Intro to the Phase Locked Loop

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- Basic Block Diagram

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Op Amp vs Phase Locked Loop

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- inputs:NI & INV input & feedback

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- output: voltage — freq (or phase)

Op Amp vs Phase Locked Loop

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◆ -fb => $V_{INV} = V_{NI}$	-fb => $f_{fb} = f_{in}$

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Op Amp vs Phase Locked Loop

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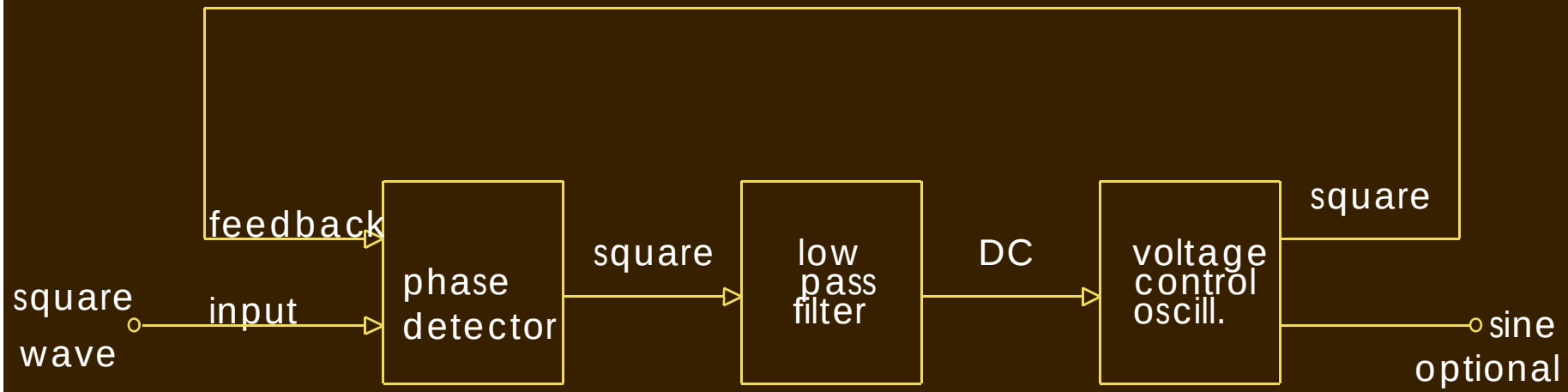
◆ output: voltage	freq (or phase)
◆ -fb => $V_{INV} = V_{NI}$	-fb => $f_{fb} = f_{in}$
◆ v div in -fb => volt x	freq div => freq x
◆ very robust wrt V	very robust wrt f
– self correcting	self correcting

Basic Block Diagram



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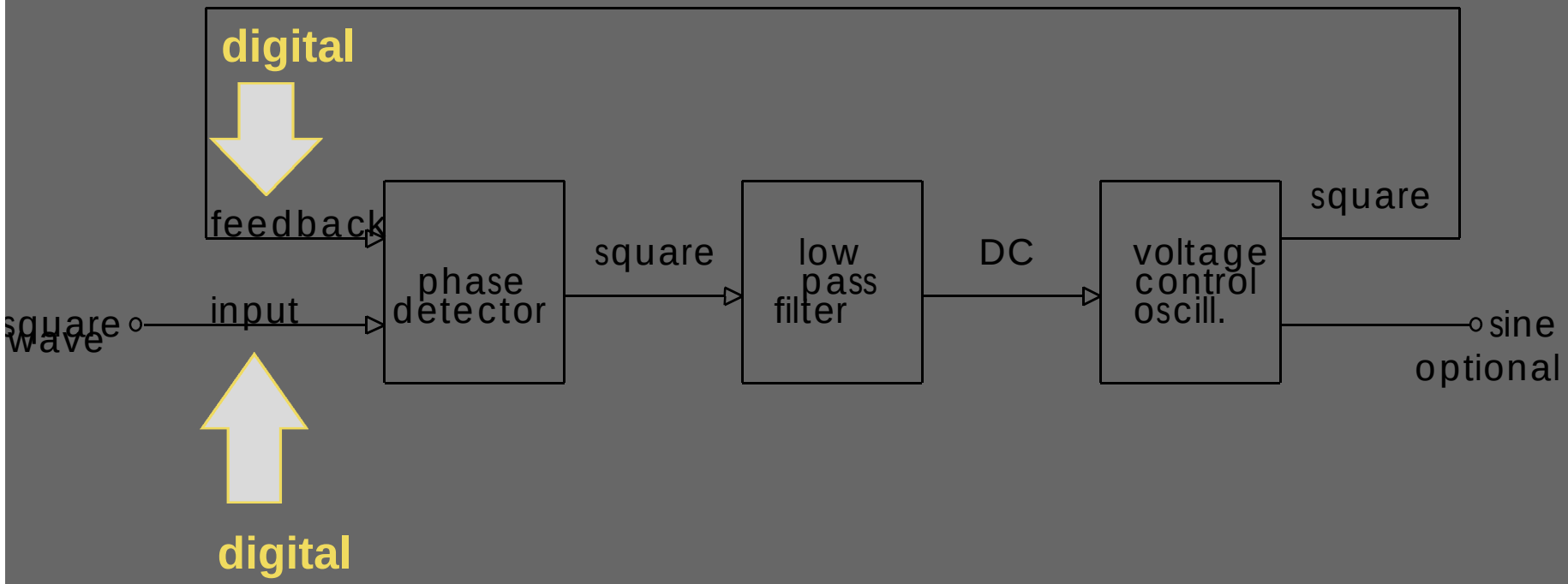
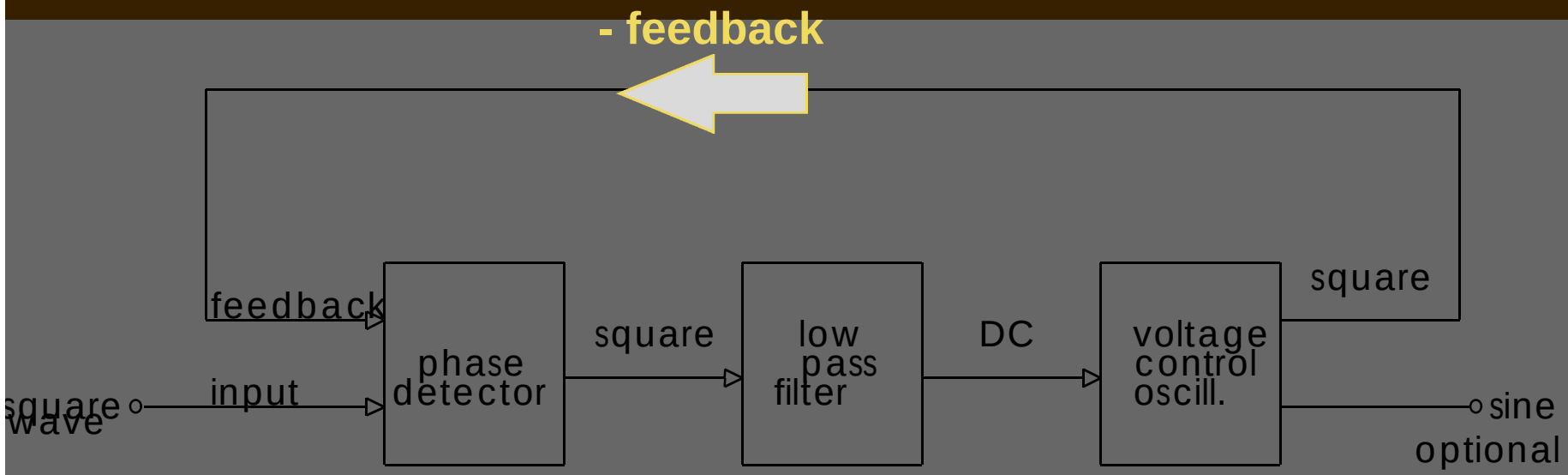
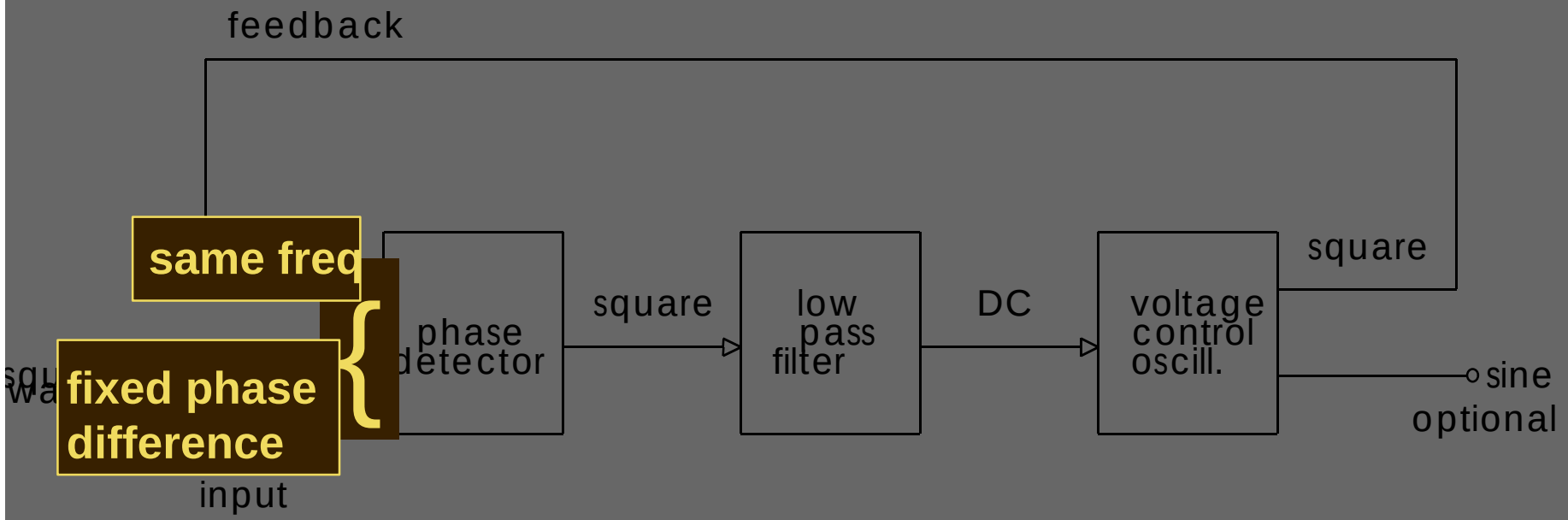
Basic Block Diagram



Basic Block Diagram

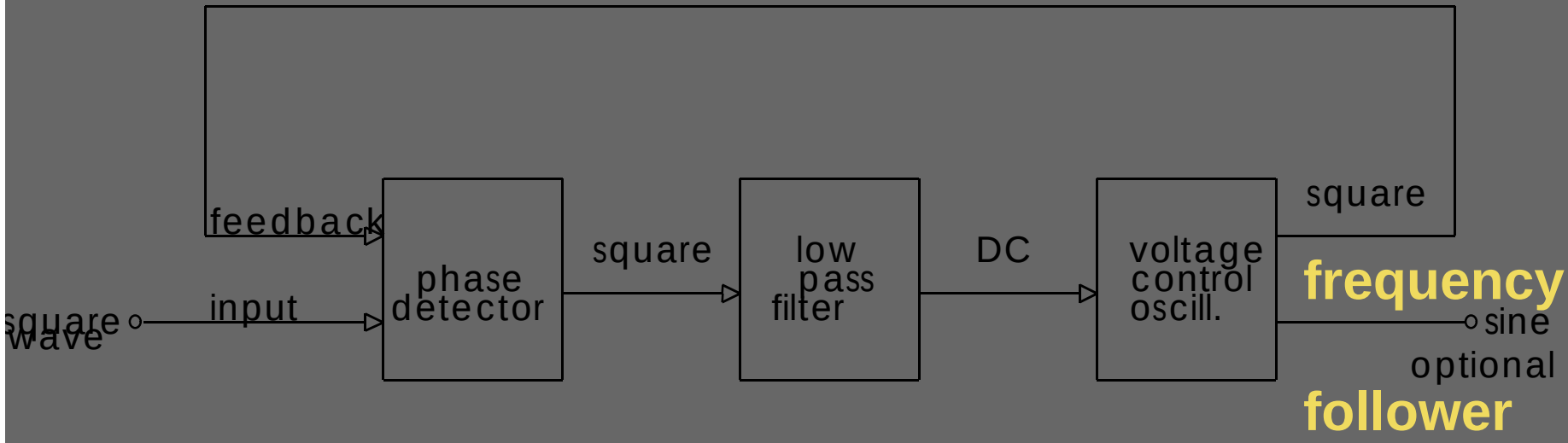


Basic Block Diagram

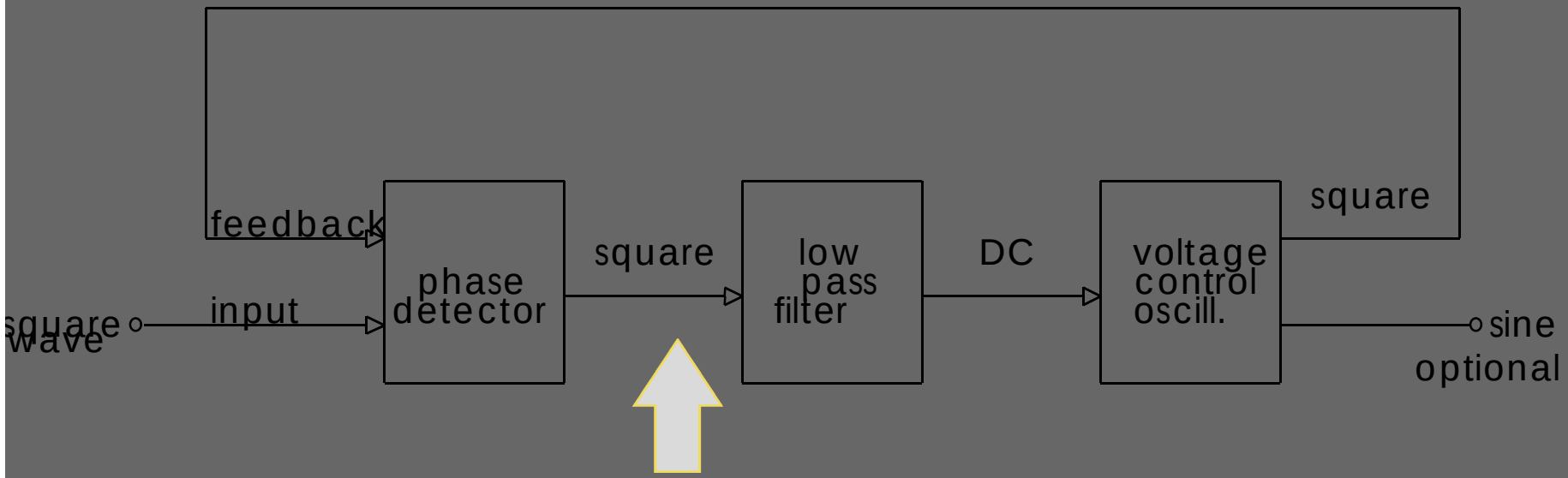


Basic Block Diagram

Assuming that the loop is locked $f_{fb} = f_{in}$.

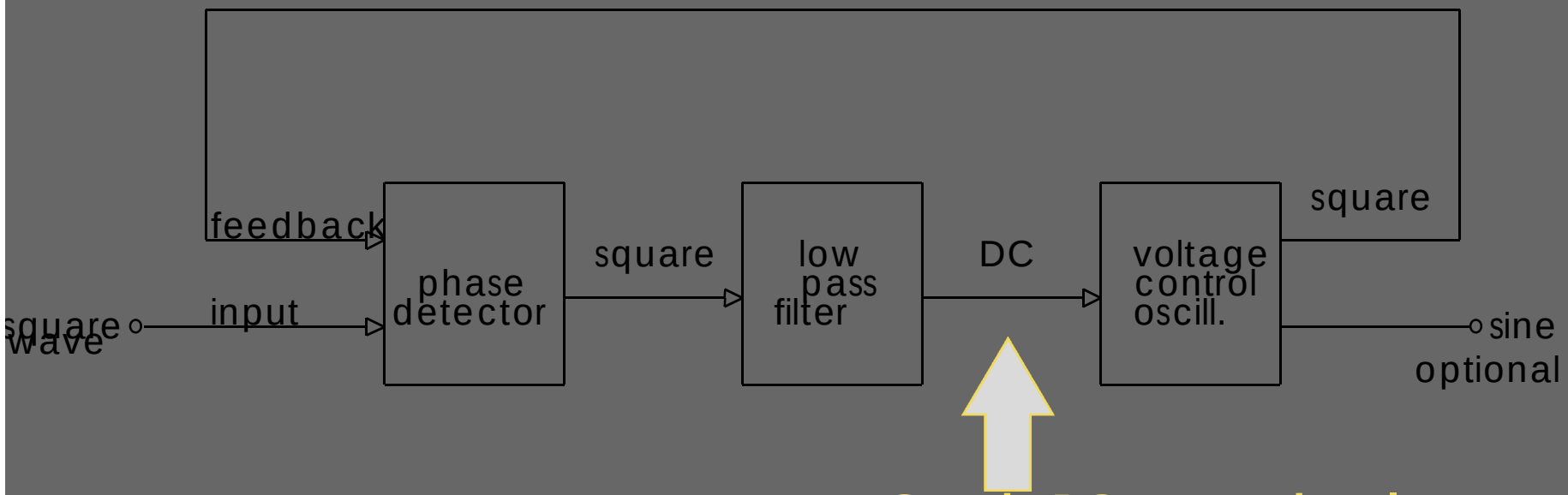


Basic Block Diagram

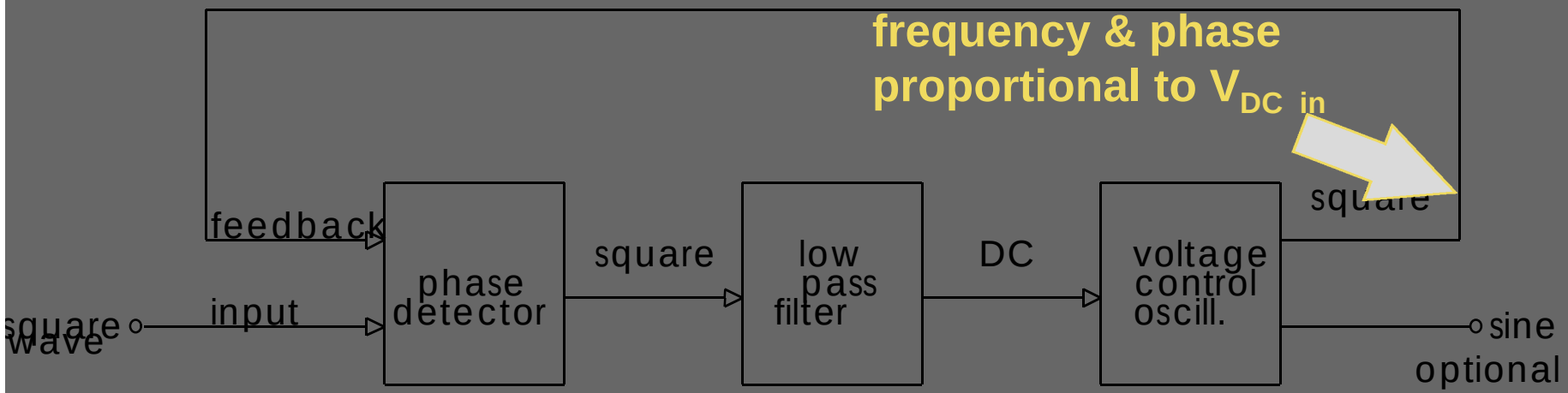


Average value proportional to phase difference between f_{in} and f_{fb}.

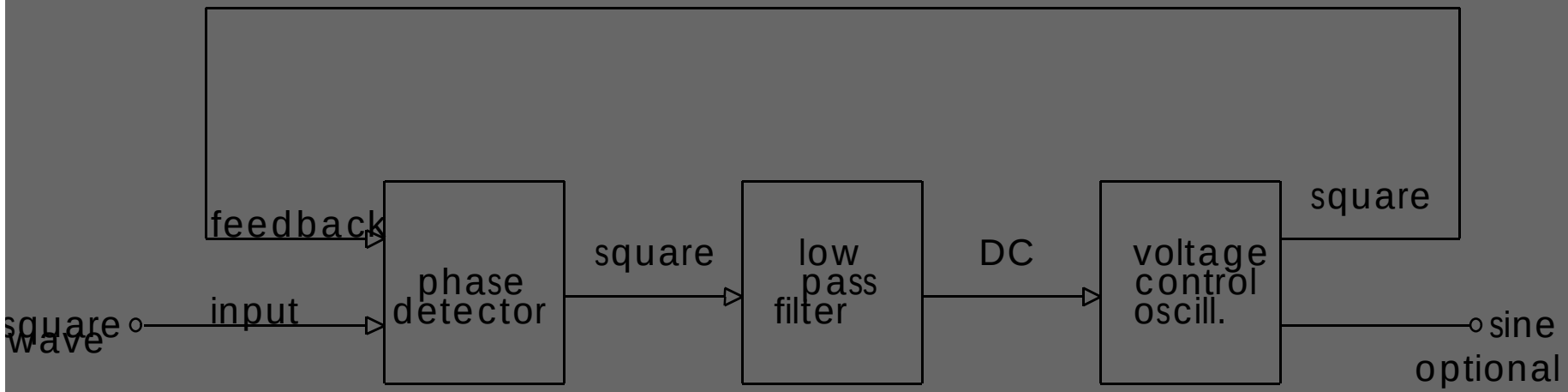
Basic Block Diagram



Basic Block Diagram



Effects of Variations



Overview

- Basic Block Diagram
- diagram operation
- Phase Detector
- xor CD4046 phase II
- Loop Filter
- VCO

Phase Detector

Digital output:

aveage value is proportional to the difference in phase between f_{in} and f_{fb}.

Phase Detector

Digital output:

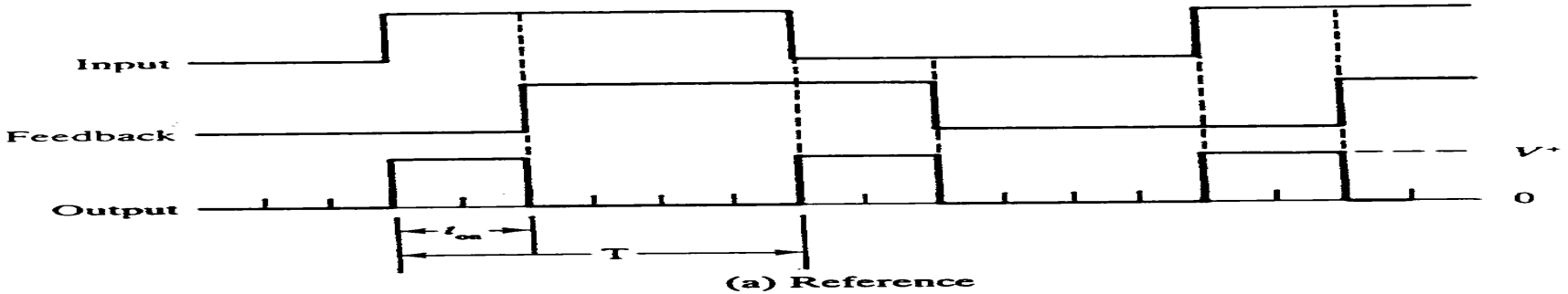
aveage value is proportional to the difference in phase between f_{in} and f_{fb}.

Exclusive OR

input	feedback	output
0	0	0
0	1	1
1	0	1
1	1	0

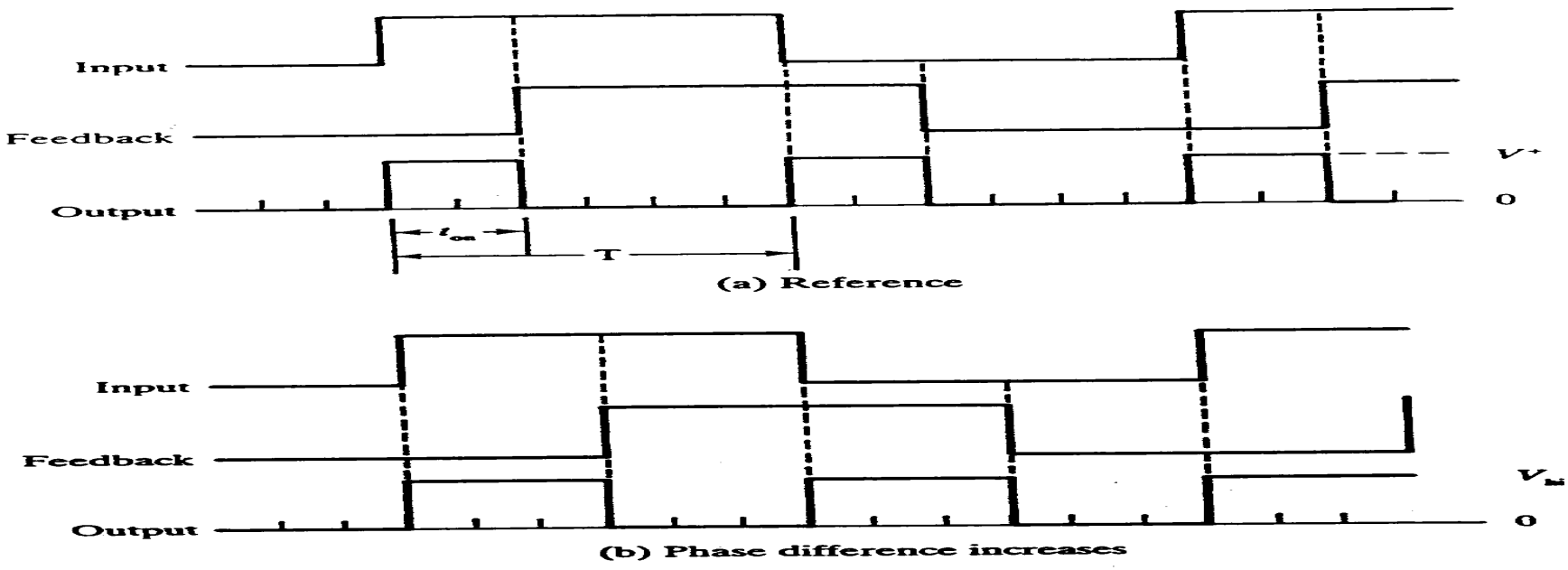
XOR phase detector

Figure 6-40 a, b, c page 325



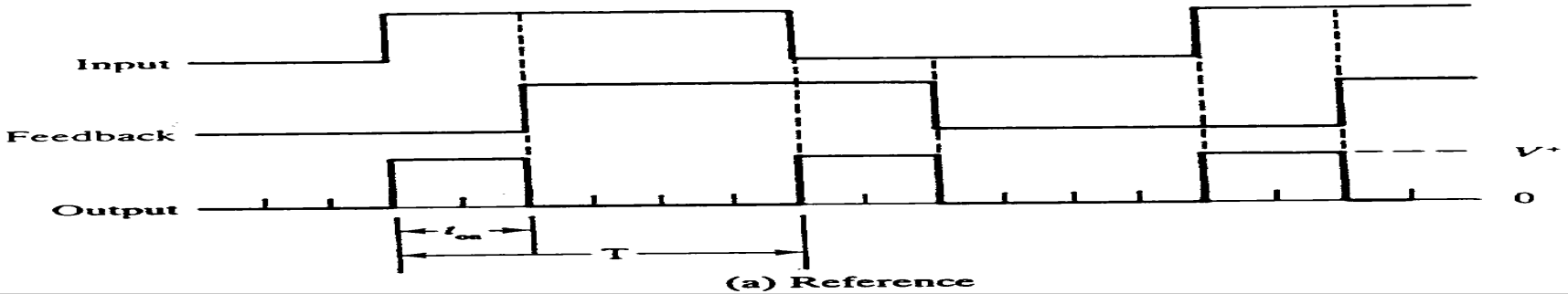
XOR phase detector

Figure 6-40 a, b, c page 325

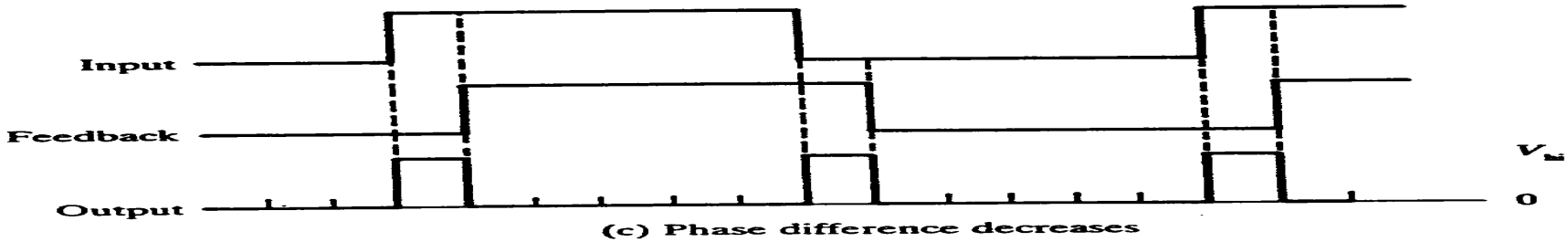


XOR phase detector

Figure 6-40 a, b, c page 325



(a) Reference



(c) Phase difference decreases

Figure 6-40 Exclusive OR waveforms produce phase detection

Transfer Funtion (Math)

$$V_{AVE} = V_{pk} \frac{t_{on}}{T}$$

typical pulse width modulation equation

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$$V_{out\ ave} = V_{hi} \frac{q}{180°}$$

output voltage proportional to the difference in phase

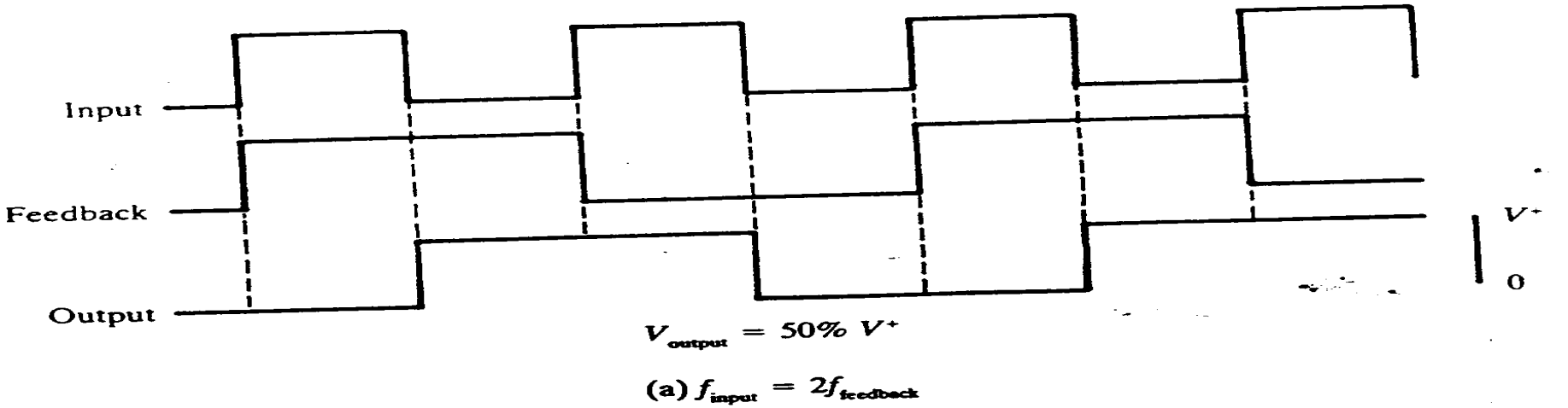
What if f_{in} < or > f_{fb} ?

Figure 6-42 a & b

page 328

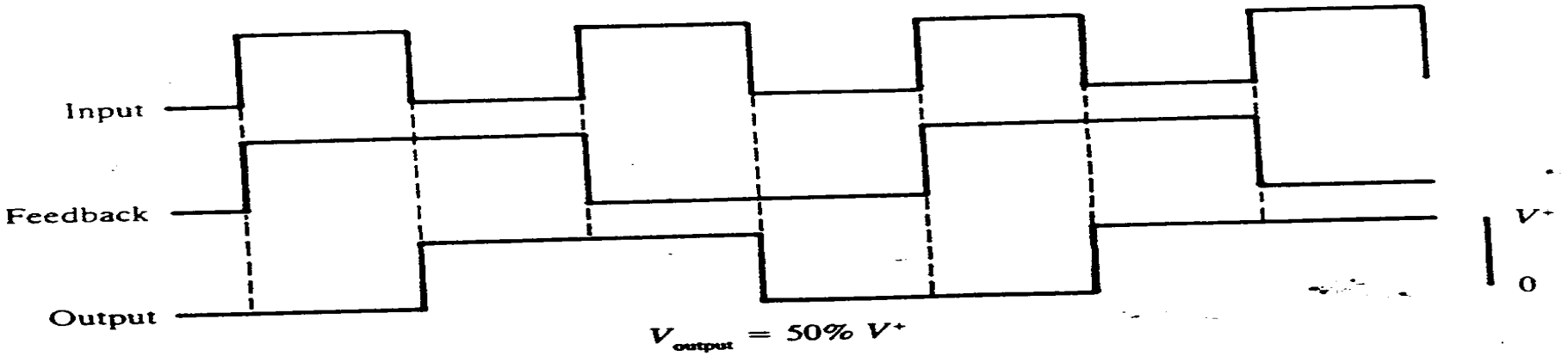
XOR phase detector

Figure 6-42 a, b page 327



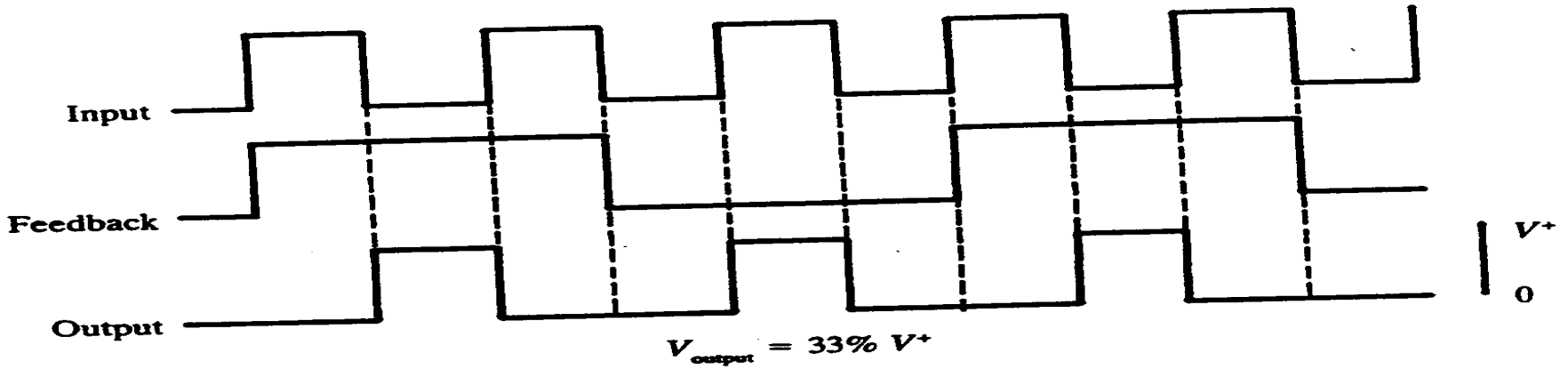
XOR phase detector

Figure 6-42 a, b page 327



$V_{output} = 50\%\ V^+$

(a) $f_{input} = 2f_{feedback}$



$V_{output} = 33\%\ V^+$

(b) $f_{input} = 3f_{feedback}$

CD4046 phase II detector

CD4046 phase II detector

- considerable additional logic

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- $f_{in} > f_{fb} \Rightarrow V_{out}$ high most of each cycle
  - rest of each cycle V_{out} is open

CD4046 phase II detector

- considerable additional logic
- $f_{in} > f_{fb}$ => V_{out} high most of each cycle
  - rest of each cycle V_{out} is open
- $f_{in} < f_{fb}$ => V_{out} ground most of each cycle
  - rest of each cycle V_{out} is open

CD4046 phase II detector

- considerable additional logic
- $f_{in} > f_{fb}$ => V_{out} high most of each cycle
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- phase of f_{in} leads => v_{out} high while leading

CD4046 phase II detector

- considerable additional logic
- $f_{in} > f_{fb}$ => V_{out} high most of each cycle
  - rest of each cycle V_{out} is open
- $f_{in} < f_{fb}$ => V_{out} ground most of each cycle
  - rest of each cycle V_{out} is open
- phase of f_{in} leads => v_{out} high while leading
- phase of f_{in} lags => v_{out} gnd while lagging

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Low Pass Filter

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Low Pass Filter

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- slow => very little ripple => stable freq
- slow => sluggish response to changes
- fast => quick response to upsets
- fast => ripple on output => variation in freq

What size RxC ?

Laplace, closed loop analysis:

$$\frac{1}{t\ s}$$

What size RxC ?

Laplace, closed loop analysis:

$$\frac{1}{t\ s} \qquad \frac{G(s)H(s)}{1+G(s)H(s)}$$

What size RxC ?

Laplace, closed loop analysis:

$$\frac{1}{t\ s} \qquad \frac{G(s)H(s)}{1+G(s)H(s)}$$

Must know transfer function [G(s) & H(s)] of phaseII detector and VCO

Simplier: Heavily overdamped

$$t = RC \approx \frac{50\% T_{longest}}{\%ripple}$$

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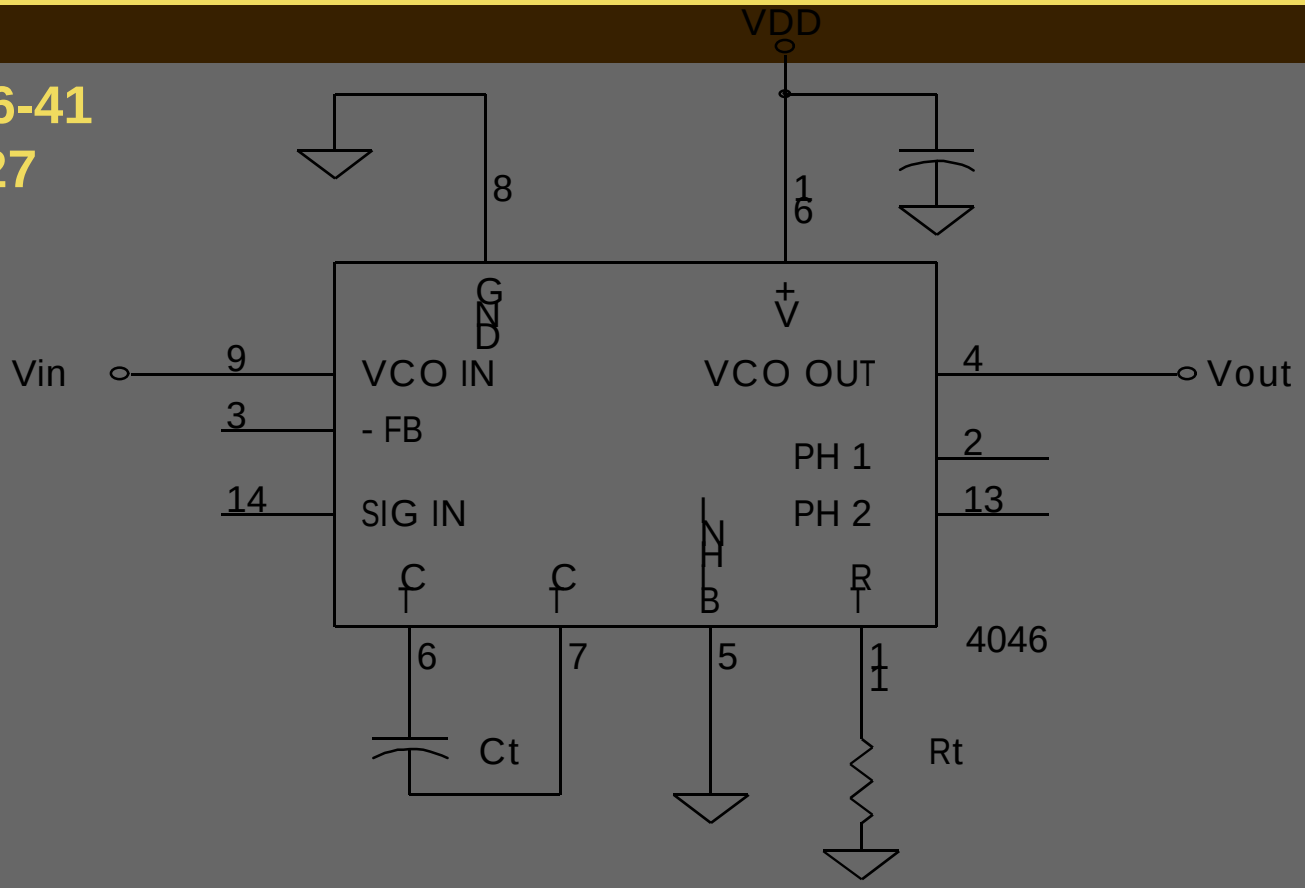
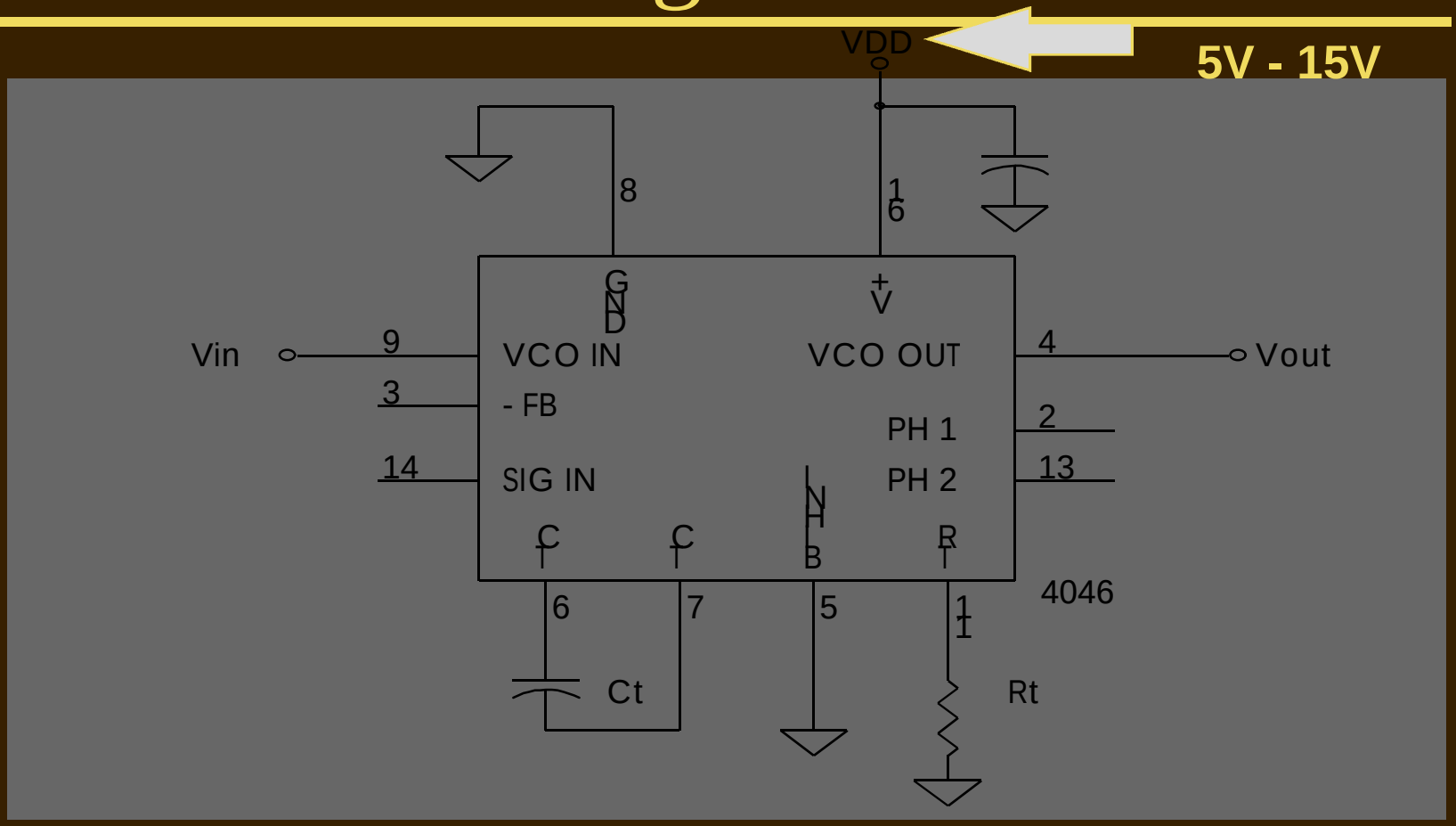
CD4046 Voltage Controlled Osc

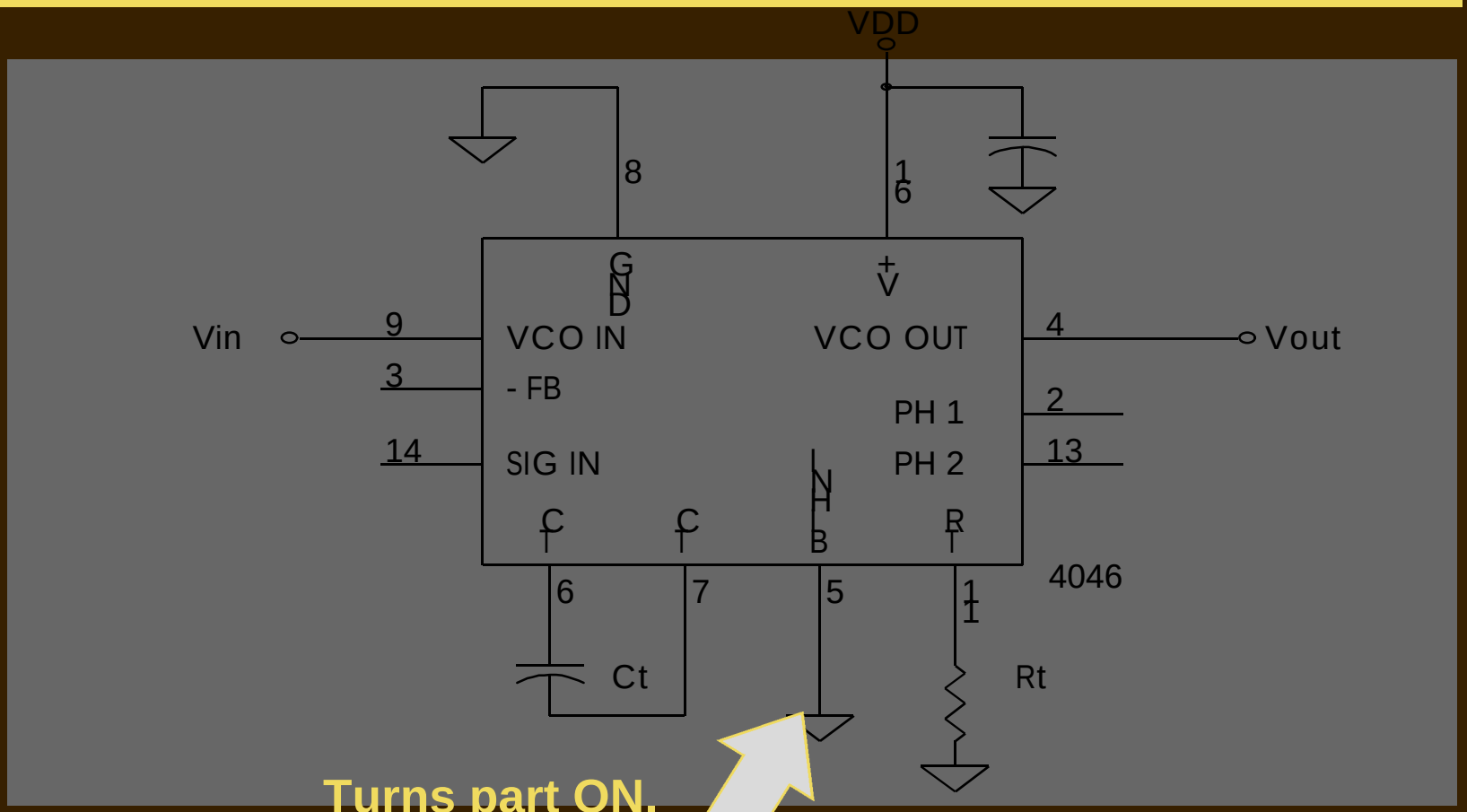
Figure 6-41
page 327



CD4046 Voltage Controlled Osc

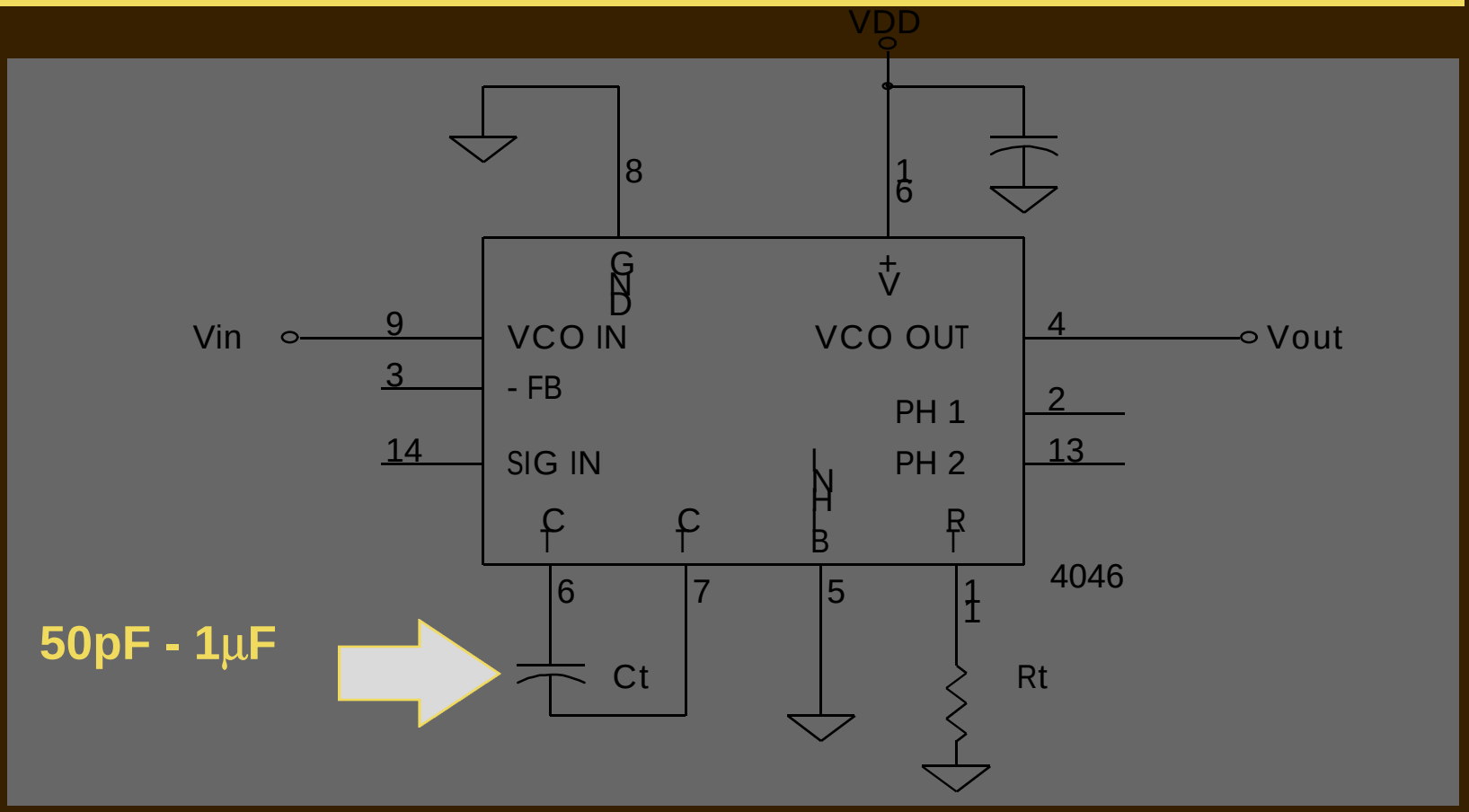


CD4046 Voltage Controlled Osc

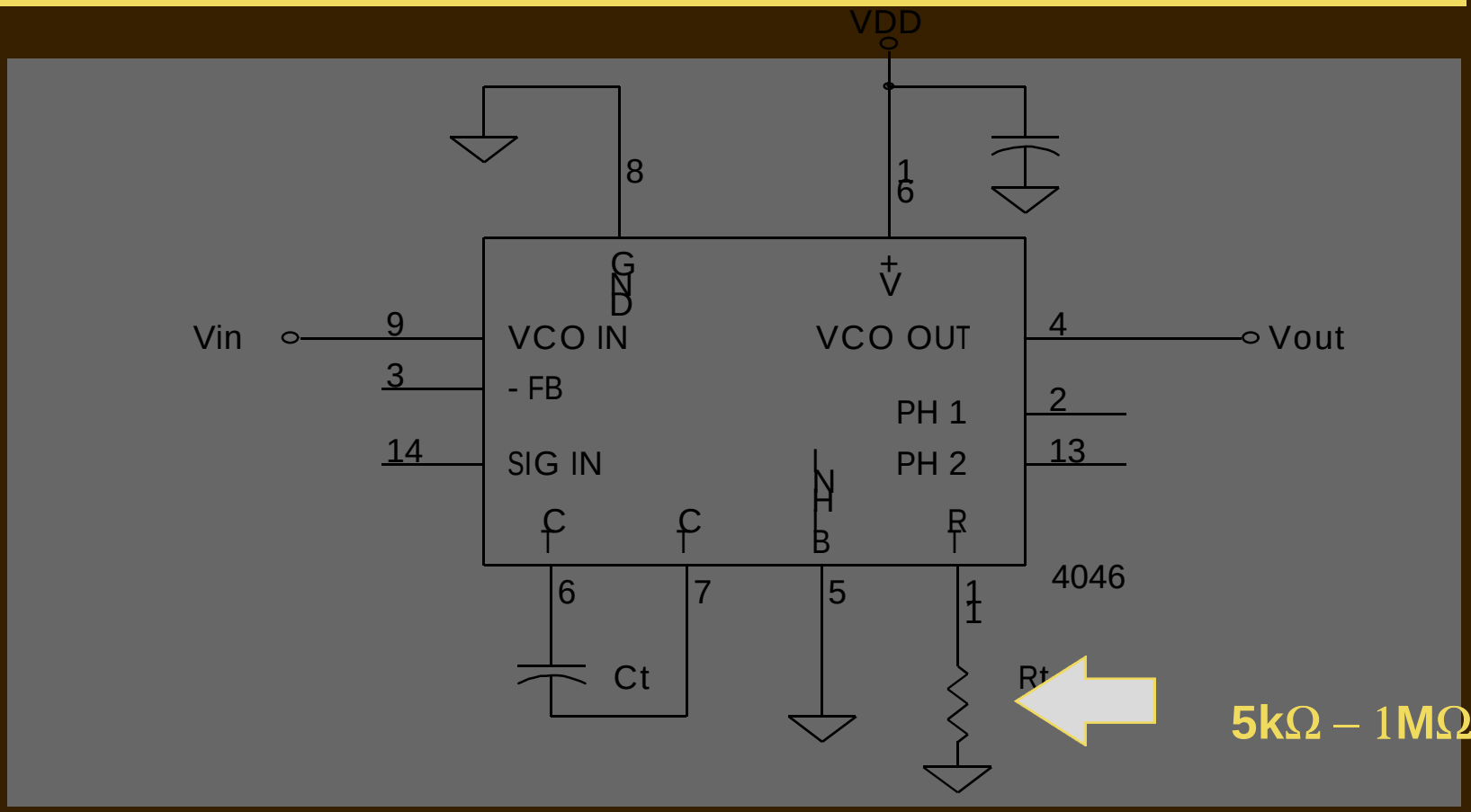


Turns part ON.

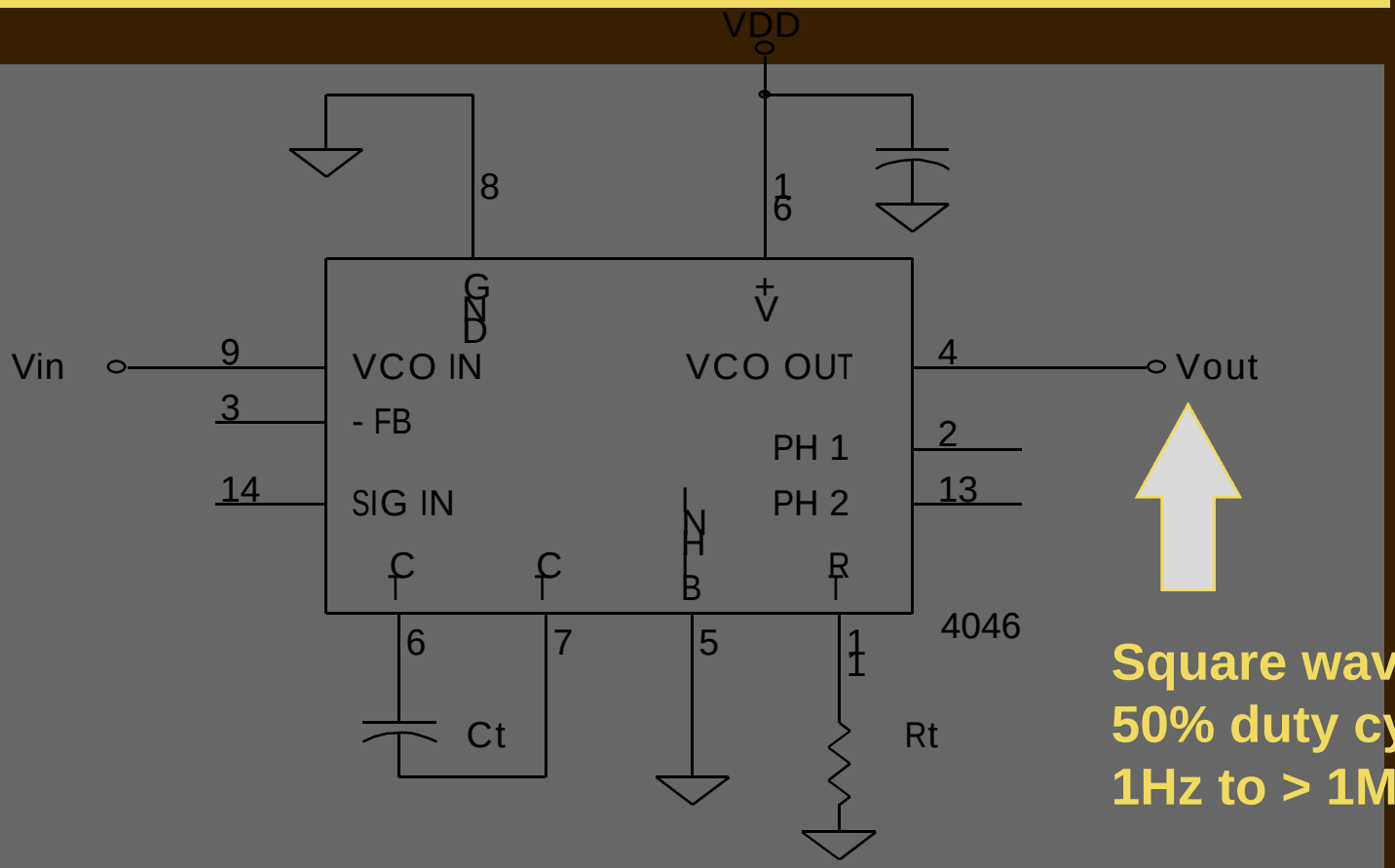
CD4046 Voltage Controlled Osc



CD4046 Voltage Controlled Osc



CD4046 Voltage Controlled Osc



Square wave
50% duty cycle
1Hz to > 1MHz

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