



## TDA9112A

# HIGH-END I<sup>2</sup>C CONTROLLED DEFLECTION PROCESSOR FOR MULTISYNC MONITOR

## FEATURES

### General

- Advanced I<sup>2</sup>C-bus controlled deflection processor dedicated for high-end CRT monitors
- Single supply voltage 12V
- Very low jitter
- DC/DC converter controller
- Advanced EW drive
- Advanced asymmetry corrections
- Automatic multistandard synchronization
- 2 dynamic correction waveform outputs
- X-ray protection and Soft-start & stop on horizontal and DC/DC drive outputs
- I<sup>2</sup>C-bus status register

### Horizontal section

- 150 kHz maximum frequency
- Corrections of geometric asymmetry: Pin cushion asymmetry, Parallelogram, separate Top/Bottom corner asymmetry
- Tracking of asymmetry corrections with vertical size and position
- Fully integrated horizontal moiré cancellation

### Vertical section

- 200 Hz maximum frequency
- Vertical ramp for DC-coupled output stage with adjustments of: C-correction, S-correction for super-flat CRT, Vertical size, Vertical position
- Vertical size and position prescales for factory adjustment
- Vertical moiré cancellation through vertical ramp waveform
- Compensation of vertical breathing with EHT variation; I<sup>2</sup>C-bus gain adjustment

### EW section

- Symmetrical geometry corrections: Pin cushion, Keystone, Top/Bottom corners separately, S- and W-corrections
- Horizontal size adjustment
- Tracking of EW waveform with Vertical size and position, horizontal size and frequency

- Compensation of horizontal breathing with EHT variation, I<sup>2</sup>C-bus gain adjustment

### Dynamic correction section

- Generates waveforms for dynamic corrections like focus, brightness uniformity, ...
- 1 output with vertical dynamic correction waveform, both polarities, tracking with vertical size and position
- 1 output with composite HV dynamic correction waveform, both polarities, shape control on horizontal waveform component, tracking with horizontal size

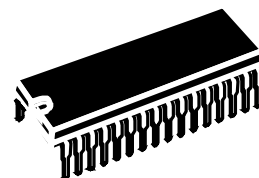
### DC/DC controller section

- Step-up and step-down conversion modes
- External sawtooth configuration
- I<sup>2</sup>C-bus-controlled output voltage
- Synchronized on hor. frequency with phase selection
- Selectable polarity of drive signal
- Protection at H unlock condition

## DESCRIPTION

The TDA9112A is a monolithic integrated circuit assembled in a 32-pin shrink dual-in-line plastic package. This IC controls all the functions related to horizontal and vertical deflection in multimode or multi-frequency computer display monitors.

Combined with other ST components dedicated for CRT monitors (microcontroller, video preamplifier, video amplifier, OSD controller), the TDA9112A allows fully I<sup>2</sup>C bus-controlled computer display monitors to be built with a reduced number of external components.



**SDIP 32** (Shrink DIP package)  
**ORDER CODE:** TDA9112A

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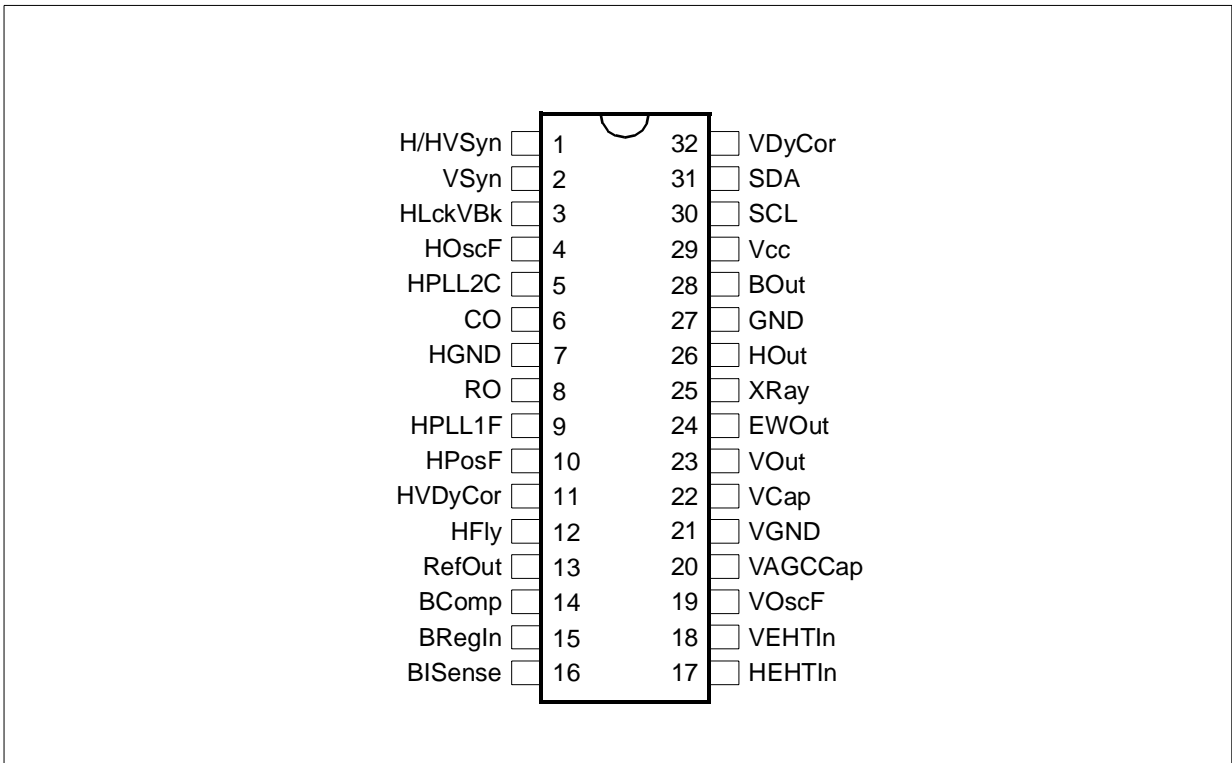
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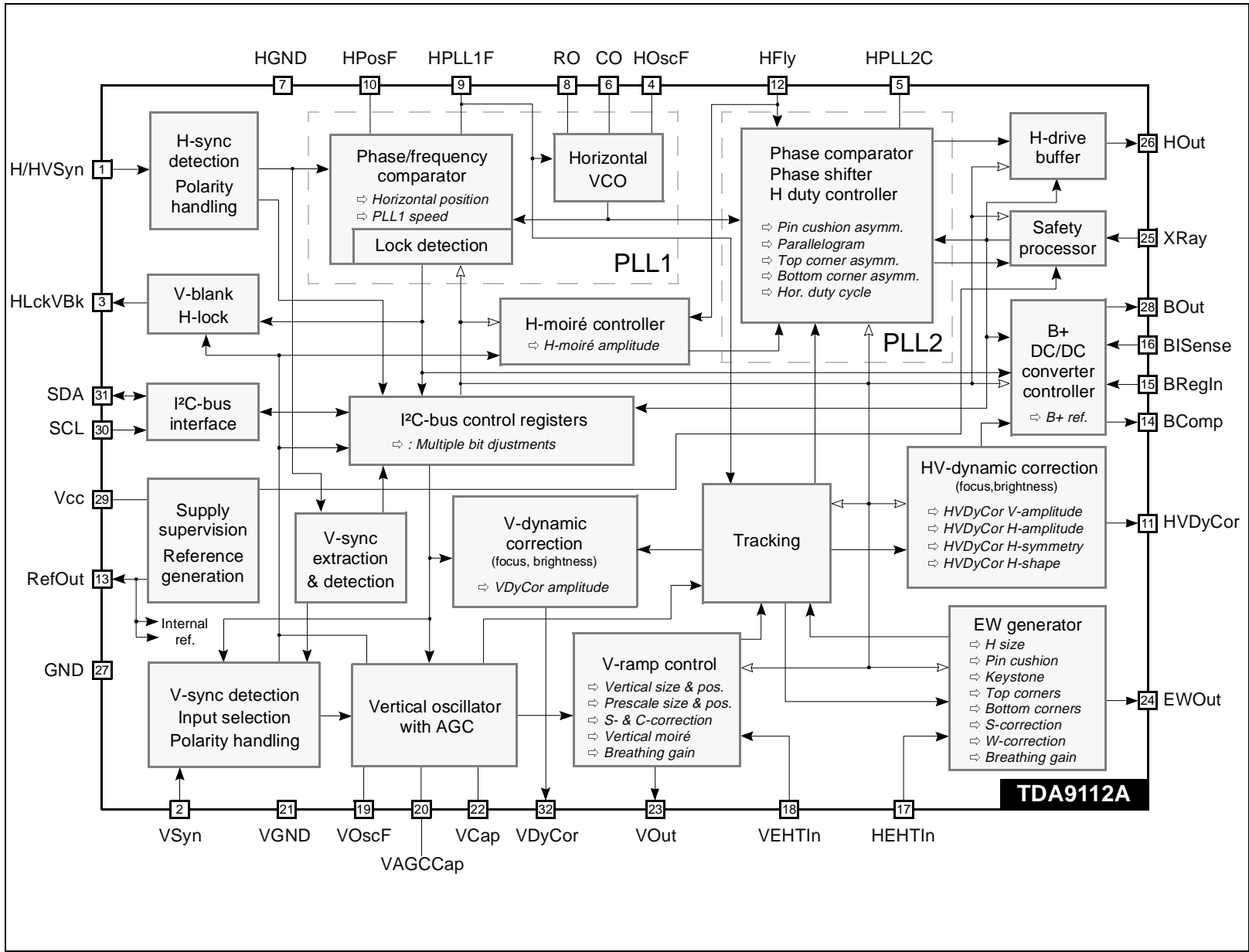
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1 PIN CONFIGURATION





### 3 PIN FUNCTION REFERENCE

Pin	Name	Function
1	H/HVSyn	TTL compatible <b>H</b> orizontal / <b>H</b> orizontal and <b>V</b> ertical <b>S</b> ync. input
2	VSyn	TTL compatible <b>V</b> ertical <b>S</b> ync. input
3	HLckVBk	<b>H</b> orizontal PLL1 <b>L</b> ock detection and <b>V</b> ertical early <b>B</b> lanking composite output
4	HOscF	High <b>H</b> orizontal <b>O</b> scillator sawtooth threshold level <b>F</b> ilter input
5	HPLL2C	<b>H</b> orizontal <b>P</b> LL2 loop <b>C</b> apacitive filter input
6	CO	<b>H</b> orizontal <b>O</b> scillator <b>C</b> apacitor input
7	HGND	<b>H</b> orizontal section <b>G</b> rou <b>N</b> D
8	RO	<b>H</b> orizontal <b>O</b> scillator <b>R</b> esistor input
9	HPLL1F	<b>H</b> orizontal <b>P</b> LL1 loop <b>F</b> ilter input
10	HPosF	<b>H</b> orizontal <b>P</b> osition <b>F</b> ilter and soft-start time constant capacitor input
11	HVDyCor	<b>H</b> orizontal and <b>V</b> ertical <b>D</b> ynamic <b>C</b> orrection output
12	HFly	<b>H</b> orizontal <b>F</b> lyback input
13	RefOut	<b>R</b> eference voltage <b>O</b> utput
14	BComp	<b>B+</b> DC/DC error amplifier ( <b>C</b> ompensation) output
15	BRegIn	<b>R</b> egulation feedback <b>I</b> nput of the <b>B+</b> DC/DC converter controller
16	BISense	<b>B+</b> DC/DC converter current ( <b>I</b> ) <b>S</b> ense input
17	HEHTIn	<b>I</b> nput for compensation of <b>H</b> orizontal amplitude versus <b>E</b> HT variation
18	VEHTIn	<b>I</b> nput for compensation of <b>V</b> ertical amplitude versus <b>E</b> HT variation
19	VOscF	<b>V</b> ertical <b>O</b> scillator sawtooth low threshold <b>F</b> ilter (capacitor to be connected to VGND)
20	VAGCCap	<b>I</b> nput for storage <b>C</b> apacitor for <b>A</b> utomatic <b>G</b> ain <b>C</b> ontrol loop in <b>V</b> ertical oscillator
21	VGND	<b>V</b> ertical section <b>G</b> rou <b>N</b> D
22	VCap	<b>V</b> ertical sawtooth generator <b>C</b> apacitor
23	VOut	<b>V</b> ertical deflection drive <b>O</b> utput for a DC-coupled output stage
24	EWOut	<b>E</b> /W <b>O</b> utput
25	XRy	<b>X</b> - <b>R</b> ay protection input
26	HOut	<b>H</b> orizontal drive <b>O</b> utput
27	GND	Main <b>G</b> rou <b>N</b> D
28	BOut	<b>B+</b> DC/DC converter controller <b>O</b> utput
29	Vcc	Supply voltage
30	SCL	I <sup>2</sup> C-bus <b>S</b> erial <b>C</b> lock <b>I</b> nput
31	SDA	I <sup>2</sup> C-bus <b>S</b> erial <b>D</b> Ata input/output
32	VDyCor	<b>V</b> ertical <b>D</b> ynamic <b>C</b> orrection output

## 4 QUICK REFERENCE DATA

Characteristic	Value	Unit
<b>General</b>		
Package	SDIP 32	
Supply voltage	12	V
Supply current	65	mA
Application category	High-end	
Means of control • Maximum clock frequency	I <sup>2</sup> C-bus • 400	kHz
EW drive	Yes	
DC/DC converter controller	Yes	
<b>Horizontal section</b>		
Frequency range	15 to 150	kHz
Autosync frequency ratio (can be enlarged in application)	4.28	
Positive • Negative polarity of horizontal sync signal • Automatic adaptation	Yes • Yes • Yes	
Duty cycle range of the drive signal	30 to 65	%
Position adjustment range with respect to H period	±10	%
Soft start • Soft stop feature	Yes • Yes	
Hardware • Software PLL lock indication	Yes • Yes	
Parallelogram	Yes	
Pin cushion asymmetry correction (also called Side pin balance)	Yes	
Top • Bottom • Common corner asymmetry correction	Yes • Yes • No	
Tracking of asymmetry corrections with vertical size & position	Yes	
Horizontal moiré cancellation (int.) for Combined • Separated architecture	Yes • Yes	
<b>Vertical section</b>		
Frequency range	35 to 200	Hz
Autosync frequency range (150nF at VCap and 470nF at VAGCCap)	50 to 180	Hz
Positive • Negative polarity of vertical sync signal • Automatic adaptation	Yes • Yes • Yes	
S-correction • C-correction • Super-flat tube characteristic	Yes • Yes • Yes	
Vertical size • Vertical position • Prescale adjustments	Yes • Yes • Yes	
Vertical moiré cancellation (internal)	Yes	
EHT breathing compensation • With I <sup>2</sup> C-bus gain control	Yes • Yes	
<b>EW section</b>		
Pin cushion correction	Yes	
Keystone correction	Yes	
Top • Bottom • Common corner correction	Yes • Yes • No	
S-correction • W-correction	Yes • Yes	
Horizontal size adjustment	Yes	
Tracking of EW waveform with Frequency • Vertical size & position	Yes • Yes	
EHT breathing compensation • With I <sup>2</sup> C-bus gain control	Yes • Yes	
<b>Dynamic correction section (dyn. focus, dyn. brightness,...)</b>		
Vertical dynamic correction output VDyCor • Positive or negative polarity	Yes • Yes	
Horizontal dynamic correction output HDyCor	No	
Composite HV dynamic correction output HVDyCor • Positive or negative polarity	Yes • Yes	
Shape control on H waveform component of HVDyCor output	Yes	
Tracking of horizontal waveform component with Horizontal size • EHT	Yes • No	
Tracking of vertical waveforms (component) with V. size & position	Yes	
<b>DC • DC controller section</b>		
Step-up • Step-down conversion mode	Yes • Yes	
Internal • External sawtooth configuration	No • Yes	
Bus-controlled output voltage • Inhibition at H unlock	Yes • Yes	
Mute • Soft start • Soft stop feature	Yes • Yes • Yes	
Positive (N-MOS) • Negative (P-MOS) polarity of BOut signal	Yes • Yes	
Phase selection • Max current selection • Frequency selection	Yes • Yes • Yes	

## 5 ABSOLUTE MAXIMUM RATINGS

All voltages are given with respect to ground.

Currents flowing from the device (sourced) are signed negative. Currents flowing to the device are signed positive.

Symbol	Parameter	Value		Unit
		Min	Max	
$V_{CC}$	Supply voltage (pin Vcc)	-0.4	13.5	V
$V_{(pin)}$	Pins HEHTIn, VEHTIn, XRay, HOut, BOut	-0.4	VCC	V
	Pins H/HVSyn, VSyn, SCL, SDA	-0.4	5.5	V
	Pins HLckVBk, CO, RO, HPLL1F, HPosF, HVDyCor, BRegIn, BISense, VAGCCap, VCap, VDyCor, HOscF, VOscF	-0.4	VRefO	V
	Pin HPLL2C	-0.4	VRefO/2	V
	Pin HFly	-0.4	VRefO	V
$V_{ESD}$	ESD susceptibility (human body model: discharge of 100pF through 1.5k $\Omega$ )	-2000	2000	V
$T_{stg}$	Storage temperature	-40	150	°C
$T_j$	Junction temperature		150	°C



## 6 ELECTRICAL PARAMETERS AND OPERATING CONDITIONS

Medium (middle) value of an I<sup>2</sup>C-bus control or adjustment register composed of bits D0, D1,...,Dn is the one having Dn at "1" and all other bits at "0". Minimum value is the one with all bits at 0, maximum value is the one with all at "1".

Currents flowing from the device (sourced) are signed negative. Currents flowing to the device are signed positive.

T<sub>H</sub> is period of horizontal deflection.

### 6.1 Thermal data

Symbol	Parameter	Value			Unit
		Min.	Typ.	Max.	
T <sub>amb</sub>	Operating ambient temperature	0		70	°C
R <sub>th(j-a)</sub>	Junction-ambience thermal resistance		65		°C/W

### 6.2 Supply and Reference voltages

T<sub>amb</sub> = 25°C

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
V <sub>CC</sub>	Supply voltage at Vcc pin		10.8	12	13.2	V
I <sub>CC</sub>	Supply current to Vcc pin	VCC = 12V		65		mA
V <sub>RefO</sub>	Reference output voltage at RefOut pin	VCC = 12V, I <sub>RefO</sub> = -2mA	7.65	7.9	8.2	V
I <sub>RefO</sub>	Current capability of RefOut output		-5		0	mA

### 6.3 Synchronization inputs

V<sub>CC</sub> = 12V, T<sub>amb</sub> = 25°C

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
V <sub>LoH/HVSyn</sub>	LOW level voltage on H/HVSyn		0		0.8	V
V <sub>HiH/HVSyn</sub>	HIGH level voltage on H/HVSyn		2.2		5	V
V <sub>LoVSyn</sub>	LOW level voltage on VSyn		0		0.8	V
V <sub>HiVSyn</sub>	HIGH level voltage on VSyn		2.2		5	V
R <sub>PdSyn</sub>	Internal pull-down on H/HVSyn, VSyn		100	175	250	kΩ
t <sub>PulseHSyn</sub>	H sync. pulse duration on H/HVSyn pin		0.5			μs
t <sub>PulseHSyn</sub> /T <sub>H</sub>	Proportion of H sync pulse to H period	Pin H/HVSyn			0.2	
t <sub>PulseVSyn</sub>	V sync. pulse duration	Pins H/HVSyn, VSyn	0.5		750	μs
t <sub>PulseVSyn</sub> /T <sub>V</sub>	Proportion of V sync pulse to V period	Pins H/HVSyn, VSyn			0.15	
t <sub>extrV</sub> /T <sub>H</sub>	Proportion of H sync pulse length to H period for extraction as V sync pulse	Pin H/HVSyn, cap. on pin CO = 820pF	0.21	0.35		
t <sub>HPolDet</sub>	Polarity detection time (after change)	Pin H/HVSyn	0.75			ms

## 6.4 Horizontal section

Table 1. Horizontal section (V<sub>CC</sub> = 12V, T<sub>amb</sub> = 25°C)

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
<b>PLL1</b>						
I <sub>RO</sub>	Current load on RO pin				1.5	mA
C <sub>CO</sub>	Capacitance on CO pin		390			pF
f <sub>HO</sub>	Frequency of hor. oscillator				150	kHz
f <sub>HO(0)</sub>	Free-running frequency of hor. oscill. <sup>(1)</sup>	R <sub>RO</sub> =5.23kΩ, C <sub>CO</sub> =820pF	27	28.5	29.9	kHz
f <sub>HOCapt</sub>	Hor. PLL1 capture frequency <sup>(4)</sup>	f <sub>HO(0)</sub> = 28.5kHz	29		122	kHz
$\frac{\Delta f_{HO(0)}}{f_{HO(0)} \cdot \Delta T}$	Temperature drift of free-running freq. <sup>(3)</sup>			-150		ppm/°C
$\Delta f_{HO}/\Delta V_{HO}$	Average horizontal oscillator sensitivity	f <sub>HO(0)</sub> = 28.5kHz		20.2		kHz/V
V <sub>HO</sub>	H. oscill. control voltage on pin HPLL1F	V <sub>RefO</sub> =8V	1.4		6.0	V
V <sub>HOThrfr</sub>	Threshold on H. oscill. control voltage on HPLL1F pin for tracking of EW with freq.	V <sub>RefO</sub> =8V		5.0		V
V <sub>HPosF</sub>	Control voltage on HPosF pin	HPOS (Sad01h): 11111111b 10000000b 00000000b		2.8 3.4 4.0		V V V
V <sub>HOThrLo</sub>	Bottom of hor. oscillator sawtooth <sup>(6)</sup>			1.6		V
V <sub>HOThrHi</sub>	Top of hor. oscillator sawtooth <sup>(6)</sup>			6.4		V
<b>PLL2</b>						
R <sub>In(HFly)</sub>	Input impedance on HFly input	V <sub>(HFly)</sub> > V <sub>ThrHFly</sub> <sup>(2)</sup>	300	500	700	Ω
I <sub>InHFly</sub>	Current into HFly input	At top of H flyback pulse			5	mA
V <sub>ThrHFly</sub>	Voltage threshold on HFly input		0.5	0.6		V
V <sub>S(0)</sub>	H flyback lock middle point <sup>(6)</sup>	No PLL2 phase modulation		4.0		V
V <sub>BotHPLL2C</sub>	Low clamping voltage on HPLL2C pin <sup>(5)</sup>			1.6		V
V <sub>TopHPLL2C</sub>	High clamping voltage on HPLL2C pin <sup>(5)</sup>			4.0		V
t <sub>ph(min)</sub> /T <sub>H</sub>	Min. advance of H-drive OFF before middle of H flyback <sup>(7)</sup>	Null asym. correction		0		%
t <sub>ph(max)</sub> /T <sub>H</sub>	Max. advance of H-drive OFF before middle of H flyback <sup>(8)</sup>	Null asym. correction		44		%
<b>H-drive output on pin HOut</b>						
I <sub>HOut</sub>	Current into HOut output	Output driven LOW			30	mA
t <sub>Hoff</sub> /T <sub>H</sub>	Duty cycle of H-drive signal	f <sub>H</sub> = 31kHz; HDUTY (Sad00h): x11111111b x00000000b Soft-start/Soft-stop value		27 65 85		% % %

**Table 1. Horizontal section** ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
<b>Picture geometry corrections through PLL1 &amp; PLL2</b>						
$t_{Hph}/T_H$	Hor. VCO phase vs. sync signal (via PLL1), see Figure 7	<i>HPOS</i> (Sad01h): 11111111b 10000000b 00000000b		+11 0 -11		% % %
$t_{PCAC}/T_H$	Contribution of pin cushion asymmetry correction to phase of H-drive vs. static phase (via PLL2), measured in corners	<i>PCAC</i> (Sad11h) full span <sup>(9)</sup> <i>VPOS</i> at medium <i>VSIZE</i> at minimum <i>VSIZE</i> at medium <i>VSIZE</i> at maximum		$\pm 0.9$ $\pm 1.6$ $\pm 2.6$		% % %
$t_{ParalC}/T_H$	Contribution of parallelogram correction to phase of H-drive vs. static phase (via PLL2), measured in corners	<i>PARAL</i> (Sad12h) full span <sup>(9)</sup> <i>VPOS</i> at medium <i>VSIZE</i> at minimum <i>VSIZE</i> at medium <i>VSIZE</i> at maximum		$\pm 1.4$ $\pm 1.9$ $\pm 2.4$		% % %
$t_{TCAC}/T_H$	Contribution of top corner asymmetry correction to phase of H-drive vs. static phase (via PLL2), measured in corners	<i>TCAC</i> (Sad13h) full span <sup>(9)</sup> <i>VPOS</i> at medium <i>VSIZE</i> at minimum <i>VSIZE</i> at medium <i>VSIZE</i> at maximum		$\pm 0.4$ $\pm 1.4$ $\pm 3.5$		% % %
$t_{BCAC}/T_H$	Contribution of bottom corner asymmetry correction to phase of H-drive vs. static phase (via PLL2), measured in corners	<i>BCAC</i> (Sad14h) full span <sup>(9)</sup> <i>VPOS</i> at medium <i>VSIZE</i> at minimum <i>VSIZE</i> at medium <i>VSIZE</i> at maximum		$\pm 0.4$ $\pm 1.4$ $\pm 3.5$		% % %

**Notes about horizontal section**

- Note 1:** Frequency at no sync signal condition. For correct operation, the frequency of the sync signal applied must always be higher than the free-running frequency. The application must consider the spread of values of real electrical components in  $R_{RO}$  and  $C_{CO}$  positions so as to always meet this condition. The formula to calculate the free-running frequency is  $f_{HO}(0) = 0.122 / (R_{RO} C_{CO})$
- Note 2:** Base of NPN transistor with emitter to ground is internally connected on pin HFLy through a series resistance of about  $500\Omega$  and a resistance to ground of about  $20k\Omega$ .
- Note 3:** Evaluated and figured out during the device qualification phase. Informative. Not tested on every single unit.
- Note 4:** This capture range can be enlarged by external circuitry.
- Note 5:** The voltage on HPLL2C pin corresponds to immediate phase of leading edge of H-drive signal on HOut pin with respect to internal horizontal oscillator sawtooth. It must be between the two clamping levels given. Voltage equal to one of the clamping values indicates a marginal operation of PLL2 or non-locked state.
- Note 6:** Internal threshold. See Figure 6.
- Note 7:** The  $t_{ph}(\min)$  parameter is fixed by the application. For correct operation of asymmetry corrections through dynamic phase modulation, this minimum must be increased by maximum of the total dynamic phase required in the direction leading to bending of corners to the left. Marginal situation is indicated by reach of VTopHPLL2C high clamping level by waveform on pin HPLL2C. Also refer to Note 5 and Figure 6.

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Notes about horizontal section (continued)

**Note 8:** The  $t_{ph(max)}$  parameter is fixed by the application. For correct operation of asymmetry corrections through dynamic phase modulation, this maximum must be reduced by maximum of the total dynamic phase required in the direction leading to bending of corners to the right. Marginal situation is indicated by reach of  $V_{BotHPLL2C}$  low clamping level by waveform on pin HPLL2C. Also refer to Note 5 and Figure 6.

**Note 9:** All other dynamic phase corrections of picture asymmetry set to their neutral (medium) positions.

## 6.5 Vertical section

**Table 2. Vertical section** ( $V_{cc} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
<b>AGC-controlled vertical oscillator sawtooth; <math>V_{RefO} = 8V</math></b>						
$R_{L(VAGCCap)}$	Ext. load resistance on VAGCCap pin <sup>(10)</sup>	$\Delta V_{amp}/V_{amp}(R=\infty) \leq 1\%$	65			$M\Omega$
$V_{VOB}$	Sawtooth bottom voltage on VCap pin <sup>(11)</sup>	No load on VOscF pin <sup>(11)</sup>		2		V
$V_{VOTref}$	Sawtooth top voltage internal reference			5		V
$V_{VOT}$	Sawtooth top voltage on VCap pin	AGC loop stabilized		5		V
$t_{VODis}$	Sawtooth Discharge time	$C_{VCap}=150nF$		80		$\mu s$
$f_{VO(0)}$	Free-running frequency	$C_{VCap}=150nF$		100		Hz
$f_{VOCapt}$	AGC loop capture frequency	$C_{VCap}=150nF$	50		185	Hz
$\frac{\Delta V_{VOdev}}{V_{VOamp}}$	Sawtooth non-linearity <sup>(12)(17)</sup>	AGC loop stabilized <sup>(12)</sup>		0.5		%
$\frac{\Delta V_{VOamp}}{V_{VOamp} \cdot \Delta f_{VO}}$	Frequency drift of sawtooth amplitude <sup>(18)(19)</sup>	AGC loop stabilized $f_{VOCapt(min)} \leq f_{VO} \leq f_{VOCapt(max)}$		200		ppm/Hz
<b>Vertical output drive signal (on pin VOut); <math>V_{RefO} = 8V</math></b>						
$V_{midref}$	Internal reference for vertical sawtooth middle point			3.5		V
$V_{mid(VOut)}$	Middle point on VOut sawtooth	$V_{POS}$ (Sad08h): <sup>(22)</sup> x0000000b x1000000b x1111111b $V_{POF}$ (Sad1Eh): <sup>(21)</sup> x0000000b x1000000b x1111111b	3.65	3.1 3.45 3.8	3.3	V V V
$V_{amp}$	Amplitude of VOut sawtooth (peak-to-peak voltage)	$V_{SIZE}$ (Sad07h): <sup>(23)</sup> x0000000b x1000000b x1111111b $V_{SAG}$ (Sad1Dh): <sup>(20)</sup> x0000000b x1000000b x1111111b	3.5	2.25 3.0 3.75	2.5	V V V
$V_{offVOut}$	Level on VOut pin at V-drive "off"	I <sup>2</sup> C-bus bit VOutEn at 0		4.0		V

Table 2. Vertical section ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
$I_{VOut}$	Current delivered by VOut output		-5		0.25	mA
$V_{SCor}/V_{amp}$	S-correction range	(13)(20)(21) AGC loop stabilized $t_{VR}=1/4 T_{VR}^{(15)}$ $t_{VR}=3/4 T_{VR}$		-4.5 +4.5		% %
$V_{CCor}/V_{amp}$	C-correction range	(14)(20)(21) AGC loop stabilized $t_{VR}=1/2 T_{VR}^{(15)}$ CCOR(Sad0Ah): x0000000b x1000000b x1111111b		-2.5 0 +2.5		% % %
$V_{VEHT}$	Control input voltage range on-VEHTIn pin		1	4	6	V
$V_{VEHTnull}$	Neutral point on breathing characteristics <sup>(16)</sup>			4.0		V
$\frac{\Delta V_{amp}}{V_{amp} \cdot \Delta V_{VEHT}}$	Breathing compensation	$V_{RefO} < V_{VEHT} < V_{CC}$ $V_{VEHT}_{(min)} \leq V_{VEHT} \leq V_{VEHT}_{(max)}$ VEHTG (Sad1Ch): x0000000b x1000000b x1111111b		0 5 0 -5		%/V %/V %/V %/V

### Notes about vertical section

**Note 10:** Value of acceptable cumulated parasitic load resistance due to humidity, AGC storage capacitor leakage, etc., for less than 1% of  $V_{amp}$  change.

**Note 11:** The threshold for VVOB is generated internally and routed to VOscF pin. Any DC current on this pin will influence the value of VVOB.

**Note 12:** Maximum of deviation from an ideally linear sawtooth ramp at null S-correction (*SCOR* at 0000000b) and null C-correction (*CCOR* at 1000000b). The same rate applies to V-drive signal on VOut pin, no effect on EWOt.

**Note 13:** Maximum S-correction (*SCOR* at x1111111b), null C-correction (*CCOR* at 1000000b).

**Note 14:** Null S-correction (*SCOR* at 0000000b).

**Note 15:** " $t_{VR}$ " is time from the beginning of vertical ramp of V-drive signal on VOut pin. " $T_{VR}$ " is the duration of this ramp, see Chapter 7 - page 22 and Figure 19.

**Note 16:** If  $V_{VEHT}=V_{VEHTnull}$  or  $V_{HEHT}=V_{HEHTnull}$ , respectively, the influence of  $V_{VEHT}$  on vertical drive amplitude or the influence of  $V_{HEHT}$  on EW drive signal, respectively, is null.

**Note 17:**  $V_{VOamp} = V_{VOT} - V_{VOB}$

**Note 18:** Only the top of the saw tooth drifts. The same rate applies to V-drive signal on VOut pin.

**Note 19:** Informative, not tested on each unit.

**Note 20:** *VSIZE* at medium value 1000000b.

**Note 21:** *VPOS* at medium value 1000000b.

**Note 22:** *VPOF* at medium value 1000000b.

**Note 23:** *VSAG* at maximum value 1111111b.

## 6.6 EW drive section

Table 3. EW drive section ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
$V_{EW}$	Output voltage on EWOut pin		1.8		6.5	V
$I_{EWout}$	Current delivered by EWOut output		-1.5		0.1	mA
$V_{HEHT}$	Control voltage range on HEHTIn pin		1		6	V
$V_{HEHTnull}$	Neutral point on breathing characteristics. See Figure 15. <sup>(16)</sup>			4.0		V
$V_{EW-DC}$	DC component of the EW-drive signal on EWOut pin <sup>(30)</sup>	(24)(25)(26)(27)(28)(36)(42)(43) EWTrHFr=0 or VHO>VHO-Thrfr HSIZE (Sad10h): 0000000b 1000000b 1111111b		2 3.25 4.5		V V V
$V_{EW-base}$	DC reference for the EW-drive signal on EWOut pin			2		V
$\frac{\Delta V_{EW-DC}}{\Delta V_{HEHT}}$	Breathing compensation on DC component of the EW-drive signal <sup>(30)</sup>	(24)(25)(26)(27)(42)(43) VRefO < VHEHT < VCC VHEHT <sub>(min)</sub> ≤ VHEHT ≤ VHEHT <sub>(max)</sub> : HEHTG (Sad1Bh): x000000b x100000b x111111b		0 0 -0.25 0 +0.25		V/V V/V V/V V/V V/V
$\frac{\Delta V_{EW-DC}}{V_{EW-DC} \cdot \Delta T}$	Temperature drift of DC component of the EW-drive signal <sup>(30)</sup>	(24)(25)(26)(27)(28)(36)(42)(43) (44)		100		ppm/°C
$V_{EW-PCC}$	Pin cushion correction component of the EW-drive signal	(24)(25)(26)(28)(29)(31) (32)(36)(42)(43) VSIZE at maximum PCC (Sad0Ch): x000000b x100000b x111111b Tracking with VSIZE: PCC at x100000b VSIZE (Sad07h): x000000b x100000b		0 0.75 1.5  0.25 0.5		V V V  V V
$\frac{V_{EW-PCC}[t_{vr}=0]}{V_{EW-PCC}[t_{vr}=T_{VR}]}$	Tracking of PCC component of the EW-drive signal with vertical position adjustment	(24)(25)(26)(29)(33)(35)(36)(42)(43)		0.5 2.0		
$V_{EW-Key}$	Keystone correction component of the EW-drive signal	(25)(26)(27)(28)(29)(33)(34)(36)(42)(43)		0.4 -0.4		V V

Table 3. EW drive section ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
$V_{EW-TCor}$	Top corner correction component of the EW-drive signal	(24)(26)(27)(28)(29)(31)(33)(36)(42)(43) <i>TCC</i> (Sad0Eh): x0000000b x1000000b x1111111b		-1.4 0 +1.4		V V V
$V_{EW-BCor}$	Bottom corner correction component of the EW-drive signal	(24)(25)(27)(28)(29)(32)(33)(36)(42)(43) <i>BCC</i> (Sad0Fh): x0000000b x1000000b x1111111b		-1.4 0 +1.4		V V V
$V_{EW-S}$	Pin Cushion S correction component of EW-drive signal	(24)(25)(26)(27)(28)(29)(33)(36)(41)(43) <i>EWSC</i> (Sad19h): x0000000b x1000000b x1111111b		-0.3 0 0.3		V V V
$V_{EW-W}$	Pin Cushion W correction component of EW-drive signal	(24)(25)(26)(27)(28)(29)(33)(36)(41)(42) <i>EWWC</i> (Sad1Ah): x0000000b x1000000b x1111111b		-0.1 0 0.1		V V V
$\frac{\Delta V_{EW-AC}}{V_{EW-AC}[f_{max}] \cdot \Delta V_{HO}}$	Tracking of AC component of EW-drive signal with horizontal frequency <sup>(37)(38)(39)</sup>	I <sup>2</sup> C bit EWT <sub>r</sub> HF <sub>r</sub> =1 VHO>VHOT <sub>hr</sub> VHO(min)≤VHO≤VHOT <sub>hr</sub>		0 20		%/V %/V
$\frac{\Delta V_{EW-DC}}{V_{EW-DC}[span] \cdot \Delta V_{HO}}$	Tracking of DC component of EW-drive signal with horizontal frequency <sup>(30)(38)(39)</sup>	I <sup>2</sup> C bit EWT <sub>r</sub> HF <sub>r</sub> =1 VHO>VHOT <sub>hr</sub> VHO(min)≤VHO≤VHOT <sub>hr</sub>		0 20		%/V %/V
$\frac{V_{EW-AC}}{V_{EW-AC}[HSIZE_{max}]}$	Tracking of AC component of EW-drive signal with horizontal size <sup>(37)</sup>	I <sup>2</sup> C bit EWT <sub>r</sub> HSize=1 <i>HSIZE</i> (Sad10h): 0000000b 1000000b 1111111b		138 119 100		% % %
$\frac{\Delta V_{EW-AC}}{V_{EW-AC} \cdot \Delta V_{HEHT}}$	Breathing compensation on AC component of the EW-drive signal <sup>(37)</sup>	VRefO < VHEHT < VCC VHEHT <sub>(min)</sub> ≤VHEHT≤VHEHT <sub>(max)</sub> : <i>HEHTG</i> (Sad1Bh): 0000000b 1000000b 1111111b		0 3.5 0 -3.5		%/V %/V %/V %/V

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### Notes about EW drive section

- Note 24:** *KEYST* at medium (neutral) value.
- Note 25:** *TCC* at medium (neutral) value.
- Note 26:** *BCC* at medium (neutral) value.
- Note 27:** *PCC* at minimum value.
- Note 28:** *VPOS* at medium (neutral) value.
- Note 29:** *HSIZE* I<sup>2</sup>C field at maximum value.
- Note 30:** VEW-DC is defined as voltage at  $t_{VR}=1/2 T_{VR}$ .
- Note 31:** Defined as difference of (voltage at  $t_{VR}=0$ ) minus (voltage at  $t_{VR}=1/2 T_{VR}$ ).
- Note 32:** Defined as difference of (voltage at  $t_{VR}=T_{VR}$ ) minus (voltage at  $t_{VR}=1/2 T_{VR}$ ).
- Note 33:** *VSIZE* at maximum value.
- Note 34:** Difference (voltage at  $t_{VR}=0$ ) minus (voltage at  $t_{VR}=T_{VR}$ ).
- Note 35:** Ratio "A/B" of parabola component voltage at  $t_{VR}=0$  versus parabola component voltage at  $t_{VR}=T_{VR}$ .  
See Figure 2.
- Note 36:**  $V_{HEHT>VRefO}$ ,  $V_{VEHT>VRefO}$
- Note 37:**  $V_{EW-AC}$  is defined as overall peak-to-peak value between  $t_{VR}=0$  and  $t_{VR}=T_{VR}$  of all components other than VEW-DC (contribution of PCC, keystone correction, corner corrections and S- and W-corrections).
- Note 38:** More precisely tracking with voltage on HPLL1F pin which itself depends on frequency at a rate given by external components on PLL1 pins
- Note 39:**  $VEW-DC[span] = VEW-DC[VHO>VHOThrfr] - VEW-DC[HSIZE=0000000b]$ .  
 $V_{EW-AC}[f_{max}] = V_{EW-AC}[VHO>VHOThrfr]$ .
- Note 40:** Defined as difference of (voltage at  $t_{VR}=1/4 T_{VR}$ ) minus (voltage at  $t_{VR}=3/4 T_{VR}$ ).
- Note 41:** Defined as difference of (voltage at  $t_{VR}=1/2 T_{VR}$ ) minus (voltage at  $t_{VR}=1/4 T_{VR}$ ).
- Note 42:** *EWSC* at medium (neutral) value.
- Note 43:** *EWWC* at medium (neutral) value.
- Note 44:** Informative, not tested on each unit.



## 6.7 Dynamic correction outputs section

Table 4. Dynamic correction outputs section ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
<b>Composite Horizontal and Vertical Dynamic Correction output HVDyCor</b>						
$I_{HVDyCor}$	Current delivered by HVDyCor output		-2		1	mA
$V_{HVD-DC}$	DC component of the drive signal on HVDyCor output	HVDyCorPol = 0 HVDyCorPol = 1	TBD TBD	2.1 7.30	TBD TBD	V V
$\frac{\Delta V_{HVD-DC}}{V_{HVD-DC} \cdot \Delta T}$	Temperature drift of DC component of the drive signal on HVDyCor	(19)		200		ppm/ $^{\circ}C$
$V_{HVD-H}$	Amplitude of H-component of the drive signal on HVDyCor output	(45)(46) HDyCorTr = 0 HVDC-HSHAP = min HVDC-HAMP (Sad04h): x0000000b x1000000b x1111111b  HVDC-HSHAP = max HVDC-HAMP (Sad04h): x0000000b x1000000b x1111111b		4.8 1.8 1  4.5 1.5 1		V V V  V V V
$S_{HVDC-HSHAP}$	Power index of the H-component of the drive signal on HVDyCor output	(53) HVDC-HSHAP (Sad18h) x0000000b x1000000b x1111111b		2 2.8 4		
$\frac{V_{HVD-H}[TrHSOn]}{V_{HVD-H}[TrHSOff]}$	Impact of horizontal size adjustment on HVDyCor H-parabola component (tracking) (47)	H SIZE (Sad10h): 0000000b 1111111b		(48) 1		
$t_{HVD-Hoffset}/T_H$	Offset (phase) of H-parabola component of the drive signal on HVDyCor output (50)	HVDC-HPH (Sad05h): x0000000b x1000000b (51) x1111111b		+24.5 0 -24.5		% % %
$t_{HVD-Hflat}$	Duration of the flat part at the start of H-parabola component of the drive signal on HVDyCor output (50)	fHO=31kHz HDCFlatEn = 0 or/and HDyCorPh = 0  HDCFlatEn = 1 HDyCorPh = 1		850  (54)		ns
$V_{HVD-V}$	Amplitude of V-parabola component of the drive signal on HVDyCor output	(28) V SIZE at x1000000b HVDC-VAMP (Sad06h): x0000000b x1000000b x1111111b  HVDC-VAMP at max.: V SIZE (Sad07h): x0000000b x1111111b		0 0.6 1.2  0.7 1.9		V V V  V V

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**Table 4. Dynamic correction outputs section** ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
$\frac{V_{HVD-V}[t_{VR}=0]}{V_{HVD-V}[t_{VR}=T_{VR}]}$	Tracking of V-parabola component of the drive signal on HDyCor output with vertical position <sup>(49)</sup>	<i>HVDC-VAMP</i> at max.: <i>VPOS</i> (Sad08h): x0000000b x1111111b		0.5 2.0		
<b>Vertical Dynamic Correction output VDyCor</b>						
$I_{VDyCor}$	Current delivered by VDyCor output		-1.5		0.1	mA
$V_{VD-DC}$	DC component of the drive signal on VDyCor output	$R_{L(VDyCor)}=10k\Omega$		4		V
$V_{VD-V}$	Amplitude of V-parabola on VDyCor output <sup>(52)</sup>	<sup>(28)</sup> <i>VSIZE</i> at medium <i>VDC-AMP</i> (Sad15h): x0000000b x1000000b x1111111b <i>VDC-AMP</i> at maximum <i>VSIZE</i> (Sad07h): x0000000b x1111111b		0 0.5 1  0.6 1.6		V V V  V V
$\frac{V_{VD-V}[t_{VR}=0]}{V_{VD-V}[t_{VR}=T_{VR}]}$	Tracking of V-parabola on VDyCor output with vertical position <sup>(49)</sup>	<i>VDC-AMP</i> at maximum <i>VPOS</i> (Sad08h): x0000000b x1111111b		0.5 2.0		

### Notes about dynamic output section

**Note 45:** *HVDC-VAMP* at minimum.

**Note 46:** *HVDC-HPH* at medium.

**Note 47:** Ratio of the amplitude at HDyCorTr=1 to the amplitude at HDyCorTr=0 (refer to chapter "I<sup>2</sup>C-bus control register map") as a quadratic function of horizontal size adjustment.

**Note 48:**  $(1.38)^{SHVDC-HSHAP}$

**Note 49:** Ratio "A/B" of vertical parabola component voltage at  $t_{VR}=0$  versus vertical parabola component voltage at  $t_{VR}=T_{VR}$ .

**Note 50:** Refer to Figure 16.

**Note 51:** Taken for reference at given position of HDyCorPh flag.

**Note 52:** Unsigned value. Polarity selection by VDyCorPol I<sup>2</sup>C-bus bit. Refer to section I<sup>2</sup>C-bus control register map.

**Note 53:** Value gives the shape characteristics of the H-component. Refer to Figure 17.

**Note 54:** The flat part begins at the start of fly-back and ends at the same moment as for combination HDCFlatEn = 0, HDyCorPh = 1. Refer to Figure 16.

## 6.8 DC/DC controller section

**Table 5. DC/DC controller section** ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
$R_{B+FB}$	Ext. resistance applied between BComp output and BRegIn input		5			k $\Omega$
$A_{OLG}$	Open loop gain of error amplifier on BRegIn input	Low frequency <sup>(19)</sup>		100		dB
$f_{UGBW}$	Unity gain bandwidth of error amplifier on BRegIn input	(19)		6		MHz
$I_{RI}$	Bias current delivered by BRegIn			-0.2		$\mu A$
$I_{BComp}$	Output current capability of BComp output.	BOut enabled BOut disabled <sup>(55)</sup>	-0.5	0.5	2.0	mA mA
$A_{BISense}$	Voltage gain on BISense input			3		
$V_{ThrBIsCurr}$	Threshold voltage on BISense input corresponding to current limitation	ThrBIsense = 0 ThrBIsense = 1	TBD TBD	2.1 1.2		V
$I_{BISense}$	Bias current delivered by BISense			-1		$\mu A$
$t_{BOn}$	Conduction time of the power transistor				$T_H - 300ns$	
$I_{BOut}$	Output current capability of BOut output		0		10	mA
$V_{BOSat}$	Saturation voltage of the internal output transistor on BOut	IBOut=10mA		0.25		V
$V_{BReg}$	Regulation reference for BRegIn voltage <sup>(56)</sup>	VRefO=8V BREF (Sad03h): x0000000b x1000000b x1111111b		3.8 4.9 6.0		V V V
$t_{BTrigDel}/T_H$	Delay of BOut "Off-to-On" edge after middle of flyback pulse <sup>(57)</sup>	BOutPh = 0 and BO-HEdge = 0		16		%

**Note 55:** A current sink is provided by the BComp output while BOut is disabled.

**Note 56:** Internal reference related to VRefO. The same values to be found on pin BRegIn, while regulation loop is stabilized.

**Note 57:** Only applies to configuration specified in "Test conditions" column, i.e. synchronization of BOut "Off-to-On" edge with horizontal fly-back signal. Refer to chapter "DC/DC controller" for more details.

## 6.9 Miscellaneous

Table 6. Miscellaneous ( $V_{CC} = 12V$ ,  $T_{amb} = 25^{\circ}C$ )

Symbol	Parameter	Test Conditions	Value			Units
			Min.	Typ.	Max.	
<b>Vertical blanking and horizontal lock indication composite output HLckVBk</b>						
$I_{SinkLckBk}$	Sink current to HLckVBk pin	<sup>(58)</sup>		100		$\mu A$
$V_{OLckBk}$	Output voltage on HLckVBk output	<u>V. blank</u>	<u>H. lock</u>			
		No	Yes		0.1	V
		Yes	Yes		1.1	V
		No	No		5	V
		Yes	No		6	V
<b>Horizontal moiré canceller</b>						
$\frac{\Delta T_{H(H-moire)}}{T_H}$	Modulation of $T_H$ by H. moiré function	HMoiréMode = 0 HMOIRE (Sad02h): x0000000b x1111111b			0 0.02	% %
		HMoiréMode = 1 HMOIRE (Sad02h): x0000000b x1111111b			0 0.04	% %
<b>Vertical moiré canceller</b>						
$V_{V-moiré}$	Amplitude of modulation of V-drive signal on VOut pin by vertical moiré.	VMOIRE (Sad0Bh): x0000000b x1111111b		0 3		mV mV
<b>Protection functions</b>						
$V_{ThrXRy}$	Input threshold on XRay input <sup>(59)</sup>		VRefO -10mV	VRefO	VRefO +10mV	
$t_{XRyDelay}$	Delay time between XRay detection event and protection action		$T_H$		$2T_H$	
$V_{CCXRyEn}$	Minimum VCC value for operation of XRay detection and protection <sup>(62)</sup>			10.2	10.8	V
$V_{CCEn}$	VCC value for start of operation at VCC ramp-up <sup>(60)</sup>			8.0		V
$V_{CCDis}$	VCC value for stop of operation at VCC ramp-down <sup>(60)</sup>			6.8		V
<b>Control voltages on HPosF pin and VCC for Soft start/stop operation<sup>(19)(61)</sup></b>						
$V_{HOn}$	Threshold for start/stop of H-drive signal			1		V
$V_{BOn}$	Threshold for start/stop of B-drive signal			1.7		V
$V_{HBNorm}$	Threshold for full operation duty cycle of H-drive and B-drive signals			2.4		
$V_{CCStop}$	Minimum supply voltage when voltage on HPosF pin reaches VHOn threshold <sup>(63)</sup>			4.8		

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**Notes about Miscellaneous section**

**Note 58:** Current sunk by the pin if the external voltage is higher than one the circuit tries to force.

**Note 59:** See VRefO in Section 6.2.

**Note 60:** In the regions of VCC where the device's operation is disabled, the H-drive, V-drive and B+-drive signals on HOut, VOut and BOut pins, resp., are inhibited, the I<sup>2</sup>C-bus does not accept any data and the XRayAlarm flag is reset. Also see Figure 10.

**Note 61:** See Figure 10.

**Note 62:** When VCC is below VCCXRayEn XRay detection and protection are disabled.

**Note 63:** Minimum momentary supply voltage to ensure a correct performance of Soft stop function at VCC fall down is defined at the moment when the voltage on HPosF pin reaches VHOn threshold.

7 TYPICAL OUTPUT WAVEFORMS

Table 7. Typical output waveforms - Note 64

Function	Sad	Pin	Byte	Waveform	Effect on Screen
Vertical Size	07	VOut (23)	x0000000		
			x1111111		
Vertical Size After Gain	1D	VOut (23)	x0000000		
			x1111111		
Vertical Position	08	VOut (23)	x0000000		
			x1000000		
			x1111111		
Vertical Position Offset	1E	VOut (23)	x0000000		
			x1000000		
			x1111111		
S-correction	09	VOut (23)	x0000000: Null		
			x1111111: Max.		

Table 7. Typical output waveforms - Note 64

Function	Sad	Pin	Byte	Waveform	Effect on Screen
C-correction	0A	VOut (23)	x0000000		
			x1000000 : Null		
			x1111111		
Vertical moiré amplitude	0B	VOut (23)	x0000000: Null		
			x1111111: Max.		
Horizontal size	10h	EWOut (24)	00000000		
			11111111		
Keystone correction	0D	EWOut (24)	x0000000		
			x1111111		
Pin cushion correction	0C	EWOut (24)	x0000000		
			x1111111		

Table 7. Typical output waveforms - Note 64

Function	Sad	Pin	Byte	Waveform	Effect on Screen
Top corner correction	0E	EWOut (24)	x11111111		
			x00000000		
Bottom corner correction	0F	EWOut (24)	x11111111		
			x00000000		
Pin Cushion S-correction	19	EWOut (24)	x11111111		
			x00000000		
Pin Cushion W-correction	1A	EWOut (24)	x11111111		
			x00000000		
Parallelogram correction	12h	Internal	x00000000		
			x11111111		
Pin cushion asymmetry correction	11h	Internal	x00000000		
			x11111111		



Table 7. Typical output waveforms - Note 64

Function	Sad	Pin	Byte	Waveform	Effect on Screen
Top corner asymmetry correction	13h	Internal	x0000000		
			x1111111		
Bottom corner asymmetry correction	14h	Internal	x0000000		
			x1111111		
Vertical dynamic correction amplitude	15h	VDyCor (32)	01111111		Application dependent
			x0000000		
			11111111		
HVDyCor vertical amplitude	06	HVDyCor (11) HVDyCorPol=0	x0000000		Application dependent
			x1111111		

Table 7. Typical output waveforms - Note 64

Function	Sad	Pin	Byte	Waveform	Effect on Screen
HVDyCor vertical amplitude	06	HVDyCor (11) HVDyCorPol=1	x0000000		Application dependent
			x1111111		
HVDyCor horizontal adjustments	04 05 18h	HVDyCor (11)		See Figure 16 on page 47	Application dependent

**Note 64:** For any H and V correction component of the waveforms on EWOOut and VOut pins and internal waveform for corrections of H asymmetry, displayed in the table, the weight of the other relevant components is nullified (minimum for parabola, S-correction, medium for keystone, all corner corrections, C-correction, S- and W-pin cushion corrections, parallelogram, pin cushion asymmetry correction, written in corresponding registers).

## 8 I<sup>2</sup>C-BUS CONTROL REGISTER MAP

The device slave address is 8C in write mode and 8D in read mode. The control register map is given in Table .

**Bold** weight denotes default value at Power-On-Reset.

I<sup>2</sup>C-bus data in the adjustment register is buffered and internally applied with discharge of the vertical oscillator <sup>(65)</sup>.

In order to ensure compatibility with future devices, all "Reserved" bits should be set to 0.

**Table 8. I<sup>2</sup>C-bus control registers**

Sad	D7	D6	D5	D4	D3	D2	D1	D0
WRITE MODE (SLAVE ADDRESS = 8C)								
00	HDutySyncV 1: Synchro. 0: Asynchro.	<i>HDUTY</i> Horizontal duty cycle						
		0	0	0	0	0	0	0
01	1	<i>HPOS</i> Horizontal position						
		0	0	0	0	0	0	0
02	HMoiréMode 1: Separated 0: Combined	<i>HMOIRE</i> Horizontal moiré amplitude						
		0	0	0	0	0	0	0
03	B+SyncV 0: Asynchro.	<i>BREF</i> B+reference						
		1	0	0	0	0	0	0
04	HDyCorTr 0: Not active	<i>HVDC-HAMP</i> HVDyCor horizontal amplitude						
		1	0	0	0	0	0	0
05	HDyCorPh 1: Middle 0: Start	<i>HVDC-HPH</i> HVDyCor horizontal phase						
		1	0	0	0	0	0	0
06	BOutPol 0: Type N	<i>HVDC-VAMP</i> HVDyCor vertical amplitude						
		1	0	0	0	0	0	0
07	BOutPh 0: H-flyback 1: H-drive	<i>VSIZE</i> Vertical size						
		1	0	0	0	0	0	0
08	EWTrHFr 0: No tracking	<i>VPOS</i> Vertical position						
		1	0	0	0	0	0	0
09	Reserved	<i>SCOR</i> S-correction						
		1	0	0	0	0	0	0
0A	Reserved	<i>CCOR</i> C-correction						
		1	0	0	0	0	0	0
0B	Reserved	<i>VMOIRE</i> Vertical moiré amplitude						
		0	0	0	0	0	0	0
0C	Reserved	<i>PCC</i> Pin cushion correction						
		1	0	0	0	0	0	0
0D	Reserved	<i>KEYST</i> Keystone correction						
		1	0	0	0	0	0	0
0E	Reserved	<i>TCC</i> Top corner correction						
		1	0	0	0	0	0	0
0F	Reserved	<i>BCC</i> Bottom corner correction						
		1	0	0	0	0	0	0

**Table 8. I<sup>2</sup>C-bus control registers**

Sad	D7	D6	D5	D4	D3	D2	D1	D0
10	<i>HSIZE Horizontal size</i>							
	1	0	0	0	0	0	0	0
11	Reserved	<i>PCAC Pin cushion asymmetry correction</i>						
		1	0	0	0	0	0	0
12	Reserved	<i>PARAL Parallelogram correction</i>						
		1	0	0	0	0	0	0
13	Reserved	<i>TCAC Top corner asymmetry correction</i>						
		1	0	0	0	0	0	0
14	Reserved	<i>BCAC Bottom corner asymmetry correction</i>						
		1	0	0	0	0	0	0
15	VDyCorPol 0: "U"	<i>VDC-AMP Vertical dynamic correction</i>						
		1	0	0	0	0	0	0
16	XRayReset 0: No effect 1: Reset	VSynAuto 1: On	VSynSel 0:Comp 1:Sep	SDetReset 0: No effect 1: Reset	PLL1Pump 1,1: Fastest 0,0: Slowest		PLL1InhEn 1: On	HLockEn 1: On
17	TV 0: Off <sup>(67)</sup>	TH 0: Off <sup>(67)</sup>	TVM 0: Off <sup>(67)</sup>	THM 0: Off <sup>(67)</sup>	BOHEdge 0: Falling	HBOutEn 0: Disable	VOutEn 0: Disable	BlankMode 1: Perm.
18	Reserved 0:	<i>HVDC-HSHAP HVDyCor horizontal shape</i>						
		0	0	0	0	0	0	0
19	Reserved 0:	<i>EWSC East-West S-correction</i>						
		1	0	0	0	0	0	0
1A	Reserved 0:	<i>EWWC East-West W-correction</i>						
		1	0	0	0	0	0	0
1B	Reserved 0:	<i>HEHTG Horizontal EHT compensation gain</i>						
		0	0	0	0	0	0	0
1C	Reserved 0:	<i>VEHTG Vertical EHT compensation gain</i>						
		0	0	0	0	0	0	0
1D	Reserved 0:	<i>VSAG Vertical size after-gain</i>						
		1	1	1	0	0	0	0
1E	Reserved 0:	<i>VPOF Vertical position offset</i>						
		1	0	0	0	0	0	0
1F	ThrBIsense 0: High	BMute 0: Off	BSafeEn 0: Disable	EWTrHSize 0: Tracking	Ident 0: No effect	HLockSpeed 0: Slow	HVDyCorPol 0: "U"	HDCFlatEn 0: Disable
READ MODE (SLAVE ADDRESS = 8D)								
XX <sup>(66)</sup> )	HLock 0: Locked 1: Not locked	VLock 0: Locked 1: Not lock.	XRayAlarm 1: On 0: Off	<i>Polarity detection</i>		<i>Sync detection</i>		
				HVPol 1: Negative	VPol 1: Negative	VExtrDet 0: Not det.	HVDet 0: Not det.	VDet 0: Not det.

**Note 65:** With exception of *HDUTY* and *BREF* adjustments data that can take effect instantaneously if switches *HDutySyncV* and *B+SyncV* are at 0, respectively.

**Note 66:** In Read Mode, the device always outputs data of the status register, regardless of sub address previously selected.

**Note 67:** The TV, TH, TVM and THM bits are for testing purposes and must be kept at 0 by application.

DESCRIPTION OF I<sup>2</sup>C-BUS SWITCHES AND FLAGS

## Write-to bits

**Sad00h/D7 - HDutySyncV**

Synchronization of internal application of **H**orizontal **D**uty cycle data, buffered in I<sup>2</sup>C-bus latch, with internal discharge of **V**ertical oscillator.

0: Asynchronous mode, new data applied with ACK bit of I<sup>2</sup>C-bus transfer on this sub address

1: Synchronous mode

**Sad02h/D7 - HMoiréMode**

Horizontal **M**oiré characteristics.

0: Adapted to an architecture with EHT generated in deflection section

1: Adapted to an architecture with separated deflection and EHT sections

**Sad03h/D7 - B+SyncV**

Same as HDutySyncV, applicable for **B+** reference data

**Sad04h/D7 - HDyCorTr**

Tracking of **H**orizontal **D**ynamic **C**orrection waveform amplitude with *HSIZE* adjustment.

0: Not active

1: Active

**Sad05h/D7 - HDyCorPh**

Phase of start of **H**orizontal **D**ynamic **C**orrection waveform in relation to horizontal flyback pulse.

0: Start of the flyback

1: Middle of the flyback

**Sad06h/D7 - BOutPol**

Polarity of **B+** drive signal on **B**Out pin.

0: adapted to N type of power MOS - high level to make it conductive

1: adapted to P type of power MOS - low level to make it conductive

**Sad07h/D7 - BOutPh**

Phase of start of **B+** drive signal on **B**Out pin

0: End of horizontal flyback or horizontal frequency divided by 2, see **BOHE**Edge bit.

1: With one of edges of line drive signal on **H**Out pin, selected by **BOHE**Edge bit

**Sad08h/D7 - EWTrHFr**

Tracking of all corrections contained in waveform on pin **E**WOut with **H**orizontal **F**requency

0: Not active

1: Active

**Sad15h/D7 - VDyCorPol**

Polarity of **V**ertical **D**ynamic **C**orrection waveform (parabola)

0: Concave (minimum in the middle of the parabola)

1: Convex (maximum in the middle of the parabola)

**Sad16h/D0 - HLockEn**

Enable of output of **H**orizontal **P**LL1 **L**ock/unlock status signal on pin **H**LckVBk

0: Disabled, vertical blanking only on the pin **H**LckVBk

1: Enabled

**Sad16h/D1 - PLL1InhEn**

Enable of **I**nhibition of horizontal **P**LL1 during extracted vertical synchronization pulse

0: Disabled, PLL1 is never inhibited

1: Enabled

**Sad16h/D2 and D3- PLL1Pump**

Horizontal **P**LL1 charge **P**ump current

D3	D2	Time Constant
0	0	Slowest PLL1, lowest current
1	0	Moderate Slow PLL1, low current
0	1	Moderate Fast PLL1, high current
1	1	Fastest PLL1, highest current

**Sad16h/D4 - SDetReset**

**R**eset to 0 of **S**ynchronization **D**etection flags **V**Det, **H**VDet and **V**ExtrDet of status register effected with ACK bit of I<sup>2</sup>C-bus data transfer into register containing the **S**DetReset bit. Also see description of the flags.

0: No effect

1: Reset with automatic return of the bit to 0

**Sad16h/D5 - VSyncSel**

Vertical **S**ynchronization input **S**election between the one extracted from composite HV signal on pin H/HVSyn and the one on pin VSyn. No effect if VSyncAuto bit is at 1.

- 0: V. sync extracted from composite signal on H/HVSyn pin selected
- 1: V. sync applied on VSyn pin selected

**Sad16h/D6 - VSyncAuto**

Vertical **S**ynchronization input selection **A**utomatic mode. If enabled, the device automatically selects between the vertical sync extracted from composite HV signal on pin H/HVSyn and the one on pin VSyn, based on detection mechanism. If both are present, the one coming first is kept.

- 0: Disabled, selection done according to bit VSyncSel
- 1: Enabled, the bit VSyncSel has no effect

**Sad16h/D7 - XRayReset**

**R**eset to 0 of **X**Ray flag of status register effected with ACK bit of I<sup>2</sup>C-bus data transfer into register containing the XRayReset bit. Also see description of the flag.

- 0: No effect
- 1: Reset with automatic return of the bit to 0

**Sad17h/D0 - BlankMode**

**B**lanking operation **M**ode.

- 0: Blanking pulse starting with detection of vertical synchronization pulse and ending with end of vertical oscillator discharge (start of vertical sawtooth ramp on the VOut pin)
- 1: Permanent blanking - high blanking level in composite signal on pin HLckVBk is permanent

**Sad17h/D1 - VOutEn**

Vertical **O**utput **E**nable.

- 0: Disabled, VoffVOut on VOut pin (see Section 6.5 Vertical section)
- 1: Enabled, vertical ramp with vertical position offset on VOut pin

**Sad17h/D2 - HBOutEn**

Horizontal and **B**+ **O**utput **E**nable.

- 0: Disabled, levels corresponding to "power transistor off" on HOut and BOut pins (high

for HOut, high or low for BOut, depending on BOutPol bit).

- 1: Enabled, horizontal deflection drive signal on HOut pin providing that it is not inhibited by another internal event (activated XRay protection). B+ drive signal on BOut pin if not inhibited by another internal event.

Programming the bit to 1 after prior value of 0, will initiate soft start mechanism of horizontal drive and, if this is not inhibited by another internal event, also the soft start of B+ DC/DC converter controller. See also bits BMute and BSafeEn.

**Sad17h/D3 - BOHEdge**

If the bit BOutPh is at 1, selection of **E**dge of **H**orizontal drive signal to phase **B**+ drive **O**utput signal on BOut pin.

- 1: Rising edge
- 0: Falling edge

If the bit BOutPh is at 0, selection of signal to phase **B**+ drive output on BOut pin:

- 1: Horizontal frequency divided by 2 signal, top of horizontal VCO
- 0: End of horizontal flyback

**Sad17h/D4,D5,D6,D7 - THM, TVM, TH, TV**

Test bits. They must be kept at 0 level by application S/W.

**Sad1Fh/D0 - HDCFlatEn**

**E**nlargement of the **F**lat part on **H**orizontal **D**ynamic **C**orrection waveform (starting at the beginning of horizontal flyback).

- 0: Disable
- 1: Enable

**Sad1Fh/D1 - HVDyCorPol**

**P**olarity of **H**V **D**ynamic **C**orrection waveform.

- 0: Concave (minimum in the middle of the parabola)
- 1: Convex (maximum in the middle of the parabola)

**Sad1Fh/D2 - HLockSpeed**

Response **S**peed of lock-to-unlock transition of H-lock component on **H**Lock output and HLock I<sup>2</sup>C-bus flag at signal change.

- 0: Low
- 1: High

**Sad1Fh/D3 - Ident**

Device **I**dentification bit.  
 If **HBO**utEn is at 1, the bit has no effect.  
 If **HBO**utEn is at 0, then  
 0: The value of **Hlock** status bit is 1  
 1: The value of **Hlock** status bit is 0

**Sad1Fh/D4 - EWTrHSize**

Tracking of all corrections contained in waveform on pin **EW**Out with **H**orizontal **S**ize I<sup>2</sup>C-bus register **HSIZE**.  
 0: Active  
 1: Not active

**Sad1Fh/D5 - BSafeEn**

**B+** Output **S**afety **E**nable.  
 0: Disabled  
 1: Enabled, **B**Out goes off as soon as **H**Lock status of Horizontal PLL1 indicates “unlock”

**Read-out flags****SadXX/D0 - VDet**<sup>(68)</sup>

Flag indicating **D**etection of **V** synchronization pulses on **VSyn** pin.  
 0: Not detected  
 1: Detected

**SadXX/D1 - HVDet**<sup>(68)</sup>

Flag indicating **D**etection of **H** or **HV** synchronization pulses applied on **H/HV**Syn pin. Once the sync pulses are detected, the flag is set and latched. Disappearance of the sync signal will not lead to reset of the flag.  
 0: Not detected  
 1: Detected.

**SadXX/D2 - VExtrDet**<sup>(68)</sup>

Flag indicating **D**etection of **E**xtracted **V**ertical synchronization signal from composite **H+V** signal applied on **H/HV**Syn pin.  
 0: Not detected  
 1: Detected

**SadXX/D3 - VPol**

Flag indicating **P**olarity of **V** synchronization pulses applied on **VSyn** pin with respect to mean level of the sync signal.  
 0: Positive  
 1: Negative

**Note 68:** This flag, by its value of 1, indicates an event of detection of at least one synchronization pulse since its last reset (by means of the **SDetReset** I<sup>2</sup>C-bus bit). This is to be taken into account by application S/W in a way that enough time (at least the period between 2 synchronization pulses of analyzed signal) must be provided

state. Retrieval of “lock” state will initiate soft start mechanism of DC/DC controller on **B**Out output.

**Sad1Fh/D6 - BMute**

**B+** Output **M**ute.  
 0: Disabled  
 1: Enabled, **B**Out goes unconditionally off. Programming this bit back to 0 will initiate soft start mechanism of DC/DC controller on **B**Out output.

**Sad1Fh/D7 - ThrBIsense**

**T**hreshold on **B**ISense input corresponding to current limitation.  
 0: High  
 1: Low

**SadXX/D4 - HVPol**

Flag indicating **P**olarity of **H** or **HV** synchronization pulses applied on **H/HV**Syn pin with respect to mean level of the sync signal.  
 0: Positive  
 1: Negative

**SadXX/D5 - XRayAlarm**

**A**larm indicating that an event of excessive voltage has passed on **X**Ray pin. Can only be reset to 0 through I<sup>2</sup>C-bus bit **X**RayReset or by power-on reset.  
 0: No excess since last reset of the bit  
 1: At least one event of excess appeared since the last reset of the bit, **H**Out inhibited

**SadXX/D6 - VLock**

Status of “**L**ocking” or stabilizing of **V**ertical oscillator amplitude to an internal reference by **AGC** regulation loop.  
 0: Locked (amplitude stabilized)  
 1: Not locked (amplitude non-stabilized)

**SadXX/D7 - HLock**

**L**ock status of **H**orizontal PLL1.  
 0: Locked  
 1: Not locked  
 See also bit **Ident** (**Sad1Fh/D3**)

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between reset of the flag through SDetReset bit and validation of information provided in the flag after read-out of status register.



## 9 OPERATING DESCRIPTION

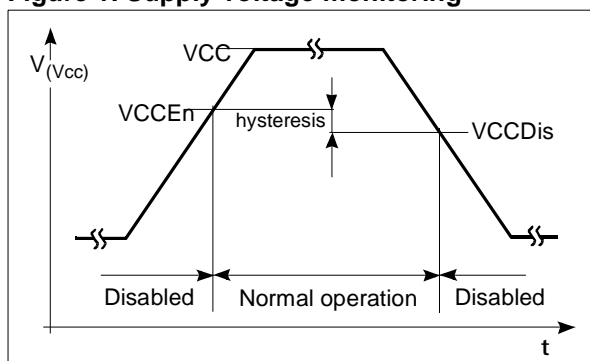
### 9.1 Supply and control

#### 9.1.1 Power supply and voltage references

The device is designed for a typical value of power supply voltage of 12 V.

In order to avoid erratic operation of the circuit at power supply ramp-up or ramp-down, the value of VCC is monitored. See Figure 1 and electrical specifications. At switch-on, the device enters a "normal operation" as the supply voltage exceeds VCCEn and stays there until it decreases below VCCDis. The two thresholds provide, by their difference, a hysteresis to bridge potential noise. Outside the "normal operation", the signals on HOut, BOut and VOut outputs are inhibited and the I<sup>2</sup>C-bus interface is inactive (high impedance on SDA, SCL pins, no ACK), all I<sup>2</sup>C-bus control registers being reset to their default values (see Chapter 8 - page 27). The stop of HOut and BOut drive signals when the VCC falls from normal operation below VCCDis is not instantaneous. It is only a trigger point of Soft Stop mechanism (see Subsection 9.3.7 - page 38).

**Figure 1. Supply voltage monitoring**



### 9.2 Synchronization processor

#### 9.2.1 Synchronization signals

The device has two inputs for TTL-level synchronization signals, both with hysteresis to avoid erratic detection and with a pull-down resistor. On H/HVSyn input, pure horizontal or composite horizontal/vertical signal is accepted. On VSyn input, only pure vertical sync. signal is accepted. Both positive and negative polarities may be applied on either input, see Figure 2. Polarity detector and programmable inverter are provided on each of the two inputs. The signal applied on H/HVSyn pin, after polarity treatment, is directly lead to horizontal

Internal thresholds in all parts of the circuit are derived from a common internal reference supply VRefO that is lead out to RefOut pin for external filtering against ground as well as for external use with load currents limited to IRefO. The filtering is necessary to minimize interference in output signals, causing adverse effects like e.g. jitter.

#### 9.1.2 I<sup>2</sup>C-bus control

The I<sup>2</sup>C-bus is a 2 line bidirectional serial communication bus introduced by Philips. For its general description, refer to corresponding Philips I<sup>2</sup>C-bus specification.

This device is an I<sup>2</sup>C-bus slave, compatible with fast (400kHz) I<sup>2</sup>C-bus protocol, with write mode slave address of 8Ch (read mode slave address 8Dh). Integrators are employed at the SCL (Serial Clock) input and at the input buffer of the SDA (Serial Data) input/output to filter off the spikes up to 50ns.

The device supports multiple data byte messages (with automatic incrementing of the I<sup>2</sup>C-bus subaddress) as well as repeated Start Condition for I<sup>2</sup>C-bus subaddress change inside the I<sup>2</sup>C-bus messages. All I<sup>2</sup>C-bus registers with specified I<sup>2</sup>C-bus subaddress are of WRITE ONLY type, whereas the status register providing a feedback information to the master I<sup>2</sup>C-bus device has no attributed I<sup>2</sup>C-bus subaddress and is of READ ONLY type. The master I<sup>2</sup>C-bus device reads this register sending directly, after the Start Condition, the READ device I<sup>2</sup>C-bus slave address (8Dh) followed by the register read-out, NAK (No Acknowledge) signal and the Stop Condition.

For the I<sup>2</sup>C-bus control register map, refer to Chapter 8 - page 27.

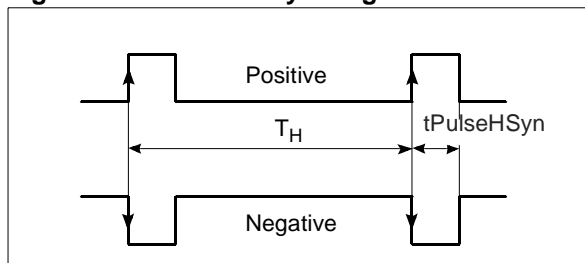
part and to an extractor of vertical sync. pulses, working on principle of integration, see Figure 3. The vertical sync. signal applied to the vertical deflection processor is selected between the signal extracted from the composite signal on H/HVSyn input and the one applied on VSyn input. The selector is controlled by VSyncSel I<sup>2</sup>C-bus bit.

Besides polarity detection, the device is capable of detecting presence of sync. signals on each of the inputs and at the output of vertical sync. extractor. The information from all detectors is provided in the I<sup>2</sup>C-bus status register (5 flags: VDet, HVDet,

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VExtrDet, VPol, HVPol). The device is equipped with an automatic mode (switched on or off by VSyncAuto I<sup>2</sup>C-bus bit) that also uses the detection information.

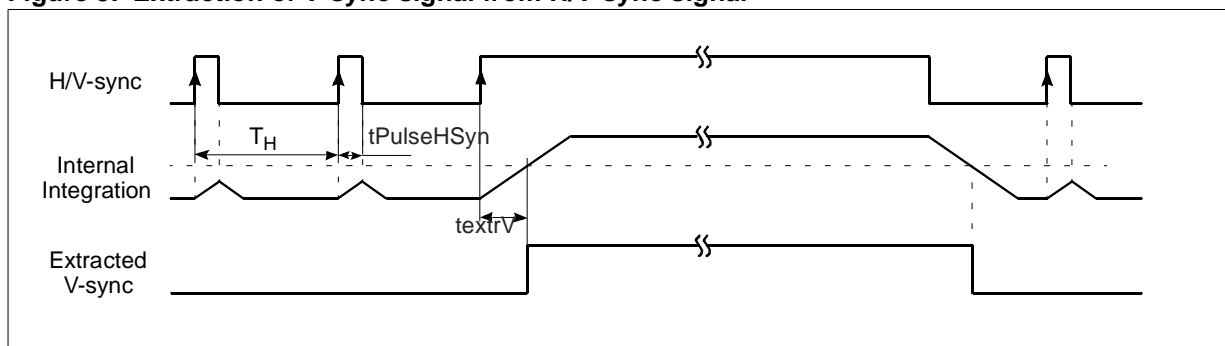
**Figure 2. Horizontal sync signal**



### 9.2.2 Sync. presence detection flags

The sync. signal presence detection flags in the status register (VDet, HVDet, VExtrDet) do not show in real time the presence or absence of corresponding sync. signal. They are latched to 1 as soon as a single sync. pulse is detected. In order to reset them to 0 (all at once), a 1 must be written into SDetReset I<sup>2</sup>C-bus bit, the reset action taking effect with ACK bit of the I<sup>2</sup>C-bus transfer to the register containing SDetReset bit. The detection circuits are ready to capture another event (pulse). See Note 68.

**Figure 3. Extraction of V-sync signal from H/V-sync signal**



### 9.2.3 MCU controlled sync. selection mode

I<sup>2</sup>C-bus bit VSyncAuto is set to 0. The MCU reads the polarity and signal presence detection flags, after setting the SDetReset bit to 1 and an appropriate delay, to obtain a true information of the signals applied, reads and evaluates this information and controls the vertical signal selector accordingly. The MCU has no access to polarity inverters, they are controlled automatically.

See also chapter Chapter 8 - page 27.

### 9.2.4 Automatic sync. selection mode

I<sup>2</sup>C-bus bit VSyncAuto is set to 1. In this mode, the device itself controls the I<sup>2</sup>C-bus bits switching the polarity inverters (HVPol, VPol) and the vertical sync. signal selector (VSyncSel), using the information provided by the detection circuitry. If both extracted and pure vertical sync. signals are present, the one already selected is maintained. No intervention of the MCU is necessary.

## 9.3 Horizontal section

### 9.3.1 General

The horizontal section consists of two PLLs with various adjustments and corrections, working on horizontal deflection frequency, then phase shifting and output driving circuitry providing H-drive signal on HOut pin. Input signal to the horizontal section is output of the polarity inverter on H/HVSyn input. The device ensures automatically that this polarity be always positive.

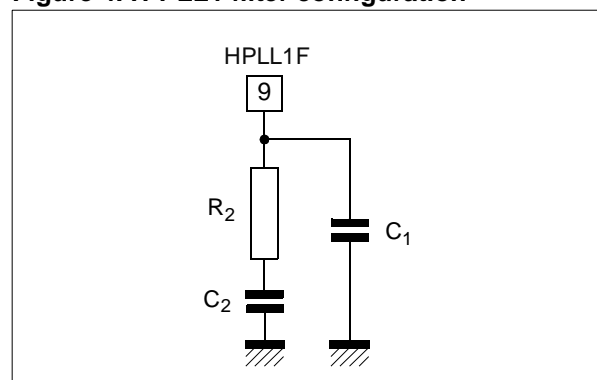
### 9.3.2 PLL1

The PLL1 block diagram is in Figure 5. It consists of a voltage-controlled oscillator (VCO), a shaper with adjustable threshold, a charge pump with inhibition circuit, a frequency and phase comparator and timing circuitry. The goal of the PLL1 is to make the VCO ramp signal match in frequency the sync. signal and to lock this ramp in phase to the sync. signal. On the screen, this offset results in the change of horizontal position of the picture. The loop, by tuning the VCO accordingly, gets and maintains in coincidence the rising edge of input sync. signal with signal REF1, deriving from the VCO ramp by a comparator with threshold adjustable through *HPOS* I<sup>2</sup>C-bus control. The coincidence is identified and flagged by lock detection circuit on pin HLckVBk as well as by HLock I<sup>2</sup>C-bus flag.

The charge pump provides positive and negative currents charging the external loop filter on HPLL1F pin. The loop is independent of the trailing edge of sync. signal and only locks to its leading edge. By design, the PLL1 does not suffer from any dead band even while locked. The speed of the PLL1 depends on current value provided by the charge pump. While not locked, the current is very low, to slow down the changes of VCO frequency and thus protect the external power components at

sync. signal change. In locked state, the currents are much higher, four different values being selectable via PLL1Pump I<sup>2</sup>C-bus bits to provide a means to control the PLL1 speed by S/W. Lower value make the PLL1 slower, but more stable. Higher values make it faster and less stable. In general, the PLL1 speed should be higher for high deflection frequencies. The response speed and stability (jitter level) depend on the choice of external components making up the loop filter. A "CRC" filter is generally used (see Figure 4).

**Figure 4. H-PLL1 filter configuration**



The PLL1 is internally inhibited during extracted vertical sync. pulse (if any) to avoid taking into account missing or wrong pulses on the phase comparator. Inhibition is obtained by forcing the charge pump output to high impedance state. The inhibition mechanism can be disabled through PLL1InhEn I<sup>2</sup>C-bus bit.

The Figure 7, in its upper part, shows the position of the VCO ramp signal in relation to input sync. pulse for three different positions of adjustment of horizontal position control *HPOS*.

Figure 5. Horizontal PLL1 block diagram

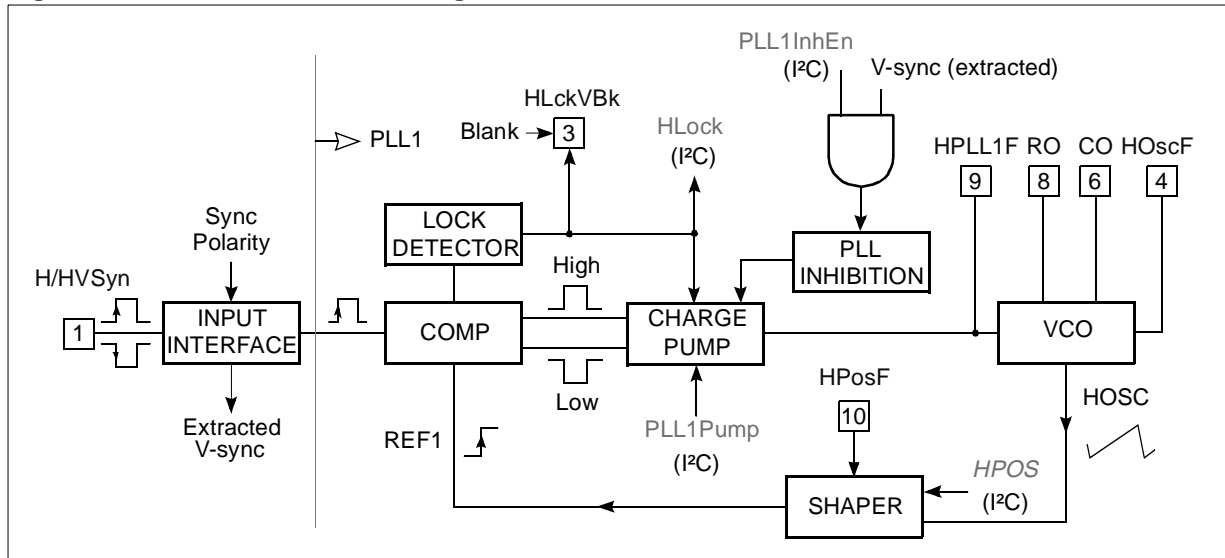
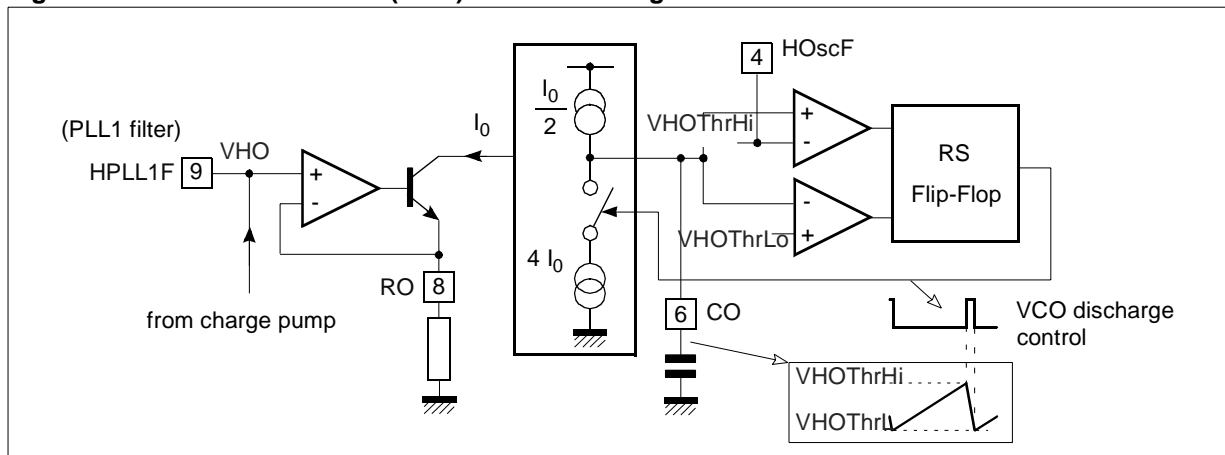


Figure 6. Horizontal oscillator (VCO) schematic diagram



### 9.3.3 Voltage controlled oscillator

The VCO makes part of both PLL1 and PLL2 loops, being an “output” to PLL1 and “input” to PLL2. It delivers a linear sawtooth. Figure 6 explains its principle of operation. The linears are obtained by charging and discharging an external capacitor on pin CO, with currents proportional to the current forced through an external resistor on pin RO, which itself depends on the input tuning voltage VHO (filtered charge pump output). The rising and falling linears are limited by VHOThrLo and VHOThrHi thresholds filtered through HOscF pin.

At no signal condition, the VHO tuning voltage is clamped to its minimum (see section 6.4 - page 10), which corresponds to the free-running VCO frequency  $f_{HO(0)}$ . Refer to subsection 9.3.1 for formula to calculate this frequency using external components values. The ratio between the frequency corresponding to maximum VHO and the one corresponding to minimum VHO (free-running frequency) is about 4.5. This range can easily be increased in the application. The PLL1 can only lock to input frequencies falling inside these two limits.



### 9.3.6 Output Section

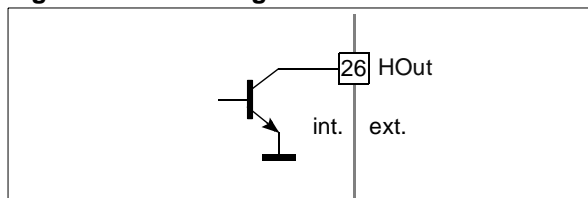
The H-drive signal is inhibited (high level) during flyback pulse, and also when VCC is too low, when X-ray protection is activated (*XRayAlarm* I<sup>2</sup>C-bus flag set to 1) and when I<sup>2</sup>C-bus bit *HBOutEn* is set to 0 (default position).

The duty cycle of the H-drive signal is controlled via I<sup>2</sup>C-bus register *HDUTY*. This is overruled during soft-start and soft-stop procedures (see Section 9.3.7 and Figure 10).

The PLL2 is followed by a rapid phase shifting which accepts the signal from H-moiré canceller (see Section 9.3.8)

The output stage consists of a NPN bipolar transistor, the collector of which is routed to HOut pin (see Figure 9).

**Figure 9.** HOut configuration



### 9.3.7 Soft-start and soft-stop on H-drive

The soft-start and soft-stop procedure is carried out at each switch-on or switch-off of the H-drive signal, either via *HBOutEn* I<sup>2</sup>C-bus bit or after reset of *XRayAlarm* I<sup>2</sup>C-bus flag, to protect external power components. By its second function, the external capacitor on pin *HPosF* is used to time out this procedure, during which the duty cycle of H-drive signal starts at its maximum (*tHoff* for soft start/stop in electrical specifications) and slowly decreases to the value determined by the control I<sup>2</sup>C-bus register *HDUTY* (vice versa at soft-stop). This is controlled by voltage on pin *HPosF*. In case of supply voltage switch off, the transients on HOut and BOut have different characteristics. See Figure 10, Figure 11 and Section 9.8.1.

### 9.3.8 Horizontal moiré cancellation

The horizontal moiré canceller is intended to blur a potential beat between the horizontal video pixel period and the CRT pixel width, which causes visible moiré patterns in the picture.

It introduces a microscopic indent on horizontal scan lines by injecting little controlled phase shifts to output circuitry of the horizontal section. Their amplitude is adjustable through *HMOIRE* I<sup>2</sup>C-bus control.

The behaviour of horizontal moiré is to be optimized for different deflection design configurations using *HMoiréMode* I<sup>2</sup>C-bus bit. This bit is to be kept at 0 for common architecture (B+ and EHT common regulation) and at 1 for separated architecture (B+ and EHT each regulated separately). The maximum amplitude adjustable through *HMOIRE* I<sup>2</sup>C-bus control is optimized according to selection by *HMoiréMode* I<sup>2</sup>C-bus bit: larger when B+ and EHT are each regulated separately, smaller when B+ and EHT are common regulation.

Figure 10. Control of HOut and BOut at start/stop at nominal VCC

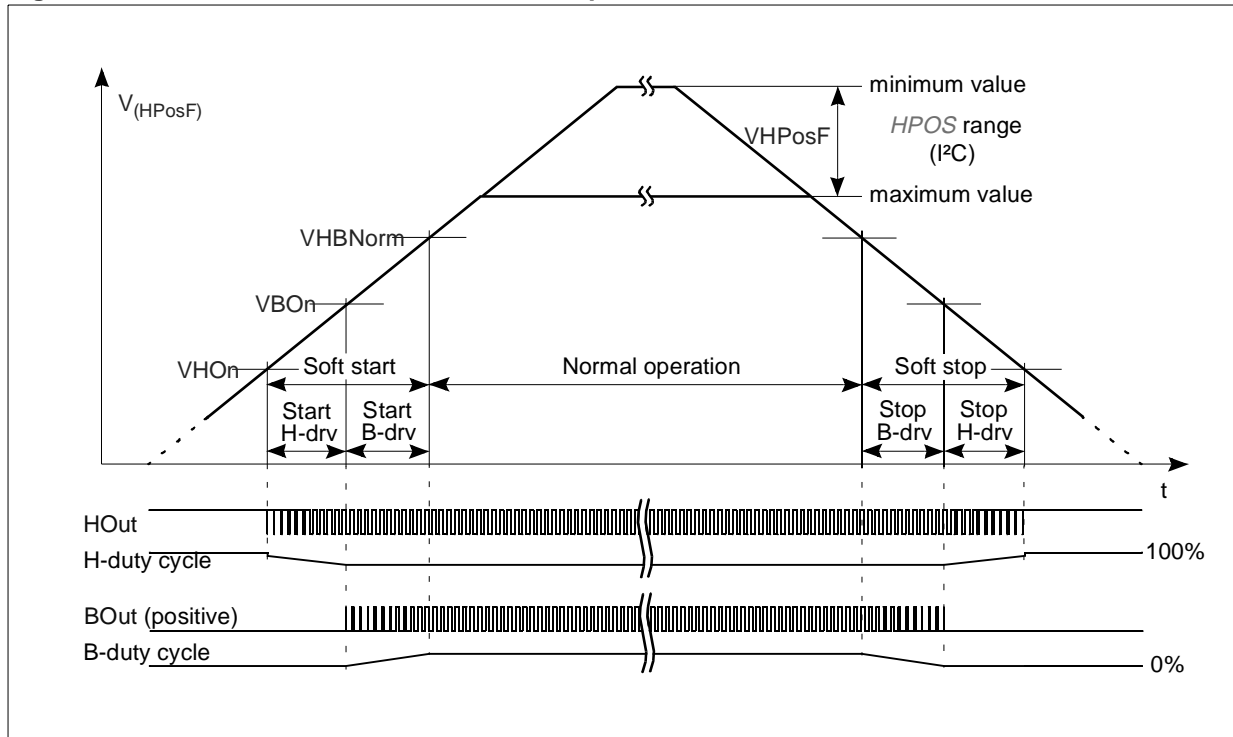
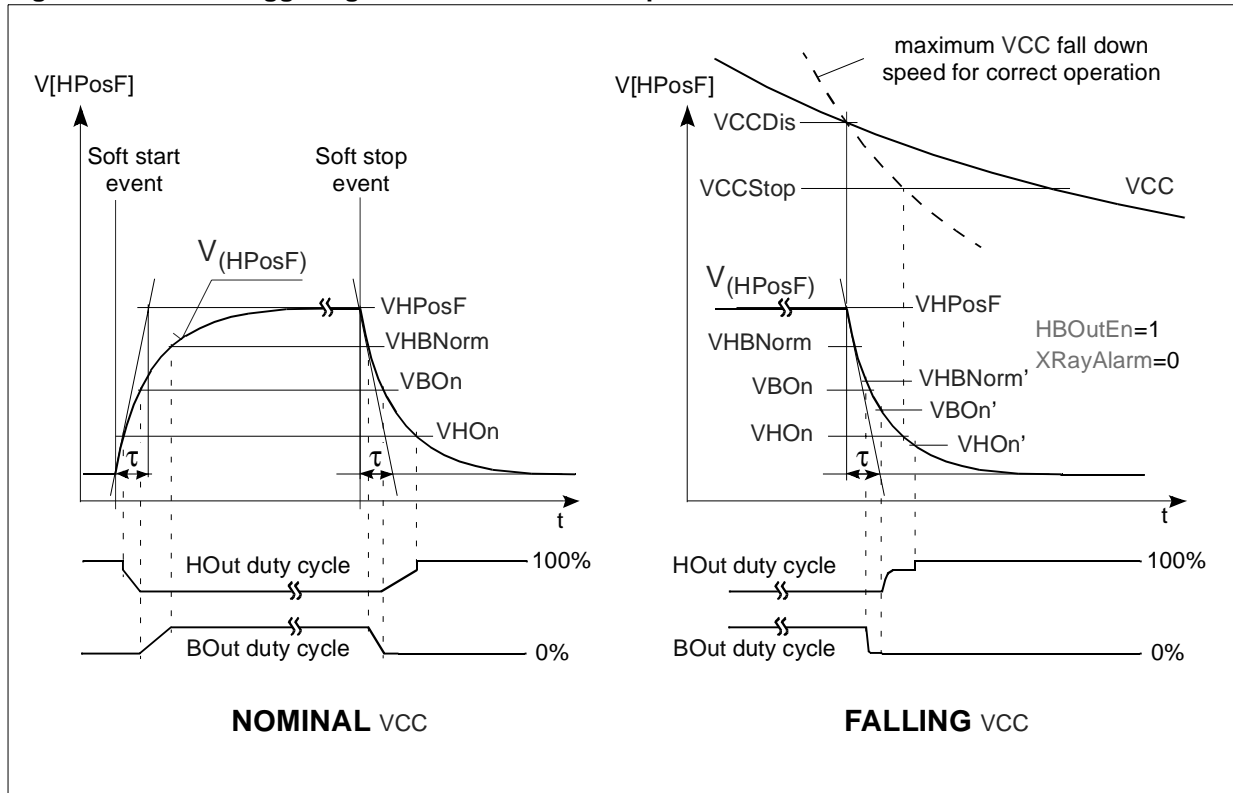


Figure 11. Events triggering Soft start and Soft stop



## 9.4 Vertical section

### 9.4.1 General

The goal of the vertical section is to drive vertical deflection output stage. It delivers a sawtooth waveform with an amplitude independent of deflection frequency, on which vertical linearity corrections of C- and S-type are superimposed (see Chapter 7 - page 22).

Block diagram is in Figure 12. The sawtooth is obtained by charging an external capacitor on pin VCap with controlled current and by discharging it via transistor Q1. This is controlled by the CONTROLLER. The charging starts when the voltage across the capacitor drops below VVOB threshold. The discharging starts either when it exceeds VVOT threshold (free run mode) or a short time after arrival of synchronization pulse. This time is necessary for the AGC loop to sample the voltage at the top of the sawtooth. The VVOB reference is routed out onto VOscF pin in order to allow for further filtration.

The charging current influences amplitude of the sawtooth. Just before the discharge, the voltage across the capacitor on pin VCap is sampled and compared to VVOTref. The comparison error voltage is stored on a storage capacitor connected on pin VAGCCap. This voltage tunes gain of the transconductance amplifier providing the charging current in the next vertical period. Speed of this AGC loop depends on the storage capacitance on pin VAGCCap. The VLock I<sup>2</sup>C-bus flag is set to 1 when the loop is stabilized, i.e. when the tops of saw tooth on pin VCap match VVOT value. On the screen, this corresponds to stabilized vertical size of picture. After a change of frequency on the sync. input, the stabilization time depends on the frequency difference and on the capacitor value. The lower its value, the shorter the stabilization time, but on the other hand, the lower the loop stability. A practical compromise is a capacitance of 470nF. The leakage current of this capacitor results in difference in amplitude between low and high frequencies. The higher its parallel resistance RL(VAGCCap), the lower this difference.

When the synchronization pulse is not present, the charging current is fixed. As a consequence, the free-running frequency  $f_{VO(0)}$  only depends on the value of the capacitor on pin VCap. It can be roughly calculated using the following formula

$$f_{VO(0)} = \frac{150\text{nF}}{C_{(\text{VCap})}} \cdot 100\text{Hz}$$

The frequency range in which the AGC loop can regulate the amplitude also depends on this capacitor.

The vertical sawtooth with regulated amplitude is lead to amplitude control stage. The discharge exponential is replaced by VVOB level, which, under control of the CONTROLLER, creates a rapid falling edge and a flat part before beginning of new ramp.

The AGC output signal passes through gain and position adjustment stages controlled through VSIZE and VPOS I<sup>2</sup>C-bus registers. The resulting signal serves as input to all geometry correction circuitry including EW-drive signal, horizontal phase modulation and dynamic correction outputs.

### 9.4.2 S and C corrections

For the sake of vertical picture linearity, the S- and C-corrections are now superimposed on the linear ramp signal. They both track with VSIZE and VPOS adjustments to ensure unchanged linearity on the screen at changes of vertical size or vertical position. As these corrections are not included in the AGC loop, their adjustment via CCOR and SCOR I<sup>2</sup>C-bus registers, controlling shape of vertical output sawtooth affects by principle its peak-to-peak amplitude. However, this stage is conceived in a way that the amplitude be independent of these adjustments if VSIZE and VPOS registers are set to their medium values.

### 9.4.3 Vertical breathing compensation

The signal provided with the linearity corrections is amplitude affected in a gain control stage, ruled by the voltage on VEHTIn input and its I<sup>2</sup>C-bus control VEHTG.

### 9.4.4 Vertical after-gain and offset control

Another gain control is applied via VSAG I<sup>2</sup>C-bus register. Then an offset is added, its amount corresponding to VPOF I<sup>2</sup>C-bus register value. These two controls result in size and position changes with no effect on shape of output vertical sawtooth or any geometry correction signal.



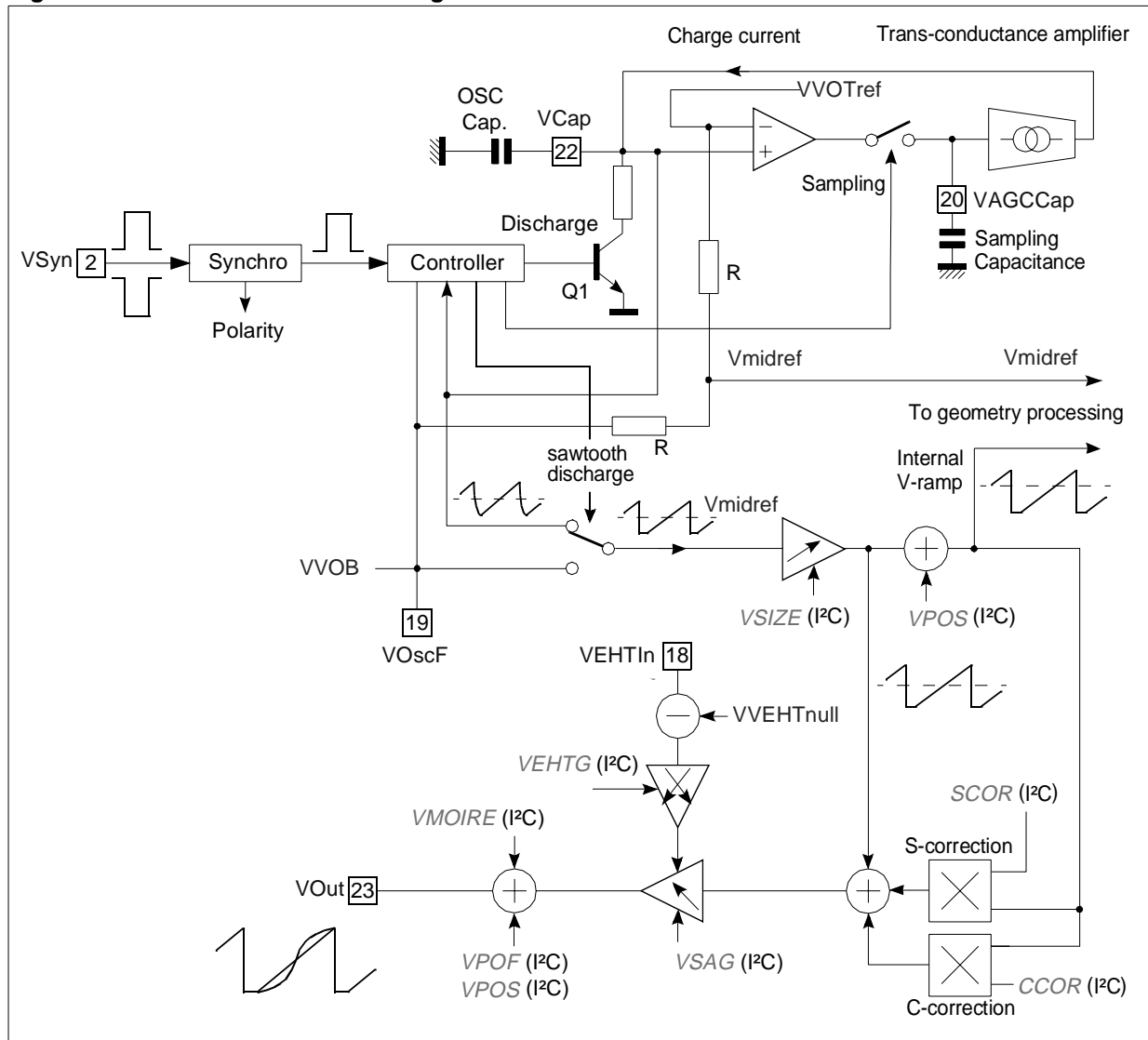
**9.4.5 Vertical moiré**

To blur potential moiré patterns due to interaction of deflection lines with CRT mask grid, the picture position is to be slightly alternated at frame frequency. For this purpose, a square waveform at half-frame frequency is superimposed on the output waveform. Its amplitude is adjustable through *VMOIRE* I<sup>2</sup>C-bus control.

**9.4.6 Biasing of vertical booster**

The biasing voltage for external DC-coupled vertical power amplifier is to be derived from *VRefO* voltage provided on pin *RefOut*, using a resistor divider, this to ensure the same temperature drift of mean (DC) levels on both differential inputs and to compensate for spread of *VRefO* value (and so mean output value) between particular devices.

**Figure 12. Vertical section block diagram**



## 9.5 EW drive section

The goal of the EW drive section is to provide, on pin EWOut, a waveform which, used by an external DC-coupled power stage, serves to compensate for those geometry errors of the picture that are symmetric versus vertical axis across the middle of the screen.

The waveform consists of an adjustable DC value, corresponding to horizontal size, a parabola of 2nd order for "pin cushion" correction, a linear for "keystone" correction, independent half-parabolas of 4th order for top and bottom corner corrections, S-shape for "S" correction and W shape for "W" correction. All of them are adjustable via I<sup>2</sup>C-bus, see Chapter 8 - page 27.

Refer to Figure 14, Figure 15 and chapter Chapter 7 - page 22. The adjustments of these correction waveforms have no effect in the middle of the vertical scan period (if the *VPOS* control is adjusted to its medium value). As they are summed, the resulting waveform tends to reach its maximum span at top and bottom of the picture. The voltage at the EWOut is top and bottom limited (see parameter *VEW*). According to Figure 15, especially the bottom limitation seems to be critical for maximum horizontal size (minimum DC). Actually it is not critical since the parabola component must always be applied to obtain a picture without pin cushion distortion. As all the components of the resulting correction waveform are generated from an internal linear vertical sawtooth waveform bearing *VSIZE* and *VPOS* adjustments, they all track with vertical amplitude and position, thus being fixed vertically on the screen. They are not affected by C- and S-cor-

rections, by prescale adjustments (*VSAG* and *VPOF*), by vertical breathing compensation and by vertical moire cancellation. The sum of components other than DC is conditionally affected by value in *HSIZE* I<sup>2</sup>C-bus control in reversed sense. Refer to electrical specifications for value. This tracking with *HSIZE* can be switched off by *EWTrHSize* I<sup>2</sup>C-bus bit. The DC value, adjusted via *HSIZE* control, is also affected by voltage on *HEHTIn* input, thus providing a horizontal breathing compensation. The effect of this compensation is controlled by *HEHTG*. The resulting waveform is conditionally multiplied with voltage on *HPLL1F*, which depends on frequency. Refer to electrical specifications for values. This tracking with frequency provides a rough compensation of variation of picture geometry with frequency and allows to fix the adjustment ranges of I<sup>2</sup>C-bus controls throughout the operating range of horizontal frequencies. It can be switched off by *EWTrHFr* I<sup>2</sup>C-bus bit (off by default). The functionality is explained in Figure 13. The upper part gives the influence on DC component, the lower part on AC component, showing also the tracking with *HSIZE*. Grey zones give the total span of breathing correction using the whole range of input operating voltage on *HEHTIn* input and whole range of adjustment of *HEHTG* register.

The EW waveform signal is buffered by an NPN emitter follower, the emitter of which is directly routed to EWOut output. It is internally biased (see electrical specifications for current value).

Figure 13. Tracking of EWOut signal with frequency

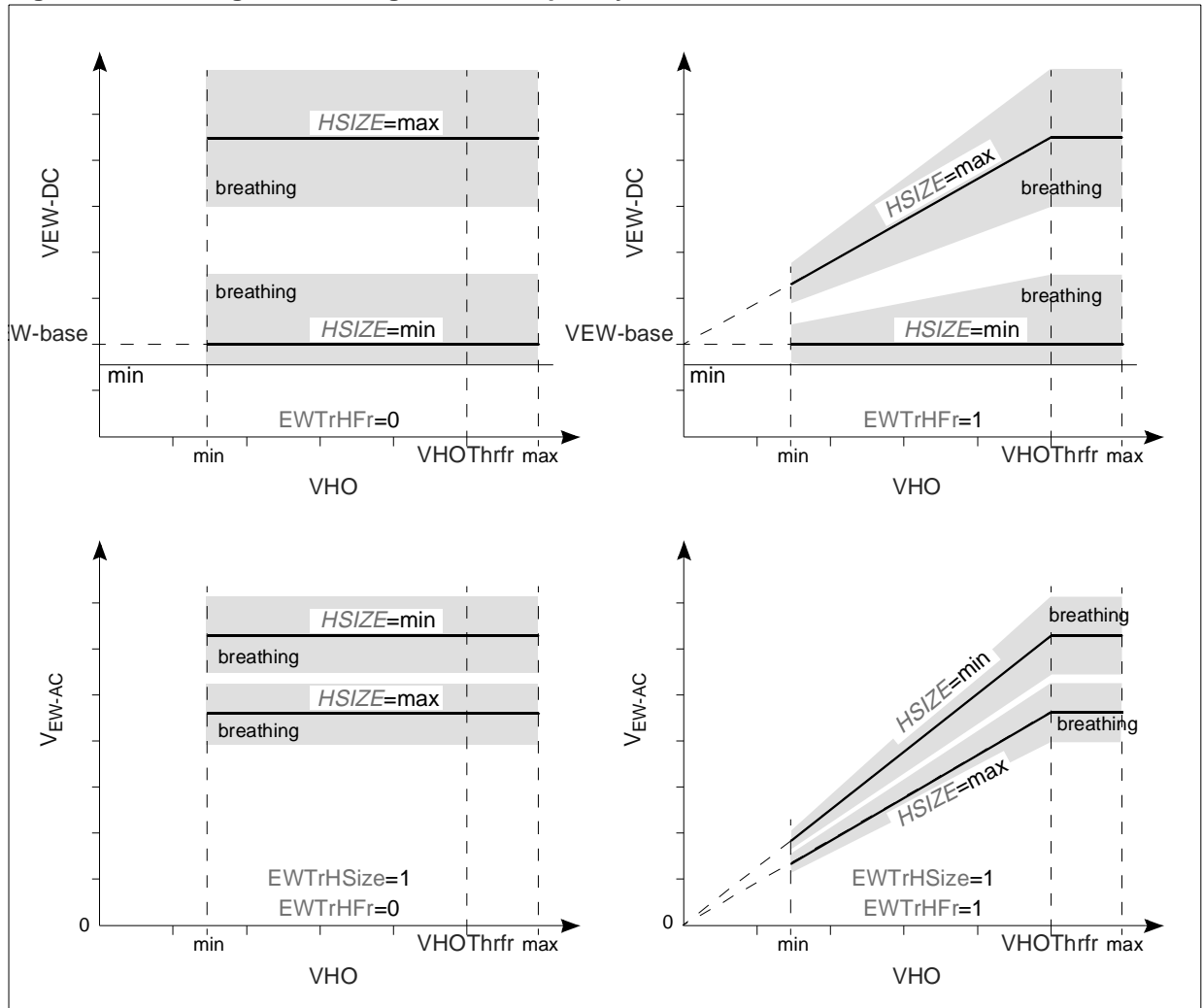
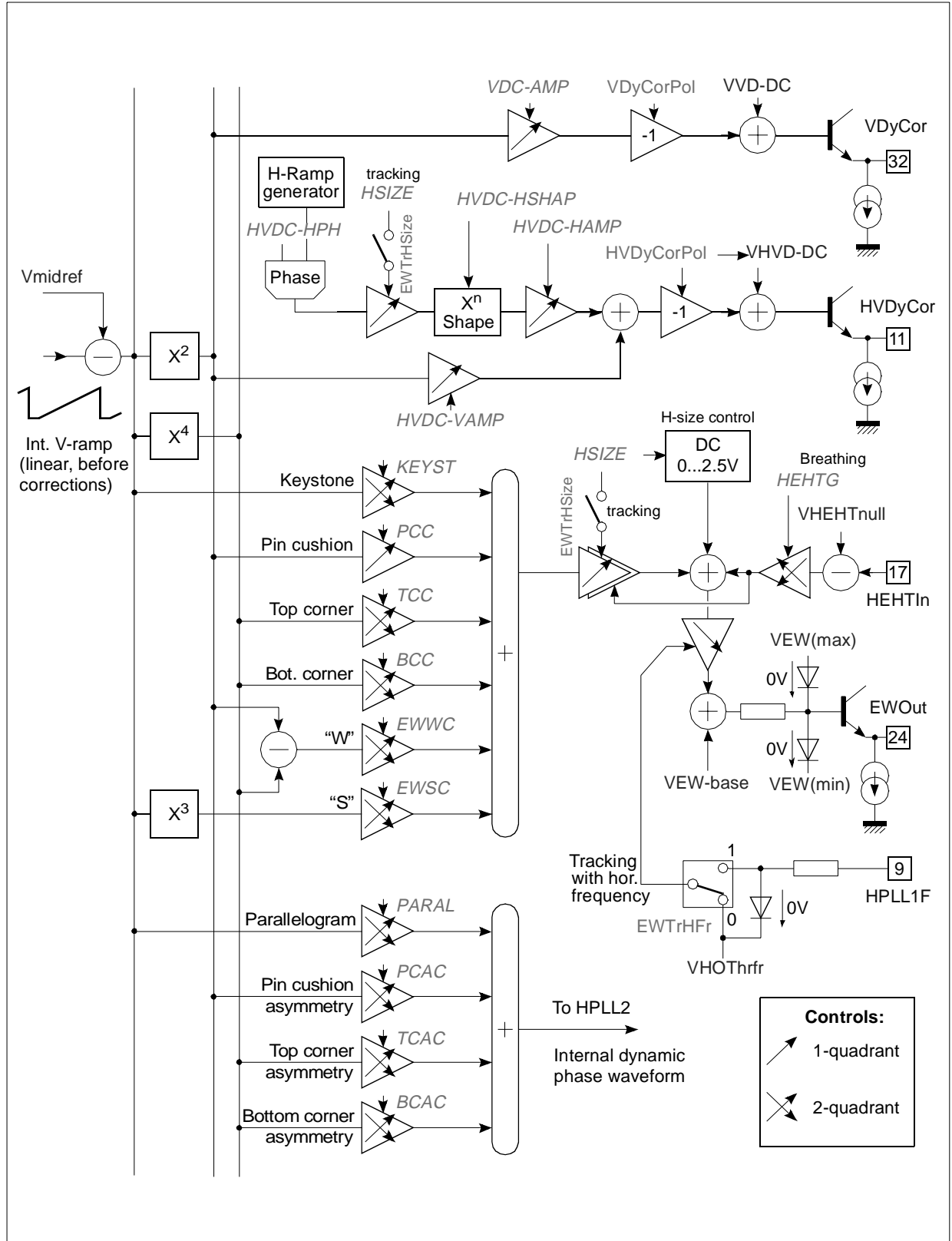


Figure 14. Geometric corrections' schematic diagram





## 9.6 Dynamic correction outputs section

### 9.6.1 Composite horizontal and vertical dynamic correction output HVDyCor

A composite waveform is output on pin HVDyCor. It consists of a parabola of vertical deflection frequency, on which a parabola of horizontal deflection frequency is superimposed. The two parabolic components can independently be adjusted via I<sup>2</sup>C-bus, the vertical parabola in amplitude (*HVDC-VAMP* I<sup>2</sup>C-bus control), the horizontal parabola in amplitude, phase and shape (*HVDC-HAMP*, *HVDC-HPH* and *HVDC-HSHAP* I<sup>2</sup>C-bus controls). See also Chapter 8 - page 27 chapter. The influence of the vertical component can be nullified by adjusting its control to minimum. For horizontal waveform component, refer to Figure 16 and Figure 17. The minimum value in *HVDC-HAMP* I<sup>2</sup>C-bus control does not correspond to null horizontal amplitude. The phase of the horizontal parabola can roughly be adjusted via HDyCorPh I<sup>2</sup>C-bus bit for the waveform's start to coincide either with the beginning or the middle of the H-flyback pulse. Moreover, its centre can be offset via *HVDC-HPH* I<sup>2</sup>C-bus control. The shape of the horizontal parabola can be adjusted via *HVDC-HSHAP* I<sup>2</sup>C-bus control from a power-of-two to about a power-of-four. Between the waves of two subsequent lines, a flat is inserted at level corresponding to the beginning of the new wave. Putting HDCFlatEn and HDyCorPh to "1" will cause the flat part to begin at start of H-flyback and end a delay after its middle. Only this delay (its duration is quasi-constant) is applied

when HDCFlatEn is at "0". Refer to electrical specifications for values.

The horizontal parabola component tracks with value in *H SIZE* control provided that HDyCorTr I<sup>2</sup>C bit is set to 1 (0 by default).

As the vertical parabola component is generated from the output vertical deflection drive waveform, it tracks with real vertical amplitude and position. It is not affected by C- and S-corrections or vertical breathing compensation. It does not track with *Vertical size after-gain* (Sad1Dh) nor with *Vertical position offset* (Sad1Eh) adjustments.

The polarity of the HVDyCor output can be adjusted via HVDyCorPol I<sup>2</sup>C-bus bit.

### 9.6.2 Vertical dynamic correction output VDyCor

A parabola at vertical deflection frequency is available on pin VDyCor. Its amplitude is adjustable via *VDC-AMP* I<sup>2</sup>C-bus control and polarity controlled via VDyCorPol I<sup>2</sup>C-bus bit. It tracks with real vertical amplitude and position. It is not affected by C- and S-corrections or breathing compensation. It does not track with *Vertical size after-gain* (Sad1Dh) nor with *Vertical position offset* (Sad1Eh) adjustments.

The use of both correction waveforms is up to the application (e.g. dynamic focus, dynamic brightness control).

Figure 16. HVDyCor output horizontal component waveform

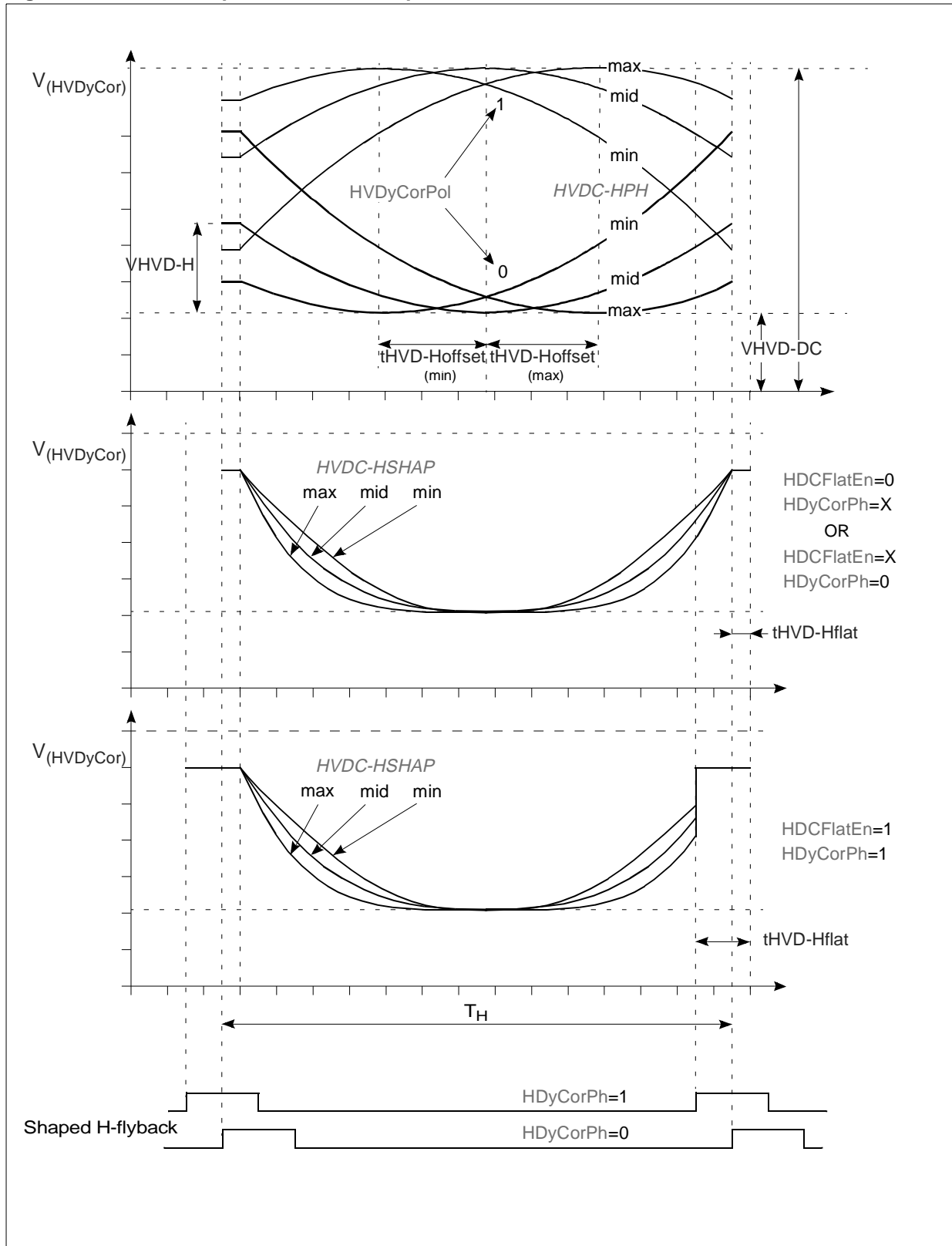
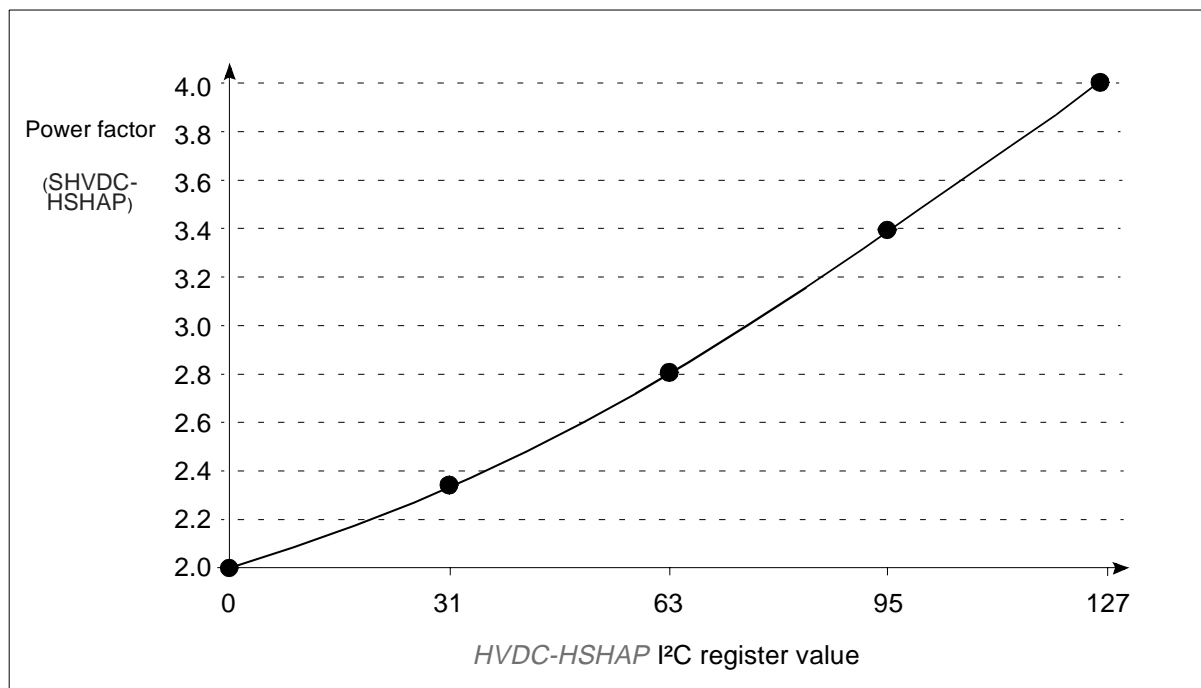


Figure 17. Shape characteristic versus *HVDC-HSHAP* register adjustment.

## 9.7 DC/DC controller section

The section is designed to control a switch-mode DC/DC converter. A switch-mode DC/DC converter generates a DC voltage from a DC voltage of different value (higher or lower) with little power losses. The DC/DC controller is synchronized to horizontal deflection frequency to minimize potential interference into the picture.

Its operation is similar to that of standard UC3842.

The schematic diagram of the DC/DC controller is in Figure 18. The BOut output controls an external switching circuit (a MOS transistor) delivering pulses synchronized on horizontal deflection frequency, the phase of which depends on H/W and I<sup>2</sup>C-bus configuration. See the table at the end of this chapter. Their duration depends on the feedback provided to the circuit, generally a copy of DC/DC converter output voltage and a copy of current passing through the DC/DC converter circuitry (e.g. current through external power component). The polarity of the output can be controlled by BOutPol I<sup>2</sup>C-bus bit. A NPN transistor open-collector is routed out to the BOut pin.

During the operation, a sawtooth is to be found on pin BISense, generated externally by the application. According to BOutPh I<sup>2</sup>C-bus bit, the R-S flip-flop is set either at H-drive signal edge (rising or falling, depending on BOHEdge I<sup>2</sup>C-bus bit), or a

certain delay (tBTrigDel) after middle of H-flyback, or at horizontal frequency divided by two (phase corresponding to VH0ThrHi on the VCO ramp). The output is set On at the end of the short pulse generated by the monostable trigger.

Timing of reset of the R-S flip-flop affects duty cycle of the output square signal and so the energy transferred from DC/DC converter input to its output. A reset edge is provided by comparator C2 if the voltage on pin BISense exceeds the internal threshold VThrBIsCurr. This represents current limitation if a voltage proportional to the current through the power component or deflection stage is available on pin BISense. This threshold is affected by voltage on pin HPosF, which rises at soft start and descends at soft stop. This ensures self-contained soft control of duty cycle of the output signal on pin BOut. Refer to Figure 10. Another condition for reset of the R-S flip-flop, OR-ed with the one described before, is that the voltage on pin BISense exceeds the voltage V<sub>C2</sub>, which depends on the voltage applied on input BRegIn of the error amplifier O1. The two voltages are compared, and the reset signal generated by the comparator C1. The error amplifier amplifies (with a factor defined by external components) the difference between the input voltage proportional to DC/DC converter output voltage and internal reference VReg. The



internal reference and so the output voltage is I<sup>2</sup>C-bus adjustable by means of *BREF* I<sup>2</sup>C-bus control. Both step-up (DC/DC converter output voltage higher than its input voltage) and step-down (output voltage lower than input) can be built.

**9.7.1 Synchronization of DC/DC controller**

For sake of application flexibility, the output drive signal on BOut pin can be synchronized with one of four events in Table 9. For the first line case, the synchronization instant is every second top of horizontal VCO saw tooth. See Figure 7.

**9.7.2 Soft-start and soft-stop on B-drive**

The soft-start and soft-stop procedure is carried out at each switch-on or switch-off of the B-drive signal, either via *HBOutEn* I<sup>2</sup>C-bus bit or after re-

set of *XRayAlarm* I<sup>2</sup>C-bus flag, to protect external power component. See Figure 10 and sub chapter Safety functions on page 50.

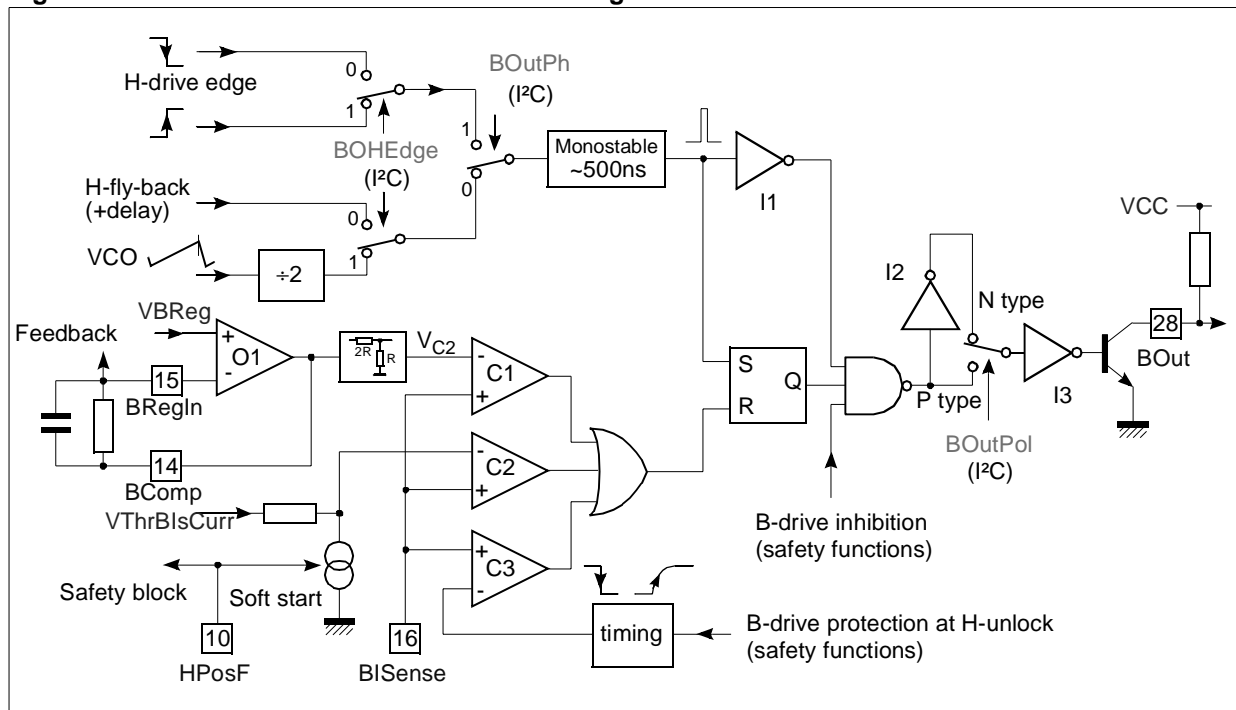
The drive signal on BOut pin can be switched off alone by means of *BMute* I<sup>2</sup>C-bus bit, without switching off the drive signal on pin HOut. The switch-off is quasi-immediate, without the soft-stop procedure. At switching back on, the soft-start of the DC/DC controller is performed, timed by an internal timing circuit, see Figure 18.

When *BSafeEn* I<sup>2</sup>C-bus bit is enabled, the drive signal on BOut pin will go off as soon as the horizontal PLL1 indicates unlocked state, without the soft-stop. Resuming of locked state will initiate the soft-start mechanism of the DC/DC controller, timed by an internal timing circuit.

**Table 9. IDC/DC controller Off-to-On edge timing**

BOutPh (Sad07h/D7)	BOHEdge (Sad17h/D3)	Timing of Off-to-On transition on BOut output
0	1	VCO ramp top at Horizontal frequency divided by two
0	0	Middle of H-flyback plus tBTrigDel
1	0	Falling edge of H-drive signal
1	1	Rising edge of H-drive signal

**Figure 18. DC/DC converter controller block diagram**



## 9.8 Miscellaneous

### 9.8.1 Safety functions

The safety functions comprise supply voltage monitoring with appropriate actions, soft start and soft stop features on H-drive and B-drive signals on HOut and BOut outputs, B-drive cut-off at unlock condition and X-ray protection.

For supply voltage supervision, refer to subsection 9.1.1 and Figure 1. A schematic diagram putting together all safety functions and composite PLL1 lock and V-blanking indication is in Figure 19.

#### 9.8.1.1 Soft start and soft stop function

For soft start and soft stop features for H-drive and B-drive signal, refer to subsection 9.3.7 and subsection 9.7, respectively. See also the Figure 10 and Figure 11. Regardless why the H-drive or B-drive signal are switched on or off (I<sup>2</sup>C-bus command, power up or down, X-ray protection), the signals always phase-in and phase-out in the way drawn in the figures, the first to phase-in and last to phase-out being the H-drive signal, which is to better protect the power stages at abrupt changes like switch-on and off. The timing of phase-in and phase-out depends on the capacitance connected to HPosF pin which is virtually unlimited for this function. However, as it has a dual function (see subsection 9.3.2), a compromise thereof is to be found.

The soft stop at power down condition can be considered as a special case. As at this condition the thresholds VHO<sub>n</sub>, VBO<sub>n</sub> and VHB<sub>Norm</sub> depend on the momentary level of supply voltage (marked VHO<sub>n</sub>', VBO<sub>n</sub>', VHB<sub>Norm</sub>' in Figure 11), the timing of soft stop mechanism depends, apart from the capacitance on HPosF, also on the falling speed of supply voltage. The device is capable of performing a correct soft stop sequence providing that, at the moment the supply voltage reaches VCC<sub>Stop</sub>, the voltage on HPosF has already fallen below VHO<sub>n</sub> (Section 9.8).

#### 9.8.1.2 B-drive cut-off at unlock condition

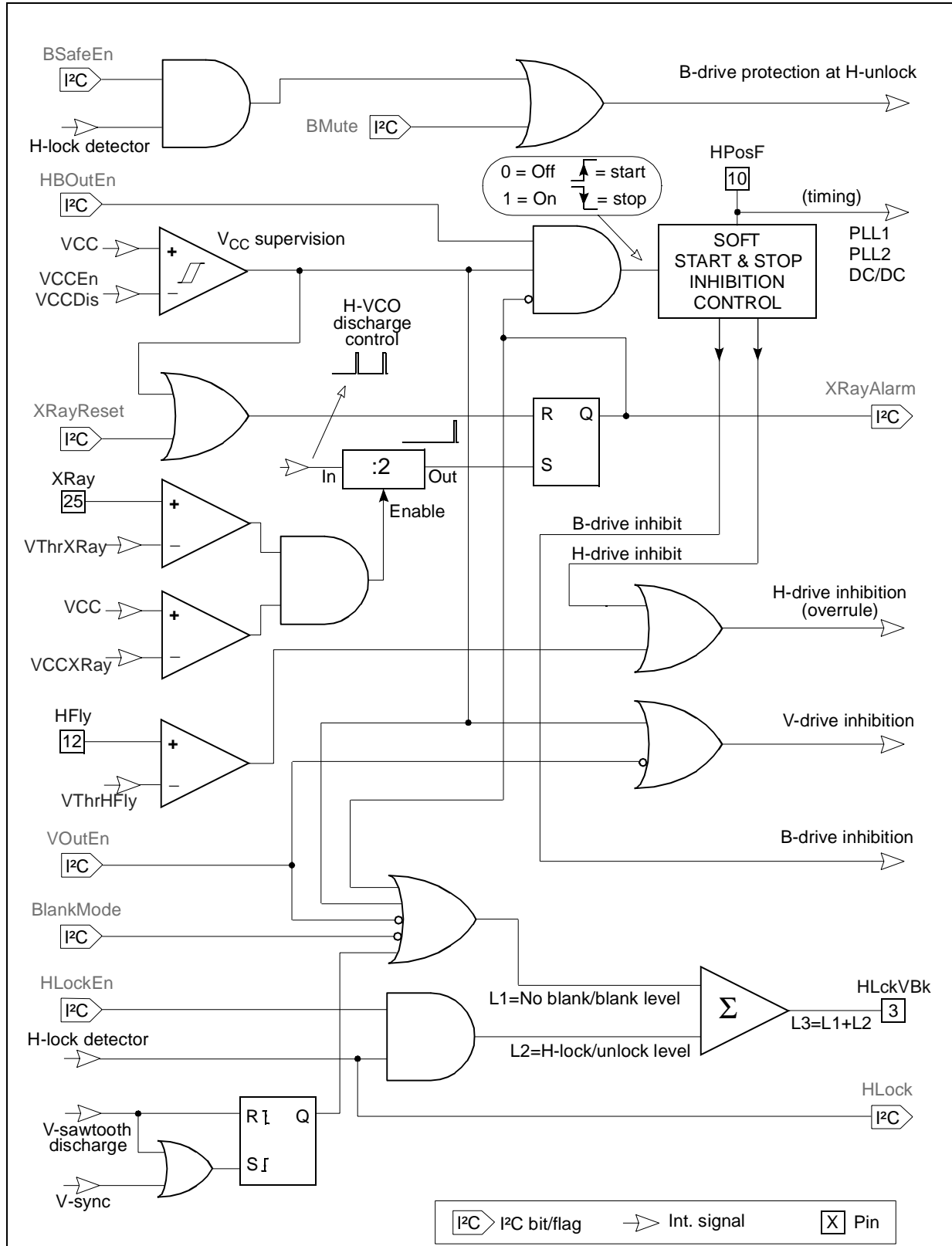
This function is described in subsection 9.7.2.

#### 9.8.1.3 X-ray protection

The X-ray protection is activated if the voltage level on XRay input exceeds VThrXRay threshold and if the VCC is higher than the voltage level VCCXRay-En. As a consequence, the H-drive and B-drive signals on HOut and BOut outputs are inhibited (switched off) after a 2-horizontal deflection line delay provided to avoid erratic excessive X-ray condition detection at short parasitic spikes. The XRayAlarm I<sup>2</sup>C-bus flag is set to 1 to inform the MCU.

This protection is latched; it may be reset either by VCC drop or by I<sup>2</sup>C-bus bit XRayReset (see Chapter 8 - page 27).

Figure 19. Safety functions - block diagram



## TDA9112A

### 9.8.2 Composite output HLckVBk

The composite output HLckVBk provides, at the same time, information about lock state of PLL1 and early vertical blanking pulse. As both signals have two logical levels, a four level signal is used to define the combination of the two. Schematic diagram putting together all safety functions and composite PLL1 lock and V-blanking indication is in Figure 19, the combinations, their respective levels and the HLckVBk configuration in Figure 20.

The early vertical blanking pulse is obtained by a logic combination of vertical synchronization pulse and pulse corresponding to vertical oscillator discharge. The combination corresponds to the drawing in Figure 20. The blanking pulse is started with

the leading edge of any of the two signals, whichever comes first. The blanking pulse is ended with the trailing edge of vertical oscillator discharge pulse. The device has no information about the vertical retrace time. Therefore, it does not cover, by the blanking pulse, the whole vertical retrace period. By means of BlankMode I<sup>2</sup>C-bus bit, when at 1 (default), the blanking level (one of two according to PLL1 status) is made available on the HLckVBk permanently. The permanent blanking, irrespective of the BlankMode I<sup>2</sup>C-bus bit, is also provided if the supply voltage is low (under VCCEn or VCCDis thresholds), if the X-ray protection is active or if the V-drive signal is disabled by VOutEn I<sup>2</sup>C-bus bit.

**Figure 20. Levels on HLckVBk composite output**

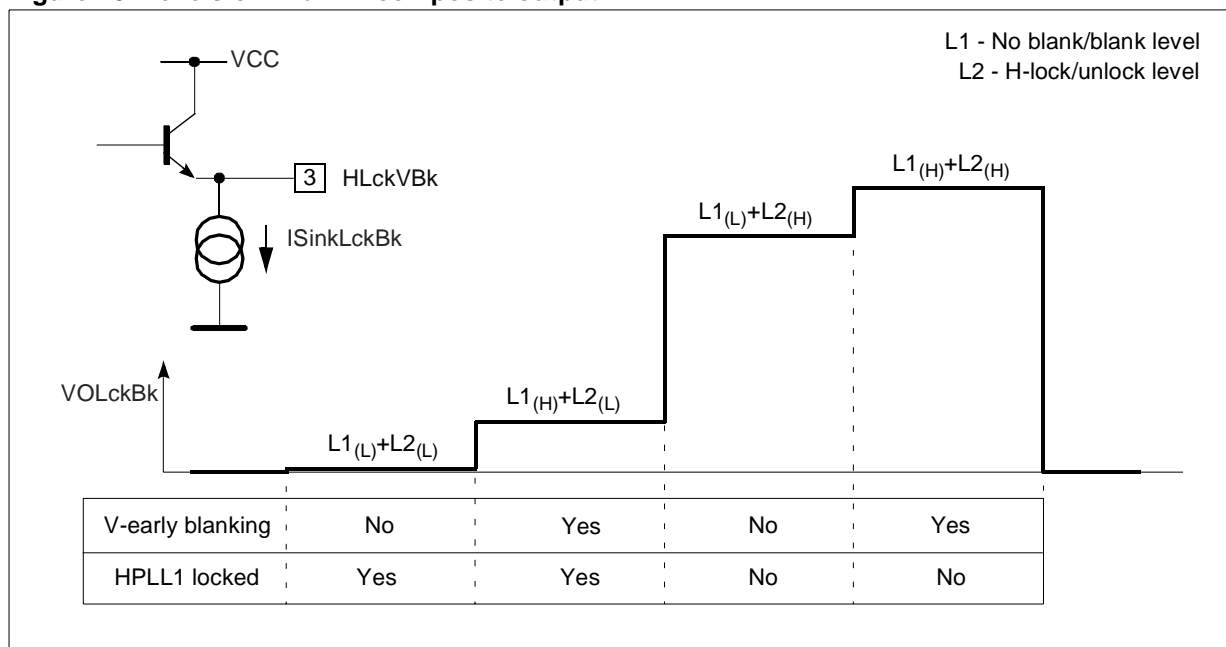
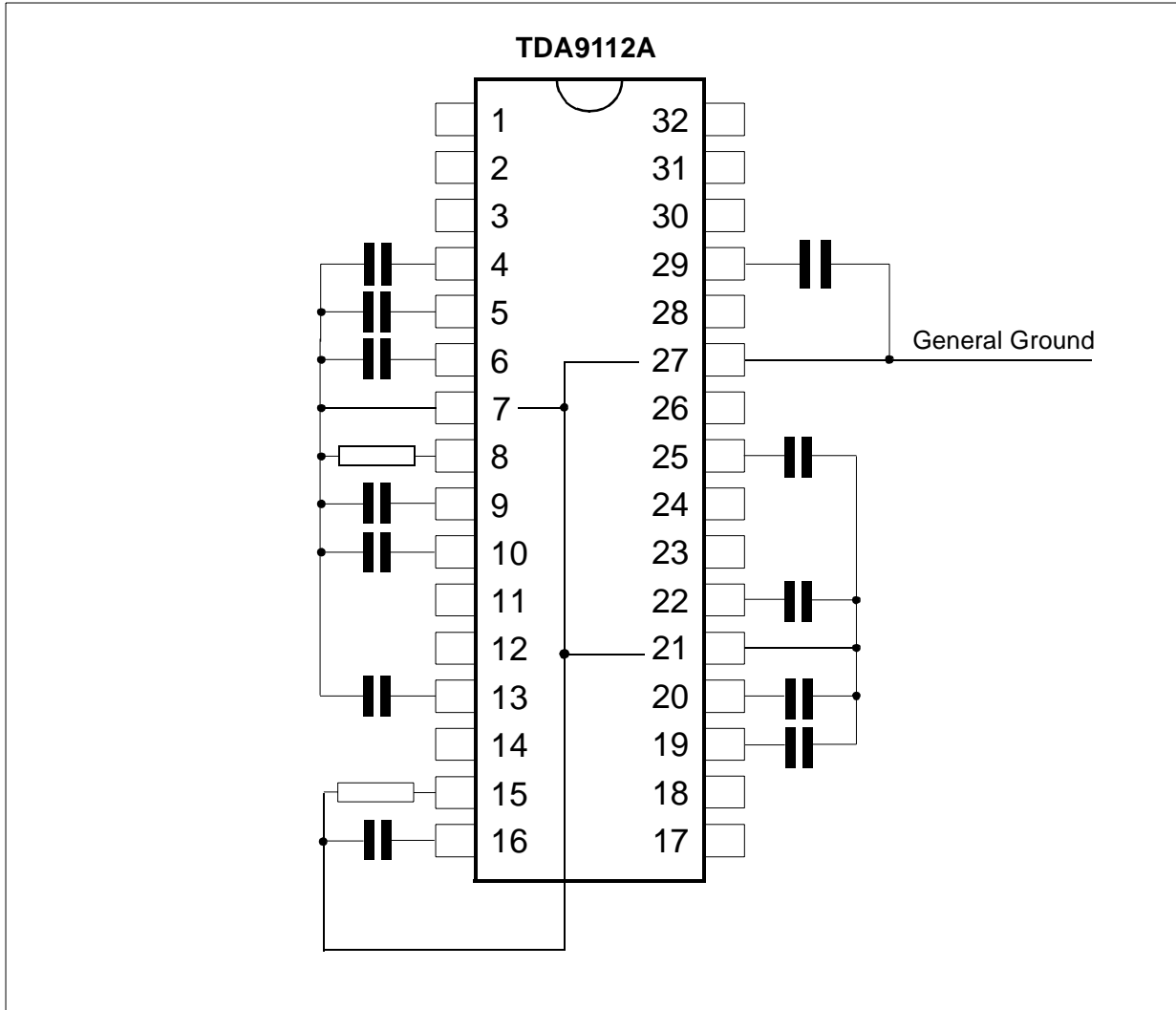


Figure 21. Ground layout recommendations



10 INTERNAL SCHEMATICS

Figure 22.

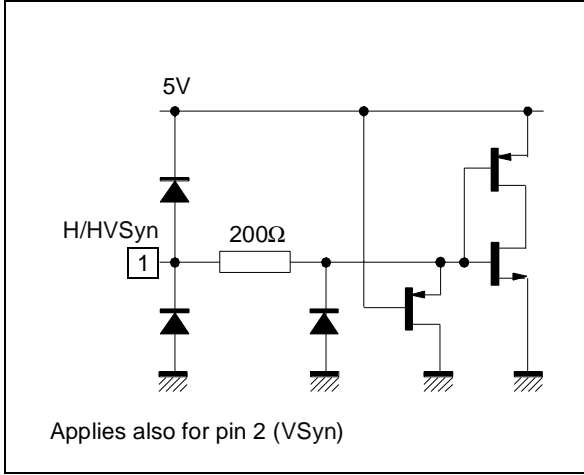


Figure 25.

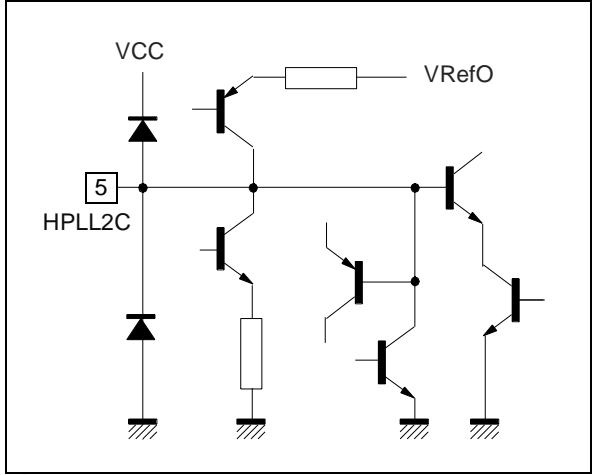


Figure 23.

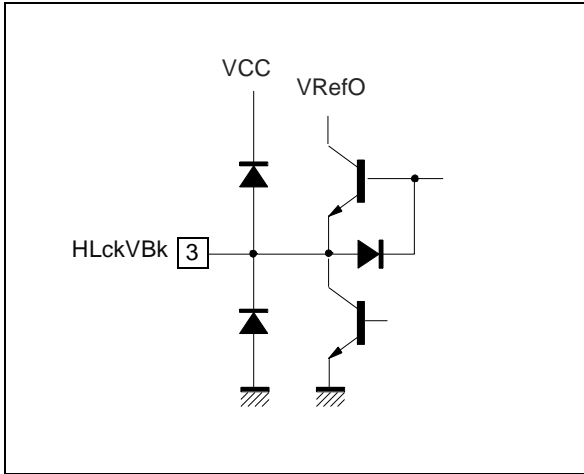


Figure 26.

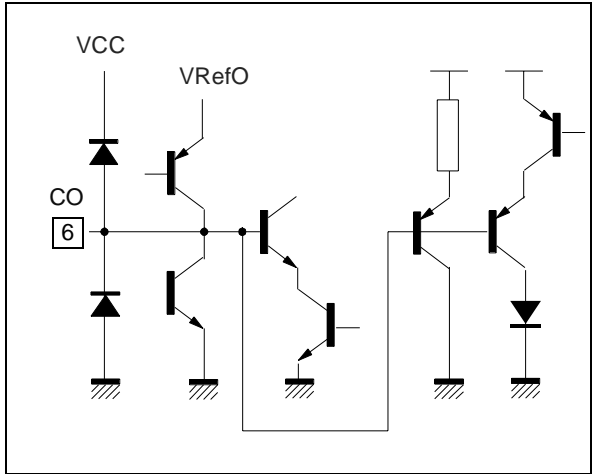


Figure 24.

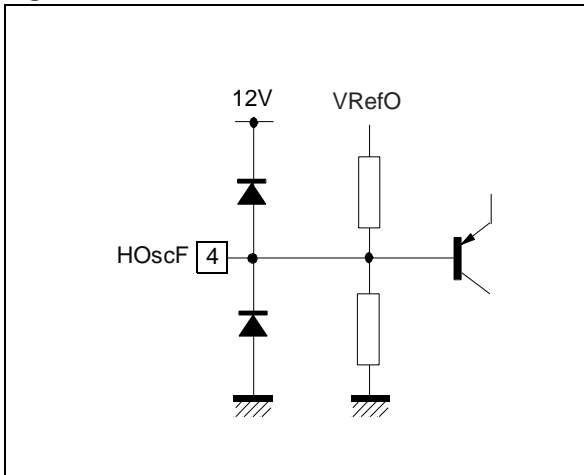


Figure 27.

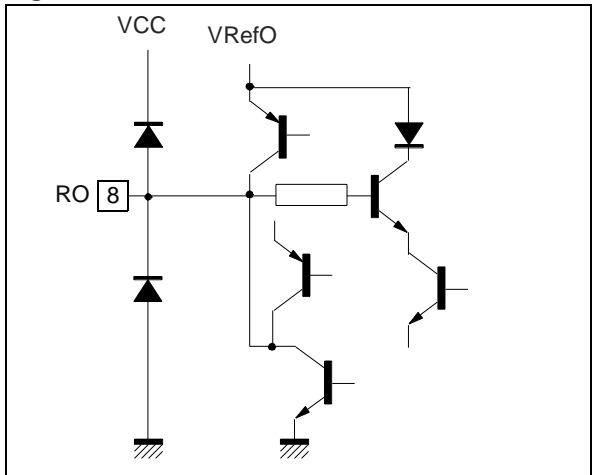


Figure 28.

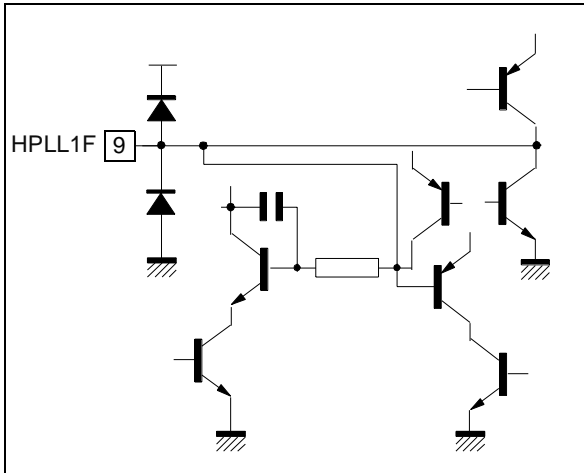


Figure 31.

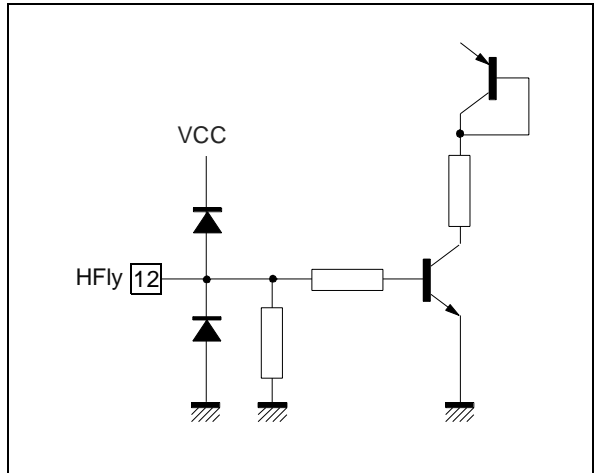


Figure 29.

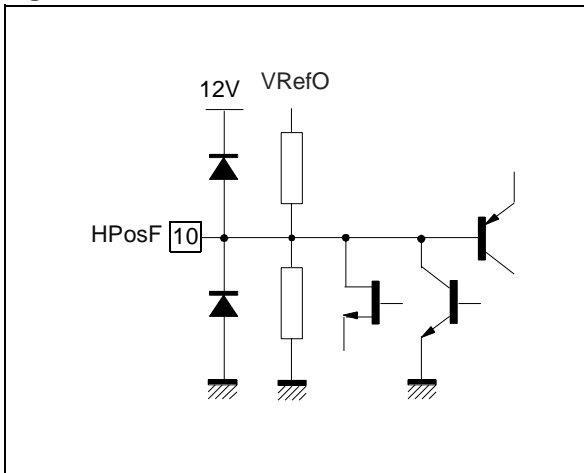


Figure 32.

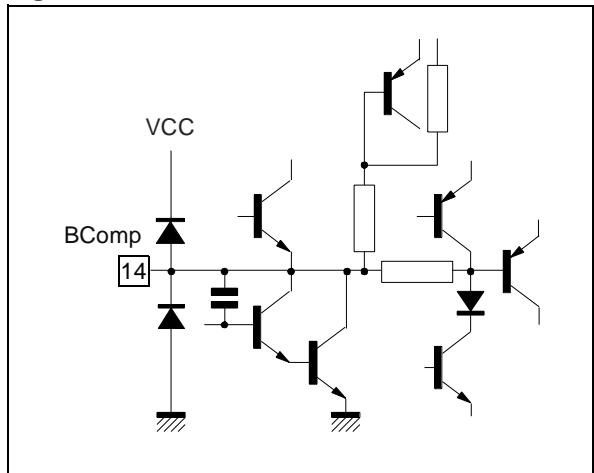


Figure 30.

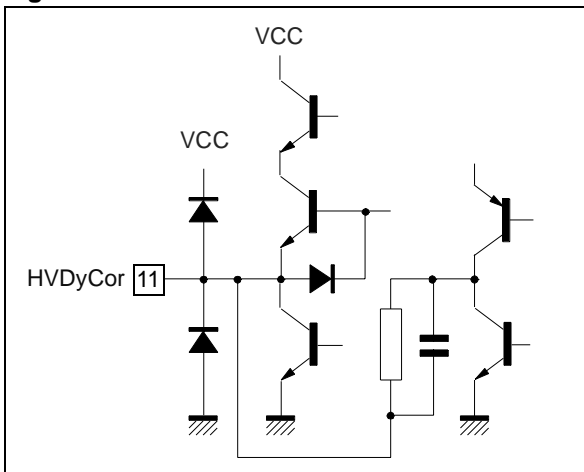


Figure 33.

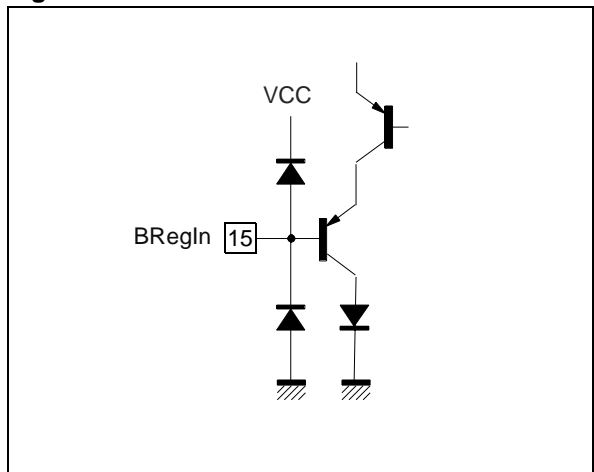


Figure 34.

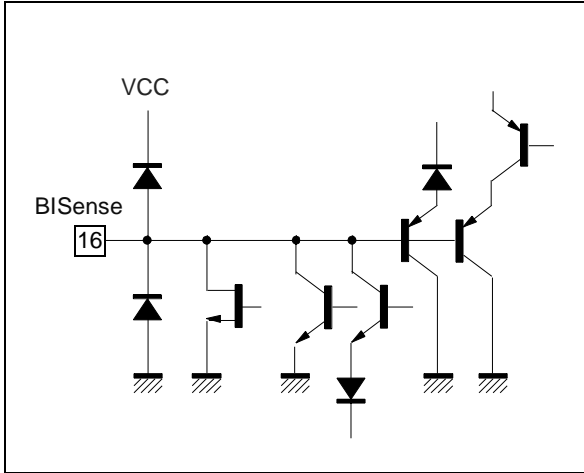


Figure 35.

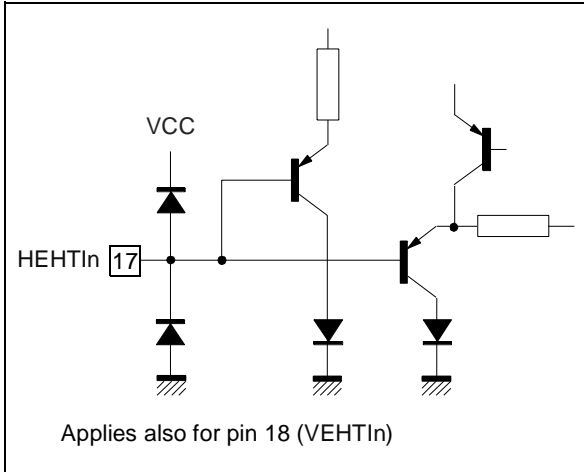


Figure 36.

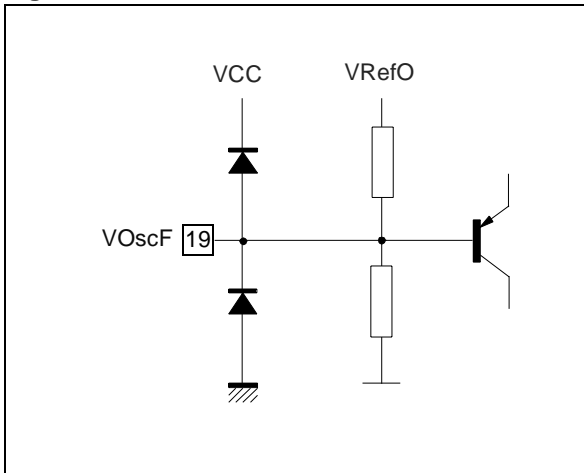


Figure 37.

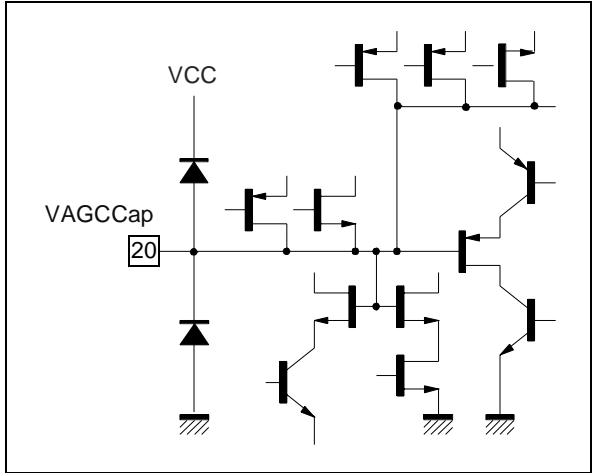


Figure 38.

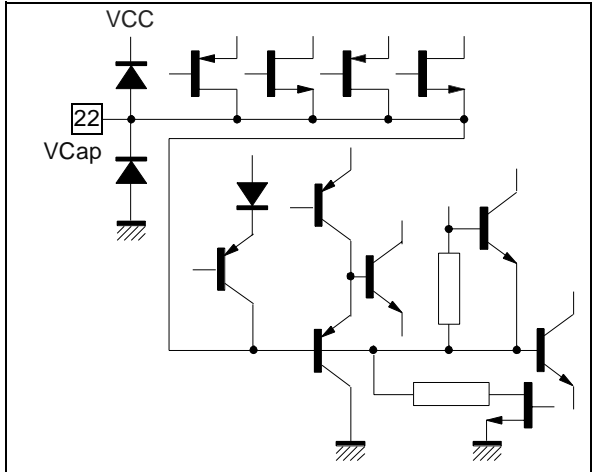


Figure 39.

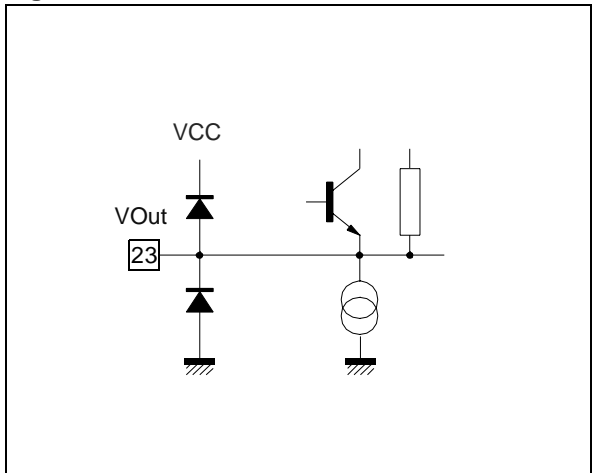




Figure 40.

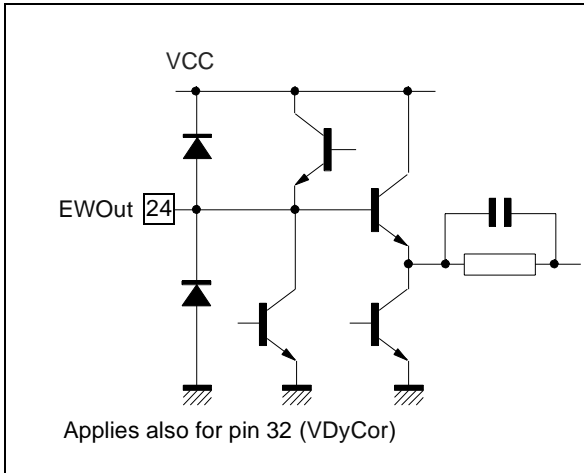


Figure 43.

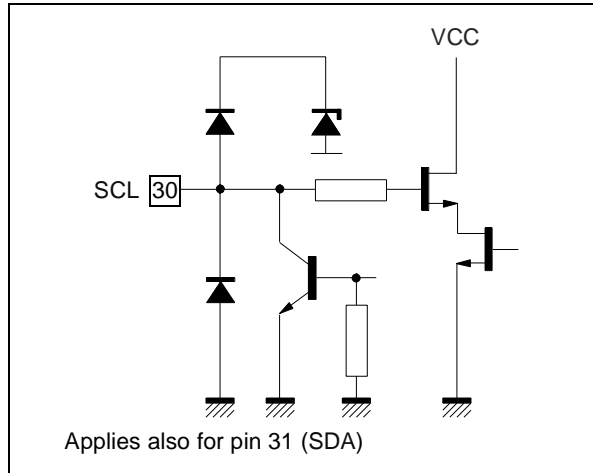


Figure 41.

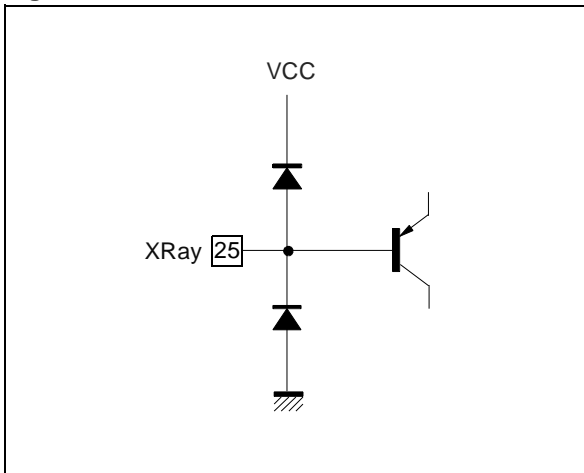
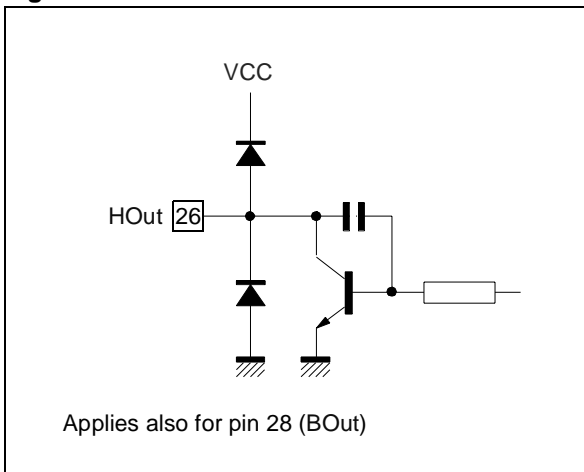


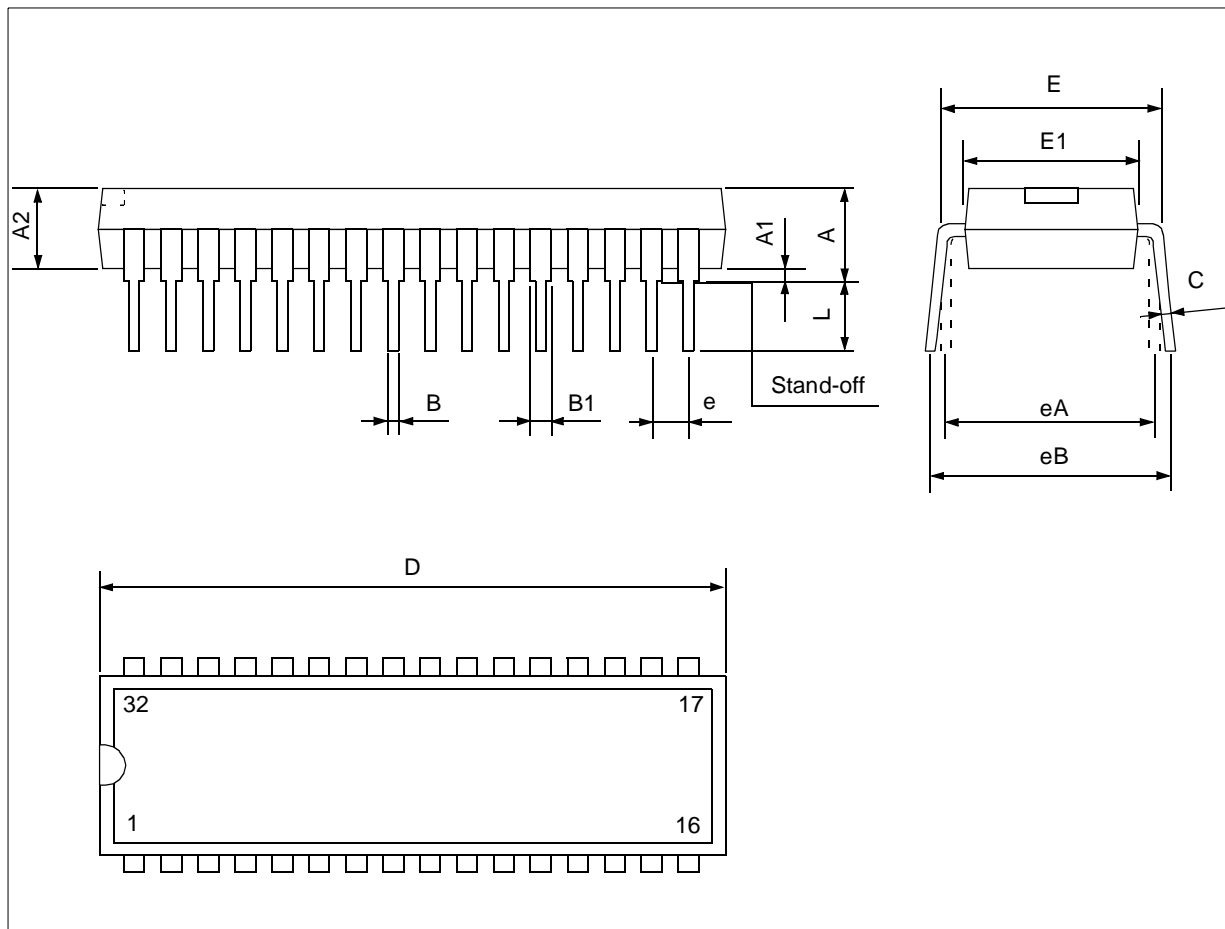
Figure 42.



# TDA9112A

## 11 PACKAGE MECHANICAL DATA

32 PINS - PLASTIC SHRINK



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	3.556	3.759	5.080	0.140	0.148	0.200
A1	0.508			0.020		
A2	3.048	3.556	4.572	0.120	0.140	0.180
B	0.356	0.457	0.584	0.014	0.018	0.023
B1	0.762	1.016	1.397	0.030	0.040	0.055
C	.203	0.254	0.356	0.008	0.010	0.014
D	27.43	27.94	28.45	1.080	1.100	1.120
E	9.906	10.41	11.05	0.390	0.410	0.435
E1	7.620	8.890	9.398	0.300	0.350	0.370
e		1.778			0.070	
eA		10.16			0.400	
eB			12.70			0.500
L	2.540	3.048	3.810	0.100	0.120	0.150

---

**12 GLOSSARY**

<b>AC</b>	<b>A</b> lternate <b>C</b> urrent
<b>ACK</b>	<b>ACK</b> nowledge bit of I <sup>2</sup> C-bus transfer
<b>AGC</b>	<b>A</b> utomatic <b>G</b> ain <b>C</b> ontrol
<b>COMP</b>	<b>COMP</b> arator
<b>CRT</b>	<b>C</b> athode <b>R</b> ay <b>T</b> ube
<b>DC</b>	<b>D</b> irect <b>C</b> urrent
<b>EHT</b>	<b>E</b> xtra <b>H</b> igh <b>V</b> oltage
<b>EW</b>	<b>E</b> ast- <b>W</b> est
<b>H/W</b>	<b>H</b> ard <b>W</b> are
<b>HOT</b>	<b>H</b> orizontal <b>O</b> utput <b>T</b> ransistor
<b>I<sup>2</sup>C</b>	<b>I</b> nter- <b>I</b> ntegrated <b>C</b> ircuit
<b>IIC</b>	<b>I</b> nter- <b>I</b> ntegrated <b>C</b> ircuit
<b>MCU</b>	<b>M</b> icro- <b>C</b> ontroller <b>U</b> nit
<b>NAND</b>	<b>N</b> egated <b>AND</b> (logic operation)
<b>NPN</b>	<b>N</b> egative- <b>P</b> ositive- <b>N</b> egative
<b>OSC</b>	<b>OSC</b> illator
<b>PLL</b>	<b>P</b> hase- <b>L</b> ocked <b>L</b> oop
<b>PNP</b>	<b>P</b> ositive- <b>N</b> egative- <b>P</b> ositive
<b>REF</b>	<b>REF</b> erence
<b>RS, R-S</b>	<b>R</b> eset- <b>S</b> et
<b>S/W</b>	<b>S</b> oft <b>W</b> are
<b>TTL</b>	<b>T</b> ransistor <b>T</b> ransistor <b>L</b> ogic
<b>VCO</b>	<b>V</b> oltage- <b>C</b> ontrolled <b>O</b> scillator

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