Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✔ VFD Filament Driver
- ✔ Current Sense for a Data Logger
- ✔ Gel Cell Charging Voltage

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to:** **Q&A@nutsvolts.com**

CONVERT RELAY LOGIC

Q I am relatively fluent in relay circuit configurations, but feel incompetent when it comes to IC design and PCB fabrication.

My goal is to replace two three-relay gate circuits with two IC counterparts. Each set of three relays has its N/O contacts connected in series to detect simultaneous occurrence of three independent phenomena.

The relays operate from separate negative-going 12V signal inputs.

My exploration thus far suggests that two of the three three-input NOR gates on a CD4025BEE4 IC will provide the starting point for the replacement circuit.

One drawback of the simple IC gate is that it will respond to momentary coincidence of all three inputs. In contrast, the inherent inertia of the relays means that all three inputs must be present for upwards of 10 milliseconds before all three relay's contacts close.

This need to ensure that all three inputs have been present for 10 milliseconds or more adds a layer of complexity to the simple IC configuration.

An R/C de-bounce circuit ahead of each input to the NOR gate seems like a good starting point. Would an R/C de-bounce circuit with a trimpot for each input be practical?

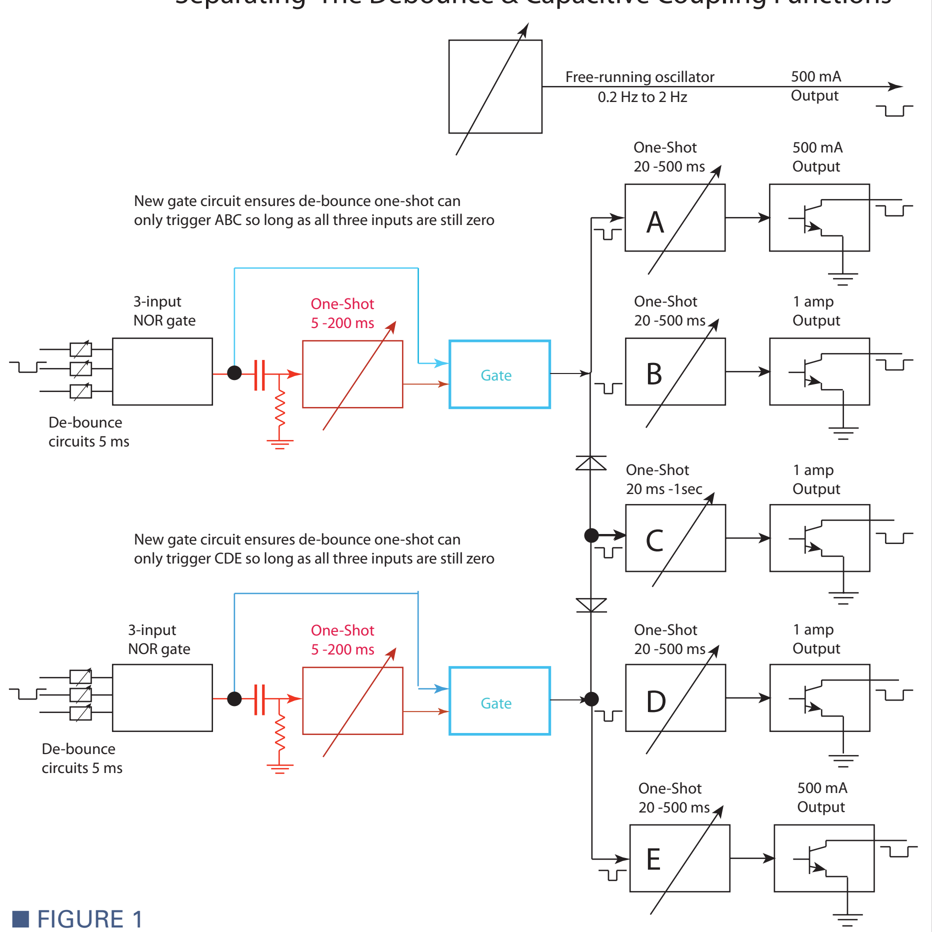
I need each of the two three-input gate circuits to feed its own buffer, capable of delivering 1A for additional circuit activation.

Besides driving separate 1A buffers, the two gates will also drive a common ONE SHOT that delivers an output whose duration is trimpot-adjustable between 150 milliseconds and one second. (Isolation diodes will separate the two gates.)

The ONE SHOT, in turn, drives a 1A rated buffer whose output is a negative 150 ms - 1 sec 12V pulse.

That's the story in a nutshell. I hope this provides enough information to ask further questions. I'd like to up the ante and add two more identical ONE SHOTs to the PCB. Is this okay?

Another tweak. The "central" ONE SHOT drives a 24V stepper and



■ FIGURE 1

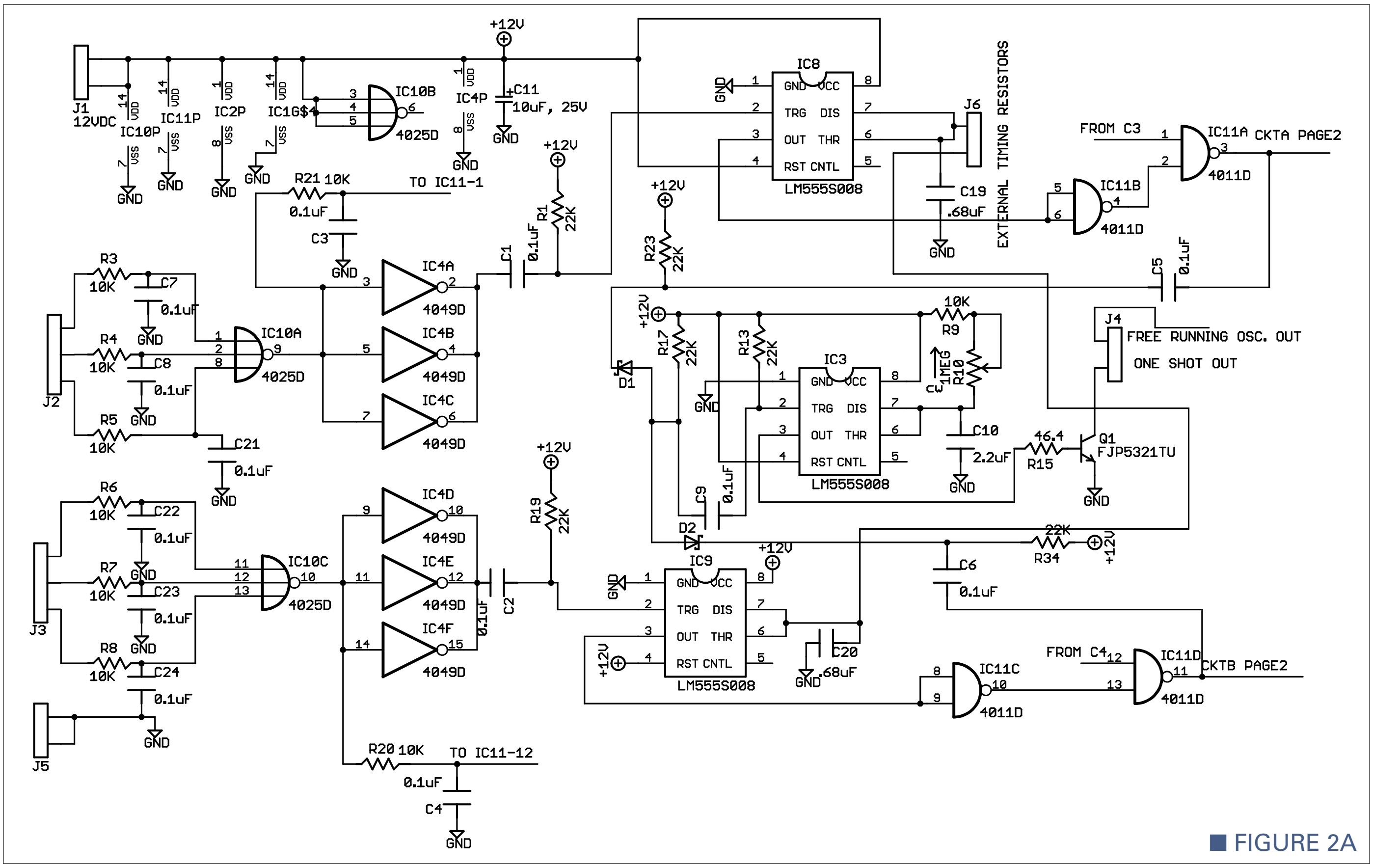


FIGURE 2A

requires a high voltage 1A output transistor.

In the revised diagram, the center ONE SHOT is triggered by the firing of either gate. In addition, two ONE SHOTs are now triggered when either of the gates is fired. The center ONE SHOT has a maximum cycle time of one second; the other four have half-second timing.

Instead of using a single resistor-capacitor circuit to provide both de-bounce and capacitive coupling, I'd like to up the ante again and separate these two functions. Can you please make these additions?

1. Add the two ONE SHOTs to the circuit.
2. Add a variable frequency oscillator 0.2 Hz to 2 Hz with potentiometer control.

Figure 1 conveys the general two-step idea. Add two new ONE SHOTs to provide the de-bounce delay, and capacitive-couple the three-input gate outputs to the two new ONE SHOTs.

I plan to use two (ganged) 10-position selector switches to select various de-bounce timing resistor values. Can you please include terminals for selector switch connections?

— Stanley Froud

A Now that we have a final block diagram (**Figure 1**), take a look at the schematic before committing to hardware. The input NOR gate acts as an inverted AND. The output is inverted to trigger the ONE SHOT. The rest of the circuit (see **Figure 2**) is all ONE SHOTs, so not much of a challenge. I used some 556 dual ONE SHOTs for a slight savings in space and cost, but in a production environment I might choose all 555s to maximize purchasing power and minimize stocking. The use of surface-mount parts is the biggest savings because the cost of the printed circuit board is based on the area and number of holes.

VFD FILAMENT DRIVER

Q I enjoy the look of Vacuum Fluorescent Displays, and use them wherever I can. My challenge is driving the filament properly. It is traditionally driven with an AC source, taken from a special winding on the power supply transformer. The filament is also the cathode of the display. The transformer winding usually has a center tap which is used as the display cathode connection to which the grid and anode are biased.

This is done to ensure even lighting of the VFD, especially in tubes with multiple segments. In this age of power bricks, etc., a transformer is often not used (as well as unavailable), and the filament is driven by a square wave with a 50% duty cycle in the pos and negative direction (essentially, a square AC). National Semiconductor made a chip to do just that — the LM9022. It is now obsolete, and has all but disappeared

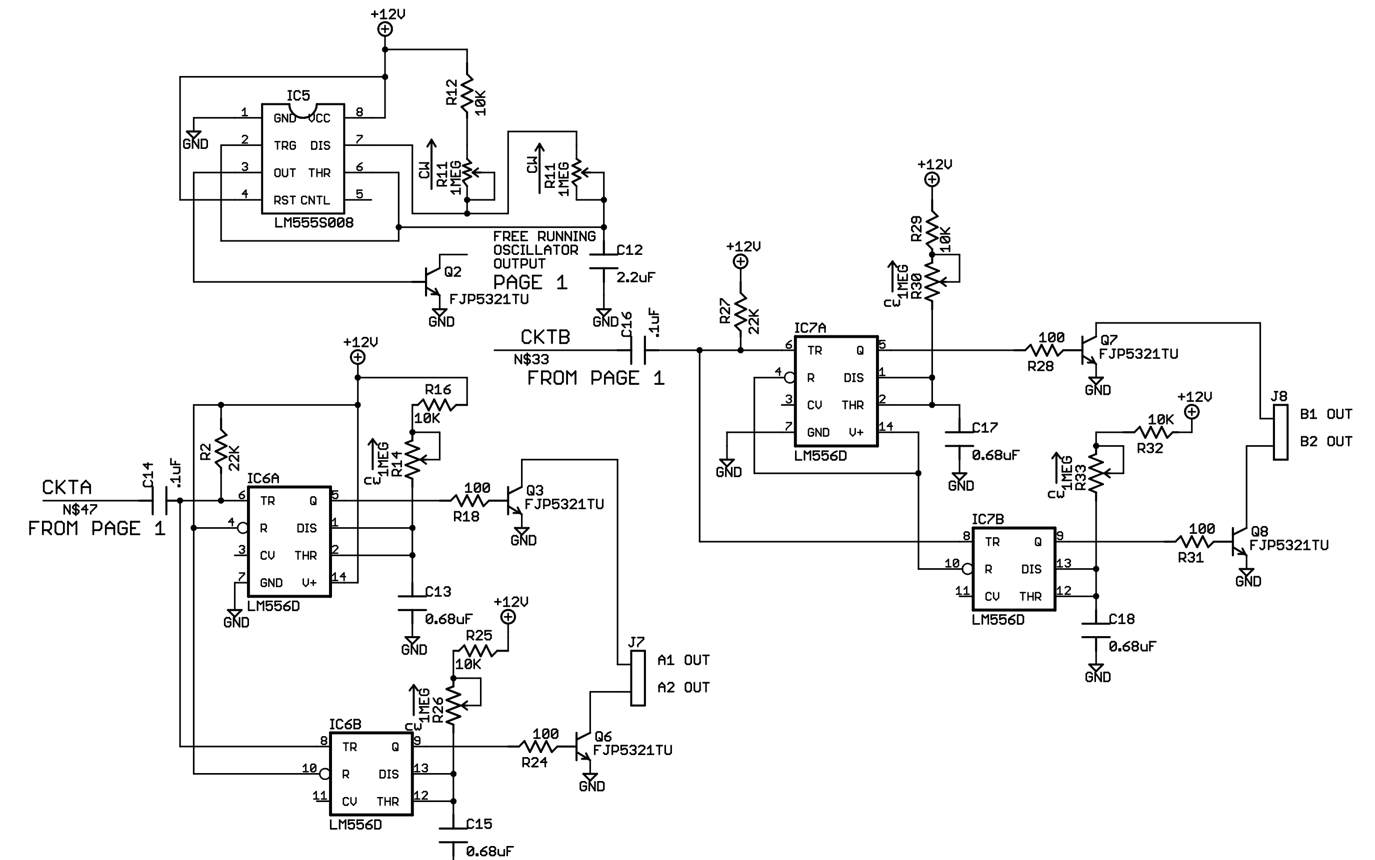


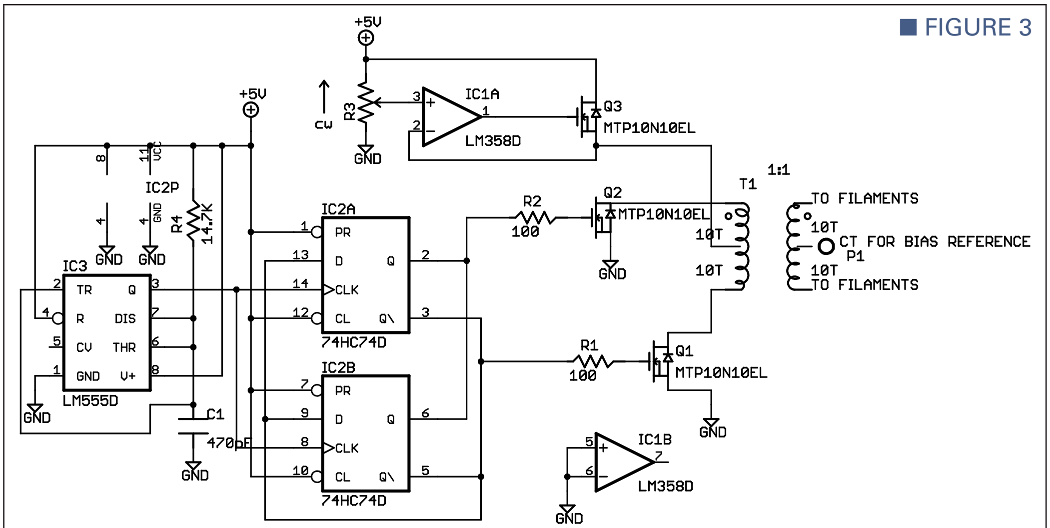
FIGURE 2B

from the market.

My question is this: Could you propose a small schematic to substitute for this chip? The output voltage is usually in the range of one to four volts (to be adjustable for different tubes), and current draw is around 40 to 50 mA per tube. It would be great if the circuit could drive at least six tubes (parallel filaments) for a current around 300 mA as a minimum. The input voltage could be either a fixed 5V or something between 12 and 50V, since both are usually available in the VFD design. Also, Noritake proposes to use a filament frequency for this type of drive of 10 kHz or more to prevent any flickering effect.

— Bill van Dijk

A I started out considering a variable pulse width circuit which would allow operation from either +5 or +12 volts, but then thought about the problem of determining the RMS value such that the filament is not overheated. The RMS of a square wave is just the amplitude, so that would make it easy to get the right value. Noritake advocates an AC center tap configuration, so that is what I will do.



In **Figure 3**, the 555 oscillator runs at 100 kHz and is divided by two in IC2. I paralleled the outputs of IC2 in order to increase the drive to the MOSFETs. IC1 and Q3 are a DC supply for the transformer. If you want 3V RMS output, just set the emitter of Q3 to 3V.

The transformer is 1:1, center-tapped. Since the output is to be 300 mA max, the magnetizing current at the input should be no more than 30 mA. I will try 10 mA which means the inductive reactance will be 5V/.01 = 500 ohms. Since the frequency is 50 kHz, the inductance has to be L = Xl/2/PI/F = 1.59 mH.

Calculating the turns from N = (L*1e6/Al)^.5, then N = .74. That's not reasonable. I can use more turns. Twenty turns will fit in one layer on the bobbin, so use 10 turns to the center-tap, then L = 230 mH. Now, check to see if the core is big enough: WaAc for the core is given as .162. WaAc is the product of the core cross-section and the window area. The equation is:

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WaAc = k*Po*10^8/B/F
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where

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k = .00528 for an E
    core
Po = 5V*0.3A = 1.5 watt
B = 1000 gauss
F = 50KHz
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Then:

WaAc = .0016 and the core is much larger than needed.

The wire size can be calculated from: AWG = -4.31*ln(1.889*I/Cd), where Cd is the current density in amperes per square centimeter. The Micrometals manual recommends 400 A/sq cm.

That yields an AWG of #28; anything bigger is okay.

CURRENT SENSE FOR A DATA LOGGER

Q I have a DATAQ EL-USB-5 data logger. I want to use it to track when 110V appliances turn on and off; for instance, a refrigerator's compressor. I wish to use a leg of an extension cord to sense current flow.

The data logger can be set to be triggered by a contact closure or to a pre-set voltage (three volts min). Can you design a circuit that can provide a satisfactory voltage trigger (using a 9V battery) from a current sensor (toroid)? The sensor would have to be adjustable such that the current draw from the control circuit of the appliance will not interfere with the sensing of the compressor's current draw.

— Charlie Young

A I measured the current draw of my small freezer to be four amps; if you use a 1,000:1 transformer, the output current will be 4 mA; 4 mA * 1K = 4V which is enough to trigger the data logger. Current transformers don't work well when the load is greater than 100 ohms, so I am using the input impedance of an op-amp (essentially zero ohms); see **Figure 4**. I am rectifying the output because I suspect that the data logger prefers DC input. The gain pot can be 2K or 10K, depending on the current range you expect to encounter.

Mouser part number 553-CST-1020 is rated at 20 amps and costs $6.11.

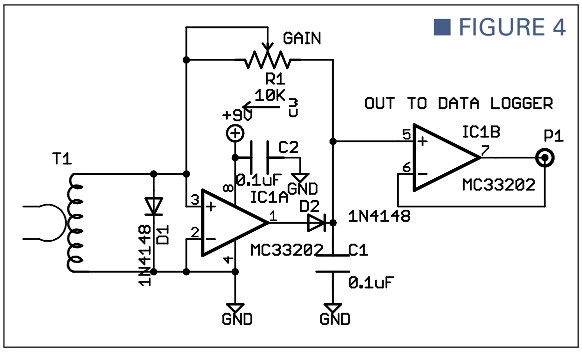

FIGURE 4

GEL CELL CHARGING VOLTAGE

Q I have a 12V flashlight with a 12V 7AH gel battery. I need to replace the internal charging circuit. I will be using an external 12V DC supply.

What would be the recommended charging voltage for this type of battery?

— Ken Bartone

A A lead-acid type battery is fully charged at 13.8 VDC. A 10 hour charge is recommended so the charging current should be 0.7 amps. You should measure the output voltage of your power supply because it may be high enough to charge the battery without any additional circuitry. My RadioShack power supply output is 14V no load which is adequate; I would put two or three ohms in series to limit the current. If the power supply voltage is greater than 15V, you will not be able to leave the battery connected for more than 10 hours or it will overcharge (the GEL cell has some overcharge protection, but don't depend on it). Another solution would be to plug it into the cigarette lighter socket in the car. The voltage is 13.8 VDC when the motor is running.

A boost circuit is needed to get 13.8V from a 12V source; I used National Semiconductor's WebBench (**www.national.com/en/webench/**

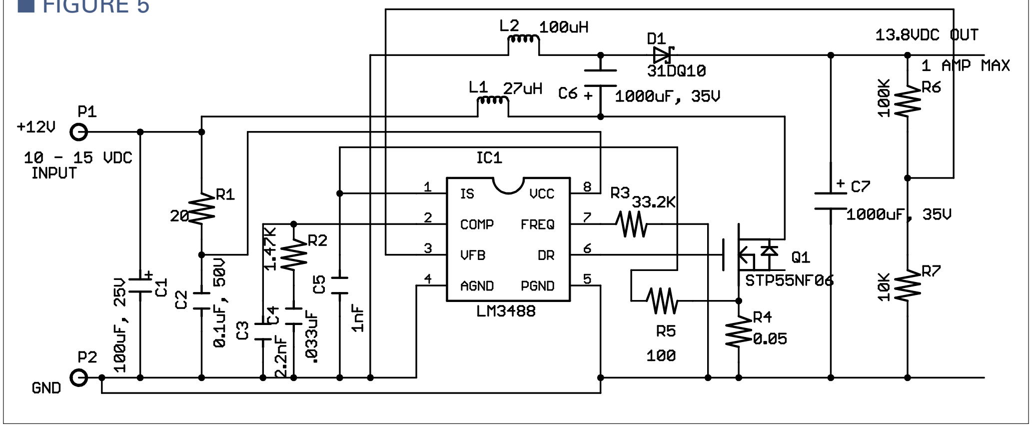

FIGURE 5

■ FIGURE 6

SEPIC PARTS LIST

PART	DESCRIPTION	PKG	PART #	PRICE
C1	100 µF, 25V, ALUM	6.3MM	647-UPW1E101MED	0.28
C2	0.1 µF, 50V, CERAMIC	5X3.5MM	81-RPER71H104K2P1A03	0.18
C3	2.2 nF, 50V, CERAMIC	5X3.5MM	81-RPER71222K2P1A03B	0.24
C4	.033 µF, 50V, CERAMIC	5X3.5MM	81-RPER71333K2P1A03B	0.23
C5	1 nF, 50V, CERAMIC	5X3.5MM	81-RPER71102K2P1A03B	0.24
C6, C7	1000 µF, 35V, ALUM	12.5x5MM	871-B41044A7108M000	0.54
L1	27 µH, 6.4A TOROID	.86DIA	542-2100HT-270H-RC	2.61
L2	100 µH, 4.6A TOROID	.86DIA	542-2100HT-101H-RC	2.61
D1	3A, 100V SHOTTKEY	AXIAL	844-31DQ10	1.06
R4	0.05 OHM, 5%, 1W	TO-220	652-PWR221T-30-R050J	2.60
ALL OTHER RESISTORS 1/8W, 1%				
IC1	LM3488 CUR. MODE	MSOP-8	LM3488QMMTR-ND	3.66

power.html) to design the circuit of **Figure 5**. National's design used all surface-mount parts but I have listed through hole parts in the parts list (except for the LM3488 which is only available as surface-mount). The part numbers in the parts list (**Figure 6**) are Mouser except the LM3488 is from Digi-Key. The LM3488 is also available at Newark.

This is a SEPIC design which means that the output can be higher or lower than the input. The operating frequency is around 500 kHz, so a good layout is necessary. The LM3488 is a current mode device because the inductor current is sensed by R4 and fed to pin 1 which will shuts off Q1 when the sensed voltage is 0.156. When Q1 shuts off, the energy stored in L1 is transferred to the output through C6 and D1. L2 provides a DC path to ground. Otherwise, C6 would keep charging to higher voltage.

Voltage regulation is obtained by feeding part of the output voltage back to pin 3 which has a threshold of 1.26V. National estimates the efficiency to be 88% but they sacrificed some efficiency for size so this design should be better. **NV**