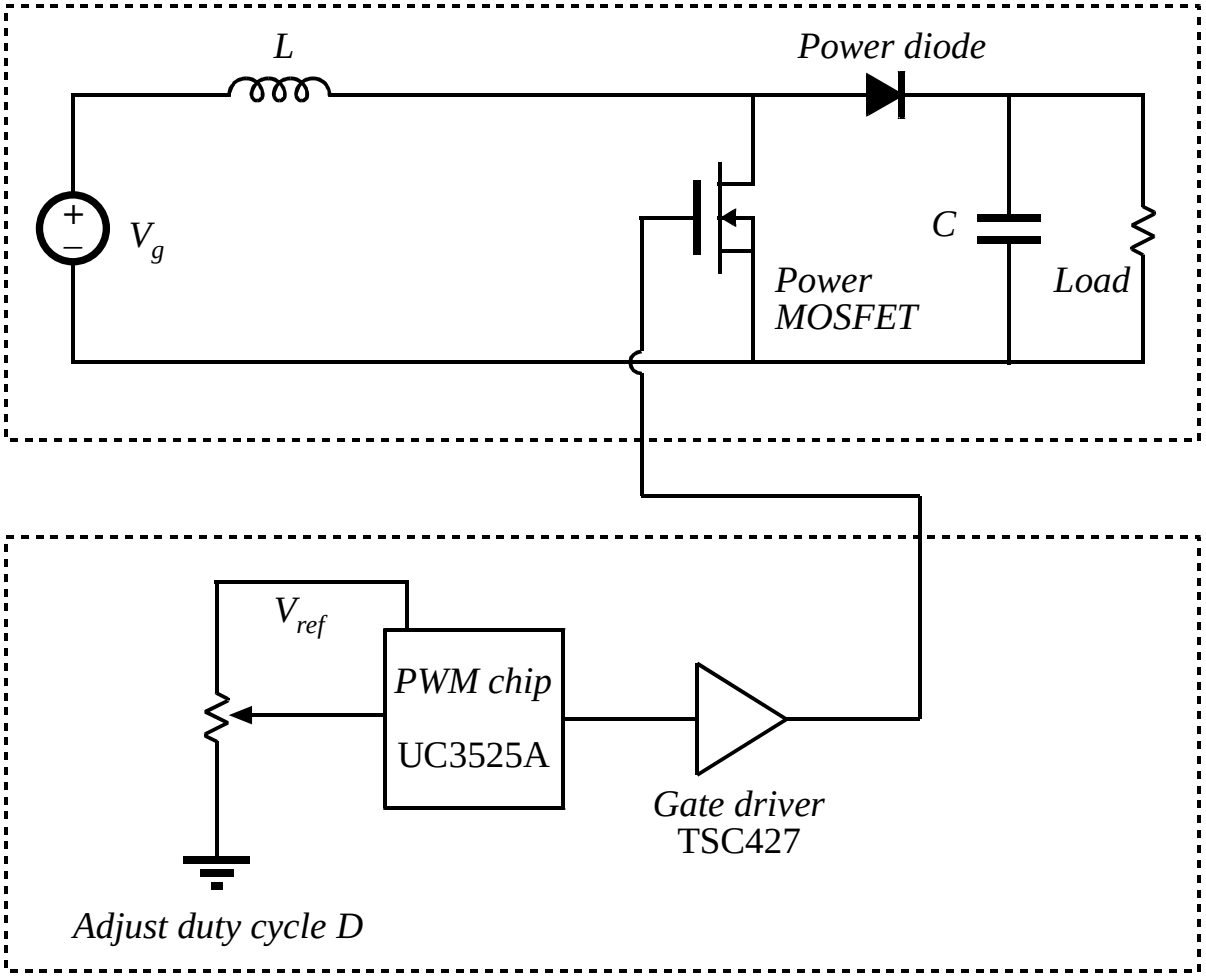
Lab Experiments



Boost converter
(Experiment 2)

Control circuit
(Experiment 1)

The UC3525 PWM Control IC

Key functions:

Oscillator (sawtooth wave generator)

PWM comparator and latch

Error amplifier

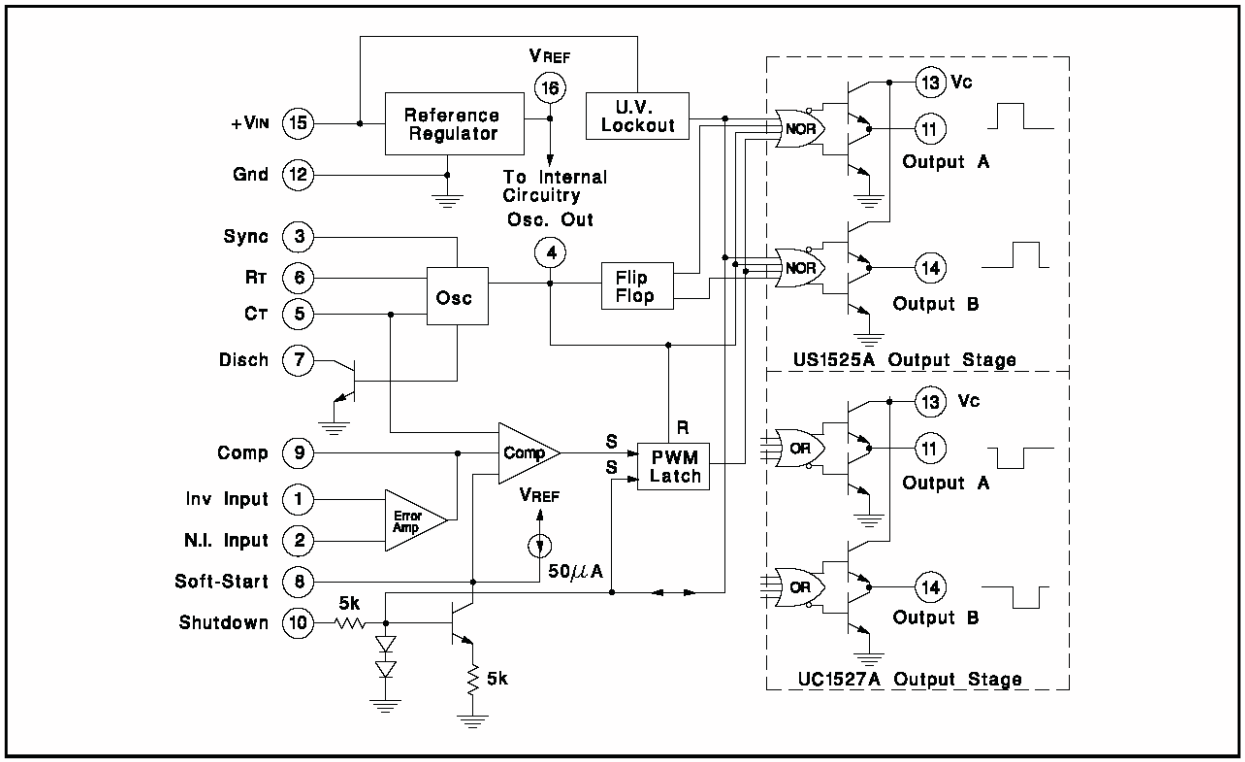
5.1 V reference

Pulse-steering logic

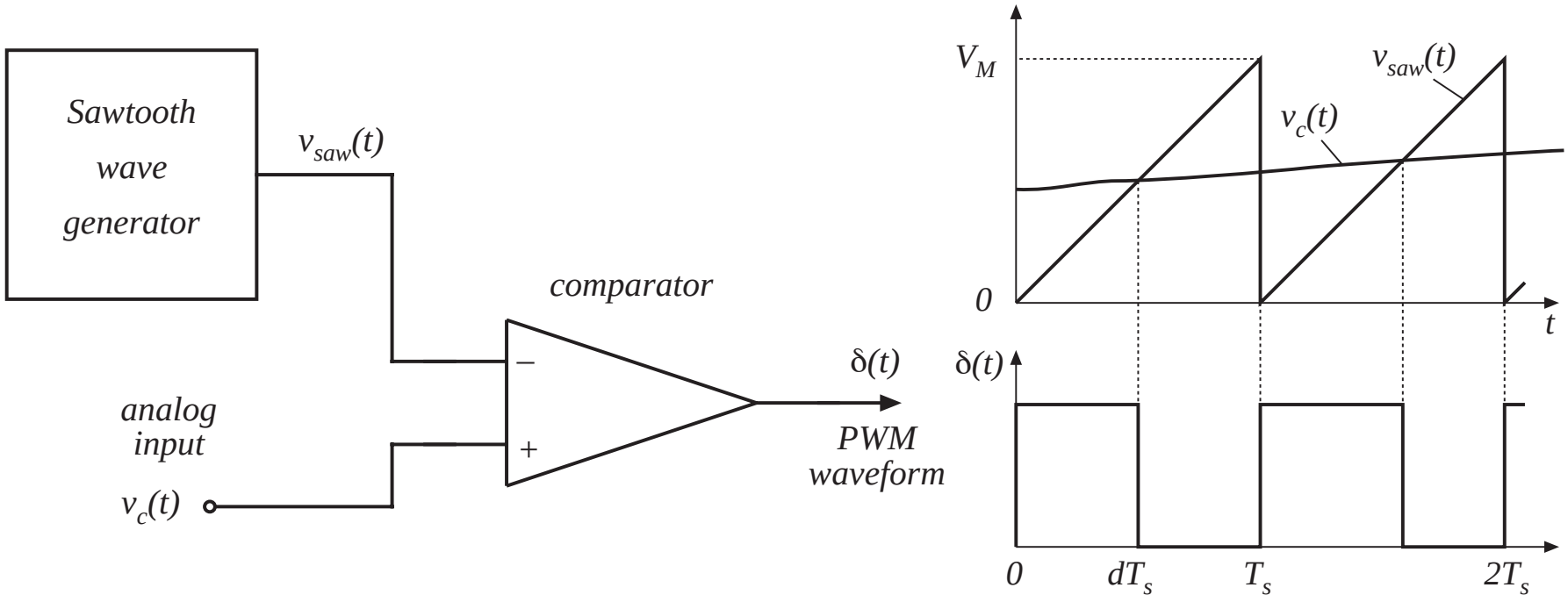
Output drivers

Shutdown and soft-start circuitry

BLOCK DIAGRAM



How a pulse-width modulator works

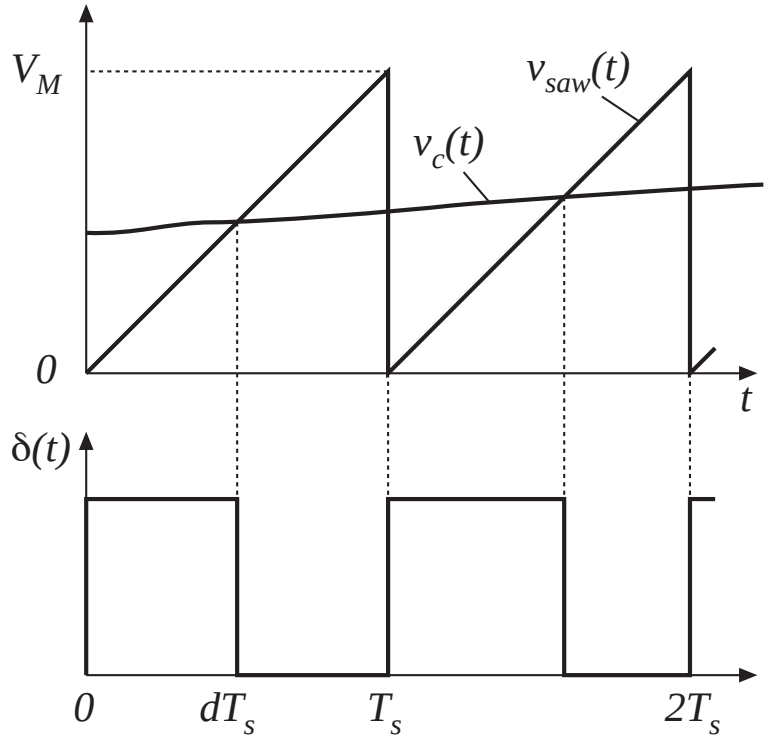


Equation of pulse-width modulator

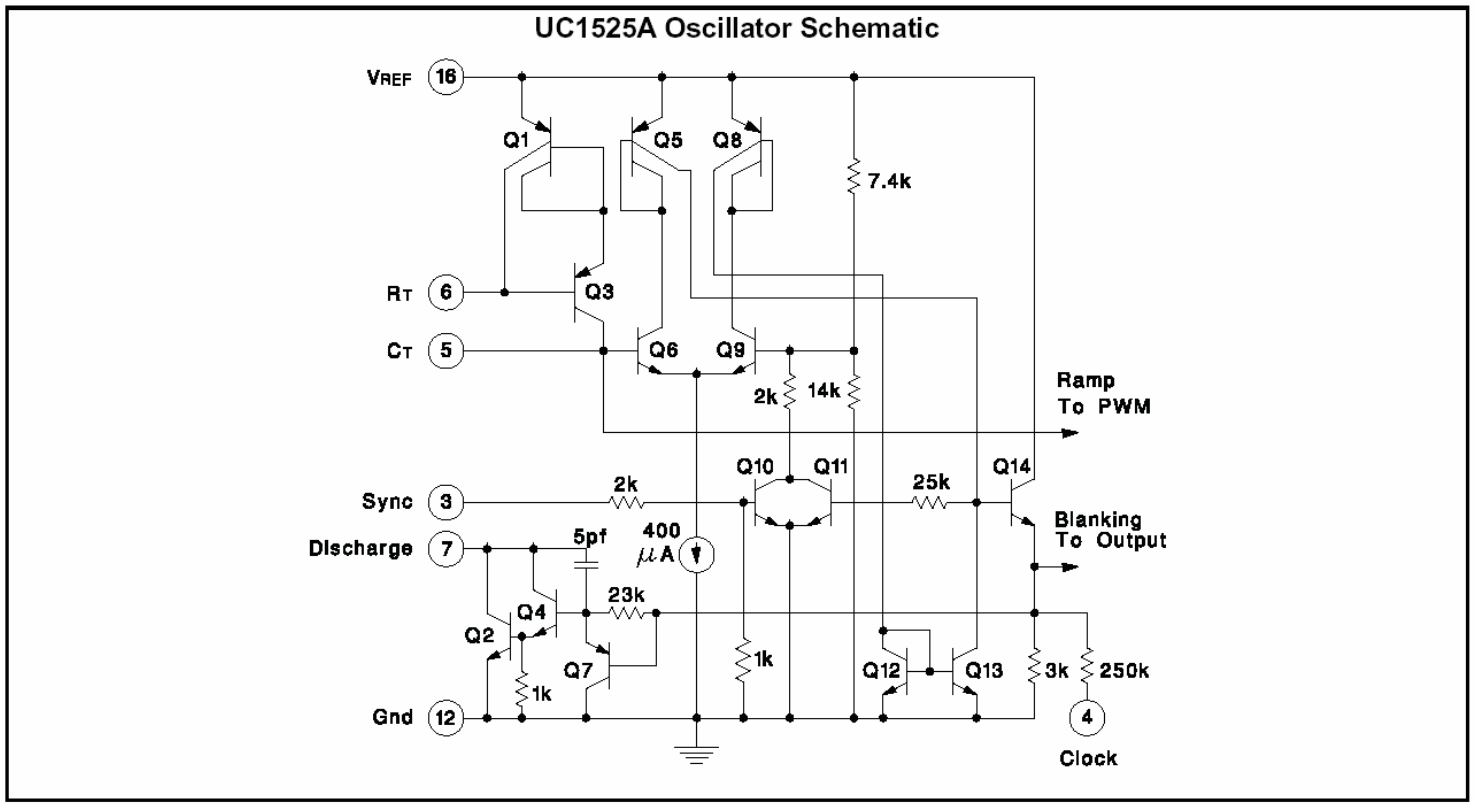
For a linear sawtooth waveform:

$$d(t) = \frac{v_c(t)}{V_M} \qquad for\ 0 \le v_c(t) \le V_M$$

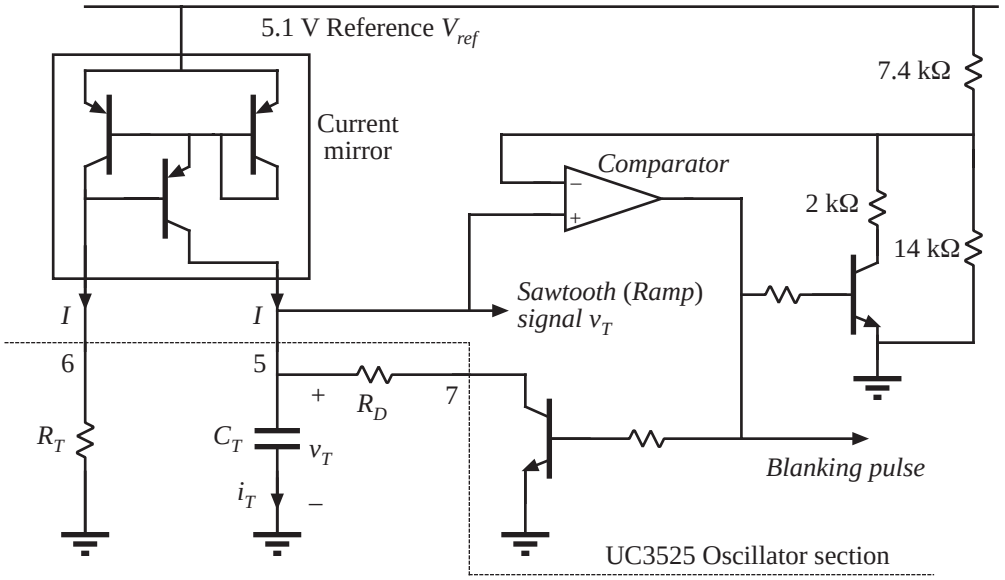
So $d(t)$ is a linear function of $v_c(t)$.



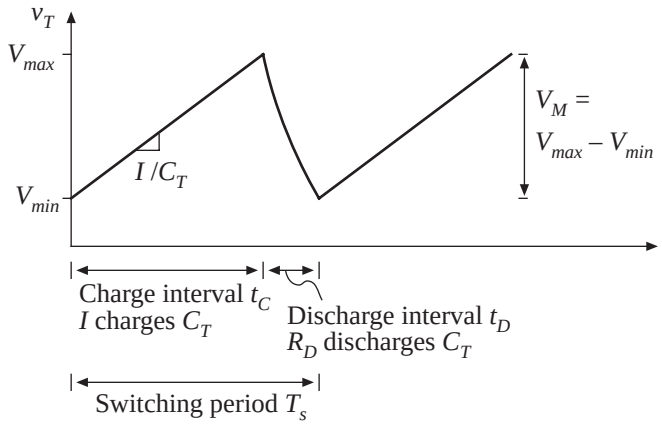
Sawtooth (Ramp) Oscillator



Simplified Block Diagram of Oscillator



$$i_T = C_T \frac{dv_T}{dt} \qquad \text{hence} \qquad \frac{dv_T}{dt} = \frac{i_T}{C_T}$$



$$I = \frac{(5.1\text{ V}) - 2(0.7\text{ V})}{R_T}$$

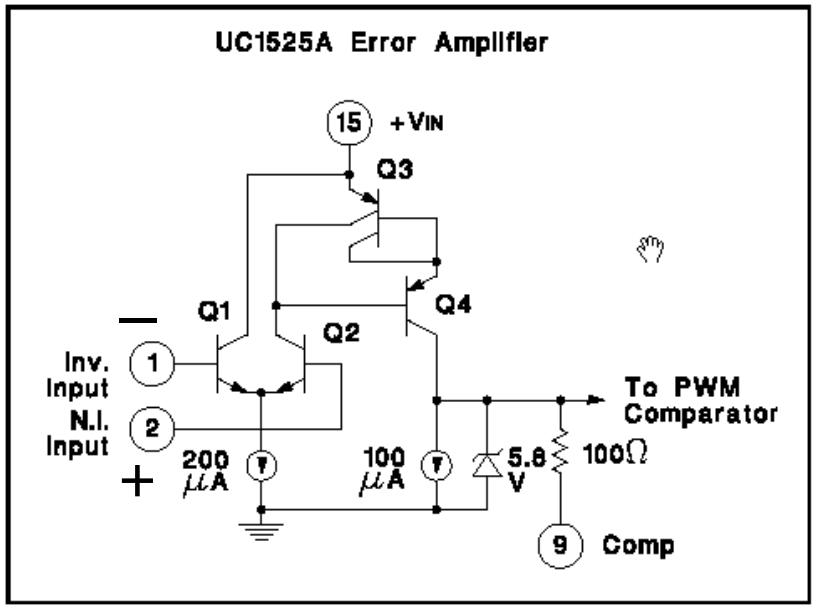
$$V_{\max} = (5.1\text{ V})\frac{14\text{ k}\Omega}{14\text{ k}\Omega + 7.4\text{ k}\Omega} = 3.3\text{ V}$$

$$V_{\min} = (5.1\text{ V})\frac{\left(2\text{ k}\Omega \parallel 14\text{ k}\Omega\right)}{\left(2\text{ k}\Omega \parallel 14\text{ k}\Omega\right) + 7.4\text{ k}\Omega} = 1.0\text{ V}$$

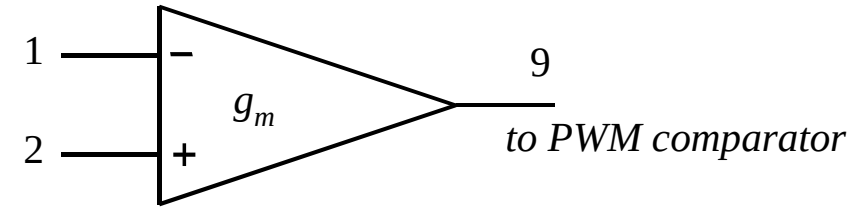
Blanking pulse causes driver outputs to be low, so that $dT_s \le t_c$

Increasing R_D reduces maximum allowed duty cycle D_{max}

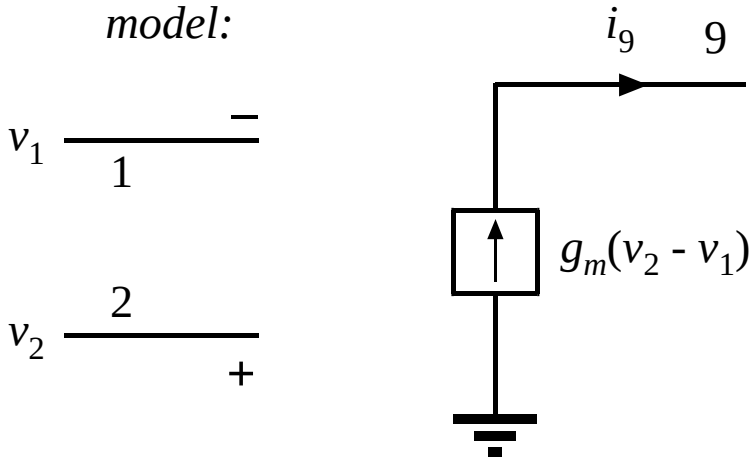
Error Amplifier



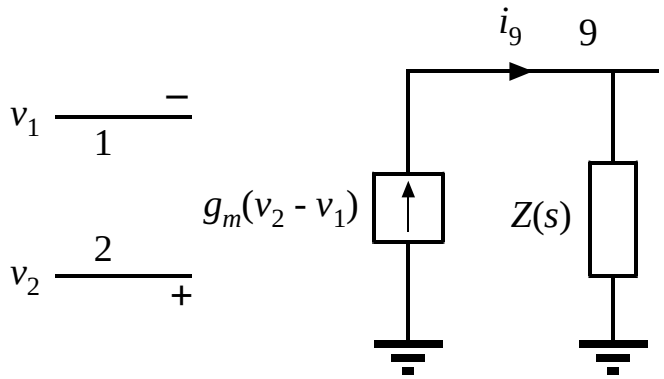
Transconductance amplifier



model:



Error Amplifier with Load

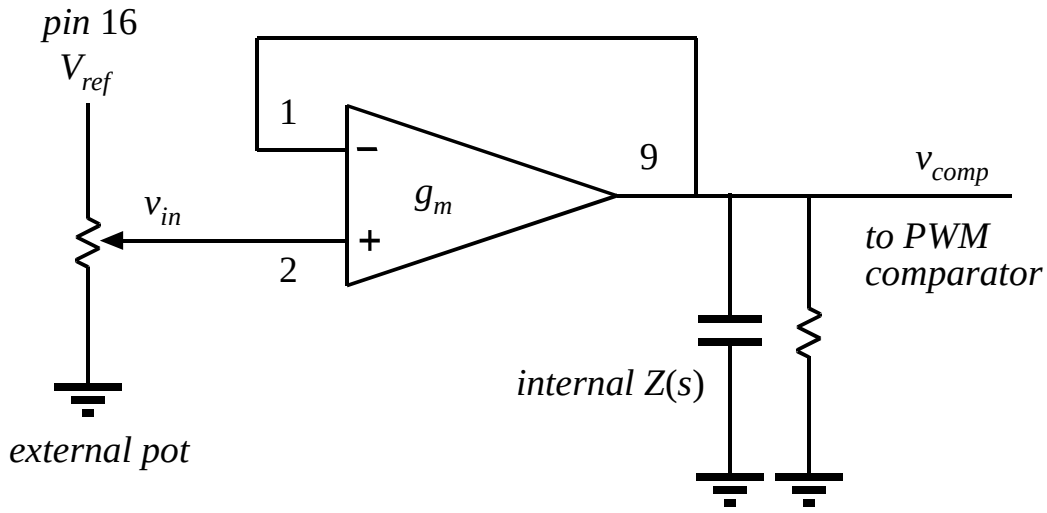


$$v_9 = g_m Z(s)(v_2 - v_1)$$

The differential voltage gain is: $g_m Z(s)$

With large $Z(s)$, the differential voltage gain is large. The data sheet specifies a low-frequency differential voltage gain of at least 1000 (60 dB).

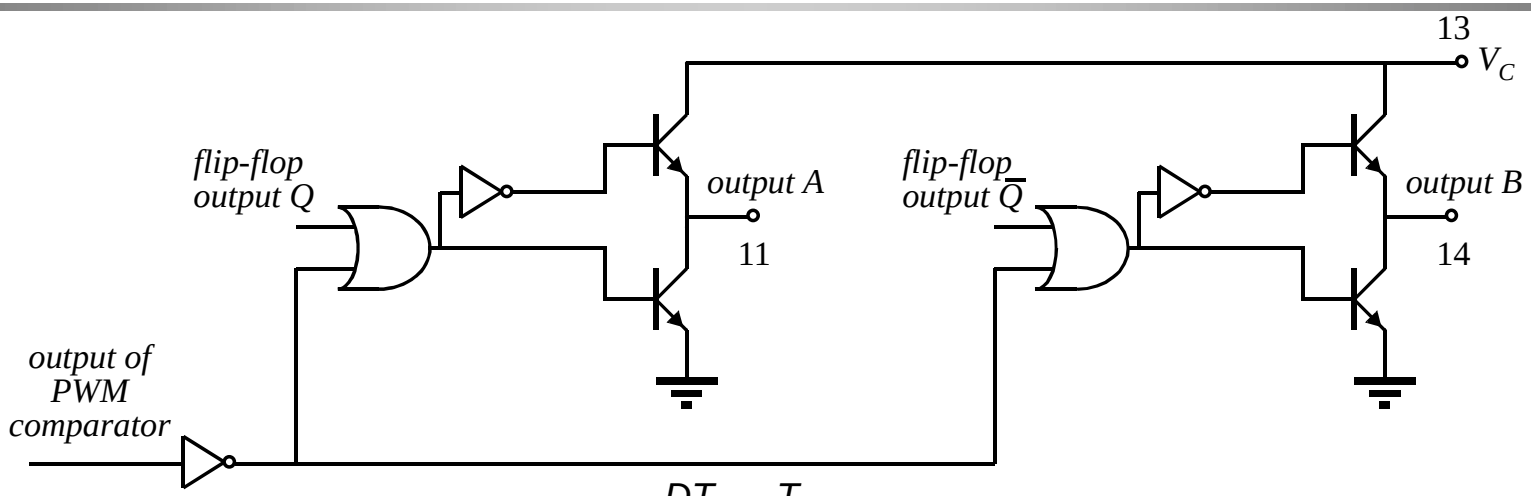
Connect to produce adjustable *D*

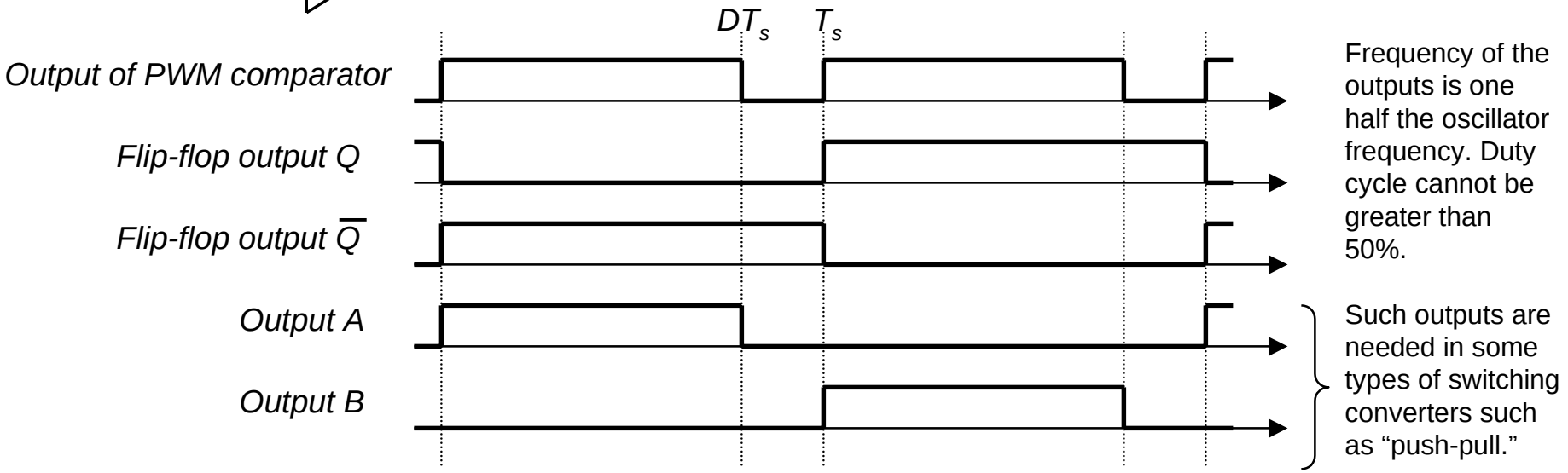


The error amplifier is connected as a unity-gain stage: $v_{comp} = v_{in}$

The duty cycle D can be adjusted by the external pot.

Outputs of the UC3515A



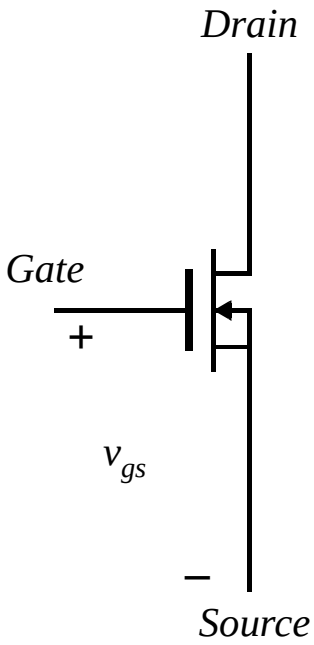


Frequency of the outputs is one half the oscillator frequency. Duty cycle cannot be greater than 50%.

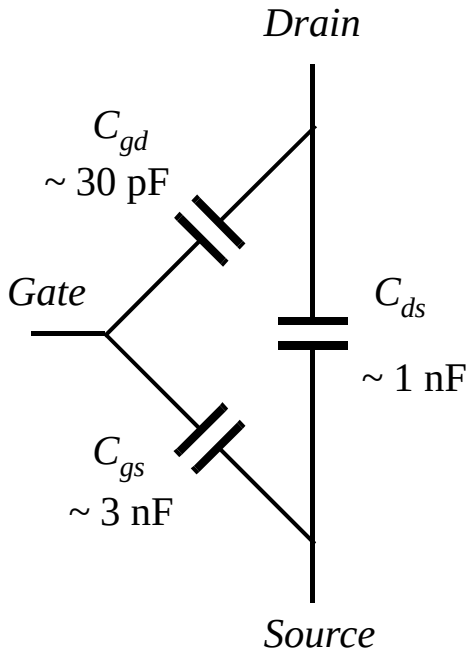
Such outputs are needed in some types of switching converters such as “push-pull.”

Outputs A and B can be OR-ed to restore the PWM pulses at the oscillator frequency.

Driving a Power MOSFET Switch



Power MOSFET



MOSFET capacitances

MOSFET is off when $v_{gs} < V_{th} \approx 2.5$ V

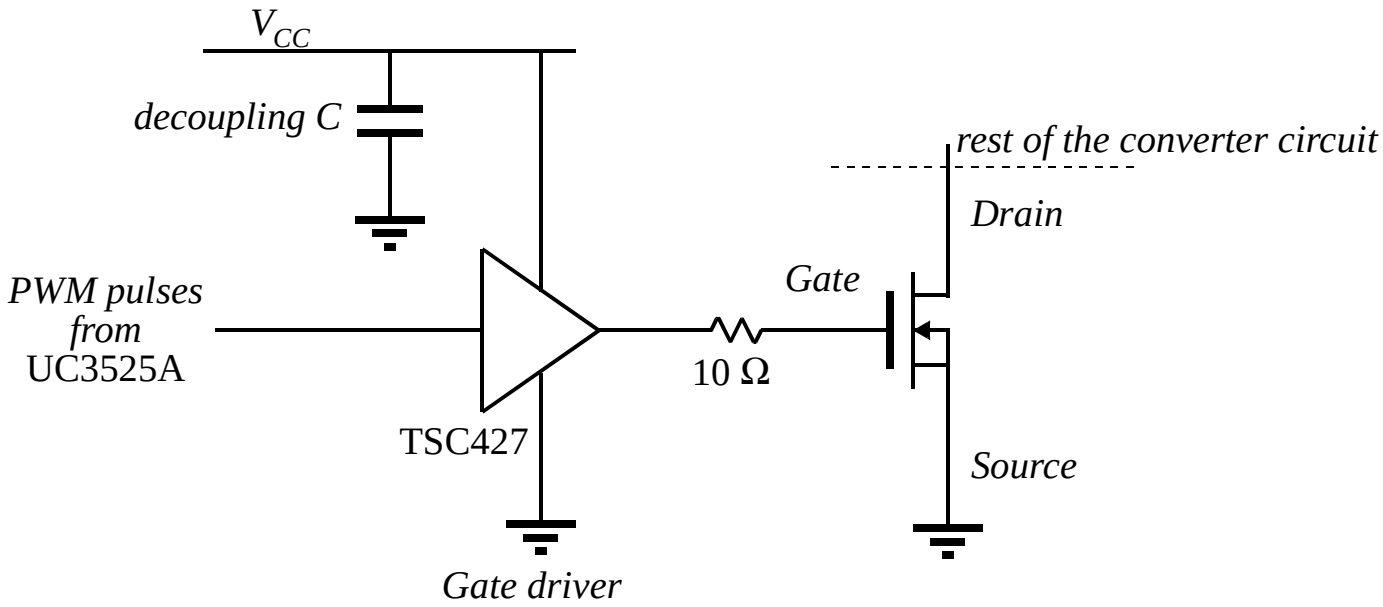
MOSFET fully on when v_{gs} is sufficiently large (10-15 V)

Warning: MOSFET gate oxide breaks down and the device fails when $v_{gs} > 20$ V.

Fast turn on or turn off (10's of ns) requires a large spike (1-2 A) of gate current to charge or discharge the gate capacitance

MOSFET gate driver is a logic buffer that has high output current capability

Driving a Power MOSFET Switch



MOSFET gate driver is used as a logic buffer with high output current (1.5 A) capability

The amplitude of the gate voltage equals the supply voltage V_{CC}

Decoupling capacitors are necessary at all supply pins of UC3525A and TSC427

Experiment 1
Pulse-Width Modulator
PRELAB ASSIGNMENT
ECEN 4517 / 5017

In the laboratory, you are going to construct a pulse-width modulator (PWM) circuit, test operation of the UC3525A PWM chip, and the TSC427 gate driver chip. The purpose of the prelab assignment is to familiarize yourself with these integrated circuits, understand their data sheets, and design the basic control circuitry that you will use in later experiments.

For the prelab assignment, do the following:

1. Reading assignment:

   Introduction to converters handout

   Data sheets for the UC3525A PWM chip and the TSC427 power MOSFET driver chip

   Laboratory procedure handout

   All of the above materials can be downloaded from the course web site

2. Circuit design:

   Design a circuit around the UC3525A and TSC427 such that the gate drive signal at the output of the TSC427 is a PWM waveform having switching frequency f_s equal to 50 kHz, and duty ratio D adjustable between 0 and 40%. The maximum duty cycle should be limited to 40% by your design. Your circuit should include bypass capacitors at the power supply pins of all chips.

A DC supply voltage of V_{CC} = 15 V is available. You may use an adjustable trimmer potentiometer for duty cycle adjustments, and as many resistors and capacitors as necessary around the chips. You should turn in a complete circuit diagram with all component names and values. For each component, not how you selected the value, referring to the UC3525A data sheet as necessary.

A separate prelab assignment is required from each student. The prelab should be turned in at the beginning of the week 2 lecture. Keep a copy of your work, for your use during the lab experiment.