Maskinorienterad programmering 2013/2014

CPU12 Reference Guide
Stencil: ”Assemblerprogrammering.pdf”

Ur innehållet:

- Räknarkretsar (”TIMERS”)
- Pulsbreddsmodulering (”PWM”)
- Analog-/Digital- omvandling (”AD”)
- Seriekommunikation, RS232

CRG, Clock Reset Generator

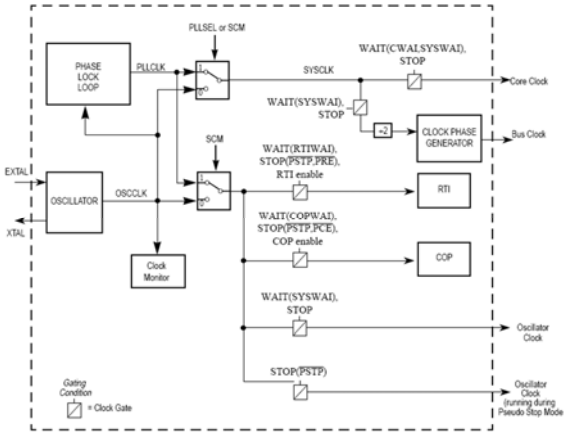
HCS12 har programmerbar arbetstakt . Kontrolleras från CRG-modul.

Address Offset	Use	Access
$_00	CRG Synthesizer Register (SYNR)	R/W
$_01	CRG Reference Divider Register (REFDV)	R/W
$_02	CRG Test Flags Register (CTFLG)[1]	R/W
$_03	CRG Flags Register (CRGFLG)	R/W
$_04	CRG Interrupt Enable Register (CRGINT)	R/W
$_05	CRG Clock Select Register (CLKSEL)	R/W
$_06	CRG PLL Control Register (PLLCTL)	R/W
$_07	CRG RTI Control Register (RTICTL)	R/W
$_08	CRG COP Control Register (COPCTL)	R/W
$_09	CRG Force and Bypass Test Register (FORBYP)[2]	R/W
$_0A	CRG Test Control Register (CTCTL)[3]	R/W
$_0B	CRG COP Arm/Timer Reset (ARMCOP)	R/W

NOTES:
1. CTFLG is intended for factory test purposes only.
2. FORBYP is intended for factory test purposes only.
3. CTCTL is intended for factory test purposes only.

$$PLLCLK = 2 \times OSCCLK \times \frac{(SYNR+1)}{(REFDV+1)}$$

BusClock (E) = PLLCLK/2



EXEMPEL: Bestäm busfrekvens

Antag 8 MHz kristall.

PLLCLK får aldrig vara *mindre än* OSCCLK eftersom detta äventyrar stabilitetsvillkoren i oscillatorn.

PLLCLK/2 får aldrig vara *större än* nominella arbetsfrekvensen hos kretsen. För första generationens HCS12 innebär detta att PLLCLK/2 < 25 MHz.

$$50MHz > 2 \times 8MHz \times \frac{(SYNR+1)}{(REFDV+1)}$$

Sätt:
SYNR = 5 och REFDV = 1

$$2 \times 8MHz \times \frac{(5+1)}{(1+1)} = 2 \times 8 \times 3MHz = 48MHz$$

Basadress = $34

Algoritm:
1. Skriv nya värden till SYNR, REFDV.

2. Vänta tills kretsen ”låser” (LOCK=1)

3. Växla till PLL (sätt PPLSEL=1)

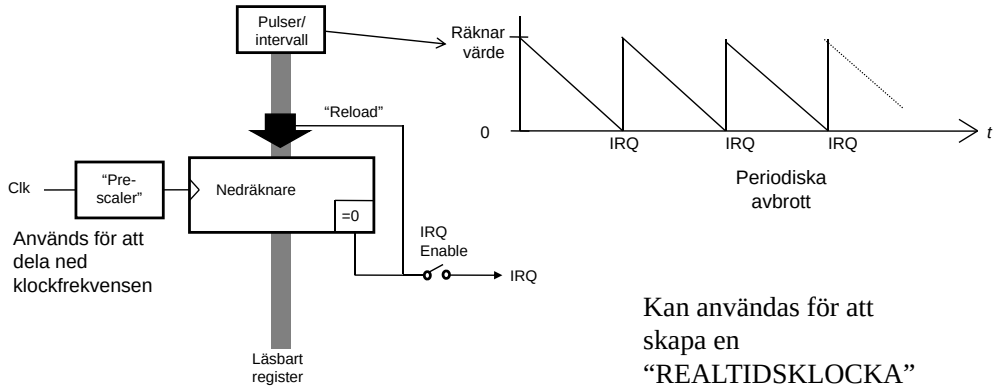
		Clock Reset Generator (CRG)									
Offset		7	6	5	4	3	2	1	0	Mnemonic	Namn
$34	$00 R	0	0	SYN5	SYN4	SYN3	SYN2	SYN1	SYN0	SYNR	Synthesizer Register
	$00 W										
$35	$01 R	0	0	0	0	REFDV3	REFDV2	REFDV1	REFDV0	REFDV	Reference Divide Register
	$01 W										
$36	$02 R	0	0	0	0	0	0	0	0	CTFLG	*)Test Flags Register
	$02 W										
$37	$03 R	RTIF	PORF	LVRF	LOCKIF	LOCK	SCMIE	SCMIF	SCM	CRGFLG	Flags Register
	$03 W										
$38	$04 R	RTIE	0	0	LOCKIE	0	0	SCMIE	0	CRGINT	Interrupt Enable Register
	$04 W										
$39	$05 R	PLLSEL	PSTP	SYSWAI	ROAWAI	PLLWAI	CWAI	RTIWAI	COPWAI	CLKSEL	Clock Select Register
	$05 W										
$3A	$06 R	CME	PLLON	AUTO	AOQ	0	PRE	PCE	SCME	PLLCTL	PLL Control Register
	$06 W										
$3B	$07 R	0	RTR6	RTR5	RTR4	RTR3	RTR2	RTR1	RTR0	RTICTL	RTI Control Register
	$07 W										
$3C	$08 R	WCOP	RSBCK	0	0	0	CR2	CR1	CR0	COPCTL	COP Control Register
	$08 W										
$3D	$09 R	0	0	0	0	0	0	0	0	FORBYP	*)Force and Bypass Test Register
	$09 W										
$3E	$0A R	0	0	0	0	0	0	0	0	CTCTL	*)Test Control Register
	$0A W										
$3F	$0B R	0	0	0	0	0	0	0	0	ARMCOP	COP Arm/Timer Reset
	$0B W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0		

	Clock Reset Generator (CRG)											
	Offset		7	6	5	4	3	2	1	0	Mnemonic	Namn
$34	$00	R	0	0	SYN5	SYN4	SYN3	SYN2	SYN1	SYN0	SYNR	Synthesizer Register
		W										
$35	$01	R	0	0	0	0	REFDV3	REFDV2	REFDV1	REFDV0	REFDV	Reference Divide Register
		W										
$36	$02	R	0	0	0	0	0	0	0	0	CTFLG	*)Test Flags Register
		W										
$37	$03	R	RTIF	PORF	LVRF	LOCKIF	LOCK	SCMIE	SCMIF	SCM	CRGFLG	Flags Register
		W										
$38	$04	R	RTIE	0	0	LOCKIE	0	0	SCMIE	0	CRGINT	Interrupt Enable Register
		W										
$39	$05	R	PLLSEL	PSTP	SYSWAI	ROAWAI	PLLWAI	CWAI	RTIWAI	COPWAI	CLKSEL	Clock Select Register
		W										
$3A	$06	R	CME	PLLON	AUTO	AOQ	0	PRE	PCE	SCME	PLLCTL	PLL Control Register
		W										
$3B	$07	R	0	RTR6	RTR5	RTR4	RTR3	RTR2	RTR1	RTR0	RTICTL	RTI Control Register
		W										
$3C	$08	R	WCOP	RSBCK	0	0	0	CR2	CR1	CR0	COPCTL	COP Control Register
		W										
$3D	$09	R	0	0	0	0	0	0	0	0	FORBYP	*)Force and Bypass Test Register
		W										
$3E	$0A	R	0	0	0	0	0	0	0	0	CTCTL	*)Test Control Register
		W										
$3F	$0B	R	0	0	0	0	0	0	0	0	ARMCOP	COP Arm/Timer Reset
		W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0		

..programmering..

Implementera i assembler och 'C'
... Vi löser på tavlan...

Räknarkrets ("timer"), principiell funktion



Kan användas för att skapa en "REALTIDSKLOCKA"

Realtidsklocka i HCS12

Address Offset	Use	Access
$_00	CRG Synthesizer Register (SYNR)	R/W
$_01	CRG Reference Divider Register (REFDV)	R/W
$_02	CRG Test Flags Register (CTFLG)[1]	R/W
$_03	CRG Flags Register (CRGFLG)	R/W
$_04	CRG Interrupt Enable Register (CRGINT)	R/W
$_05	CRG Clock Select Register (CLKSEL)	R/W
$_06	CRG PLL Control Register (PLLCTL)	R/W
$_07	CRG RTI Control Register (RTICTL)	R/W
$_08	CRG COP Control Register (COPCTL)	R/W
$_09	CRG Force and Bypass Test Register (FORBYP)[2]	R/W
$_0A	CRG Test Control Register (CTCTL)[3]	R/W
$_0B	CRG COP Arm/Timer Reset (ARMCOP)	R/W

NOTES:
1. CTFLG is intended for factory test purposes only.
2. FORBYP is intended for factory test purposes only.
3. CTCTL is intended for factory test purposes only.

Tre olika register används för realtidsklockan

Realtidsklocka i HCS12, initiering

Algoritm, initiering

2. Aktivera avbrott från kretsen

1. Skriv tidbas för avbrottsintervall till RTICTL

Clock Reset Generator (CRG)

	Offset		7	6	5	4	3	2	1	0	Mnemonic	Namn
$34	$00	R	0	0	SYN5	SYN4	SYN3	SYN2	SYN1	SYN0	SYNR	Synthesizer Register
		W										
$35	$01	R	0	0	0	0	REFDV3	REFDV2	REFDV1	REFDV0	REFDV	Reference Divide Register
		W										
$36	$02	R	0	0	0	0	0	0	0	0	CTFLG	*)Test Flags Register
		W										
$37	$03	R	RTIF	PORF	LVRF	LOCKIF	LOCK	SCMIE	SCMIF	SCM	CRGFLG	Flags Register
		W										
$38	$04	R	RTIE	0	0	LOCKIE	0	0	SCMIE	0	CRGINT	Interrupt Enable Register
		W										
$39	$05	R	PLLSEL	PSTP	SYSWAI	ROAWAI	PLLWAI	CWAI	RTIWAI	COPWAI	CLKSEL	Clock Select Register
		W										
$3A	$06	R	CME	PLLON	AUTO	AOQ	0	PRE	PCE	SCME	PLLCTL	PLL Control Register
		W										
$3B	$07	R	0	RTR6	RTR5	RTR4	RTR3	RTR2	RTR1	RTR0	RTICTL	RTI Control Register
		W										
$3C	$08	R	WCOP	RSBCK	0	0	0	CR2	CR1	CR0	COPCTL	COP Control Register
		W										
$3D	$09	R	0	0	0	0	0	0	0	0	FORBYP	*)Force and Bypass Test Register
		W										
$3E	$0A	R	0	0	0	0	0	0	0	0	CTCTL	*)Test Control Register
		W										
$3F	$0B	R	0	0	0	0	0	0	0	0	ARMCOP	COP Arm/Timer Reset
		W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0		

”Prescaler” för räknarkretsen

$$\frac{OSCCLK}{RTR} = RTIfreq$$

RTR [3:0]	RTR[6:4]							
	000 (OFF)	001	010	011	100	101	110	111
0000	OFF	2^{10}	2^{11}	2^{12}	2^{13}	2^{14}	2^{15}	2^{16}
0001	OFF	$2x2^{10}$	$2x2^{11}$	$2x2^{12}$	$2x2^{13}$	$2x2^{14}$	$2x2^{15}$	$2x2^{16}$
0010	OFF	$3x2^{10}$	$3x2^{11}$	$3x2^{12}$	$3x2^{13}$	$3x2^{14}$	$3x2^{15}$	$3x2^{16}$
0011	OFF	$4x2^{10}$	$4x2^{11}$	$4x2^{12}$	$4x2^{13}$	$4x2^{14}$	$4x2^{15}$	$4x2^{16}$
0100	OFF	$5x2^{10}$	$5x2^{11}$	$5x2^{12}$	$5x2^{13}$	$5x2^{14}$	$5x2^{15}$	$5x2^{16}$
0101	OFF	$6x2^{10}$	$6x2^{11}$	$6x2^{12}$	$6x2^{13}$	$6x2^{14}$	$6x2^{15}$	$6x2^{16}$
0110	OFF	$7x2^{10}$	$7x2^{11}$	$7x2^{12}$	$7x2^{13}$	$7x2^{14}$	$7x2^{15}$	$7x2^{16}$
0111	OFF	$8x2^{10}$	$8x2^{11}$	$8x2^{12}$	$8x2^{13}$	$8x2^{14}$	$8x2^{15}$	$8x2^{16}$
1000	OFF	$9x2^{10}$	$9x2^{11}$	$9x2^{12}$	$9x2^{13}$	$9x2^{14}$	$9x2^{15}$	$9x2^{16}$
1001	OFF	$10x2^{10}$	$10x2^{11}$	$10x2^{12}$	$10x2^{13}$	$10x2^{14}$	$10x2^{15}$	$10x2^{16}$
1010	OFF	$11x2^{10}$	$11x2^{11}$	$11x2^{12}$	$11x2^{13}$	$11x2^{14}$	$11x2^{15}$	$11x2^{16}$
1011	OFF	$12x2^{10}$	$12x2^{11}$	$12x2^{12}$	$12x2^{13}$	$12x2^{14}$	$12x2^{15}$	$12x2^{16}$
1100	OFF	$13x2^{10}$	$13x2^{11}$	$13x2^{12}$	$13x2^{13}$	$13x2^{14}$	$13x2^{15}$	$13x2^{16}$
1101	OFF	$14x2^{10}$	$14x2^{11}$	$14x2^{12}$	$14x2^{13}$	$14x2^{14}$	$14x2^{15}$	$14x2^{16}$
1110	OFF	$15x2^{10}$	$15x2^{11}$	$15x2^{12}$	$15x2^{13}$	$15x2^{14}$	$15x2^{15}$	$15x2^{16}$
1111	OFF	$16x2^{10}$	$16x2^{11}$	$16x2^{12}$	$16x2^{13}$	$16x2^{14}$	$16x2^{15}$	$16x2^{16}$

Beräkning av tidbas

$$\frac{OSCCLK}{RTR} = RTIfreq \Rightarrow \frac{8\times10^6}{RTR} = \frac{1}{10^{-2}} \Rightarrow RTR = x\times2^y = 8\times10^4$$

(Se även exempel i ”Stencil 2”)
Den bästa approximationen har vi för
RTR = 100 1001 = $49, som medför: $10x2^{13} = 81920$
Eftersom detta värde är något större än det exakta, kommer vi att få en något längre periodtid, nämligen:

avbrottsfrekvens = $8\times10^6 / 81920 = 97.656$ Hz

vilket ger periodtiden:

0.01024 s = 10,24 ms.

Klockan kommer alltså att "gå för sakta" som en följd av detta systematiska fel.

Realtidsklocka i HCS12, vid avbrott

Algoritm, kvittera avbrott

1. RTIF = 1

Clock Reset Generator (CRG)

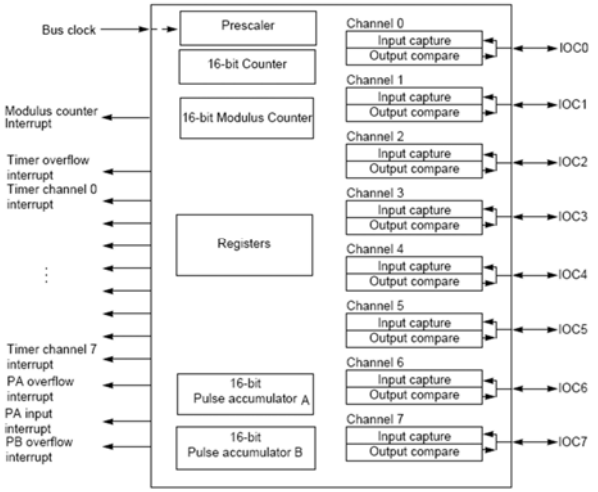
	Offset		7	6	5	4	3	2	1	0	Mnemonic	Namn
$34	$00	R	0	0	SYN5	SYN4	SYN3	SYN2	SYN1	SYN0	SYNR	Synthesizer Register
		W										
$35	$01	R	0	0	0	0	REFDV3	REFDV2	REFDV1	REFDV0	REFDV	Reference Divide Register
		W										
$36	$02	R	0	0	0	0	0	0	0	0	CTFLG	*)Test Flags Register
		W										
$37	$03	R	RTIF	PORF	LVRF	LOCKIF	LOCK	SCMIE	SCMIF	SCM	CRGFLG	Flags Register
		W										
$38	$04	R	RTIE	0	0	LOCKIE	0	0	SCMIE	0	CRGINT	Interrupt Enable Register
		W										
$39	$05	R	PLLSEL	PSTP	SYSWAI	ROAWAI	PLLWAI	CWAI	RTIWAI	COPWAI	CLKSEL	Clock Select Register
		W										
		R			ON	AUTO	AOQ	0	PRE	PCE	SCME	PLLCTL	PLL Control Register
		W										
		R			6	RTR5	RTR4	RTR3	RTR2	RTR1	RTR0	RTICTL	RTI Control Register
		W										
		R			CK	0	0	0	CR2	CR1	CR0	COPCTL	COP Control Register
		W										
		R				0	0	0	0	0	0	FORBYP	*)Force and Bypass Test Register
		W										
		R				0	0	0	0	0	0	CTCTL	*)Test Control Register
		W										
		R				0	0	0	0	0	0	ARMCOP	COP Arm/Timer Reset
		W	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0		

Adress (hex)	Funktion
FFF0	**Real Time Interrupt**
FFEE	Enhanced Capture Timer channel
FFEC	Enhanced Capture Timer channel 1
FFEA	Enhanced Capture Timer channel 2
....	....
FF8E	Port P Interrupt
FF8C	PWM Emergency Shutdown
FF8A-FF80	Reserverade

..programmering..

Implementera i assembler och 'C'
... Vi löser på tavlan...

Realtidsklocka med hög upplösning



"Enhanced Capture Timer" (ECT)

En maskincykels noggrannhet

EXEMPEL:
Arbetstakt= 24 MHz

PERIOD = 24 000

Intervall = 1 ms

Noggrannhet = 1/24 000 000 sek. ≈ $41{,}7 \times 10^{-9}$ sec.

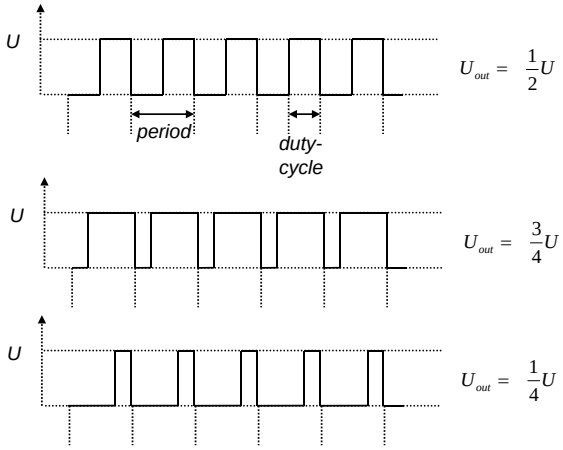
Programexempel

```
TIOS    EQU     $40
TCNT    EQU     $44
TIE     EQU     $4C
TFLG1   EQU     $4E
TOC_0   EQU     $50

PERIOD  EQU     24000

Init:   MOVB    #1,TIOS  ; ch 0 är OC
        MOVB    #1,TIE   ; tillåt IRQ
        LDD     TCNT     ; aktuell cykel
        ADDD    #PERIOD  ; addera period
        STD     TOC_0    ; nästa avbrott
        RTS

        ORG     $FFEE
        FDB     TOCirq
```

```
TOCirq : MOVB    #1,TFLG1 ; kvittera
         LDD     TCNT     ; ny period
         ADDD    #PERIOD
         STD     TOC_0
         RTI
```

Adress (hex)	Funktion
FFF0	Real Time Interrupt
FFEE	**Enhanced Capture Timer channel 0**
FFEC	Enhanced Capture Timer channel 1
FFEA	Enhanced Capture Timer channel 2
....	....
FF8E	Port P Interrupt
FF8C	PWM Emergency Shutdown
FF8A-FF80	Reserverade

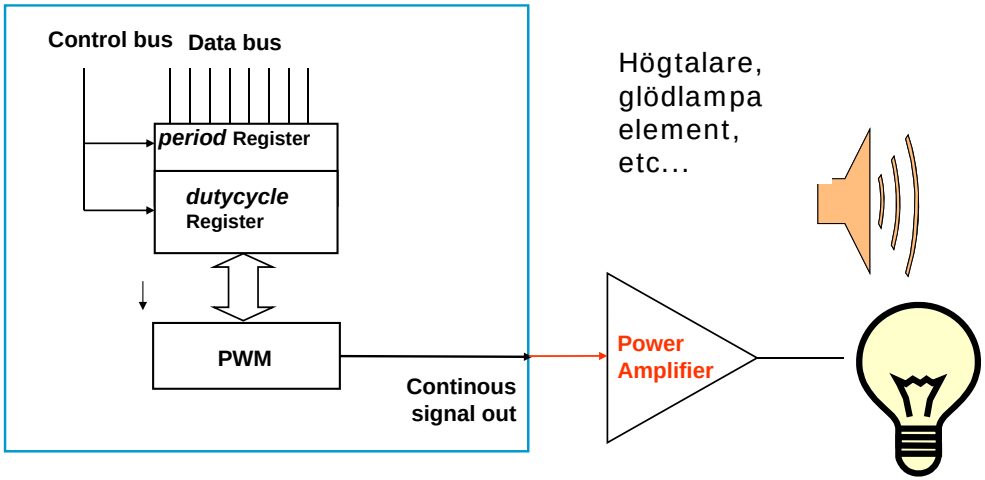
Pulsbreddsmodulering (PWM)

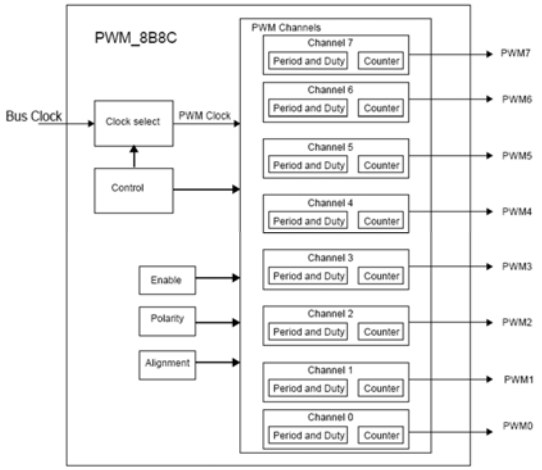


$$U_{out} = \frac{dutycycle}{period}U$$

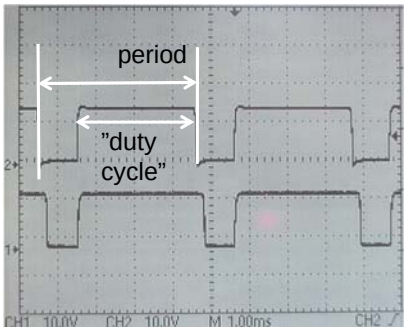
Period och "duty-cycle" är programmerbart

PWM-styrning





8 * 8 bitars
eller
4 * 16 bitars räknare

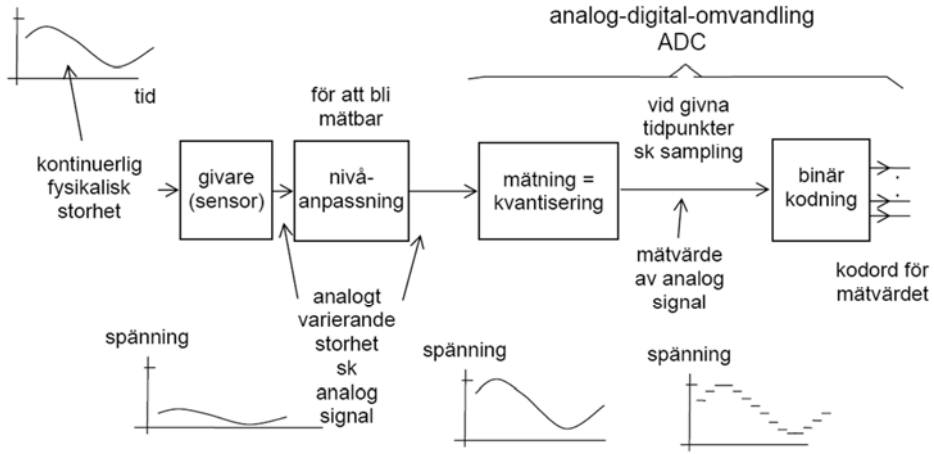


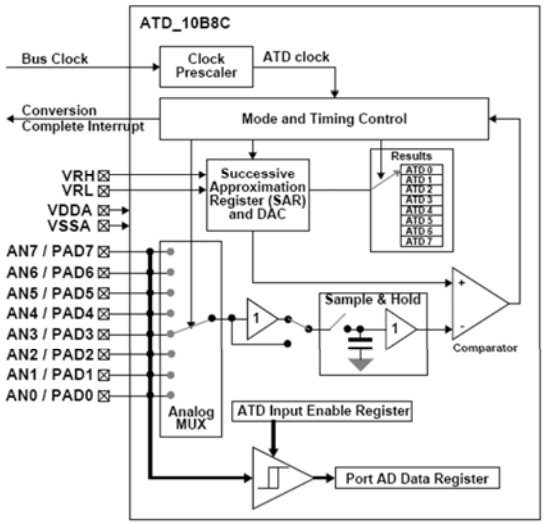
Programexempel

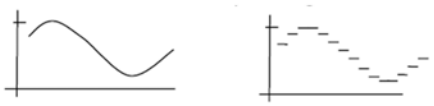
Address	Use	Access
$_00	PWM Enable Register (PWME)	R/W
$_01	PWM Polarity Register (PWMPOL)	R/W
$_02	PWM Clock Select Register (PWMCLK)	R/W
$_03	PWM Prescale Clock Select Register (PWMPRCLK)	R/W
$_04	PWM Center Align Enable Register (PWMCAE)	R/W
$_05	PWM Control Register (PWMCTL)	R/W
$_06	PWM Test Register (PWMTST)[1]	R/W
$_07	PWM Prescale Counter Register (PWMPRSC)[2]	R/W
$_08	PWM Scale A Register (PWMSCLA)	R/W
$_09	PWM Scale B Register (PWMSCLB)	R/W
$_0A	PWM Scale A Counter Register (PWMSCNTA)[3]	R/W
$_0B	PWM Scale B Counter Register (PWMSCNTB)[4]	R/W
$_0C	PWM Channel 0 Counter Register (PWMCNT0)	R/W
$_0D	PWM Channel 1 Counter Register (PWMCNT1)	R/W
$_0E	PWM Channel 2 Counter Register (PWMCNT2)	R/W
$_0F	PWM Channel 3 Counter Register (PWMCNT3)	R/W
$_10	PWM Channel 4 Counter Register (PWMCNT4)	R/W
$_11	PWM Channel 5 Counter Register (PWMCNT5)	R/W
$_12	PWM Channel 6 Counter Register (PWMCNT6)	R/W
$_13	PWM Channel 7 Counter Register (PWMCNT7)	R/W
$_14	PWM Channel 0 Period Register (PWMPER0)	R/W
$_15	PWM Channel 1 Period Register (PWMPER1)	R/W
$_16	PWM Channel 2 Period Register (PWMPER2)	R/W
$_17	PWM Channel 3 Period Register (PWMPER3)	R/W
$_18	PWM Channel 4 Period Register (PWMPER4)	R/W
$_19	PWM Channel 5 Period Register (PWMPER5)	R/W
$_1A	PWM Channel 6 Period Register (PWMPER6)	R/W
$_1B	PWM Channel 7 Period Register (PWMPER7)	R/W
$_1C	PWM Channel 0 Duty Register (PWMDTY0)	R/W
$_1D	PWM Channel 1 Duty Register (PWMDTY1)	R/W
$_1E	PWM Channel 2 Duty Register (PWMDTY2)	R/W
$_1F	PWM Channel 3 Duty Register (PWMDTY3)	R/W
$_20	PWM Channel 4 Duty Register (PWMDTY4)	R/W
$_21	PWM Channel 5 Duty Register (PWMDTY5)	R/W
$_22	PWM Channel 6 Duty Register (PWMDTY6)	R/W
$_23	PWM Channel 7 Duty Register (PWMDTY7)	R/W
$_24	PWM Shutdown Register (PWMSDN)	R/W
$_25	Reserved	R
$_26	Reserved	R
$_27	Reserved	R

```
; PWM initiering
PWME            EQU     $A0
PWPOL           EQU     $A1
PWMPRCLK        EQU     $A3
PWMPER0         EQU     $B4
PWMDTY0         EQU     $BC

; låg nivå startar period
        CLR     PWMPOL

; c:a 4 ms periodtid
        MOVB    #$77,PWMPRCLK

; pwm kanal 0
        MOVB    #$FF,PWMPER0

; börja med 80% duty cycle..
        MOVB    #$D0,PWMDTY0

; aktivera kanal 0
        MOVB    #1,PWME
```


Analog-/Digital- omvandling







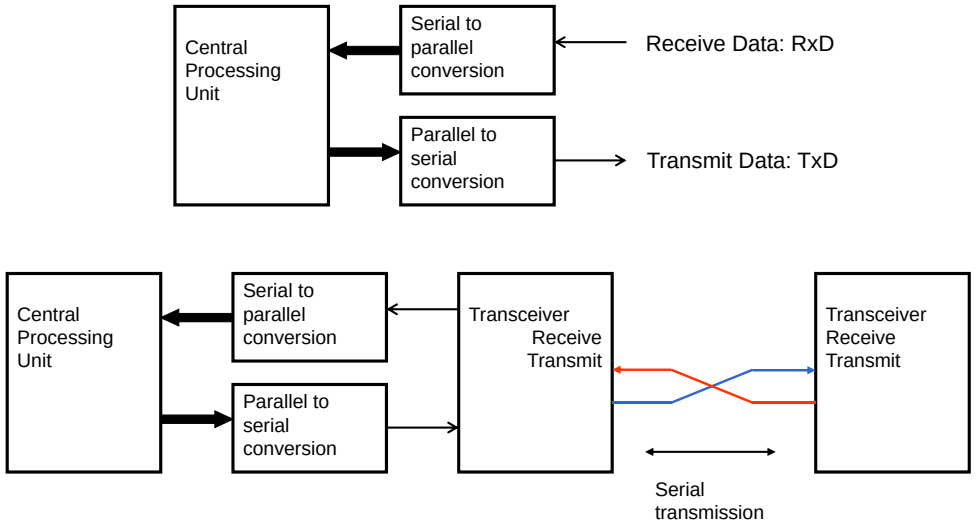
Multiplex
8 kanaler.

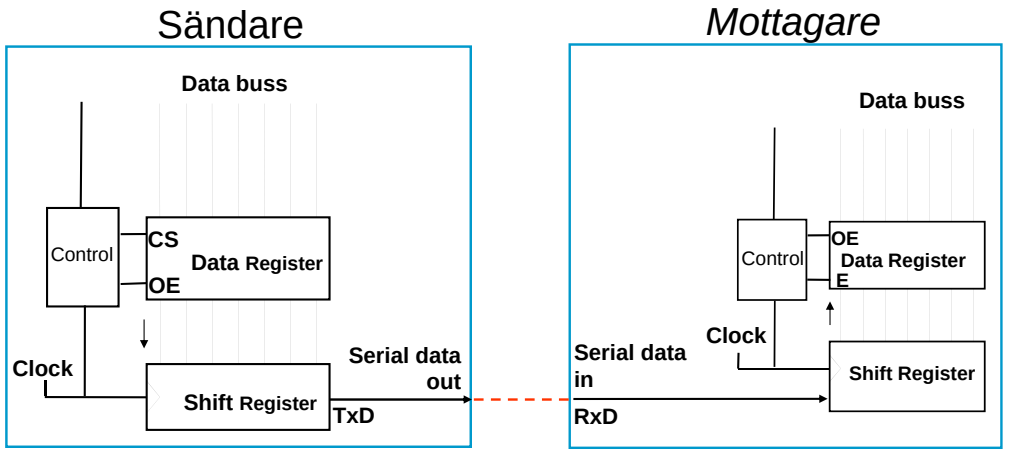
Programexempel

Address Offset	Use	Access
$_00	ATD Control Register 0 (ATDCTL0)[1]	R
$_01	ATD Control Register 1 (ATDCTL1)[2]	R
$_02	ATD Control Register 2 (ATDCTL2)	R/W
$_03	ATD Control Register 3 (ATDCTL3)	R/W
$_04	ATD Control Register 4 (ATDCTL4)	R/W
$_05	ATD Control Register 5 (ATDCTL5)	R/W
$_06	ATD Status Register 0 (ATDSTAT0)	R/W
$_07	Unimplemented	
$_08	ATD Test Register 0 (ATDTEST0)[3]	R
$_09	ATD Test Register 1 (ATDTEST1)	R/W
$_0A	Unimplemented	
$_0B	ATD Status Register 1 (ATDSTAT1)	R
$_0C	Unimplemented	
$_0D	ATD Input Enable Register (ATDDIEN)	R/W
$_0E	Unimplemented	
$_0F	Port Data Register (PORTAD)	R
$_10, $_11	ATD Result Register 0 (ATDDR0H, ATDDR0L)	R/W
$_12, $_13	ATD Result Register 1 (ATDDR1H, ATDDR1L)	R/W
$_14, $_15	ATD Result Register 2 (ATDDR2H, ATDDR2L)	R/W
$_16, $_17	ATD Result Register 3 (ATDDR3H, ATDDR3L)	R/W
$_18, $_19	ATD Result Register 4 (ATDDR4H, ATDDR4L)	R/W
$_1A, $_1B	ATD Result Register 5 (ATDDR5H, ATDDR5L)	R/W
$_1C, $_1D	ATD Result Register 6 (ATDDR6H, ATDDR6L)	R/W
$_1E, $_1F	ATD Result Register 7 (ATDDR7H, ATDDR7L)	R/W

```
; AD initiering
; Högerjustera resultat, unipolärt
; kontinuerlig mode (scan), AD kanal 6

        MOVB    #$A6,ATDCTL5

; upplösning
        MOVB    #$E5,ATDCTL4

; en konverteringssekvens
        MOVB    #$40,ATDCTL3

; normal mode
        MOVB    #$C0,ATDCTL2

; Vänta tills omvandling klar
wAD:
        BRCLR   ATD0STAT0,#$80,wAD
; När resultat färdigt, läs
        LDAB    ATD0DR0L

...
```


Seriekommunikation, SCI

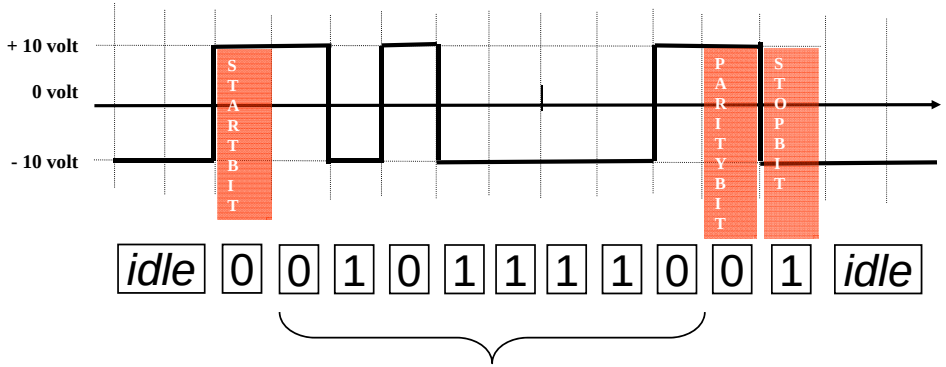




Sändare och mottagares klockor går i samma takt

RS232 – överföring av tecknet ’z’

tecknet ”z” representeras av bitmönstret ”0111 1010” (ASCII-tecken).



’z’ – minst signifikanta bit först