Chapter 9

Power Supplies

Switching Regulator for Light Duty Applications

John Hazell, G8ACE

There was a recent need to provide a regulated 12v dc supply from a 12v battery. Using a standard 78L regulator there would be insufficient supply voltage available for regulation. The solution adopted was to use a TL497 switching regulator to provide a higher supply voltage. Whilst this regulator can provide a regulated output directly, in the particular application the output was set to 15v to feed a 78L regulator. This is a 14 pin IC and includes an on board rectifier diode. The total component count for the voltage booster is therefore quite small.

The TL497 IC (available cheaply from Farnell) can be used as a step up, step down or inverting supply circuit.

Editor's comments ....

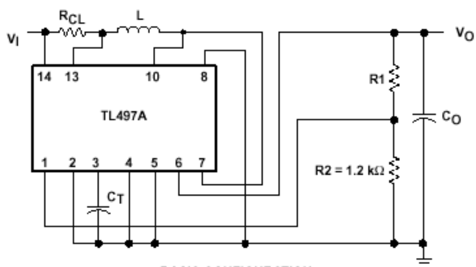
This design can be used for microwave changeover relay supplies as it can easily supply the 24V or so required by the ubiquitous Transco and Dynatech types.

The following component values on a prototype produced an output of 24.2V, for a minimum of input 8.5V, thus giving an enormous amount of headroom for a flagging 12V battery!

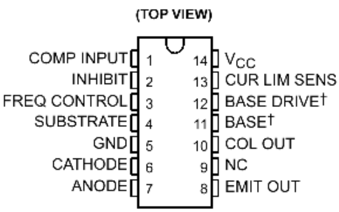
R1: 1K2, R2: 23K (made up of 10K and 13K in series) CT: 4n7, CO: 0.33uF. 470uF electrolytics were fixed across input and output supplies.

According to the data sheet, the device is good for 500mA maximum but the higher the voltage out the lower the available current. However the 24V supply should be good for several hundred mA, more than enough for a relay supply.

The TL497A is a versatile chip and can be used in a step up, step down or inverting supply circuit. Remember that it is switching at 50kHz or so and thus will require careful filtering.



BASIC CONFIGURATION
(Peak Switching Current = $I_{(PK)}$ < 500 mA)

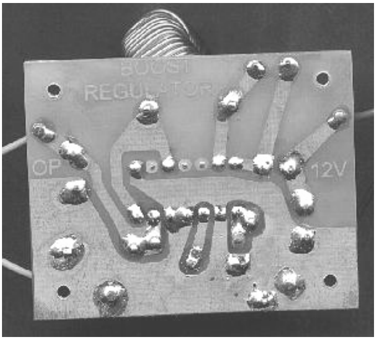


DESIGN EQUATIONS

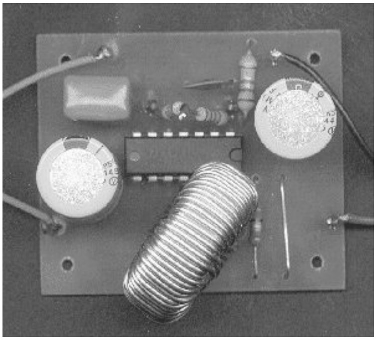
- $I_{(PK)} = 2\, I_O \max \left[\frac{V_O}{V_I}\right]$
- $L\ (\mu H) = \frac{V_I}{I_{(PK)}} t_{on}\ (\mu s)$

Choose L (50 to 500 μH), calculate t_{on} (25 to 150 μs)

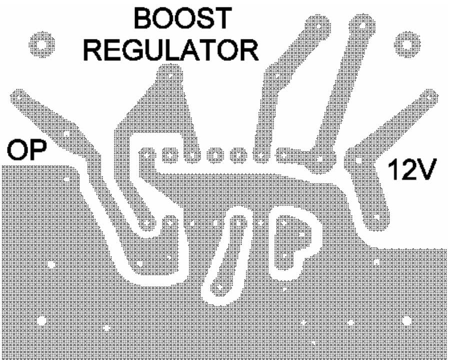
- $C_T(pF) \approx 12\ t_{on}\ (\mu s)$
- $R1 = (V_O - 1.2)\ k\Omega$
- $R_{CL} = \frac{0.5\ V}{I_{(PK)}}$
- $C_O\ (\mu F) \approx t_{on}(\mu s) \frac{\left[\frac{V_I}{V_O} I_{(PK)} + I_O\right]}{V_{ripple}\ (PK)}$



Above and below: the printed circuit board used in the proto-



The TL497A switching regulator is a cheap alternative to the LM2577T described in the Microwave Newsletter some time ago, especially when no more than a few hundred milliamps of output current are required. For supplies in excess of 0.5A, the LM2577T is to be recommended.



13.8V from your Car Battery
Modifying the Vanson SDR-120W

Chris, G3WIE

When I started on microwaves a year ago, I had to rediscover /P operating. Given that I was only running QRP (1 watt) from a borrowed 144MHz - 10GHz transverter, a morning's operation from the cigar lighter socket in my car seemed quite possible but I soon discovered that the transverter required a stable 13.6 volts, not a gradually reducing 12.6 volts and I've seen others describing the same problem in Scatterpoint through 2005.

Looking around the local Maplin shop, I found a 120 watt DC-DC converter which supplied a range of laptop computer voltages: 15-16-18-19-20-22-24 volts selling for £30 (stock number: L40BB). Gambling that I'd be able to modify
this to reduce the lowest voltage to 13.8 volts, I bought one. It turns out that you have to change just a single resistor. This article describes how I did the modification.

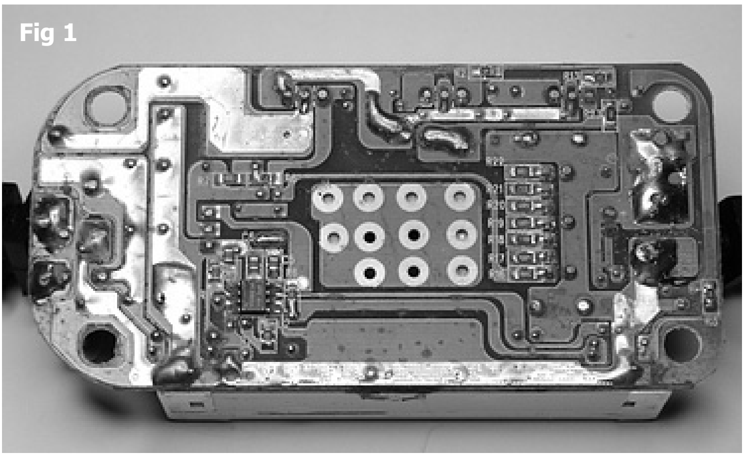
You will need:

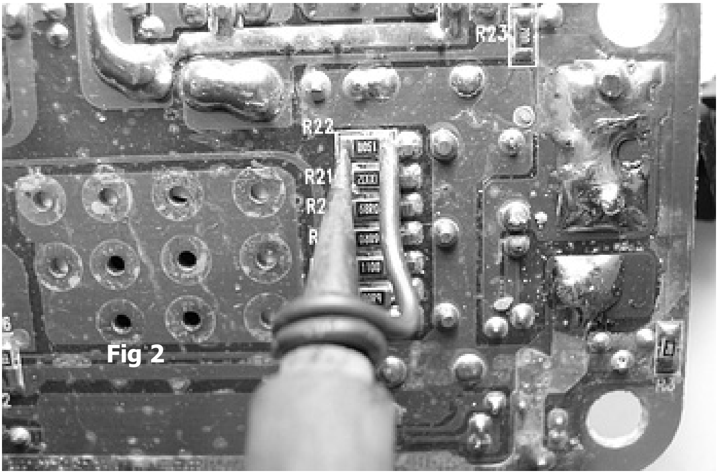
- a 5mm flat-blade screwdriver which you are prepared to modify (to remove the tamper-proof screws holding the case together)
- a set of needle files to do the screwdriver modification
- four 12 mm x 3mm self-tapping screws to replace the above!
- a temporarily-modified soldering iron to remove an SMD resistor
- a replacement SMD resistor or small wire-ended one

Dismantling the unit:

The case is held together by four tamper-proof self-tapping screws. To remove these, modify a 5mm flat-blade screwdriver by filing a rectangular notch 1.5 mm wide and 1.5 mm deep in the centre of the blade. Now you

Fig 1





can remove the screws without wrecking your small pliers!
Set the voltage selector switch to the 15 volt position, remove the silver-coloured top of the case, then lift the PSU assembly out of the other half of the case. The brass screen fitted underneath the circuit board may jam on the plastic pillars, but if you bends the screen to get access it can be straightened afterwards Slide the screen and its insulation out from under the three clips on the heatsink. The clips may jump off – replace them again as they hold semiconductors on to the heatsink.

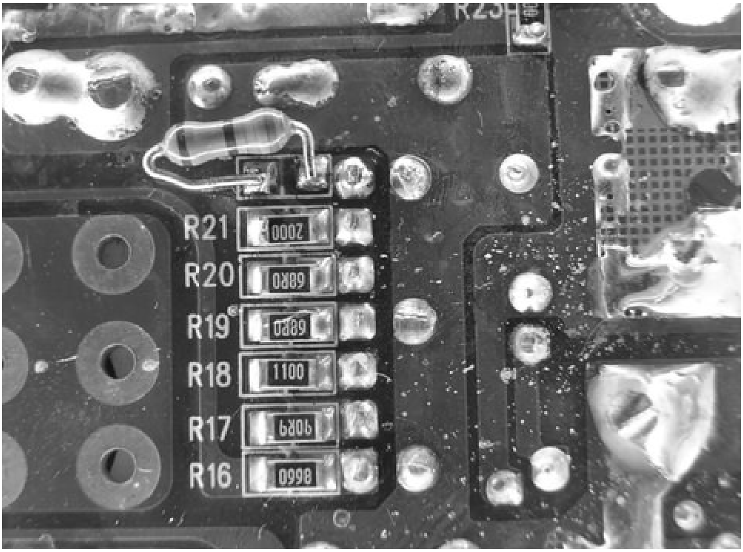
Fig 1 (previous page) shows a picture of the unit with the shield removed.

Modifying the unit:
On the underside of the unit, towards the end nearest the input cable, you will see a row of surface mount resistors labelled R16 to R22, connected in series. The voltage selector switch connects the junctions of these resistors to ground – increasing the total resistance from the top of R16 to ground produces a lower output voltage, so increasing the value of R22 will reduce the voltage at the 15V setting without affecting the higher voltage outputs.
First, note the value of R22 (130 ohms in my unit), then remove the resistor. I don't have two small soldering irons, so I modified my one and only iron by wrapping two turns of 16swg tinned copper wire round the bit and bending it so I have a double-tipped iron. File a point on the wire and you're ready to go.

Fig 2 shows the idea - it's a posed photograph but this technique does work. Usually the resistor will stick to the tips of the iron but be ready with a pair of pointed tweezers in case it doesn't.

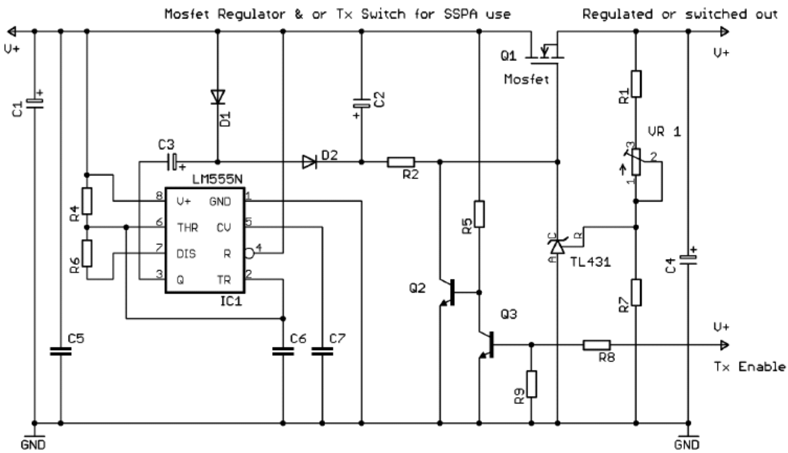
Now fit a replacement resistor. **Fig 3,** on the next page, shows how I fitted mine.
Plug the converter into your car and check the output. In my case 390 ohms at R22 produced an output voltage of 13.8volts off load, but I fitted a 330 ohm to provide a bit extra to compensate for the voltage drop along cables.
Finally, reassemble the unit, ensuring that the clips that held the screen are holding the semiconductors against the heat sink.

In use:
I use the converter to power my entire station which draws about 3 to 4 amps on transmit and 1 amp on receive. The converter runs cold even on a hot day. I have managed to short circuit the output at least twice. Each time, the 16 amp fuse I had fitted in the battery supply blew but the converter survived!



A MOSFET Regulator and/or Switch

John Hazell, G8ACE



Circuits for MOSFET regulators seem rather sparse and so this circuit was built up referring to a just a few circuit suggestions found during a web trawl. The need for the regulator arose as a low voltage drop, high current regulator was required to drive an HP 9cm 15w SSPA unit. Tests showed the SSPA gave full power from a supply of 11.7v upwards. However the upper safe voltage operating voltage was unknown so it seemed a good idea to utilise a low drop regulator to provide +12v even when running from a +13.6v supply or fully charged batteries to ensure a long PA life. The circuit below also serves for the high current part of the Tx sequencer.

An N type MOSFET is employed. These are fairly inexpensive and the criteria for selection is: Cost, Current handling, On resistance, preferably less than 0.01ohm, plus adequate voltage rating. The STP70NF3LL from Farnell was used but typically for MOSFETs its already no longer available. Device availability lasts just for a short span of time so refer to its data as a guide for other suitable selections. A low on resistance device will drop only tens of millivolts at several amps in the switch arrangement. Of course the package needs to be at least TO220 to handle the dissipation especially when used as a 9.6v regulator for a module such as the Ionica SSPA. The down side of the N MOSFET regulator is it needs a gate supply higher than the incoming supply, a minimum of 16v is a good target for an incoming nominal 12v battery voltage.

The 555 IC is used with a voltage doubler for the gate supply. Download the 555 data and refer to the 50:50 square wave oscillator. Note R6 should be less than one half the value of R4 to achieve the square wave for efficient rectification. Values used were R4 47K, R6 18K and C6 C7, 0.01nF. These values produce a low frequency so that there will be minimal interference produced onto the dc supply. C2,C3 need to be adequately sized according to the frequency used. The gate supply can also be derived from your +24v antenna relay supply of course.

The regulated output from the MOSFET is achieved by using the inexpensive TL431 shunt regulator. Again download the pdf for reference. The device current should be not less than 1mA so R2 must be selected accordingly depending how the gate supply is derived. 3K3 was used from a 26v relay supply. The reference voltage for the TL431 is 2.5v between reference input and anode (ground). R7 is non critical so using say 1K then the value of VR1 say 500W the value needed for R1 can be calculated according to the output voltage needed. Two transistors are added such that the regulator can be keyed on for Tx with a +ve supply connected to R8. By sourcing the +ve voltage to R8 and Q3 from a sequencer the regulator eliminates the need for a separate MOSFET switch in the PA supply. R9 can be around 100K. If the regulating aspects are not required then the TL431 can be omitted so the MOSFET device simply acts as a low voltage drop switch. Powering an SSPA using the MOSFET in the switch arrangement the supply voltage drop was typically 60mV

Extensions to the MOSFET Regulator

John Hazell, G8ACE

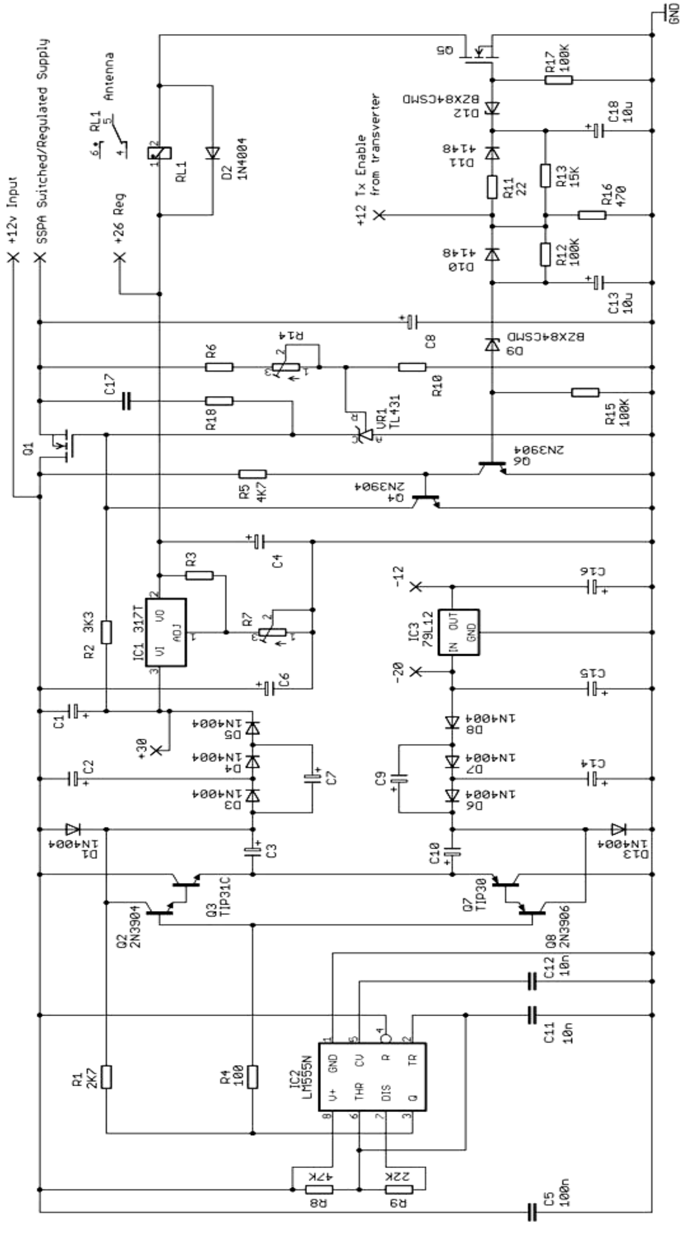
The **MOSFET Regulator and/or Switch** (previous article), for use with an SSPA, can be extended to include the other supplies needed by a home brew microwave transmitter using, for example, an Ionica 9cm Tx module. This is 'low tech' circuitry for which most parts can be found in the average 'cum handy' box.

Additional functions added here to the original circuit are:
Relay supply, -12V Bias supply and Sequencer. These circuits have, of course, been published before in some form or other, but perhaps not with these variations. The relay supplies formerly published in newsletter pages either use a switching IC regulator or voltage doubler. It's difficult to achieve more than 20 volts under load from a diode voltage doubler using a 12V battery supply. Consideration of the transistor and diode voltage drops will confirm this. It was thought rather risky to rely on such a low voltage to reliably operate a 24-28V antenna relay carrying watts of RF power.

The IC switching regulator style relay source whilst being efficient does produce problems with the 50kHz signal creeping into unwanted areas of the rig unless very good supply filtering is used hence not being used here. In the previous MOSFET Regulator/switch circuit, the 555 IC is used to supply the higher than incoming rail voltage needed for the gate of the MOSFET. This 555 is now additionally employed for the relay and bias supplies, as commonly seen before, but this time with two changes. The 24-28V is generated by a tripler rather than doubler. Complimentary transistors drive the multiplier diodes driven by bootstrapped emitter followers Q2, Q8. Referring to the circuit note the collectors of these emitter followers are connected to the first stage of the dual polarity voltage multipliers. The increased voltage on the followers enables the drive into the complimentary pair to be maintained as the bases are driven down to 0v and up to near the 12V rail. This increases the efficiency by a few percent as does the resistor R1 back to pin 3 on the 555. The value used for R1 must not be to low otherwise some unwanted oscillation takes place. Common 1N400* series diodes are used in the multiplier along with low ESR electrolytics all 25V except for the post regulator C4 which should be 40V. The multiplier supply is hung from the incoming supply rail hence the requirement for only 25V capacitors. C6 must not be omitted in this arrangement. Around +31V is achieved from the multiplier which is connected via a 317 to the relay and sequencer.

A standard N MOSFET is used for the antenna relay switching. Several ohms on resistance can be tolerated for this device as it is switching at most a few hundred mA. Poor voltage stability of the voltage multiplier output under load would indicate capacitors with an undesirably high ESR. The negative multiplier supply achieves -20V which is regulated by a 7912 regulator for the –12V bias supply. Sequencing is achieved by employing the same circuit technique as the DB6NT MOSFET sequencer. When +12V is applied to the Tx enable point C18 charges rapidly through D11 and R11 such that the antenna MOSFET switch operates almost instantly. The PA supply MOSFET switching on is delayed however by the time C13

takes to charge through R12, D10 being none conducting. When the +12V Tx enable is
removed the PA MOSFET switches off first as C13 discharges rapidly through D10 and R16 however the antenna relay is held on until C18 has discharged slowly through R13 and R16, D11 now being none conducting. Circuit values are shown where the values are standard. Unmarked circuit component values can be calculated according to requirements. Sections of the circuitry can be omitted when not required. As before the main MOSFET regulator can be used as a PA supply switch where the PA requires the same voltage as the incoming dc supply or as a switched regulator where a lower voltage is required. Output voltage
is set with R14. The resistor capacitor C17, R18 have not been used to date. An adequate heat sink is required for the regulator MOSFET when a PA voltage such as 9.6V is required from the incoming 12V. Always refer to the pdf data files readily available on the web for the various semiconductor devices used.


+12v Input
SSPA Switched/Regulated Supply
+26 Reg
RL1
Antenna
D2
1N4004
Q5
R17
100K
D12
BZX84CSMD
C18
10u
D11
4148
R11
22
R13
15K
+12 Tx Enable
from transverter
R16
470
D10
4148
R12
100K
C13
10u
C8
D9
BZX84CSMD
R6
R14
R10
C17
R18
VR1
TL431
R15
100K
Q1
Q6
2N3904
R5
4K7
Q4
2N3904
R3
C4
IC1 317T
R7
R2 3K3
-12
C16
IC3
79L12
-20
C15
C6
C1
+30
D5
1N4004
D4
1N4004
D3
1N4004
C2
C7
D8
1N4004
D7
1N4004
D6
1N4004
C9
C14
D1
1N4004
C3
C10
D13
1N4004
Q3
TIP31C
Q2
2N3904
Q7
TIP30
Q8
2N3906
C12
10n
C11
10n
IC2
LM555N
R1
2K7
R4
100
R8
47K
R9
22K
C5
100n
GND