

## Voltage Multiplying Circuit

Below is shown a two-stage voltage multiplying circuit. It is a variation of what is called the Villard cascade voltage multiplier. Its input is an AC voltage source. It uses diodes and capacitors in an ingenious method to multiply an input voltage. Many stages identical to this one can be cascaded to create an output reaching hundreds of volts.

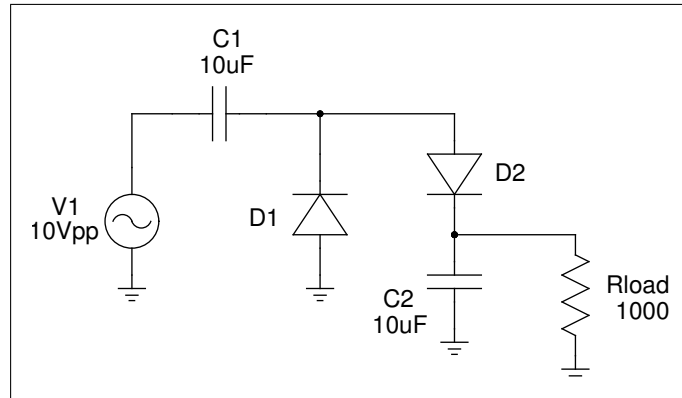


Figure 1: A Two-Stage Villard Voltage Multiplier

### Analysis:

- From time zero, suppose that  $V_1$  begins on a negative half-cycle. This means that its top terminal is more negative than its bottom one. Thus, as seen in 2, current flows out of  $V_1$  as shown.
- The current flowing out of  $V_1$  flows into  $D_1$  and  $C_1$  which begins to charge  $C_1$  to 5 volts. It cannot flow up through  $C_2$  or  $R_{load}$  as  $D_2$  opposes the flow of current in that direction.
- Also, current cannot flow down  $D_2$  towards  $C_2$  or  $R_{load}$  because ground will be at least one diode drop above the voltage on the anode of  $D_2$ .

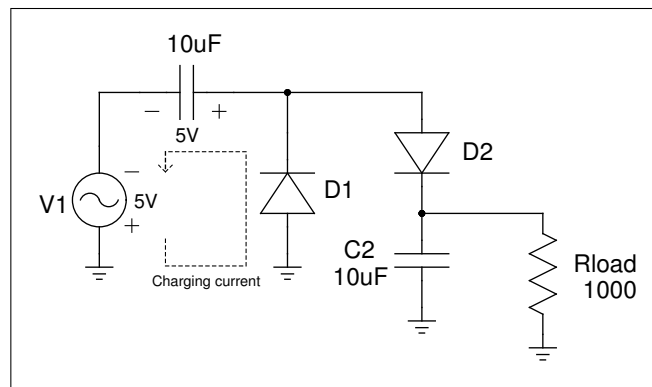


Figure 2: Two Stage Voltage Multiplier During Negative Half-Cycle

- In figure 3 when  $V1$  begins its positive half cycle,  $C1$  will have been charged to 5 volts. The 5 volts on  $C1$  plus the 5 volts on  $V1$  creates a combined 10 volts that flows through  $D2$  ( $D1$  is now reverse-biased) which charges  $C2$  and also supplies current to  $R_{load}$ . Note that  $R_{load}$  must not be so small that  $C2$  is so discharged that it cannot be recharged by  $C1$ .

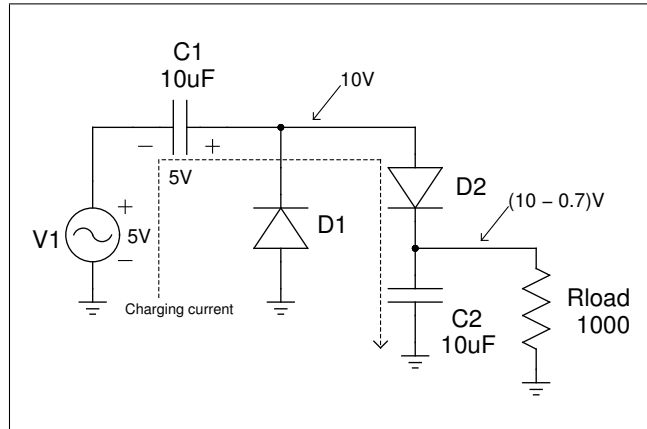


Figure 3: Two Stage Voltage Multiplier During Positive Half-Cycle

Below is shown an ngspice netlist for simulating this circuit.

```
Two Stage Voltage Multiplier
*model for fast schottky diode
.MODEL 1n5819 d IS=1.19279e-05 RS=0.0625421 N=1.16517 EG=1.3 XTI=3.22098 BV=40
+ IBV=0.001 CJO=1.50114e-10 VJ=1.5 M=0.590203 FC=0.5 TT=2.6273e-08
+ KF=0 AF=1

vs      a      0      sin(0 5 1000 0 0) ;5 Vpp, 1000hz source
c1      a      b      10uf
d1      gnd    b      1n5819      ;diode
c2      gnd    v_out  10uf
d2      b      v_out  1n5819      ;diode
rload   v_out  0      1k          ;1k load resistor

.control
set noaskquit
set hcopydevtype=postscript
set hcopypscolor=true
set color0 = rgb:f/f/f
set color1 = rgb:0/0/0
set color2 = rgb:f/0/0
tran 0.01ms 12ms
plot V(a) V(b) V(v_out) xl 0.01ms 12ms
* gnuplot v_multiplier V(a) V(b) V(v_out) xl 0.01ms 12ms ;make plot for latex
.endc
.end
```