

TV-SAT-PLL with I²C-Bus and Four Chip Addresses

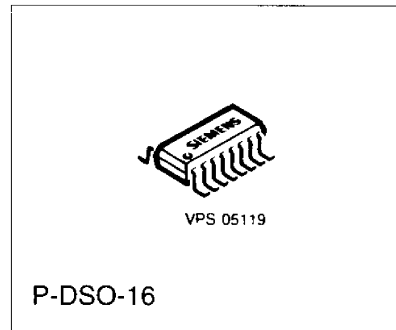
SDA 6102X

Preliminary Data

Bipolar IC

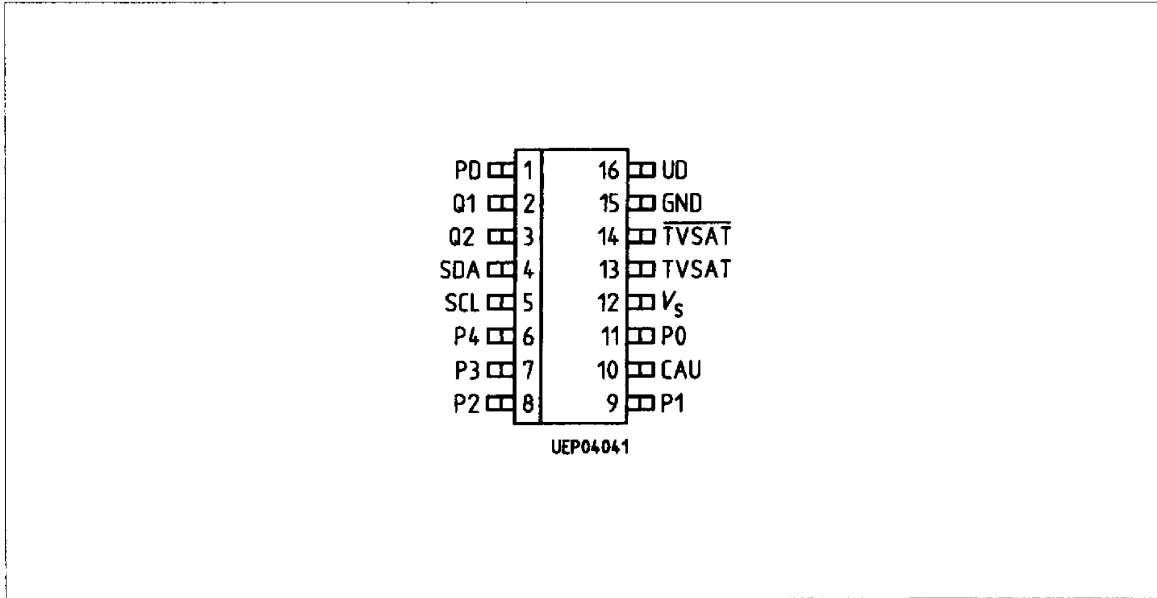
Features

- 1-chip system for MPU control (I²C-bus)
- 4 programmable chip addresses
- Short pull-in time for quick channel switch-over and optimized loop stability
- 5 high-current switch outputs (20 mA)
- Software-compatible with SDA 3302 series
- Oxis III-technology



Type	Ordering Code	Package
SDA 6102X	Q67000-A5016	P-DSO-16 (SMD)

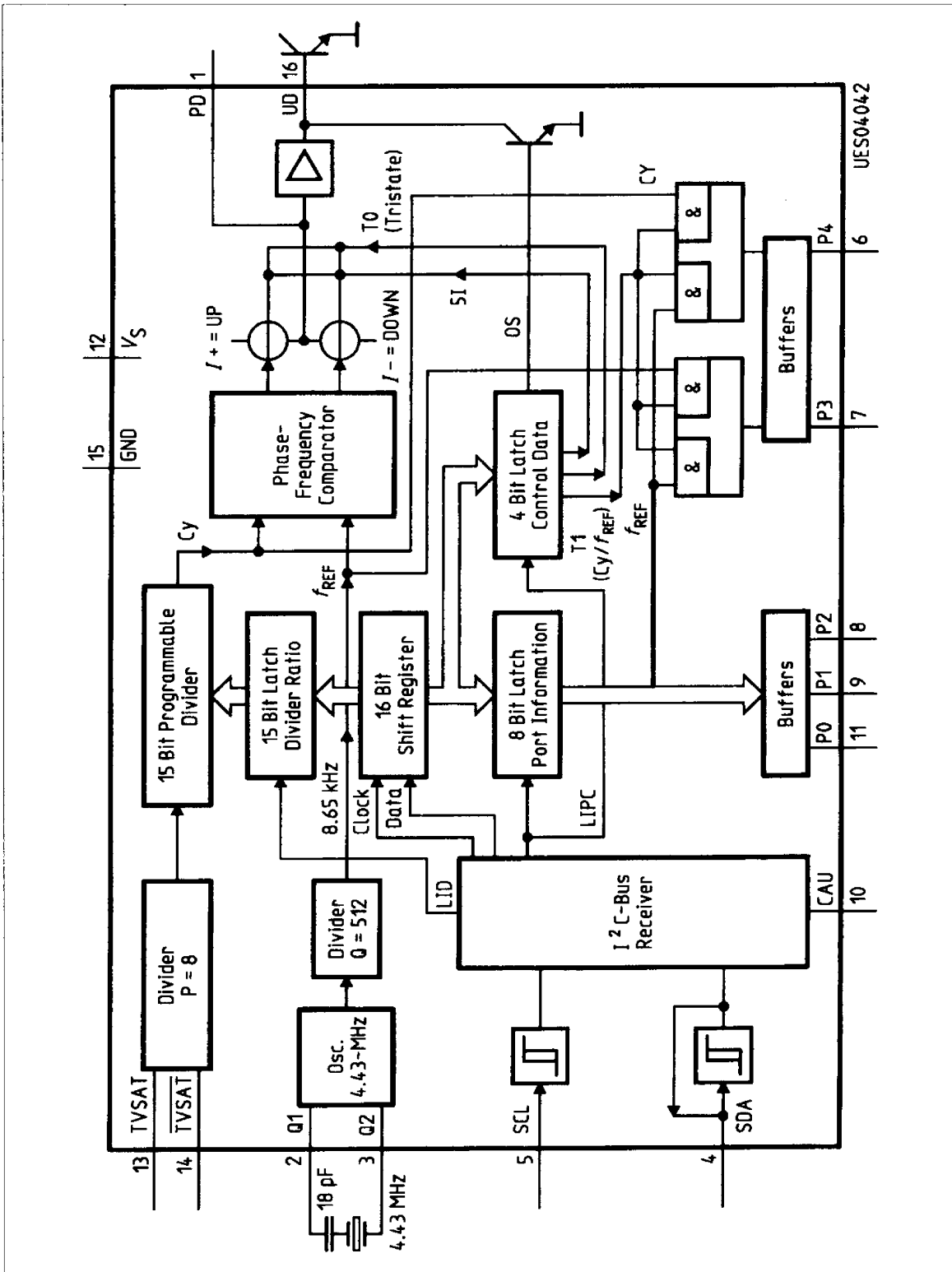
Combined with a VCO (tuner), the SDA 6102X device, with for hard-switched chip addresses, forms a digitally programmable phase-locked loop for use in satellite indoor units. It is compatible with the standard SDA 3202-2 device used in television sets with frequency synthesis tuning. With a 4.43-MHz quartz crystal, the PLL permits precise setting of the frequency of the tuner oscillator up to 2.27 GHz in increments of 69.2 kHz. Higher frequencies (up to 2.4 GHz) are possible at the expense of coarser frequency resolution. The tuning process is controlled by a microprocessor via an I²C-bus. The I²C-bus noise immunity has been improved by a factor of 10 compared to the SDA 3302-2, and the new crystal oscillator generates a sinusoidal signal, suppressing the higher-order harmonics, which reduces the moire noise considerably.



Pin Configuration
(top view)

Pin Definitions and Functions

Pin No.	Symbol	Function
1	PD	Input active filter / charge pump output
2	Q1	Quartz crystal
3	Q2	Quartz crystal
4	SDA	Data input / output for I ² C bus
5	SCL	Clock input for I ² C bus
6	P4	Port output (open collector)
7	P3	Port output (open collector)
8	P2	Port output (open collector)
9	P1	Port output (open collector)
10	CAU	Address switch input
11	P0	Port output (open collector)
12	V _S	Supply voltage
13	TVSAT	Non-inverting signal input
14	$\overline{\text{TVSAT}}$	Inverting signal input
15	GND	Ground
16	UD	Output active filter



Block Diagram

Circuit Description

Tuning Section (refer to block diagram)

- TVSAT, $\overline{\text{TVSAT}}$** The tuner signal is capacitively coupled as a differential signal at the TVSAT/ $\overline{\text{TVSAT}}$ inputs. Alternatively, the tuner signal is capacitively coupled at the TVSAT-input and the $\overline{\text{TVSAT}}$ input is decoupled to ground using a capacitor of low series inductance. The signal subsequently passes through an asynchronous divider with a fixed ratio of $P = 8$, an adjustable divider with ratio $N = 256$ through 32767, and is then compared in a digital frequency/phase detector to a reference frequency $f_{\text{REF}} = 8.65 \text{ KHz}$.
- Q1, Q2** This frequency is derived from a balanced, low-impedance 4.43 MHz crystal oscillator (pin Q1, Q2) by dividing its output signal by $Q = 512$. The phase detector has two outputs UP and DOWN that drive the two current sources I + and I – of a charge pump. If the negative edge of the divided VCO-signal appears prior to the negative edge of the reference signal, the I + current source pulses for the duration of the phase difference. In the reserve case the I – current source pulses.
- PD, UD** If the two signals are in phase, the charge pump output (PD) goes into the high-impedance state (PLL is locked). An active low-pass filter integrates the current pulses to generate the tuning voltage for the VCO (internal amplifier, external output transistor at UD and external RC-circuitry). The charge pump output is also switched into the high-impedance state when the control bit T0 = 1. Here it should be noted, however, that the tuning voltage can alter over a long period in the high-impedance state as a result of selfdischarge in the peripheral circuitry. UD may be switched off by the control bit OS to allow external adjustments. By means of a control bit 5I the pump current can be switched between two values by software. This programmability permits alteration of the control response of the PLL in the locked-in state. In this way different VCO gains in the different TV-bands can be compensated, for example.
- P0 ... P4** The software-switched ports P0 ... P4 are general-purpose 20 mA open-collector outputs and can be used for direct band selection. The test bit T1 = 1 switches the test signals f_{REF} (4.43 MHz/512) and Cy (divided input signal) to P3 and P4 respectively.
- CAU** Four different chip addresses can be set by appropriate connection of pin CAU.

I²C- Bus Interface

Data are exchanged between the processor and the PLL on the I²C-bus.

- SCL, SDA** The clock is generated by the processor (input SCL), while pin SDA works as an input or output depending on the direction of the data (open collector; external pull-up resistor).

Both inputs have hysteresis and a low-pass characteristic, which enhances the noise immunity of the I²C-bus.

The data from the processor pass through an I²C-bus control. Depending on their function the data are subsequently stored in registers. If the bus is free, both lines will be in the marking state (SDA, SCL are high). Each telegram begins with the start condition and ends with the stop condition. Start condition: SDA goes low, while SCL remains high.

Stop condition: SDA goes high, while SCL remains high. All further information transfer takes place during SCL = low, and the data is forwarded to the control logic on the positive clock edge.

The table „bit allocation“ should be referred to in the following paragraph.

All telegrams are transmitted byte-by-byte, followed by a ninth clock pulse, during which the control logic returns the SDA-line to low (acknowledge condition). The first byte is comprised of seven address bits. These are used by the processor to select the PLL from several peripheral components (chip select). The eighth bit is always low.

In the data portion of the telegram the first bit of the first or third data byte determines whether a divider ratio or control information is to follow. In each case the second byte of the same data type or a stop condition has to follow the first byte.

$V_{S, GND}$ When the supply voltage is applied, a power-on reset circuit prevents the PLL from setting the SDA-line to low, which would block the bus.

Circuit Description (cont'd)

Bit Allocation

	MSB					A = Acknowledge			
Address byte	1	1	0	0	0	MA1	MA0	0	A
Prog. divider Byte 1	0	n14	n13	n12	n11	n10	n9	n8	A
Prog. divider Byte 2	n7	n6	n5	n4	n3	n2	n1	n0	A
Control info Byte 1	1	5I	T1	T0	1	1	1	OS	A
Control info Byte 2	P4	P3	P2	P1	X	X	P0	X	A

Divider Ratio

$$N = 16384 \times n14 + 8192 \times n13 + 4096 \times n12 + 2048 \times n11 + 1024 \times n10 + 512 \times n9 + 256 \times n8 + 128 \times n7 + 64 \times n6 + 32 \times n5 + 16 \times n4 + 8 \times n3 + 4 \times n2 + 2 \times n1 + n0$$

Port Switching

P0 ... P4 = 1 Open-collector output is active.

Pump Current Programming

5I = 1 High current

UD Disable

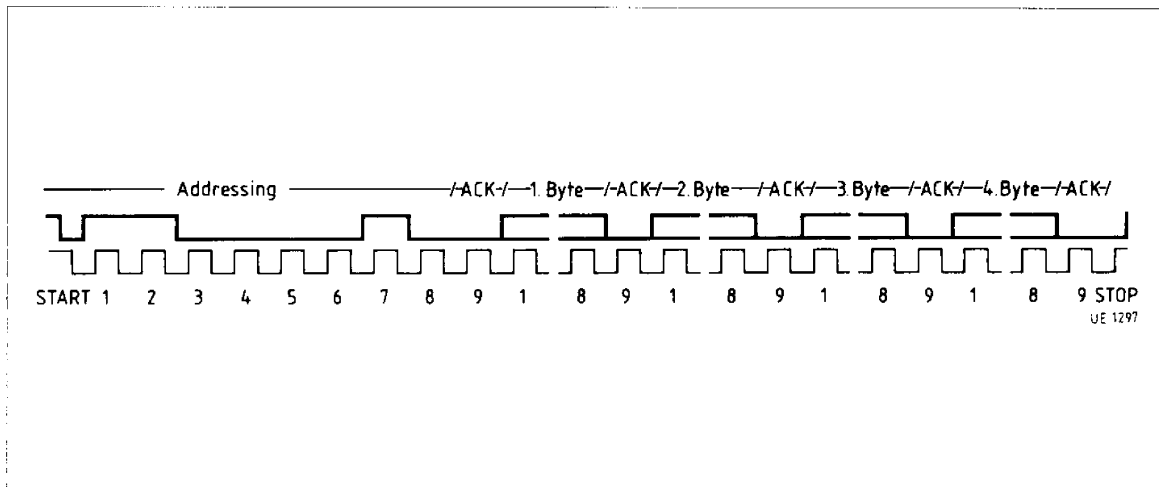
OS = 1 UD is disabled

Test Mode

T1, T0 = 0, 0 Normal operation
 T1 = 1 P3 = f_{REF} , P4 = Cy
 T0 = 0 Tristate: charge pump output PD is in high-impedance state.

Chip Address Switching

MA1	MA0	Voltage at CAU
0	0	(0 ... 0.1) V_S
0	1	open-circuit
1	0	(0.4 ... 0.6) V_S
1	1	(0.9 ... 1) V_S



Pulse Diagram

Telegram Examples

- Start-Addr-DR1-DR2-CW1-CW2-Stop
- Start-Addr-CW1-CW2-DR1-DR2-Stop
- Start-Addr-DR1-DR2-CW1-Stop
- Start-Addr-CW1-CW2-DR1-Stop
- Start-Addr-DR1-DR2-Stop
- Start-Addr-CW1-CW2-Stop
- Start-Addr-DR1-Stop
- Start-Addr-CW1-Stop

- Start = start condition
- Addr = address
- DR1 = divider ratio 1st byte
- DR2 = divider ratio 2nd byte
- CW1 = control word 1st byte
- CW2 = control word 2nd byte
- Stop = stop condition

Absolute Maximum Ratings

$T_A = -20$ to 80 °C

Parameter	Symbol	Limit Values		Unit	Remarks
		min.	max.		
Supply voltage	V_S	- 0.3	6	V	
Output PD	V_1	- 0.3	V_S	V	
Crystal oscillator pins Q1, Q2	V_2	- 0.3	V_S	V	
Bus input/output SDA	V_4	- 0.3	6	V	
Bus input SCL	V_5	- 0.3	6	V	
Port outputs P0 ... P4	V_6	- 0.3	16	V	
Chip address switch CAU	V_{10}	- 0.3	V_S	V	
Signal inputs TVSAT, $\overline{\text{TVSAT}}$	V_{13}	- 0.3	0.3	V	for $V_S = 0$ V
Output active filter UD	V_{16}	- 0.3	V_S	V	
Bus output SDA	I_{4L}	- 1	5	mA	open collector
Port outputs P0 ... P4	I_{6L}	- 1	20	mA	open collector
Total port output current	ΣI_L		25	mA	
Junction temperature	T_j		125	°C	
Storage temperature	T_{stg}	- 40	125	°C	
Thermal resistance (junction to ambient)	$R_{th JA}$		125	K/W	

Operating Range

Supply voltage	V_S	+ 4.5	5.5	V	
Ambient temperature	T_A	- 20	80	°C	
Input frequency	f_{13}		2400	MHz	(at 25 °C)
Crystal frequency	f_2		4.69	MHz	
Programmable divider factor	N	256	32767		

AC/DC-Characteristics $T_A = -20$ to 80 °C; $V_S = 4.5$ to 5.5 V

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			
Supply current	I_S		45	59	mA	$V_S = 5$ V	1
Crystal oscillator frequency	f_2		4.43		MHz	series capacitance 18 pF $f_{\text{xtal}} = 4.43$ MHz	1
Oscillator amplitude (voltage across crystal)*			2.6		V		
Margin from 1st (fundamental) to 2nd and 3rd harmonics*			20		dB		

Signal Input TVSAT/TVSAT

Sensitivity in mVrms into 50Ω	a_{13}	-10/ 71		3/315	dBm	$f_{13} = 500$ MHz ... 2.4 GHz	2
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Port Outputs P0 ... P4 (switch with open collector)

H-input current	I_{6H}			10	μ A	$V_{6H} = 13.5$ V	3
L-output voltage	V_{6L}			0.5	V	$I_{6L} = 20$ mA	3
The sum of the currents in ports P0 to P4 may not exceed 25 mA.							

Phase-Detector Output PD ($V_S = 5$ V)

Pump current	I_{1H}	± 90	± 220	± 300	μ A	5I = high; $V_1 = 2$ V	4
Pump current	I_{1H}	± 22	± 50	± 75	μ A	5I = low; $V_1 = 2$ V	4
Tristate current	I_{1Z}	-5	0	+5	nA	T1 = 1; $V_1 = 2$ V	4
Output voltage	V_{1L}	1.0		2.5	V	locked	4

Active Filter Output UD (Test mode T0 = 1; PD = tristate)

Output current	$-I_{16}$	500			μ A	$V_{16} = 0.8$ V; $I_{1H} = 90$ μ A	4
Output voltage	V_{16}			100	mV	$V_{1L} = 0$ V	4
Output voltage	V_{16}			500	mV	OS = 1	4

Chip Address Switch CAU

Input current	I_{10H}			50	μ A	$V_{10H} = 5$ V	6
Input current	$-I_{10H}$			50	μ A	$V_{10H} = 0$ V	6

* Design note only: no 100% final inspection

AC/DC Characteristics (cont'd)

$T_A = -20$ to 80 °C; $V_S = 4.5$ to 5.5 V

Parameter	Symbol	Limit Values			Unit	Test Condition	Test Circuit
		min.	typ.	max.			

Bus Input SCL, SDA

H-input voltage	V_{4IH}	3		5.5	V		5
L-input voltage	V_{4IL}			1.5	V		5
H-input current	I_{4IH}			10	μ A	$V_{4IH} = V_S$	5
L-input current	$-I_{4IL}$			20	μ A	$V_{4IH} = 0$ V	5

Bus Output SDA (open collector)

H-output current	I_{4OH}			10	μ A	$V_{4H} = 5.5$ V	5
L-output voltage	V_{4OL}			0.4	V	$I_{4L} = 3$ mA	5

Edges SCL, SDA

Rise time	t_R			1	μ s		5
Fall time	t_F			0.3	μ s		5

Shift Clock SCL

Frequency	f_S	0		100	kHz		5
H-pulse width	t_{SH}	4			μ s		5
L-pulse width	t_{SL}	4.7			μ s		5

Start

Set-up time	t_{SUSTA}	4.7			μ s		5
Hold time	t_{HDSTA}	4			μ s		5

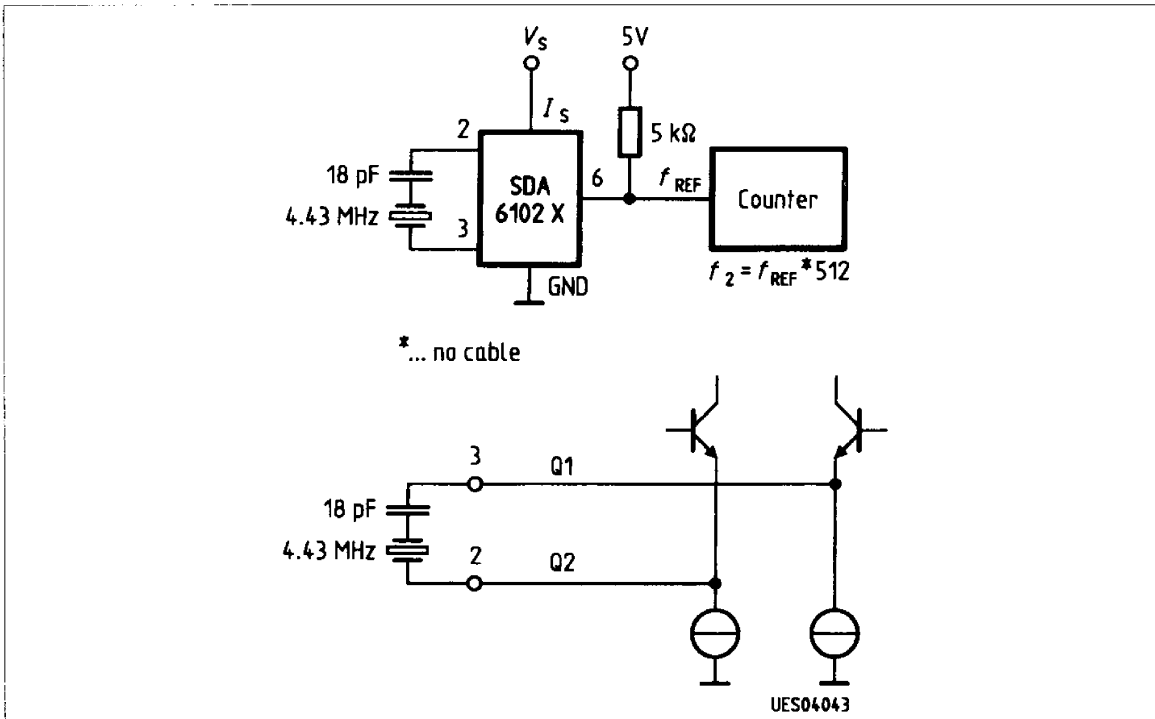
Stop

Set up time	t_{SUSTO}	4.7			μ s		5
Bus free	t_{BUF}	4.7			μ s		5

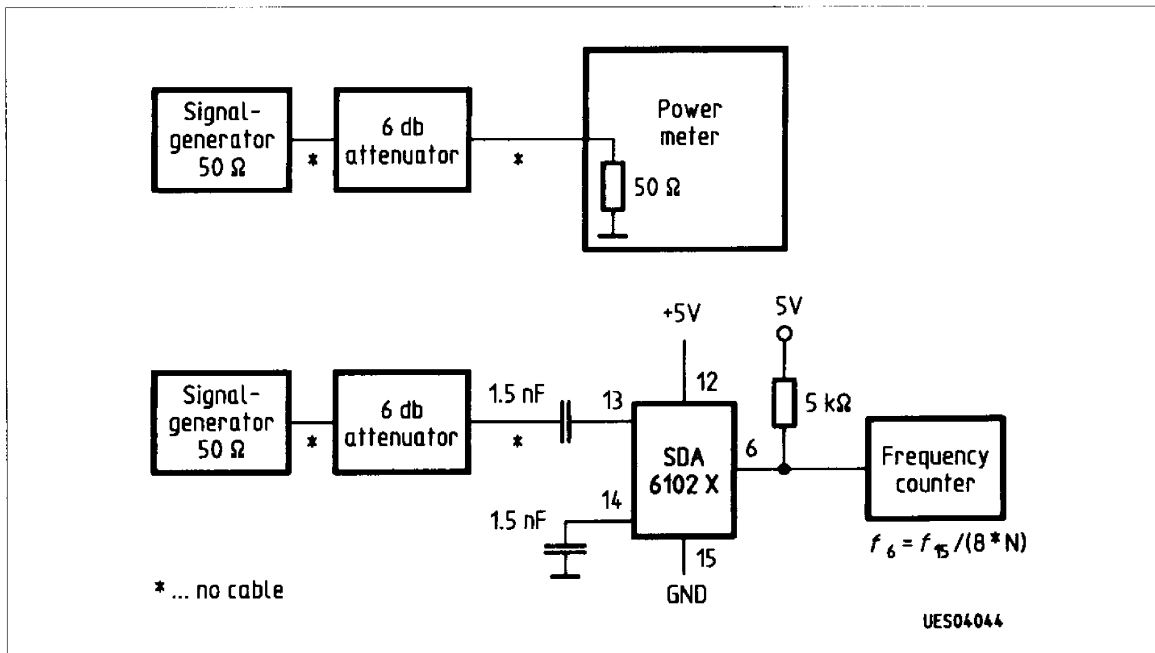
Data Transfer

Set-up time	t_{SUDAT}	0.25			μ s		5
Hold time	t_{HDDAT}	0			μ s		5
Input hysteresis SCL, SDA*			300		mV		
Low-pass cutoff frequency SCL, SDA*			500		kHz		

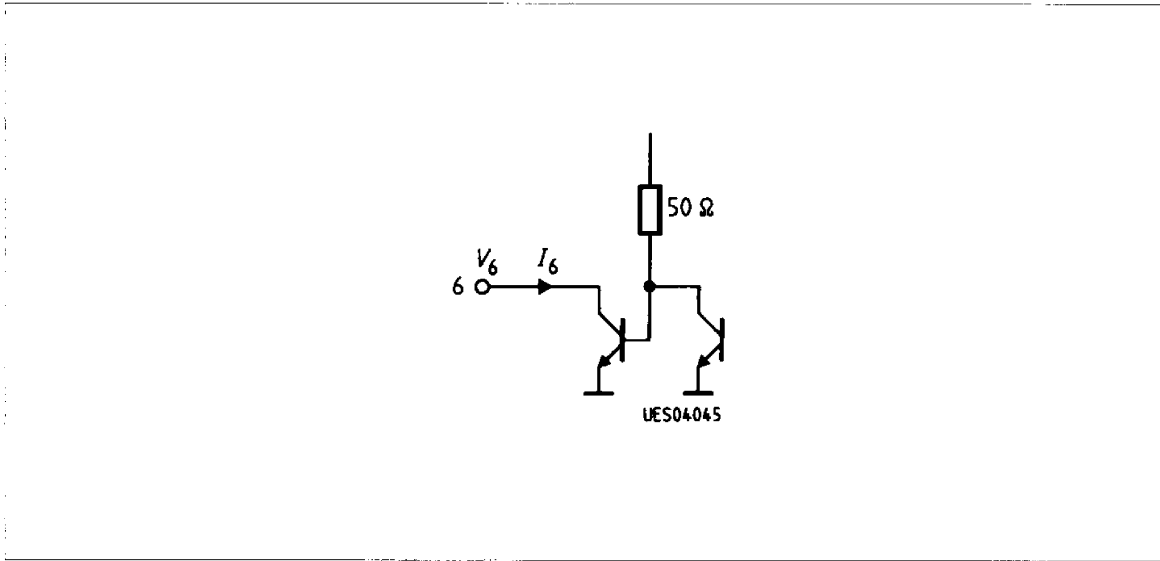
* Design note only: no 100% final inspection



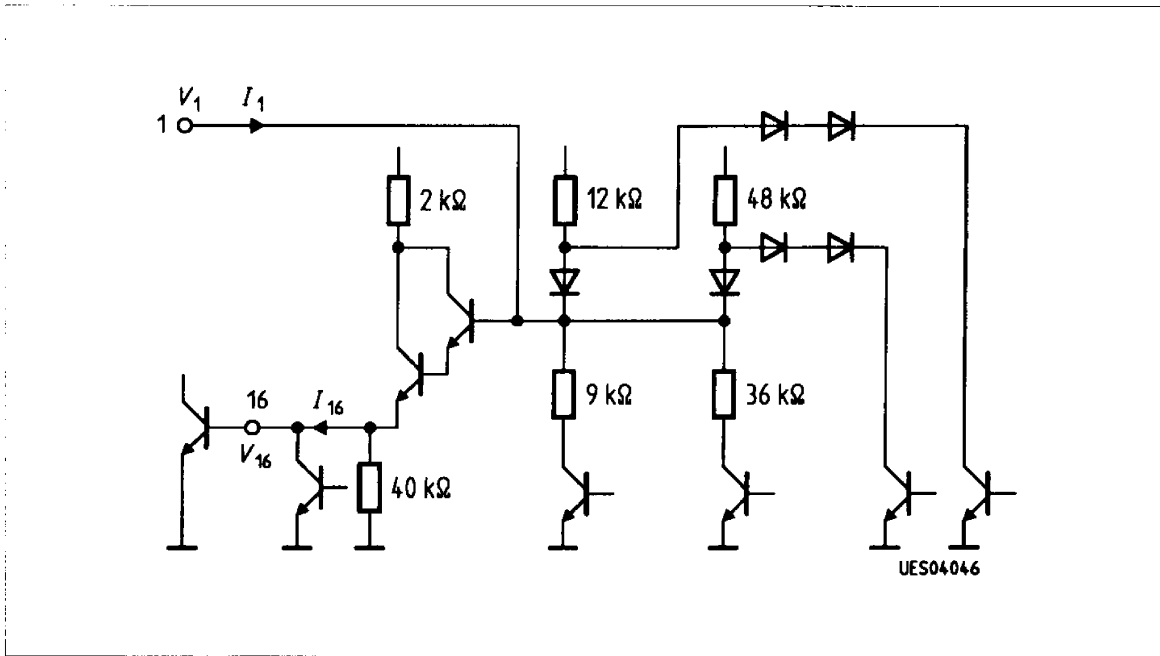
Test Circuit 1



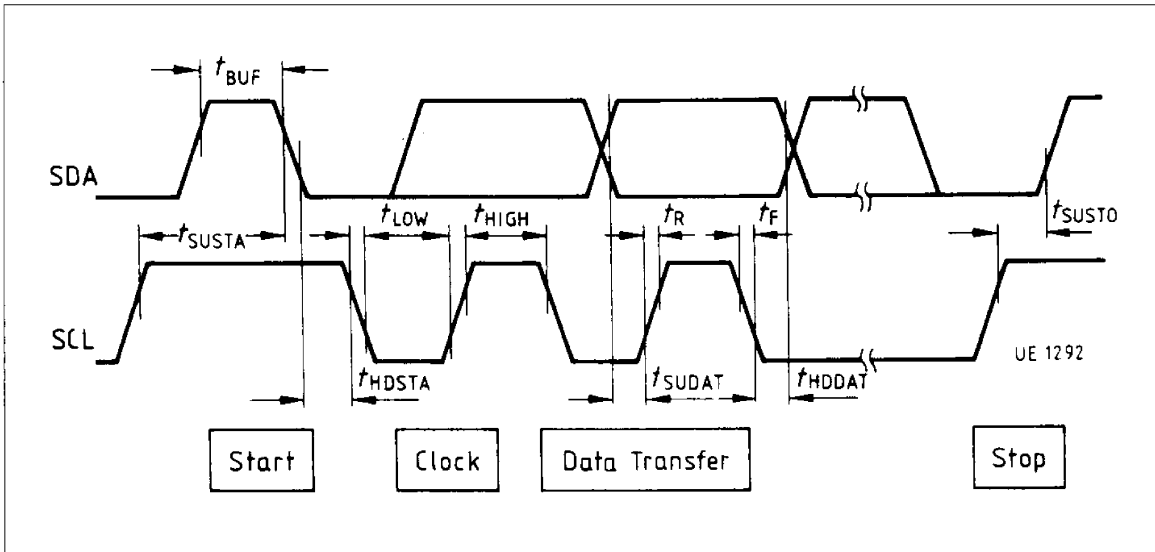
Test Circuit 2



Test Circuit 3



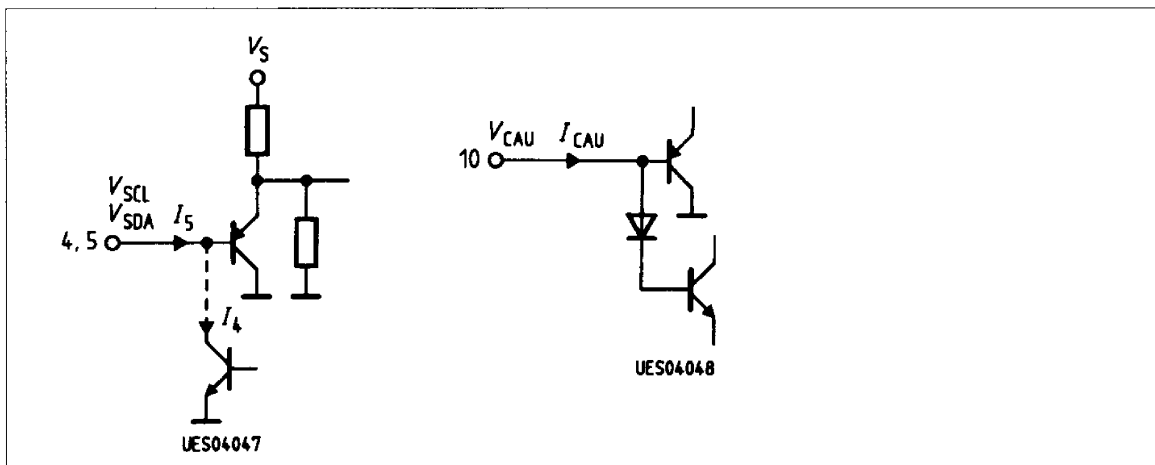
Test Circuit 4



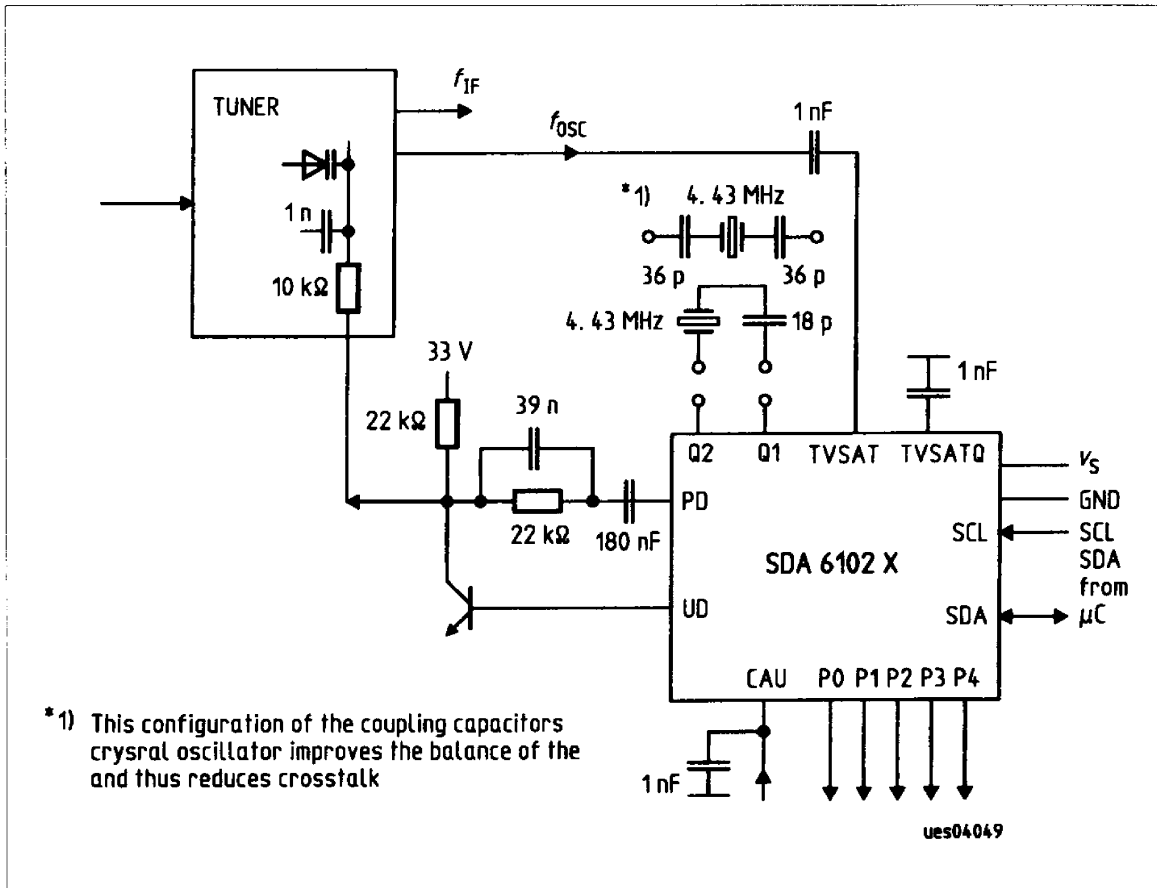
Test Circuit 5

- t_{SUSTA} Set-up time (start)
- t_{HDSTA} Hold time (start)
- t_{HIGH} H-pulse width (clock)
- t_{LOW} L-pulse width (clock)
- t_{SUDAT} Setup time (data transfer)
- t_{HDDAT} Hold time (data transfer)
- t_{SUSTO} Set-up time (stop)
- t_{BUF} Bus free time
- t_F Fall time
- t_R Rise time

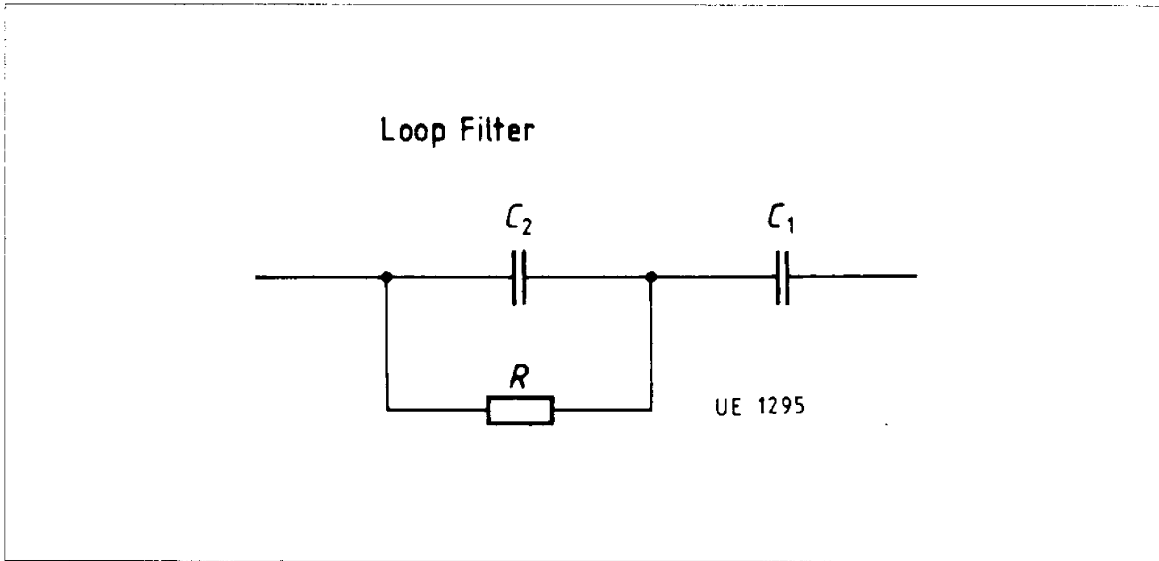
All times related to 10 % and 90 % values



Test Circuit 6



Application Circuit



Application Circuit

Calculation of loop filter

Loop bandwidth: $\omega_R = \sqrt{(I_P \times K_{VCO}) / (C_1 \times P \times N)}$

Attenuation: $a = 0.5 \times \omega_R \times R \times C_1$

- P = prescaler
- N = programmable divider
- I_P = pump current
- K_{VCO} = tuner slope
- R, C_1 = loop filter

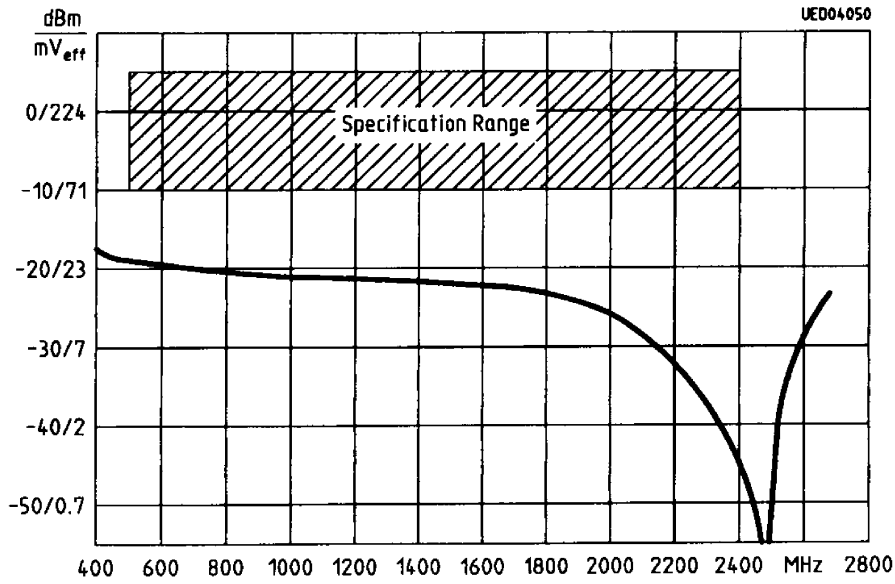
Example

$P = 8, N = 11520, I_P = 50 \mu A; K_{VCO} = 18.7 \text{ MHz/V}, R = 22 \text{ k}\Omega,$
 $C_1 = 180 \text{ nF}; \omega_R = 237 \text{ Hz}, f_r = 38 \text{ Hz}, a = 0.67$

Note: The high-impedance port outputs and CAU can be decoupled from external noise with a capacitor of 1 nF.

It is important to keep to the I²C-bus specification concerning maximum capacitance and impedance.

Sensitivity at TVSAT/TVSAT Input
(typical at 25 °C)



I²C-Bus Noise Immunity

Sinusoidal Noise Pulses are Applied via a Coupling Capacitance of 33 pF to the SCL- and SDA-Inputs

