

RTC

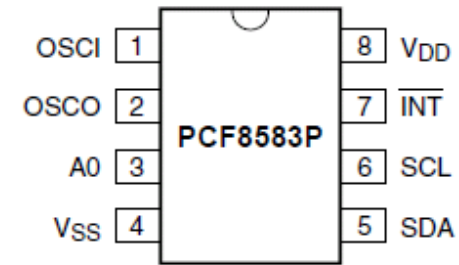
Comparison of six real time clocks

Features	PCx85x3 family				PCx212x family	
	PCF8563	PCA8565	PCF8583	PCF8593	PCF2123	PCA2125
Unique features	Very low power consumption	AEC-Q100 automotive qualification	High resolution, RAM, event counter	High resolution, event counter	Extremely low power consumption, electronic tuning	AEC-Q100 automotive qualification
Type of interface	I ² C	I ² C	I ² C	I ² C	SPI	SPI
Interface bus speed	400 kHz	400 kHz	100 kHz	100 kHz	7 MHz	7 MHz
Scratch pad RAM	no	no	240 bytes	no	no	no
Year / leap year tracking	yes / yes	yes / yes	yes / yes	yes / yes	yes / yes	yes / yes
Year counter	2 digit + 1 century bit	2 digit + 1 century bit	2 bit (4 years)	2 bit (4 years)	2 digit (99 years)	2 digit (99 years)
100 ms, 10 ms time register	no	no	yes	yes	no	no
Electronic tuning register	no	no	no	no	yes	no
Programmable alarm and timer functions	yes	yes	yes	yes	yes	yes
Low voltage detector	yes	yes	no	no	yes	no
Event counter mode	no	no	yes	yes	no	no
Option to select between two I ² C addresses	no	no	yes	no	no	no
Integrated oscillator capacitor	1 at OSC0	1 at OSC0	1 at OSC0	1 at OSC0	2	1 at OSC0
Supply voltage range	1.8 V – 5.5 V	1.8 V – 5.5 V	2.5 V – 6.0 V	2.5 V – 6.0 V	1.6 V – 5.5 V	1.6 V – 5.5 V
Clock operating voltage	1.0 V – 5.5 V	1.8 V – 5.5 V	1.0 V – 6.0 V	1.0 V – 6.0 V	1.1 V – 5.5 V	1.3 V – 5.5 V
Typical current consumption	250 nA at V _{DD} = 1 V	650 nA at V _{DD} = 3 V	2 µA at V _{DD} = 1 V	1 µA at V _{DD} = 2 V	100 nA at V _{DD} = 2 V	550 nA at V _{DD} = 3 V

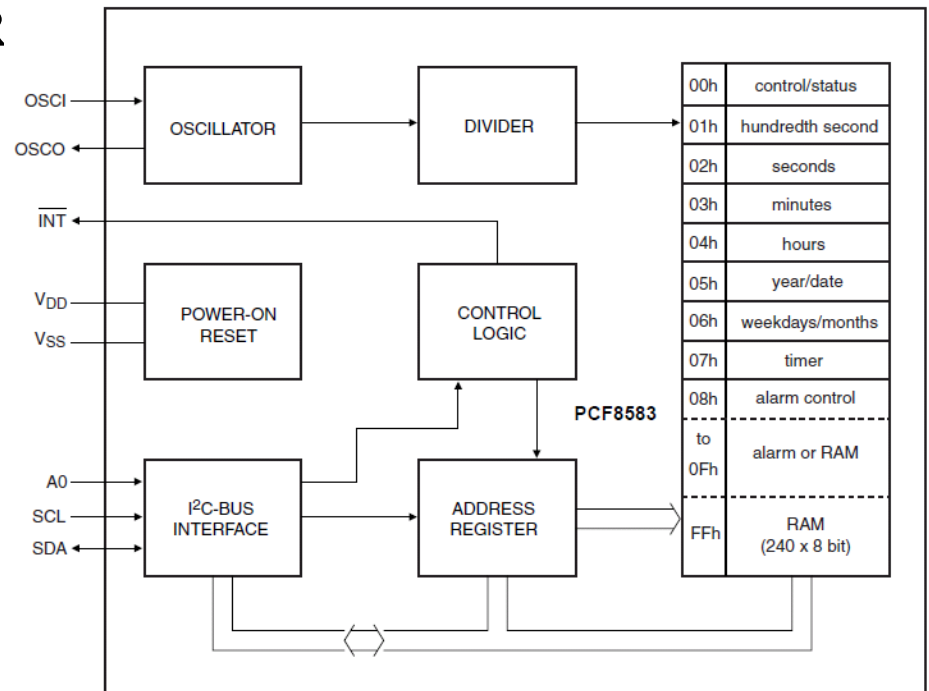
PCF 8583 – RTC

Vlastnosti:

- Základ tvorí CMOS RAM 256 B (2048b)
- I2C;
 - možnosť pripojenia dvoch obvodov (pin A0)
 - slave adresa pre: RD A1h alebo A3h
 - WR A0h alebo A2h
- zabudovaný AC sa inkrementuje automaticky po každom RD resp. WR
- zabudovaný 32768Hz osc.,
 - + 8B (hodiny, kalendár)
 - + 8B (alarm)
 - + 240 voľná RAM
- platnosť dát (1,0V až 6,0V)



Pin configuration for DIP8 (PCF8583P)



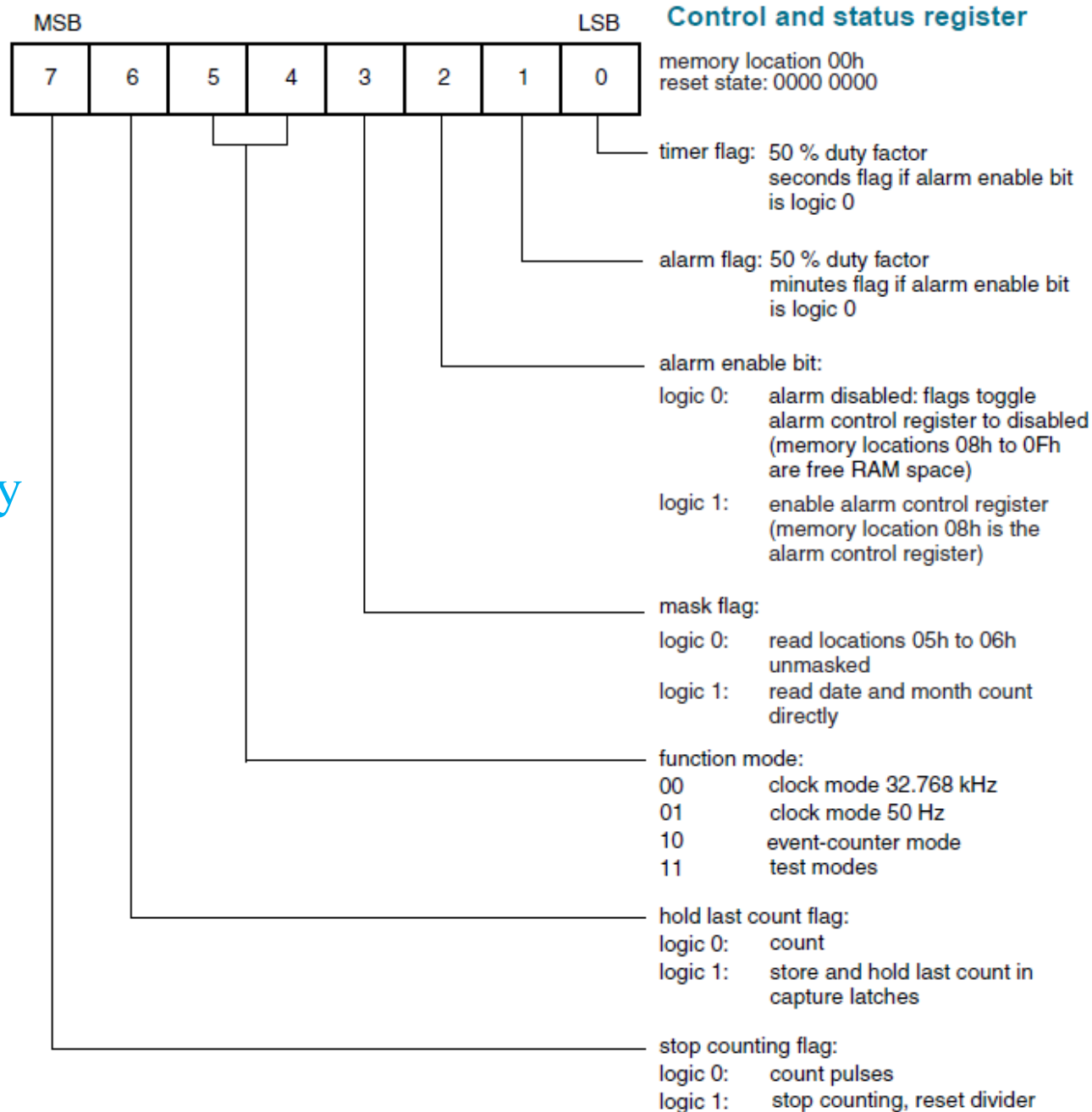
Block diagram of PCF8583

PCF 8583

00h	control/status
01h	hundredth second
02h	seconds
03h	minutes
04h	hours
05h	year/date
06h	weekdays/months
07h	timer
08h	alarm control
to 0Fh	alarm or RAM
FFh	RAM (240 x 8 bit)

Hodiny

Alarm



Ak je zvolený mód **Hodiny**, potom

00h	control/status
01h	hundredth second
02h	seconds
03h	minutes
04h	hours
05h	year/date
06h	weekdays/months
07h	timer
08h	alarm control
to 0Fh	alarm or RAM
FFh	RAM (240 x 8 bit)

hundredths of a second, seconds,
minutes, hours,
date, month(four year calendar) a weekday

sú ukladané v

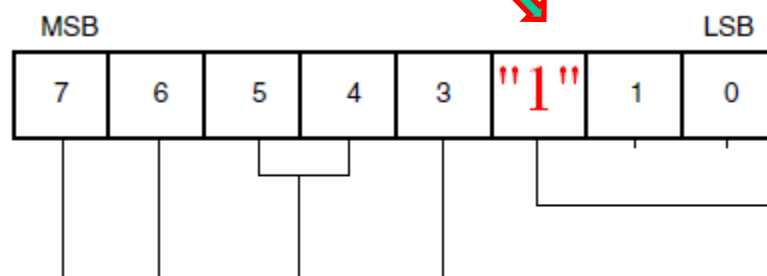
Binary Coded Decimal (BCD) formate.

Ak je jeden z čítačov (01h až 07h) **RD**
obsah ostatných sa odpamätá (na začiatku RD
operácie) do záchytných registrov. Zabráni sa tým
chybám pri inkremente cez rády.

WR operácia sa týka len jedného čítača.

Ak nastavíme

00h	control/status
01h	hundredth second
02h	seconds
03h	minutes
04h	hours
05h	year/date
06h	weekdays/months
07h	timer
08h	alarm control
to 0Fh	alarm or RAM
FFh	RAM (240 x 8 bit)



Control and status register

memory location 00h
reset state: 0000 0000

alarm enable bit:

logic 0: ~~alarm disabled: flags toggle alarm control register to disabled (memory locations 08h to 0Fh are free RAM space)~~

logic 1: enable alarm control register (memory location 08h is the alarm control register)

Aktivujeme „Alarm“ mod

Typy alarmov:

- „čas“ v rámci dňa
- „čas“ v rámci dňa + deň v mesiaci
- „čas“ v rámci dňa + deň v týždni

Signalizácia alarmov:

- nastaví sa príznak v „Control and Status reg.“
- **plus** požiadavka o prerušenie (otvorený kolektor)

Počítadlá času + dátum:

hundredth of a second	
1/10 s	1/100 s
seconds	
10 s	1 s
minutes	
10 min	1 min
hours	
10 h	1 h
year/date	
10 day	1 day
weekdays/months	
10 month	1 month
timer	
10 day	1 day

01h 0 až 99

02h 0 až 59

03h 0 až 59

04h

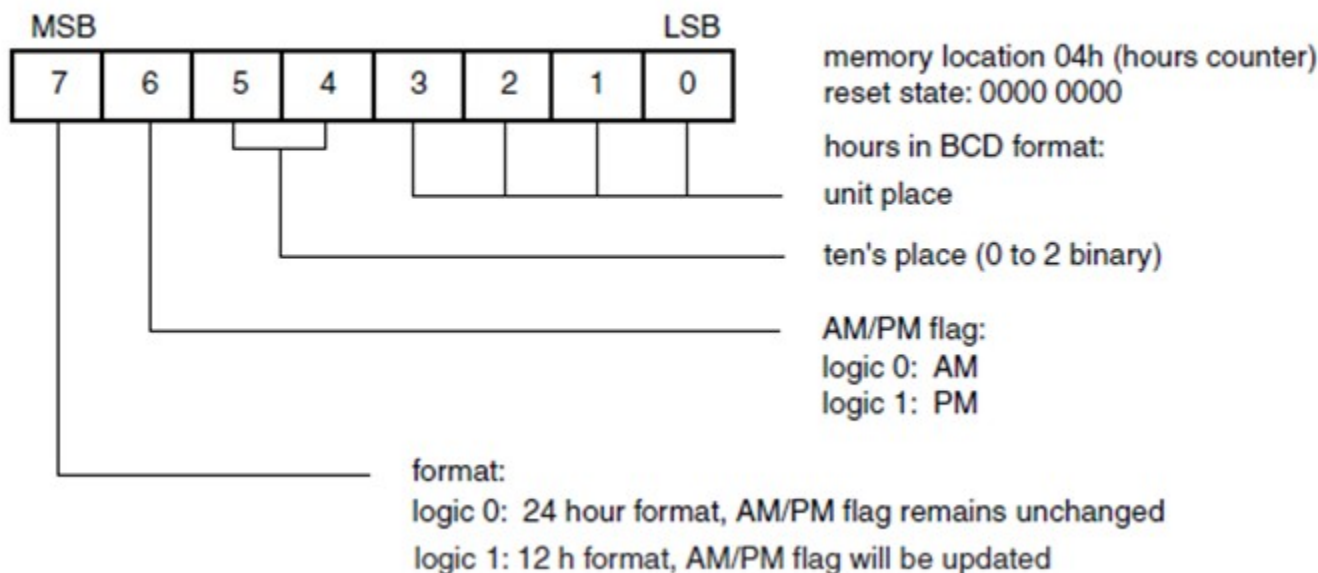
05h

06h

07h

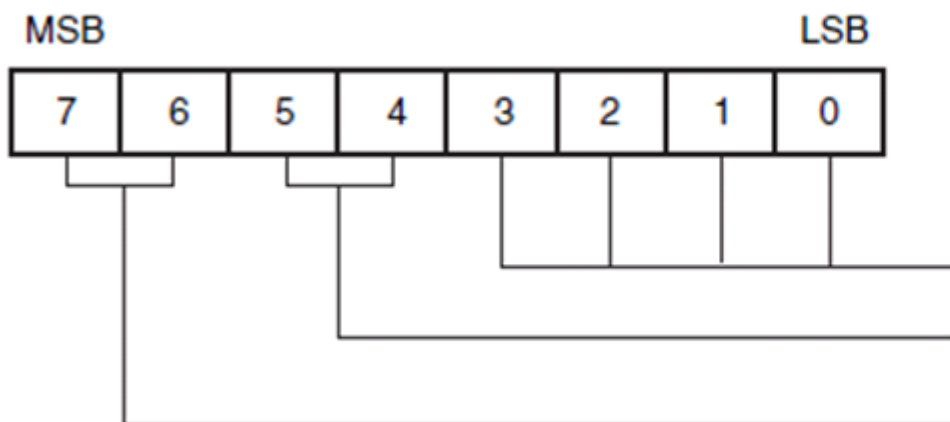
Počítadlá času + dátum:

Format of the hours counter



hundredth of a second		01h
1/10 s	1/100 s	
seconds		02h
10 s	1 s	
minutes		03h
10 min	1 min	
hours		04h
10 h	1 h	
year/date		05h
10 day	1 day	
weekdays/months		06h
10 month	1 month	
timer		07h
10 day	1 day	

Format of the year and date counter



memory location 05h (year/date)
reset state: 0000 0001

days in BCD format:

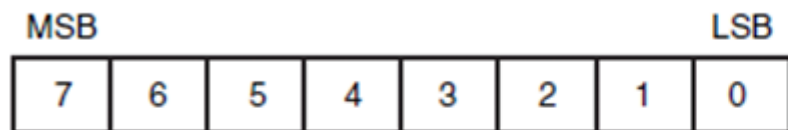
unit place

ten's place (0 to 3 binary)

year (0 to 3 binary, read as logic 0
if the mask flag is set)

hundredth of a second		01h
1/10 s	1/100 s	
seconds		02h
10 s	1 s	
minutes		03h
10 min	1 min	
hours		04h
10 h	1 h	
year/date		05h
10 day	1 day	
weekdays/months		06h
10 month	1 month	
timer		07h
10 day	1 day	

Format of the weekdays and month counter



memory location 06h (weekdays/months)

reset state: 0000 0001

months in BCD format:

unit place

ten's place

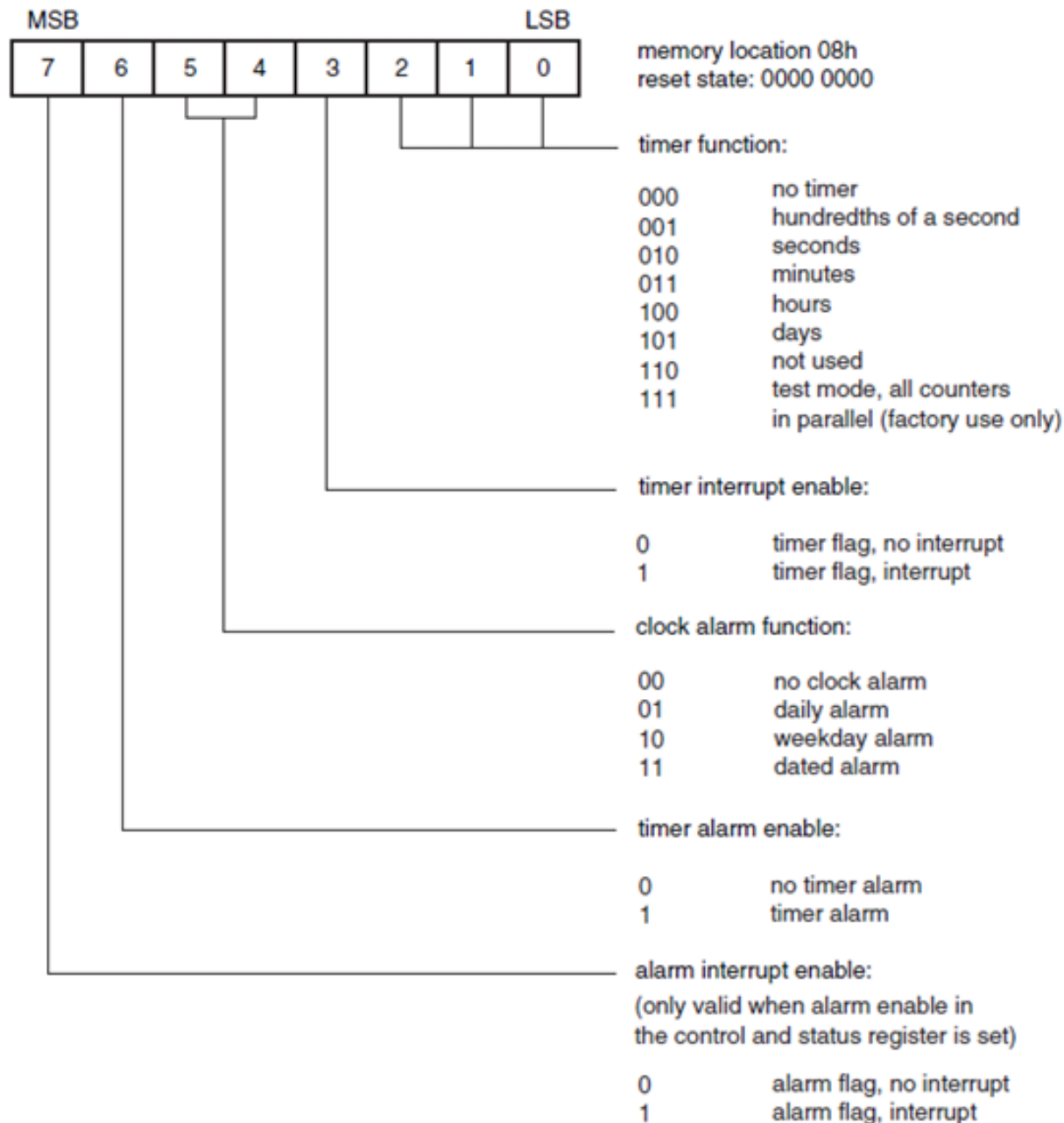
weekdays (0 to 6 binary, read as logic 0 if the mask flag is set)

hundredth of a second		01h
1/10 s	1/100 s	
seconds		02h
10 s	1 s	
minutes		03h
10 min	1 min	
hours		04h
10 h	1 h	
year/date		05h
10 day	1 day	
weekdays/months		06h
10 month	1 month	
timer		07h
10 day	1 day	

Cycle length of the time counters, clock modes

Unit	Counting cycle	Carry to next unit	Contents of month calendar
hundredths of a second	00 to 99	99 to 00	-
seconds	00 to 59	59 to 00	-
minutes	00 to 59	59 to 00	-
hours (24)	00 to 23	23 to 00	-
hours (12)	12 am	-	-
	01 am to 11 am	-	-
	12 pm	-	-
	01 pm to 11 pm	11 pm to 12 am	-
date	01 to 31	31 to 01	1, 3, 5, 7, 8, 10, and 12
	01 to 30	30 to 01	4, 6, 9, and 11
	01 to 29	29 to 01	2, year = 0
	01 to 28	28 to 01	2, year = 1, 2, and 3
months	01 to 12	12 to 01	-
year	0 to 3	-	-
weekdays	0 to 6	6 to 0	-
timer	00 to 99	no carry	-

Alarm control registers, clock mode



control/status	00h
hundredth of a second 1/10 s 1/100 s	01h
seconds 10 s 1 s	02h
minutes 10 min 1 min	03h
hours 10 h 1 h	04h
year/date 10 day 1 day	05h
weekdays/months 10 month 1 month	06h
timer 10 day 1 day	07h
alarm control	08h
hundredth of a second alarm 1/10 s 1/100 s	09h
alarm seconds	0Ah
alarm minutes	0Bh
alarm hours	0Ch
alarm date	0Dh
alarm month	0Eh
alarm timer	0Fh

+8h

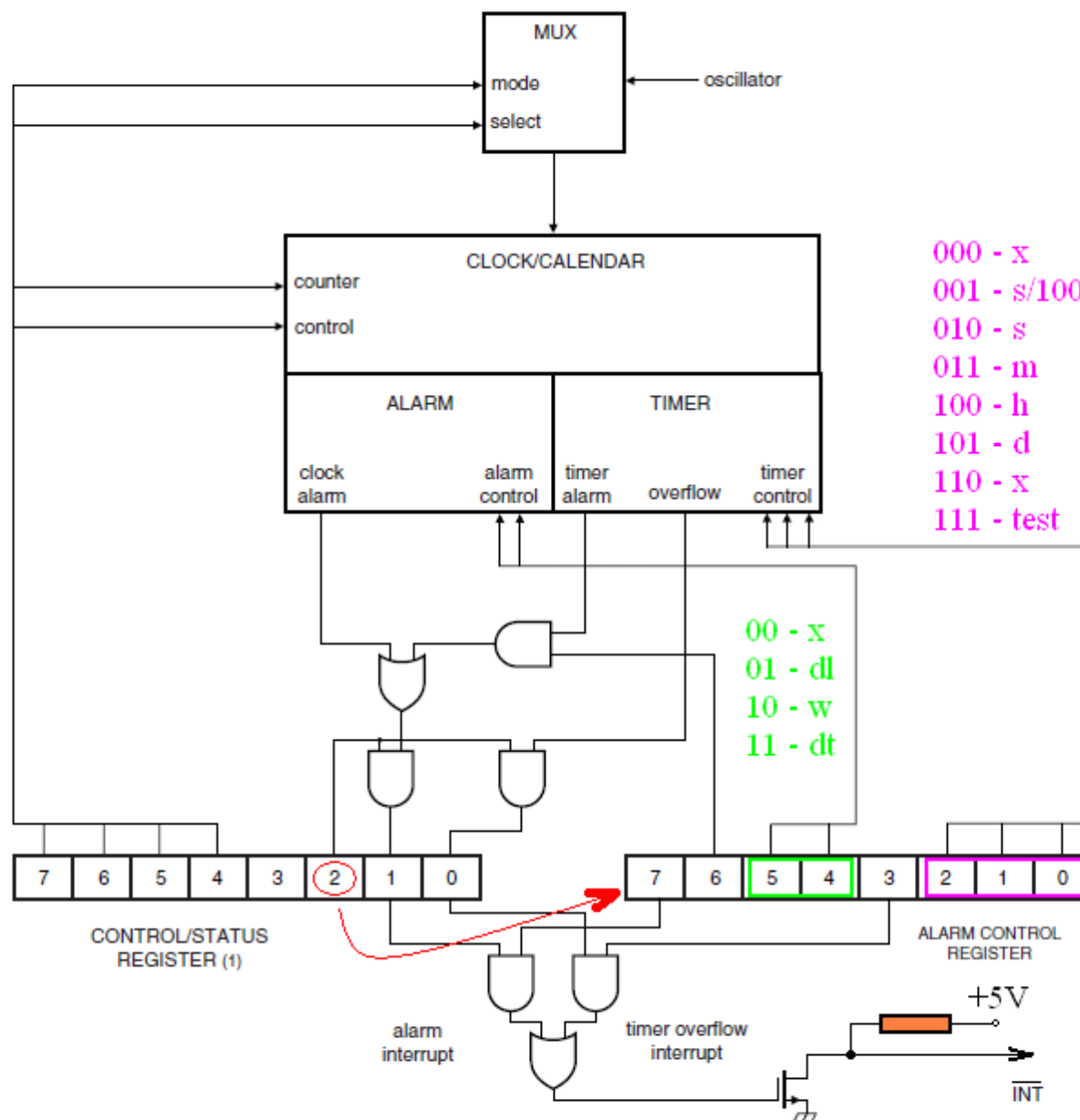
control/status	00h
hundredth of a second 1/10 s 1/100 s	01h
seconds 10 s 1 s	02h
minutes 10 min 1 min	03h
hours 10 h 1 h	04h
year/date 10 day 1 day	05h
weekdays/months 10 month 1 month	06h
timer 10 day 1 day	07h

alarm control	08h
hundredth of a second alarm 1/10 s 1/100 s	09h
alarm seconds	0Ah
alarm minutes	0Bh
alarm hours	0Ch
alarm date	0Dh
alarm month	0Eh
alarm timer	0Fh

+8h

Typy alarmov:

- „čas“ v rámci dňa
- „čas“ v rámci dňa + deň v mesiaci
- „čas“ v rámci dňa + deň v týždni



- (1) If the alarm enable bit of the control and status register is reset (logic 0), a 1 Hz signal is observed on the interrupt pin $\overline{\text{INT}}$.

Alarm and timer interrupt logic diagram

Alarm

01h	1/10 s			1/100 s	09h
02h	10 s			1 s	0Ah
03h	10 min			1 min	0Bh
04h	12/24	PM/AM	10 h	1 h	0Ch
05h	Y E A R		10 d a y	1 d a y	0Dh

if C/S (b3) = 1 => READ (0 0)

06h	week	day	10 m	1 month	0Eh
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if C/S (b3) = 1 => READ (0 0 0)

PCF 8583

	b7	b6	b5	b4	b3	b2	b1	b0
01h	1/10 s				1/100 s			
02h	10 s				1 s			
03h	10 min				1 min			
04h	12/24	PM/AM	10 h		1 h			

ACR (b5,b4) = 01 - daily alarm

x	6	5	4	3	2	1	0
---	---	---	---	---	---	---	---

01h	1/10 s				1/100 s			
02h	10 s				1 s			
03h	10 min				1 min			
04h	12/24	PM/AM	10 h		1 h			

ACR (b5,b4) = 10 - weekday alarm

Navolíme dni v týždni

+								
06h	week day			-	-	-	-	-

≡	x	6	5	4	3	2	1	0	0Eh
---	---	---	---	---	---	---	---	---	-----

01h	1/10 s				1/100 s			
02h	10 s				1 s			
03h	10 min				1 min			
04h	12/24	PM/AM	10 h		1 h			

ACR (b5,b4) = 11 - dated alarm

+								
05h	x	x	10 day		1 day			
06h	x	x	x	10 m	1 month			

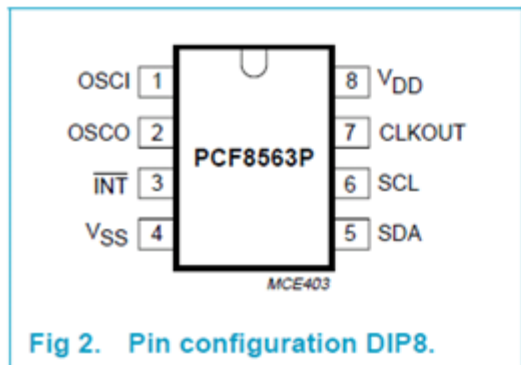
0Dh
0Eh

AlarmControlRegister

PCF8563

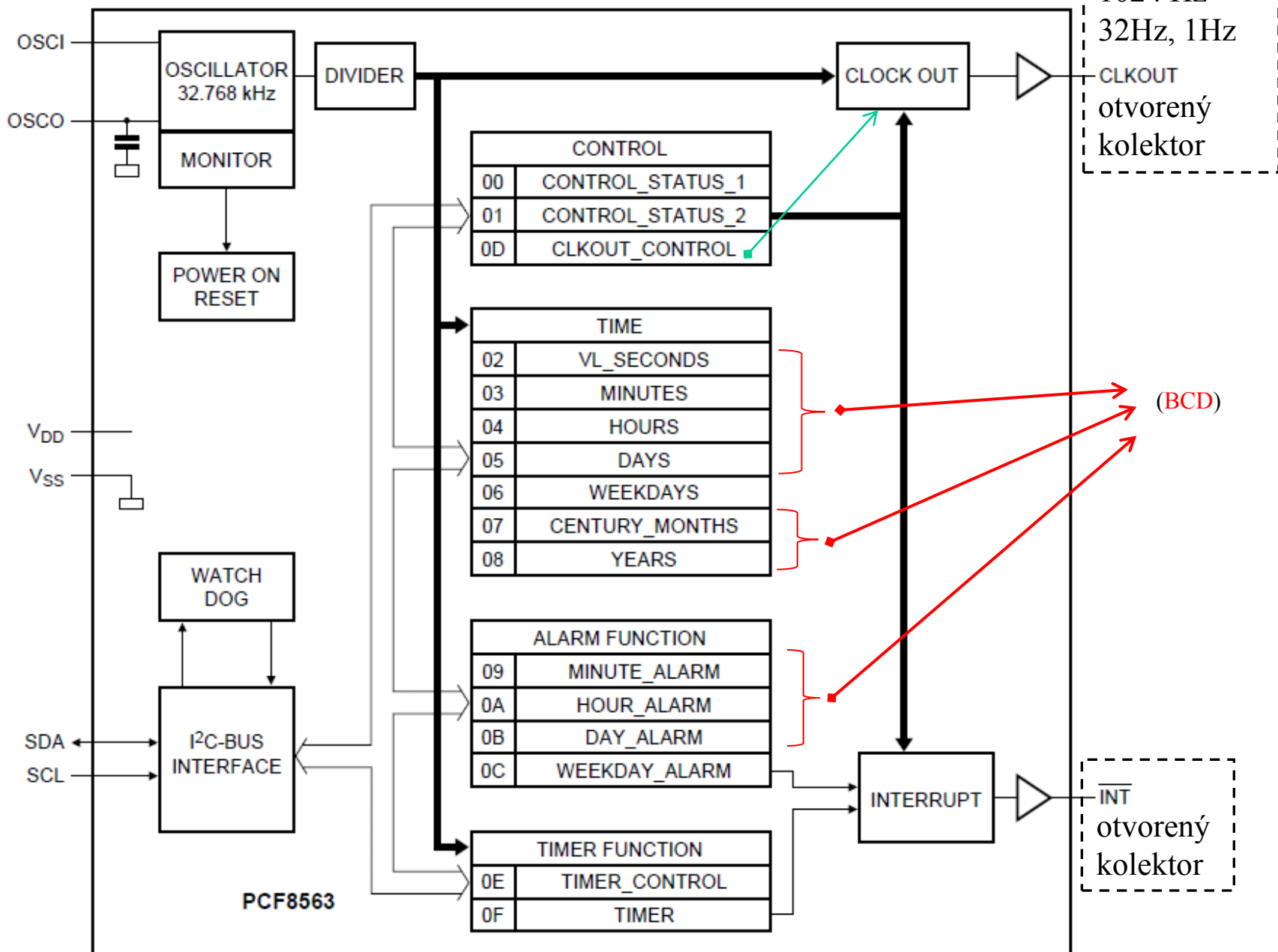
Vlastnosti:

- CMOS RTC (roky (príznak storočí), mesiac, deň, deň v týždni, hodiny, minúty, sekundy); 16 8b-ových registrov (nie všetky bity sú implementované)
- I2C; až do 400 kb/s; slave adresa pre: RD A3h
WR A2h
- má zabudovaný obvod detekcie poklesu napájania
- zabudovaný AC sa inkrementuje automaticky po každom RD resp. WR.
- pri RD, resp. WR obsah počítadiel sa „odpamätá“. To znamená, že pri prenose cez rády sa negeneruje chyba.
- zabudovaný 32768Hz osc.
- obsah počítadiel je ukladaný v BCD formáte



Symbol	Pin	Description
OSCI	1	oscillator input
OSCO	2	oscillator output
$\overline{\text{INT}}$	3	interrupt output (open-drain; active LOW)
V _{SS}	4	ground
SDA	5	serial data input and output
SCL	6	serial clock input
CLKOUT	7	clock output, open-drain
V _{DD}	8	positive supply voltage

PCF8563



Formatted registers overview

Bit positions labelled as x are not relevant. Bit positions labelled with N should always be written with logic 0; if read they could be either logic 0 or logic 1. After reset, all registers are set according to [Table 27](#).

Address	Register name	Bit							
		7	6	5	4	3	2	1	0

Control and status registers

00h	Control_status_1	TEST1	N	STOP	N	TESTC	N	N	N
01h	Control_status_2	N	N	N	TI_TP	AF	TF	AIE	TIE

Time and date registers

02h	VL_seconds	VL	SECONDS (0 to 59) (BCD)				
03h	Minutes	x	MINUTES (0 to 59) (BCD)				
04h	Hours	x	x	HOURS (0 to 23) (BCD)			
05h	Days	x	x	DAYS (1 to 31) (BCD)			
06h	Weekdays	x	x	x	x	x	WEEKDAYS (0 to 6)
07h	Century_months	C	x	x	MONTHS (1 to 12) (BCD)		
08h	Years	YEARS (0 to 99) (BCD)					

Alarm registers

09h	Minute_alarm	AE_M	MINUTE_ALARM (0 to 59) (BCD)						
0Ah	Hour_alarm	AE_H	x	HOUR_ALARM (0 to 23) (BCD)					
0Bh	Day_alarm	AE_D	x	DAY_ALARM (1 to 31) (BCD)					
0Ch	Weekday_alarm	AE_W	x	x	x	x	WEEKDAY_ALARM (0 to 6)		

CLKOUT control register

0Dh	CLKOUT_control	FE	x	x	x	x	x	FD[1:0]	
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Timer registers

0Eh	Timer_control	TE	x	x	x	x	x	TD[1:0]
0Fh	Timer	TIMER[7:0]						



Control registers

Control_status_1 - control and status register 1 (address 00h) bit description

Bit	Symbol	Value	Description
7	TEST1	0	normal mode must be set to logic 0 during normal operations
		1	EXT_CLK test mode
6	N	0	unused
5	STOP	0	RTC source clock runs
		1	all RTC divider chain flip-flops are asynchronously set to logic 0; the RTC clock is stopped (CLKOUT at 32.768 kHz is still available)
4	N	0	unused
3	TESTC	0	Power-On Reset (POR) override facility is disabled; set to logic 0 for normal operation
		1	Power-On Reset (POR) override may be enabled
2 to 0	N	000	unused

Control_status_2 - control and status register 2 (address 01h) bit description

Bit	Symbol	Value	Description
7 to 5	N	000 ^[1]	unused
4	TI_TP	0 ^[2]	$\overline{\text{INT}}$ is active when TF is active (subject to the status of TIE)
		1	$\overline{\text{INT}}$ pulses active according to Table 7 (subject to the status of TIE); Remark: note that if AF and AIE are active then $\overline{\text{INT}}$ will be permanently active
3	AF	0 ^[2]	read: alarm flag inactive write: alarm flag is cleared
		1	read: alarm flag active write: alarm flag remains unchanged
2	TF	0 ^[2]	read: timer flag inactive write: timer flag is cleared
		1	read: timer flag active write: timer flag remains unchanged
1	AIE	0 ^[2]	alarm interrupt disabled
		1	alarm interrupt enabled
0	TIE	0 ^[2]	timer interrupt disabled
		1	timer interrupt enabled

[1] Bits labeled as N should always be written with logic 0.

[2] Default value.

VL_seconds - seconds and clock integrity status register (address 02h) bit description

Bit	Symbol	Value	Place value	Description	
7	VL	0	-	clock integrity is guaranteed	OK
		1	Start-up value.	integrity of the clock information is not guaranteed	/OK
6 to 4	SECONDS	0 to 5	ten's place	actual seconds coded in BCD format, see Table 9	
3 to 0		0 to 9	unit place		

Minutes - minutes register (address 03h) bit description

Bit	Symbol	Value	Place value	Description
7	-	-	-	unused
6 to 4	MINUTES	0 to 5	ten's place	actual minutes coded in BCD format
3 to 0		0 to 9	unit place	

Hours - hours register (address 04h) bit description

Bit	Symbol	Value	Place value	Description
7 to 6	-	-	-	unused
5 to 4	HOURS	0 to 2	ten's place	actual hours coded in BCD format
3 to 0		0 to 9	unit place	

Days - days register (address 05h) bit description

Bit	Symbol	Value	Place value	Description
7 to 6	-	-	-	unused
5 to 4	DAYS ^[1]	0 to 3	ten's place	actual day coded in BCD format
3 to 0		0 to 9	unit place	

[1] The PCF8563 compensates for leap years by adding a 29th day to February if the year counter contains a value which is exactly divisible by 4, including the year 00.

Weekdays - weekdays register (address 06h) bit description

Bit	Symbol	Value	Description
7 to 3	-	-	unused
2 to 0	WEEKDAYS	0 to 6	actual weekday values, see :

Weekday assignments

Day	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Sunday	x	x	x	x	x	0	0	0
Monday	x	x	x	x	x	0	0	1
Tuesday	x	x	x	x	x	0	1	0
Wednesday	x	x	x	x	x	0	1	1
Thursday	x	x	x	x	x	1	0	0
Friday	x	x	x	x	x	1	0	1
Saturday	x	x	x	x	x	1	1	0

Months/century (address 07H) bits description

Bit	Symbol	Value	Description
7	century ^[1]		this bit is toggled when the years register overflows from 99 to 00
		0	indicates the century is 20xx
		1	indicates the century is 19xx
4 to 0	month	01 to 12	this register holds the current month coded in BCD format, see Table 16

Month assignments

Month	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
January	C	x	x	0	0	0	0	1
February	C	x	x	0	0	0	1	0
March	C	x	x	0	0	0	1	1
April	C	x	x	0	0	1	0	0
May	C	x	x	0	0	1	0	1
June	C	x	x	0	0	1	1	0
July	C	x	x	0	0	1	1	1
August	C	x	x	0	1	0	0	0
September	C	x	x	0	1	0	0	1
October	C	x	x	1	0	0	0	0
November	C	x	x	1	0	0	0	1
December	C	x	x	1	0	0	1	0

Years (address 08H) bits description

Bit	Symbol	Value	Description
7 to 0	years	00 to 99	this register holds the current year coded in BCD format

Century_months - century flag and months register (address 07h) bit description

Bit	Symbol	Value	Place value	Description
7	C ^[1]	0 ^[2]	-	indicates the century is x
		1	-	indicates the century is x + 1
6 to 5	-	-	-	unused
4	MONTHS	0 to 1	ten's place	actual month coded in BCD format, see
3 to 0		0 to 9	unit place	

[1] This bit may be re-assigned by the user.

[2] This bit is toggled when the register Years overflows from 99 to 00.

Month assignments in BCD format

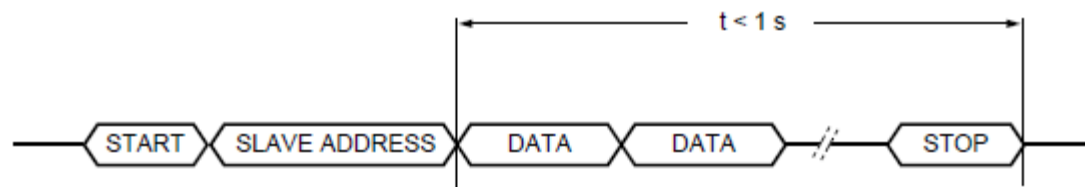
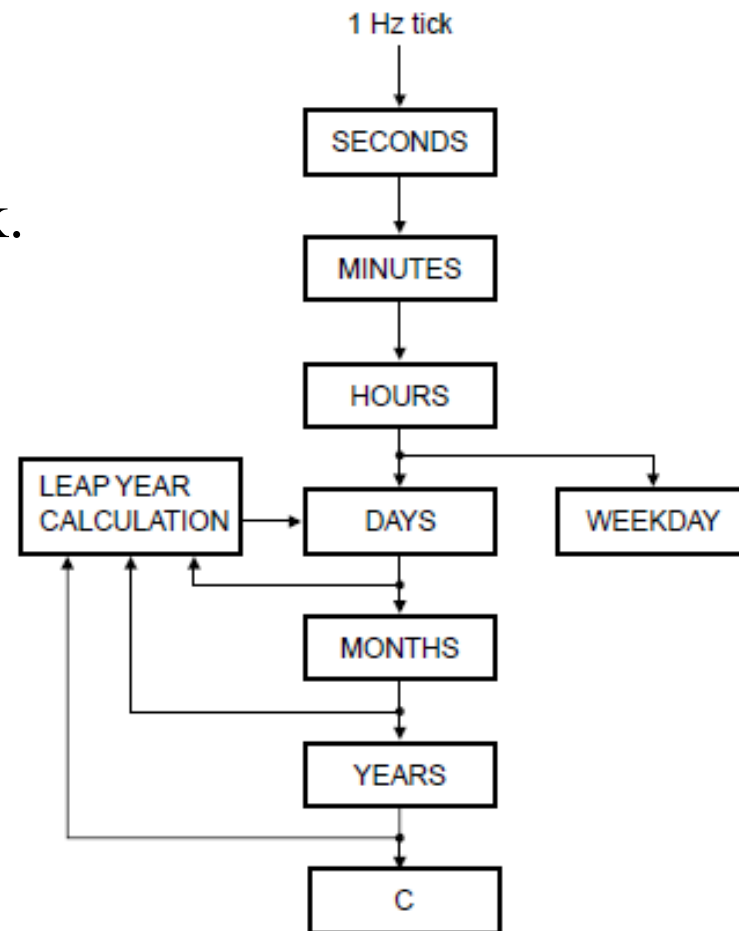
Month	Upper-digit (ten's place)	Digit (unit place)			
	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
January	0	0	0	0	1
February	0	0	0	1	0
March	0	0	0	1	1
April	0	0	1	0	0
May	0	0	1	0	1
June	0	0	1	1	0
July	0	0	1	1	1
August	0	1	0	0	0
September	0	1	0	0	1
October	1	0	0	0	0
November	1	0	0	0	1
December	1	0	0	1	0

Years - years register (08h) bit description

Bit	Symbol	Value	Place value	Description
7 to 4	YEARS	0 to 9	ten's place	actual year coded in BCD format ^[1]
3 to 0		0 to 9	unit place	

[1] When the register Years overflows from 99 to 00, the century bit C in the register Century_months is toggled.

Počas RD, WR je inkrement na 1 sek.
pozastavený.



Minute_alarm - minute alarm register (address 09h) bit description

Bit	Symbol	Value	Place value	Description
7	AE_M	0	-	minute alarm is enabled
		1[1]	-	minute alarm is disabled
6 to 4	MINUTE_ALARM	0 to 5	ten's place	minute alarm information coded in BCD format
3 to 0		0 to 9	unit place	

[1] Default value.

Hour_alarm - hour alarm register (address 0Ah) bit description

Bit	Symbol	Value	Place value	Description
7	AE_H	0	-	hour alarm is enabled
		1[1]	-	hour alarm is disabled
6	-	-	-	unused
5 to 4	HOUR_ALARM	0 to 2	ten's place	hour alarm information coded in BCD format
3 to 0		0 to 9	unit place	

[1] Default value.

Day_alarm - day alarm register (address 0Bh) bit description

Bit	Symbol	Value	Place value	Description
7	AE_D	0	-	day alarm is enabled
		1[1]	-	day alarm is disabled
6	-	-	-	unused
5 to 4	DAY_ALARM	0 to 3	ten's place	day alarm information coded in BCD format
3 to 0		0 to 9	unit place	

[1] Default value.

Weekday_alarm - weekday alarm register (address 0Ch) bit description

Bit	Symbol	Value	Description
7	AE_W	0	weekday alarm is enabled
		1 ^[1]	weekday alarm is disabled
6 to 3	-	-	unused
2 to 0	WEEKDAY_ALARM	0 to 6	weekday alarm information

[1] Default value.

Priestupný rok

Rok, v ktorom je jeden deň navyše.

Dôvod: Synchronizácia s astronomickým rokom, ktorého dĺžka je cca 365,25 dňa.

Skutočnosť je trochu kratšia. Preto nie každý štvrtý rok je priestupný.

Zo storočí sú priestupné len tie, ktoré sú súčasne bezo zvyšku deliteľné 100-ou a 400-ou.

Napr.: obvod PCF8563 bude považovať rok 2100 za priestupný, aj keď nie je.

Obvod PCF8583 počíta roky modulo štyri, to znamená treba ošetriť priestupné roky softwarovo.

Priestupný rok

PCF8563 & PCA8565:

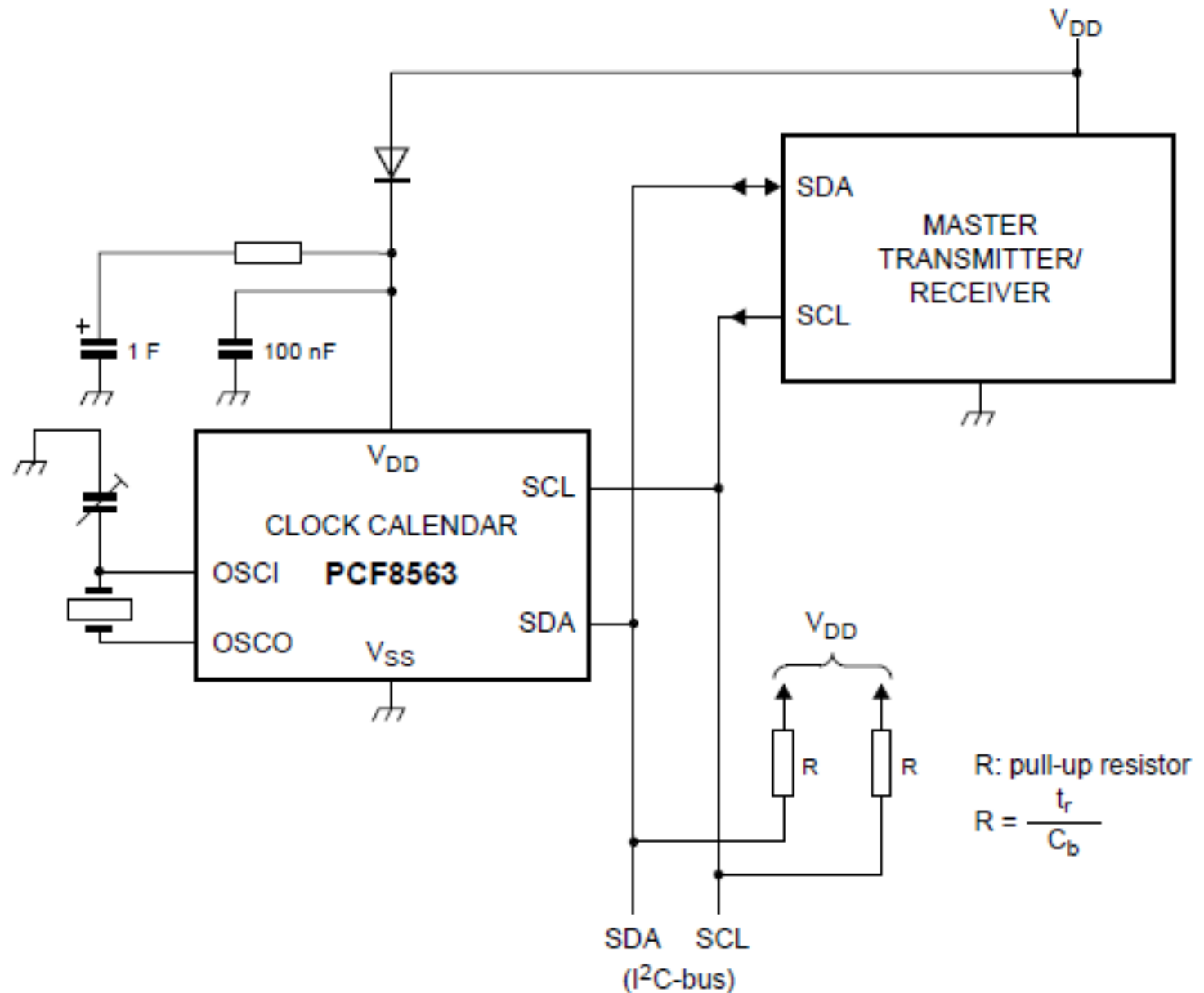
- 8-bit register rokov v BCD formate.
- Na určenie storočia je vyhradení jednobitový príznak.
Tento príznak sa zmení, ak rok „pretečie“. 99 → 00.

PCF8583 & PCF8593:

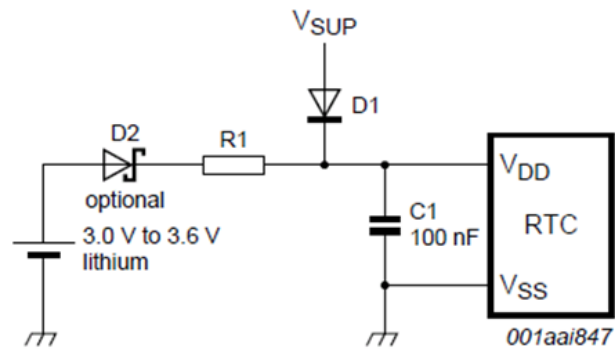
- tieto obvody majú štvorročný kalendár.

Atd'.

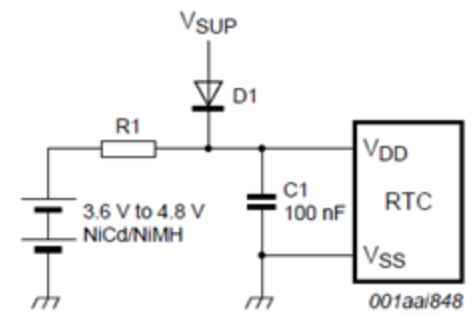
Pripojenie na I2C zbernicu.



Napájanie:



D2 may not always be necessary. Refer to text.
Backup circuit using primary lithium cell



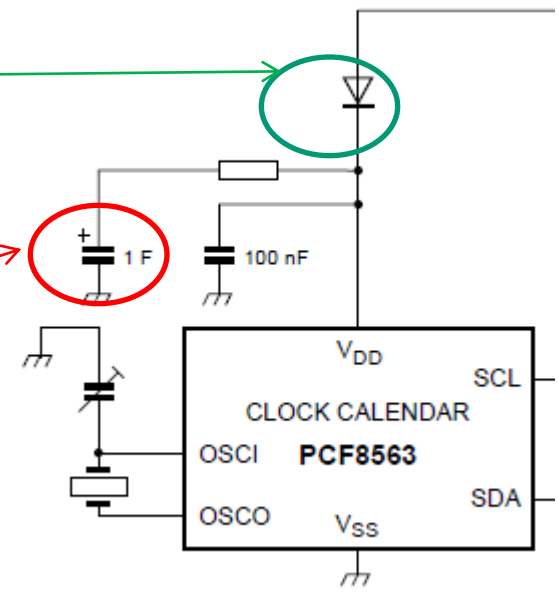
Due to the low RTC current consumption, a parallel diode over R₁ (directed from the battery to the RTC) will not be of any use.
The voltage drop over R₁ is small
Backup circuit using secondary cell (NiCd or NiMH)

Some suggestions for diode D1

	1N4148	BAS45A	BAS45AL	BAS716	BAS116	BAV170
Package	leaded	leaded	SMD	SMD	SMD	SMD
Typ. reverse current I _R at 25 °C	-	0.2 nA	0.2 nA	0.2 nA	3 pA	3 pA
Max. reverse current I _R at 25 °C	25 nA	1 nA	1 nA	5 nA	5 nA	5 nA
Price indication, relative w.r.t. 1N4148	1 (0.02 \$)	7x	8x	3.5x	3x	3x

Overview of common backup supply components and key selection criteria

Technology	Operating Temperature [° C]	Self-discharge rate	Charging circuit and nr. of cycles	Backup time	Cost	Restrictions on disposal and safety
Primary Lithium	-30 to +80	Low	n.a.	Long	Low	High
Rechargeable (NiCd / NiMH)	0 to +40 (during charging)	Medium	Simple / ± 500	Short	Medium	Medium
Super Capacitor	-40 to +85	High	Simple / unlimited	Short	Medium / High	Low



“ppm”

“The second (abbreviation, s or sec) is the Standard International (SI) unit of time.

One second is the time that elapses during 9,192,631,770 (9.192631770×10^9) cycles of the radiation produced by the transition between two levels of the cesium 133 atom.”

To odpovedá chybe 1s za niekoľko milion rokov. Čo je cca 10^{-8} ppm.

Čo je to 1ppm?

Čo to znamená, ak povieme hodiny utekajú/meškajú 1s/deň?

$1s / (\text{počet sekund za deň}) = 1 / (24 \times 3600) = 11,57 \text{ ppm}$

$1 \text{ s/year} = 0.031 \text{ ppm.}$