

DC->DC Power Converters

Parts List:

- 1 dual DC power supply
- 1 Function generator
- 1 Oscilloscope
- 1 hand held multi-meter
- 1 nchannel MOSFET power transistor (IRFZ34N)
- 1 power diode (HFA15TB60)
- 2 heat sinks for TO220 devices (for diode and transistor)
- 1 5 μ F electrolytic capacitor (20V or better)
- 2 10 Ω power resistor rated for 10W
- 1 1 Ω resistor (1/2W)
- 3 1 μ F ceramic capacitors
- 2 100 μ H inductors

Build a Ćuk Converter Circuit-constant with duty cycle

Ćuk converters have the same V_{in}/V_{out} relationship as a buck-boost converter. Assuming continuous current through the inductors:

$$V_{out} = -\frac{D}{1-D}V_{in}$$

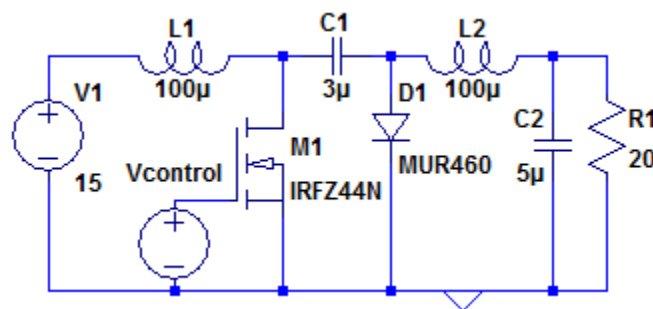


Figure 1 You will need to build up C1 and R1 out of multiple circuit elements.

- Control Signal In: $V_{control}$ is from a signal generator. Use a $f=250\text{kHz}$ square wave to cycle the transistor on (e.g., $V=10\text{V}$) and off ($V=0\text{V}$). Control the voltage across R_{load} via the duty cycle D .
- Power in: $V_d=15\text{VDC}$.
- Power out: voltage across R_{load} .

The PWM Control Signal

Before we build the circuit we will look at the output of the signal generator on the oscilloscope.

Preparing the signal

- To drive the transistor properly we need to have the signal with floating ground. **Use the ground defeater on the function generator to make its ground float.**
- With a function generator's ground floating dial in a 250kHz square wave.
- Connect the function generator to the oscilloscope on channel 1. Adjust the trigger of the scope to get a clear look at the signal, a scale of 1V/div and 20 μ s should work well.
- Adjust the amplitude to get a $V_{pp}=10V$ signal.
- Press the DC-offset button and adjust the signal so that it oscillates between $V=0V$ and $V=10V$. (How do you set the scope to measure this?)
- Press the duty cycle button and adjust D using the knob.

Once you understand how to control your signal make a $f=250kHz$, $V_{pp}=10V$, $D=0.25$ signal and show me. Keeping your control signal connected to the oscilloscope and use a splitter T to send the signal to your converter circuit may cut down on the time spend collecting data.

Construct the circuit

Construct a neat circuit. Use wires from the jumper wire kit as appropriate to neatly construct the circuit, this will make trouble shooting much easier. Connect the DC power supply and signal generator **but do not turn on the DC power supply**. Show me your circuit before you turn on the DC power supply.

Circuit Test

Once your circuit is checked turn on the DC power and test the circuit with a 50% duty cycle ($D=0.5$) control signal, (the default when the duty cycle button is off). Use the oscilloscope to measure the voltage across your resistive load. Does this behave as you would expect? Turn on the duty cycle button and adjust the duty cycle through its full range. Does this behave as you would expect?

Data Collection for basic circuit

1. Make the necessary measurements to calculate the efficiency of the converter
$$\eta = P_{out}/P_{in}$$
at $D=0.25, 0.4, 0.5,$ and $.6$. Use a hand-held multi-meter on DC settings to measure the necessary voltages and currents.
2. Calculate ratio V_{out}/V_d for each of the duty cycles and compare it to the predicted value.
3. Tweak the circuit you have built so that you can measure the current from the power supply and the current through the load with the oscilloscope. Compare the wave form to that of the Buck converter.
4. In light of the input current waveform, record the output impedance and calculate the input impedance of the circuit

Cuk converter as a maximum power point module

Inverters contain a maximum power point (MPP) module that attempts to maximize the power produced by the panels by adjusting the input impedance of the inverter.

We will model this by replacing the DC power supply with your choice of

- a pair of small solar panels or
- one large solar panel.

Data collection with solar power source

No converter

Use the spotlight on the bench to illuminate your panel(s) as strongly as possible. Connect this directly to the 100ohm 10W load resistor (but keep your converter circuit intact) and record the output power for No converter

MPP-high

Shift the power from the panels so that it must pass through the Cuk converter to get to the load (use the panels for V1 in the schematic). Again use the spotlight on the bench to illuminate your panel(s) as strongly as possible. Vary the duty cycle to maximize the power consumed by the load. Record the duty cycle, the efficiency, and the output power as the results for MPP-high.

MPP-low

Keeping the same circuit configuration, reduce the illumination. Again vary the duty cycle to maximize the power consumed by the load. Record the duty cycle, the efficiency, and the output power as the results

Data for basic circuit

Duty cycle	0.25	0.4	0.5	0.6
V_{in}				
I_{in}				
P_{in}				
V_{out}				
I_{out}				
P_{out}				
Efficiency				
V_{out}/V_{in} (Observed)				
V_{out}/V_{in} (Predicted)				
Z_{out}				
Z_{in}				

Data for solar powered circuit

configuration	No Converter	MPP-high	MPP-low
P_{out}			
Efficiency			
Duty Cycle			