer overflow and event counter alarm. An interrupt must be cleared by software. With the interrupt function, the Real-Time Clock can be utilized in various applications. *For more information on the features of the RTC-8564, refer to the corresponding Data Sheet.*

Note:
After connection of the supply voltage, or after a reset, the Real-Time Clock generates **no** interrupt. The RTC must first be initialized (*see RTC Data Sheet for more information*)

10 Serial E²PROM/FRAM (U12)

The nanoMODUL-164 is populated with a non-volatile memory with a serial interface (I²C interface) to store configuration data. According to the memory configuration of the module, an E²PROM (4 to 32 kByte) or FRAM can be mounted at U12.

A description of the I²C memory protocol of the specific memory component at U12 can be found in the respective Data Sheet.

Table 17 gives an overview of the memory components that can be used at U12 at the time of printing of this manual.

Device Type	Manufacturer	Size	Component
E²PROM	Microchip	32 kByte	MIC24LC256
	Catalyst	4 kByte*	CAT24WC32
		8 kByte	CAT24WC64
	ST	4 kByte*	M24C32
		8 kByte	M24C64
FRAM	Ramtron	512 Byte	FM24C04
		8 kByte	FM24C64

*= Default setting

Table 17: Memory Device Options for U12

Various available E²PROM/FRAM types provide a write protection function[1] Jumper J12 is used to activate this function. If this jumper is closed, then pin 7 of the serial E²PROM/FRAM is connected to VCC.

Write Protection E²PROM/FRAM	J12
Write protection of E²PROM/FRAM deactivated	open*
Write protection of E²PROM/FRAM activated	closed

* = Default setting

Table 18: E²PROM/FRAM Write Protection

Jumper J14 and J15 configure the address of the serial E²PROM/FRAM. The default configuration sets the address to 0xA8.

E2PROM/FRAM Address	J14	J15
0xA0	2 + 3	1 + 2
0xA4	1 + 2	1 + 2
0xA8	2 + 3*	2 + 3*
0xAC	1 + 2	2 + 3

* = Default setting

Table 19: E²PROM/FRAM Address

1: *Refer to the corresponding E²PROM/FRAM Data Sheet for more information on the write protection function*

11 Technical Specifications

The physical dimensions of the nanoMODUL-164 are represented in *Figure 11*. The board's profile is about 12 mm thick. The components on the soldering side have a maximum height of 5 mm and approximately 5 mm on the component side. The board itself is approximately 1.5 mm thick.

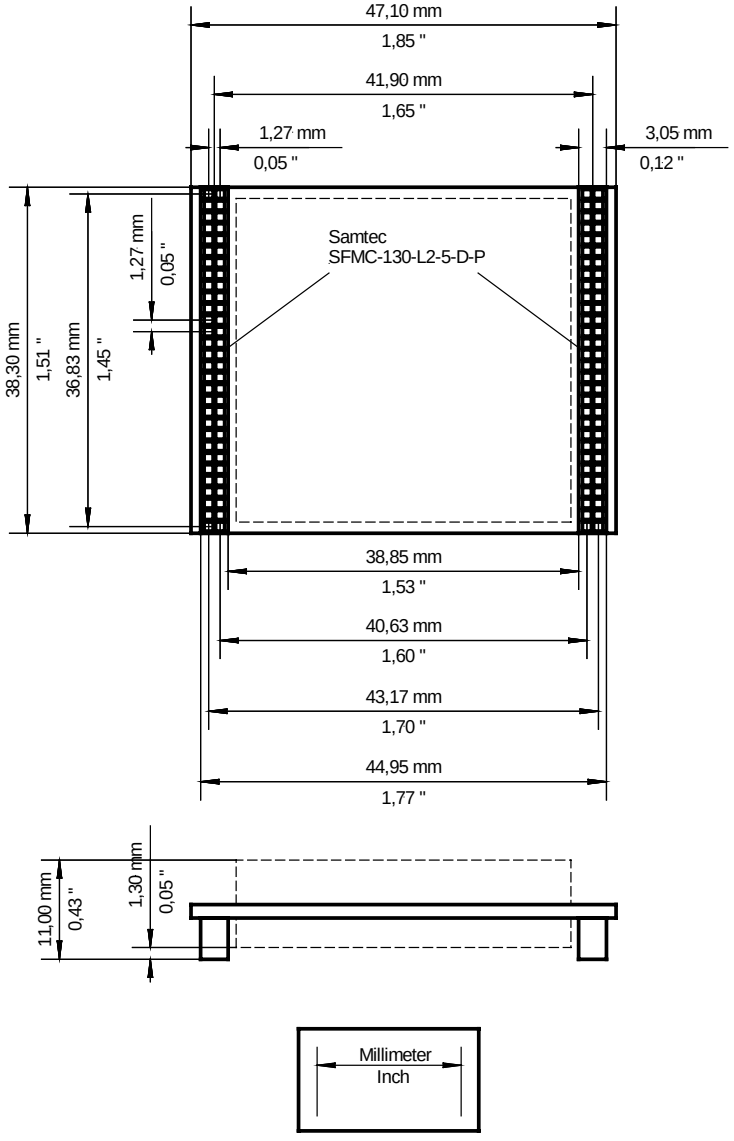

Figure 11: Physical Dimensions

Additional specifications:

- Dimensions: 38.3 x 47.1 mm, ±0.03 mm
- Weight: approximately 14 g
- Storage temperature: -40°C to +90°C, using the battery buffer 0°C to +70°C
- operating temperature: 0°C to +70°C, extended -40°C to +85°C
- humidity: 90 % r.F. not condensed
- Operating voltage: 5 V ±10 %, VBAT 3 V ±20 %
- Power consumption: maximum 300 mA at 20 MHz CPU clock
- Power consumption with battery buffer: 10 µA per RAM device, typically 1 µA per RAM device at +20 °C

These specifications describe the standard configuration of the nanoMODUL-164 as of the pressing of this manual.

Typically the power consumption is less than 120 mA with 256 kByte SRAM memory and 256 kByte Flash memory at 20°C.

Caution:
Please note that the module storage temperature is only 0°C to +70°C if a battery buffer is used for the RAM devices.

12 Hints for Handling the nanoMODUL-164

Removal or exchange of components on the nanoMODUL-164 (controller, memory, quartz etc.) is not advisable given the compact nature of the nanoMODUL-164. Should this nonetheless be necessary, please ensure that the board, as well as surrounding components and sockets, remain undamaged during removal. Overheating the board can cause the solder pads to loosen, rendering the module inoperable. Carefully heat neighbouring connections in pairs. After a few alternations, components can be removed with the solder-iron tip. Alternatively, a hot air gun can be used to heat and loosen the bonds.

When changing the controller it has to be taken care that the controller to be used is pin-compatible to the C164 controller and that special hardware features are compatible with the layout of the board.

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