P5

The Newsletter of the Severnside Television Group

December 1994

A very Merry Christmas and Prosperous New Year to all members

Looking back through past issues of P5 I found an article proposing a 10GHz repeater for the Bristol area. That was back in the September 1991 issue, over three years ago!

Since then a huge amount of technical and administrative effort has brought the proposal to fruition. On Saturday, December 10th at 11:00 **GB3XG** was switched on as an ATV repeater for the first time.

We are indebted to all those who helped to make it a success, especially Ivor G1IXF, John G3RFL and Nigel G7JZP who have spent many hours in wellies, treading the mud (and other things!) at 'XG's site.

Ted G3JMY had the honour of being the first person to broadcast through the new repeater, Phil G1HIA also managed a respectable signal, congratulations to both of you.

Ian G6TVJ gave us our most distant report, he was near Little Malvern and received 'XG on a portable dish. that's a distance of about 50 miles so it looks like the repeater covers quite a respectable range.

Several people have commented on the similarities between XG's switch on and the early days of GB3ZZ. Lets hope the new repeater is as successful and stimulates 10GHz activity in the same way 'ZZ did on 24cms.

Apologies are due for the last P5 being mailed late. Due to circumstances beyond our control it was impossible to distribute it until some of the advertised events had already taken place. You should receive this issue in time to read about the groups next major event, the **Christmas Party** on **Saturday, December 17th.** We should be holding the usual auction to raise money for the groups activities so bring along any junk, books etc., you want to get rid of.

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1995 is almost upon us and we hope to get it off to a good start with the STG annual **fancy dress party.** This year it will be held in the evening on new years day, through GB3ZZ. If you can participate all the better but in any case please join us to celebrate the start of a new year. The following day is a public holiday so you have time to recover before going back to work!

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Other News:

Ian G6TVJ has been busy improving the reception and transmission quality on GB3ZZ. He has installed a "variable active video equaliser" in line with the receiver output, this balances the levels between low and high video frequencies to overcome some of the deficiencies in the receiver and video circuits.

Matthew Bell G0ECM has been co-opted to the committee to assist with antenna sales.

A HIGH QUALITY 240V INVERTER FOR AMATEUR TELEVISION

Amateur radio often involves portable or remote operation where 240V power supplies are not available. Paul Bennett G7RHT explores some of the usual circuit topologies for 12V to Mains inversion and gives full details of his own full PWM Sine wave design.

HISTORY

In days before semiconductors almost all mobile equipment featured inverter or converter circuits for generating HT voltages. Vibrators were typically used up to 100W with rotary motor- generators used above this. A Vibrator is a self oscillating electromechanical device for turning DC to AC. Pairs of contacts alternately open and close and are connected in a push-pull arrangement to a transformer. Motor-generators were often totally self contained and then termed a rotary converter. These were popular in aircraft for generating the standard 115V 400Hz three phase. Semiconductors gradually appeared in the sixties initially with germanium and then silicon.

CIRCUITS

Inverter circuits are a subset of the general field of switch mode and power electronics in which there are many possible circuit topologies. At 12 or 24V however one particular configuration has tended to dominate, the centre tapped transformer, push pull converter. This in its simplest form is shown in the figure. Just adding a suitable drive circuit will realise a practical design.

Each transistor is driven alternately with the transformer primary combining the collector signals to give a true AC output in the secondary. Note that the off transistor sees twice the supply voltage. This is 24V for a 12V system which is within the breakdown rating of just about every power transistor made. Another advantage is that both transistors have a common emitter connection making drive easy for NPN devices.

As it stands the output is a square wave with potentially sharp edges. This is OK for some loads like universal motors and filament lamps but will often give interference such as audio buzzing on electronic equipment. Also the RMS and Peak values are the same so some equipment which just took the cream of the sine wave will lose out. Several modifications are possible to the basic circuit to transform the output to a more sinusoidal form:

Firstly the transistors can be driven in a linear mode, like an audio amplifier. The electronics for this could remain relatively simple and with output feedback some regulation could be obtained. After saturation and transformer losses are taken into account the efficiency will only be about 50% making the whole thing very bulky and will waste the valuable battery power.

Secondly the circuit can be made to resonate at 50Hz by putting an inductor in series with the centre tap and a capacitor across the transformer secondary. This works well for a fixed load but will deteriorate as the load varies and resonance is not ideally damped. At 50Hz the inductor becomes huge and a suitable high current, lowish value can be hard to obtain.

A final approach is to use a tapped primary with multiple transistors to give a stepped square wave approximation.

Ideally an inverter should survive any load placed across its output such as highly reactive or a short. Simple designs like the ones so far discussed optimistically use fuses for protection which are really too slow for semiconductors. Ultra fast fuses are available but these can be as expensive as the devices they are to protect! Reactive currents can be shunted back to the supply rails using anti parallel diodes with the transistors. If you are contemplating trying a square wave push pull inverter then RC networks and or zeners across the transistors are a good idea to control switching spikes. Also allow a short dead time between transistor conduction.

PWM DESIGNS

PWM or Pulse Width Modulation encodes the 50Hz sine wave on top of a high frequency square wave carrier. The power stage then amplifies the simple fully on or off square wave and a filter then selects the 50Hz. Efficiency is theoretically 100%. This principle can be implemented in various ways the most elegant being a two stage inverter. The first stage steps up the 12V DC to around 400V DC or a level slightly higher than the peak of the mains. The second stage is a full bridge driven by the PWM signal. Because all of the switching is done at high frequency typically 20-50 KHz, no large magnetic components are required. Regulation and protection are easily implemented by modifying the PWM signal. Reactive loads too are handled efficiently and without distortion. This circuit is the basis for most professional inverters with the penalty of considerable complexity.

A short cut employed by a lot of UPS manufacturers is to build the full bridge at the battery voltage and use the leakage inductance of the 50 Hz step up transformer to filter out the PWM. It seems that quite an ordinary 50Hz transformer will work without incurring high losses. This makes the power stage quite simple and so in recent years the cost of UPSs have fallen to amazing levels. Be warned though, the hopefully rare occurrence of power cuts and short life of the batteries mean the inverter section is only short term rated. Inside a commercial 600W UPS for example the transformer was very small, little bigger than a quality 100W unit. It is this short cut technique which forms the basis of my design but with components conservatively rated for continuous use.

Maplin market a design with a high frequency DC to DC Converter front end but simply a 50Hz bridge output. This produces a "modified square wave" output, presumably a square wave with higher peaks and some dead time. Various other companies market vehicle mains adapters using the same technique. Some loads of course, such as universal motors, filament lamps and some switch mode PSUs will work on DC avoiding the complexity of AC inversion. I have made a 600W high frequency DC to DC converter which works very well with a small mains drill and even a 600W kettle! (continued on next page)

Don't forget the fancy dress party!!

The annual STG "make a fool of yourself" evening will be on New Years Day at around 8pm. Participants (hooray) and onlookers (party poopers) are all welcome. Why not join us on GB3ZZ and start 1995 with a smile

A HIGH QUALITY 12 TO 240V 100W INVERTER

This design gives a near perfect sine wave output, in fact better than typical mains, up to about 100W. Above this some clipping can occur due to saturation and the current limit circuit but typically the best part of 200W should be obtained.

The design divides down into three main parts:

1 The analogue reference and PWM generator.
2 Full bridge power stage.
3 Power up/down and control supply circuits.

The control circuit starts off with a 3.2768 MHz crystal oscillator. This is divided down using ripple counter ICs to for the PWM carrier, 51.2 Hz to reset the current limit circuit each half carrier cycle and 50 Hz for the analogue reference. These frequencies are related by a simple power of two.

The 50 Hz alternately turns on two analogue switch ICs which switch between positive and negative levels, the positive is just the 5V rail buffered and the negative this rail inverted. The output of the switches is therefore a square wave of 5V Peak. This is low-pass filtered by a 6 order op amp filter to give a low distortion sine wave. This is finally buffered with variable gain for the reference.

Now we have the error amplifier. This compares a divided down representation of the output with the reference to produce an error signal to request a higher or lower output from the PWM. The RC network around this op amp determines the accuracy and transient response of the output. The IC used was one of a quad pack and had no offset adjustment so some DC was coupled into the positive input to facilitate this. This setting is quite critical as any slight DC fed through to the transformer will build up core saturation.

The PWM generator starts off by integrating the 25.6 KHz square wave to give a triangular waveform. The square wave is AC coupled so that the triangular waveform is evenly displaced about zero. Further AC coupling ensures this. The PWM demand is now compared to the triangular waveform by a high speed comparator to produce the basic PWM signal. This and its inverse are gated to a short pulse at 25.6 KHZ to avoid the PWM turning to DC if over driven. Monostables shorten each pulse slightly to avoid cross conduction in the bridge output stage. Finally a flip-flop is gated in to turn the outputs off for up to half a PWM cycle if an over current is detected.

The power stage is a full bridge using field effect transistors. These beat bipolar devices hands down due to speed, low drive and at this low voltage conduction loss. The STVD90 is a 50V 0.020 ohm DMOS device which is now obsolete, any combination with similar on resistance 0.01 to 0.05 ohm should suffice. Another advantage of the FET is its integral "body" diode which passes free wheel and reactive load currents without an additional device. The transformer and socket connections are shown on a separate sheet.

The PWM will approach 100% in both directions requiring the drives to pass near DC so opto couplers as opposed to a small transformer need to be used. Unfortunately high speed HP ones need to be used which are £5 each. All the FET drives are buffered by inverting driver ICs.

Over current protection is provided by terminating a PWM cycle if the switch current gets too high. This is measured using small current transformers and compared to a DC reference, current limit level, by a high speed comparator. This in turn triggers the current limit flip flop to hold the outputs off during the remainder of that PWM cycle. The current transformers will not pass DC so the PWM carrier must never disappear completely as prevented by the control circuit. This current limit scheme effectively takes control away from the analogue section and hence the waveform becomes distorted typically with flattened peaks.

Finally the power up down of all these circuits needs to be co-ordinated so that the power stage does not come on unbalanced and nothing erratic happens if the battery goes flat or is called upon to start an engine. A transformer coupled DC to DC converter provides floating 12V rails for the top bridge halves. Until this converter is delivering no output is possible from the main inverter so its supply is delayed by a timer circuit with hysteric thresholds off the 12V supply. The op amps need symmetrical rails to function correctly without offset or limited swing problems so a - 12V rail is derived from a charge pump circuit with regulator.

The circuit is packaged in two parts, the control circuitry on a strip board and the power stage on an essential ground plane. The ground plane is mounted on top of a large planar heat sink, mounted vertically on the rear of the box. The front panel features a low current LED to indicate the battery is connected, a Green LED to indicate the inverter is turned on and a second Red to indicate the current limit has come in and regulation is lost. A Green neon indicates the output is OK. The on/off switch only switches the low power control and can be duplicated by a remote switch so that the inverter can be near the battery keeping short the high current leads.

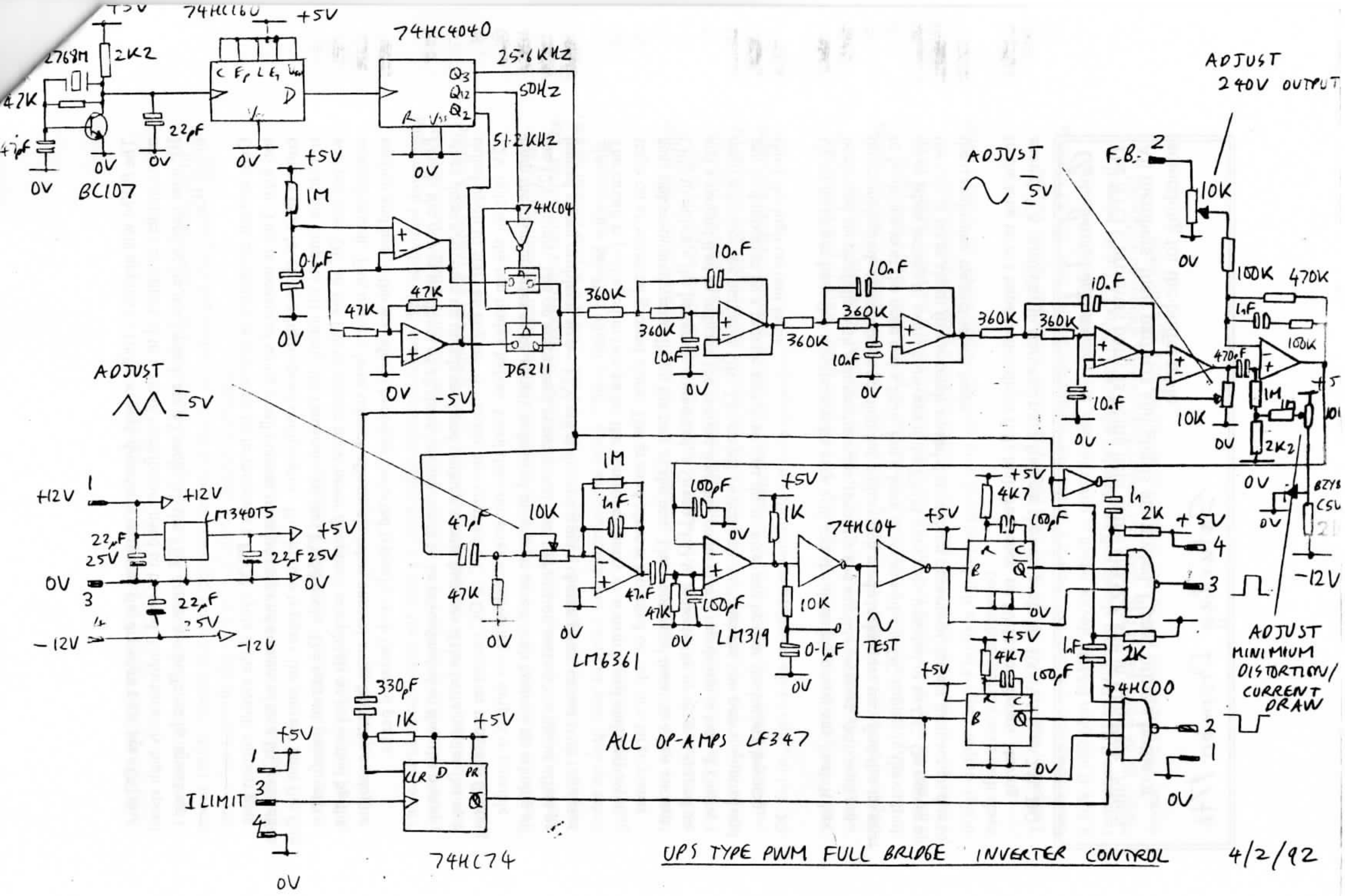
Up to its power limit this inverter works very well and should safely power any load. It has been used successfully with a domestic video recorder and satellite receiver. Although not too complicated, constructors not familiar with switch mode techniques may find this inverter to be diving in at the deep end a little. Put a lamp in series with the DC supply to the output stage when testing to avoid blow ups if the PWM goes very lopsided or to DC. On power up the circuit takes about five seconds to stabilise without occasional current limit action due to the transformer magnetisation surge.

In the long term I hope to develop a fully high frequency, no 50Hz iron design. Having enough VA capability to start and run a fridge is the aim, probably 1000VA from 24V DC.

An Invitation

The STG Christmas party is being held at the GB3ZZ site in Elm Park, Filton. All members, their partners and guests are invited. Please bring a bottle or something for the buffet table.

Saturday December 17th



UPS TYPE PWM FULL BRIDGE INVERTER CONTROL

4/2/92

UPS INVER

POWER STAG

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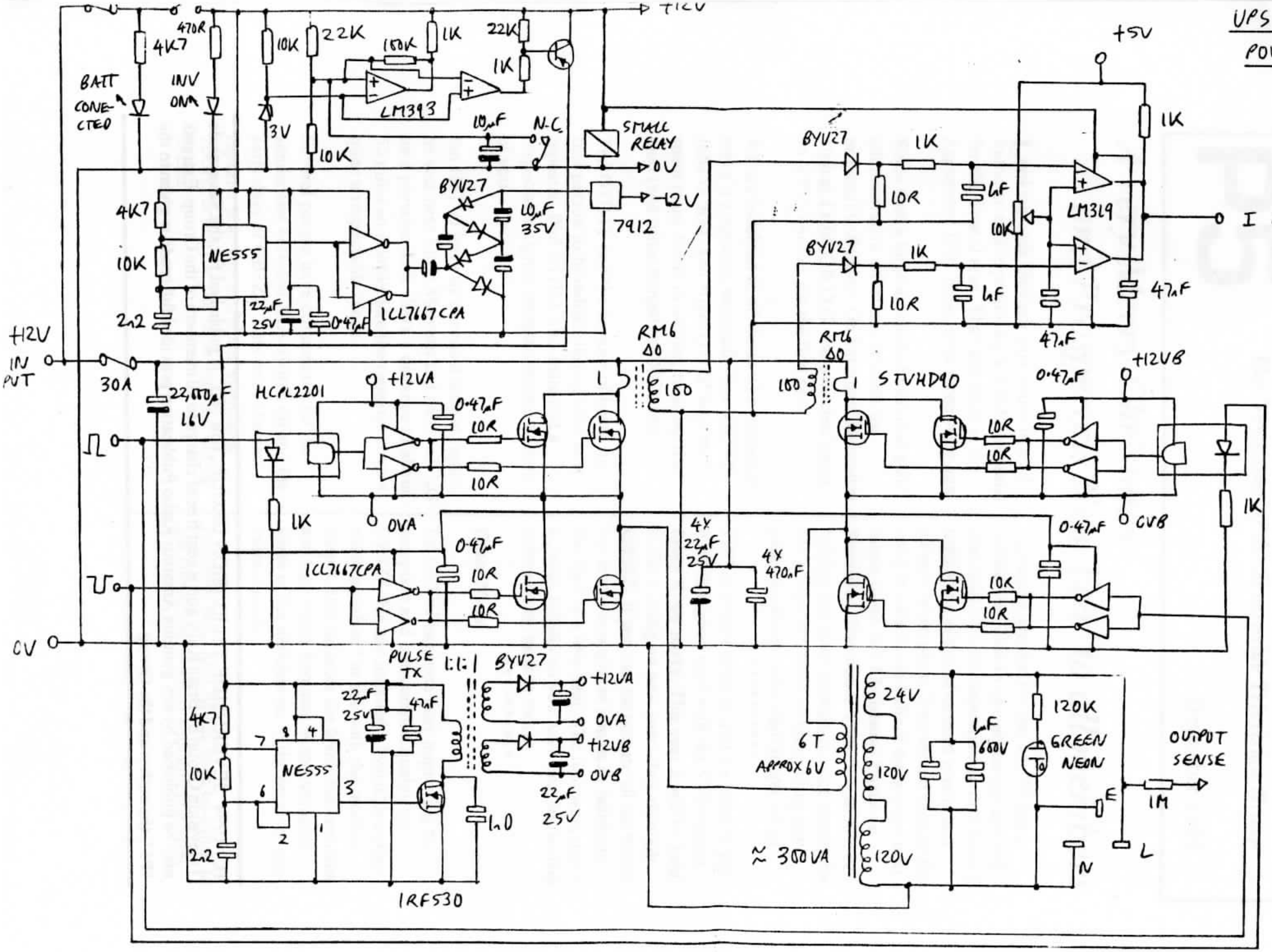

How to get the best from GB3XG

by John Hudson, G3RFL