September 2004
Volume 5, Issue 2

ANODE

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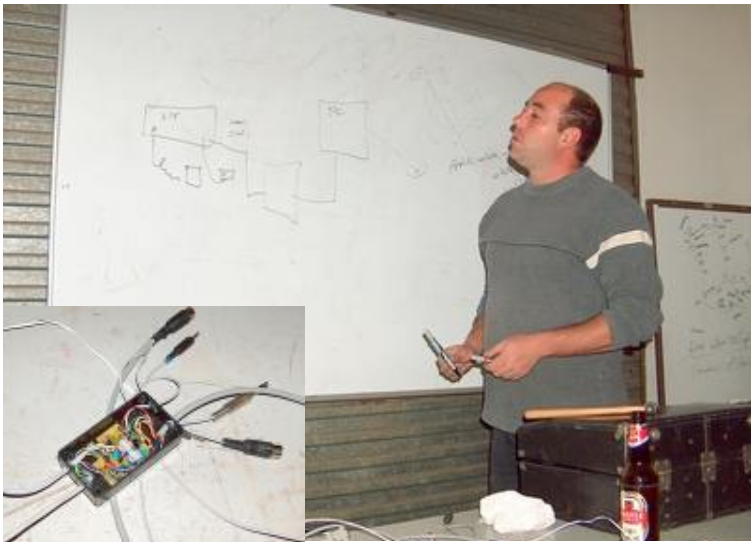
Editor's Comments

Ham Radio In Space: Iss Goes Cross-band Repeat

Speaking of repeaters. There's a new cross-band F-M system in space and its home is on the International Space Station. This, as the ARISS program announces that the amateur radio equipment aboard the orbiting outpost is now on the air in repeater mode.

(Continued on page 2)



OM Philip discussing the radio interface [insert] at the bring and fix meeting.

Understanding broad-band ferrite transformers used in solid state Power Amplifiers

(by LA7MI Stein Torp - 1994)

Special points of interest:

- Contact details on back page
-

The author is retired design engineer from A/S NERA BERGEN, a radio link manufacturer for over 50 years, and he has worked there for over 40 years. He has been a very important origin source for the ideas I have presented in several magazines over the last 35 years.

Have bought books by Helge Granberg, and

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Editors Comments & News

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The downlink frequency remains 145.80 MHz. The new uplink frequency is 437.80 MHz and all frequencies are subject to Doppler shifting.

ARISS leaders say that they realize that many hams will miss the packet station that the cross-band F-M voice repeater replaces. Burt the groups leaders say that the cross-band repeater will allow further experimentation of the ISS amateur radio system.

For further information on working satellites and adjusting for Doppler shift, please review Emily Clark's (W0EEC) excellent presentation on AMSAT's website,

http://www.amsat.org/amsat-new/information/faqs/Intro_sats.pdf (ARISS)

Ham Radio Near Space: UK Balloon Launch Licensed For Sept. 12

G3ZHI reports that a license has been granted for a United Kingdom high altitude ham radio balloon flight. The project is now authorized for operation on 2.500 GHz on Sunday, September 12th. The license has special permission to operate at up to 50,000 feet instead of the usual flight ceiling of 2,000 or 5,000 feet.

The launch is scheduled to take place at about 1.30. Plans are still afoot to relay pictures via the new 13-centimetre GB3FT repeater if the system is completed and on the air in time for the flight. More information on this experiment as it becomes available. (G3ZHI)

On The Net: Linux Continues To Grow

The use of the Linux operating system especially among experimenters including ham radio operators is quietly growing. One in five servers sold last year to handle Internet traffic and corporate networks ran on Linux.

Observers say that the economic downturn may be responsible for the Linux move. The Linux operating system was created as the people's software, free and open for everyone to use in an attempt to thwart the commercialization of all Internet technology. Amateur radio was among the first to truly embrace it and may ham radio applications are written for Linux based operation.

Restructuring: Australia To Seek New 500 KHz Ham Band

The old 500 kHz the international maritime distress frequency could become part of a new ham band down-under. This if the Wireless Institute of Australia has its way. W-I-A News anchor Graham Kemp, VK4BB, joins us from Brisbane with the details:

The WIA will shortly be writing to the ACA to request the establishment of an experimental amateur allocation at 500 kHz. That's the 600 metre band.

WIA Director Glenn Dunstan VK4DU said "500 kHz was the international maritime Morse code distress frequency for most of the 20th century."

"It was the frequency used by the RMS Titanic to send her plaintive cries for help that April night in 1912. It was the frequency used by thousands of merchant ships to signal their plight in times of peace and war."

"More often than not, 500 kHz was witness to a ship's Radio Officer's last moments. Many Radio Officers literally died at the key as their ship fell victim to enemy action or was overwhelmed by the forces of nature".

Glenn, himself an ex ship's Radio Officer, said. 500 kHz was replaced in 1999 by the Global Maritime Distress and Safety System (GMDSS), which uses a combination of automated terrestrial and satellite communications.

"Since the introduction of the GMDSS in 1999, 500 kHz use has declined rapidly. The last official users of the frequency, China, plan to discontinue operation in 2005. The frequency

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Editors Comments & News

(Continued from page 2)
is no longer used in Australia, New Zealand, the Pacific or the US."

500 kHz has been instrumental in saving tens of thousands of lives in the last 100-odd years. It is thus fitting that the frequency be preserved as a 'spectrum national park' to commemorate those who paid the supreme sacrifice in its use.

"The best way to do this is to establish a small slice of spectrum around 500 kHz - probably 495 to 510 kHz - as an amateur radio band. The band would also provide a unique opportunity for experimentation with antennas, propagation, advanced narrow band modulation techniques and receiver digital signal processing." Glenn said.

It should be noted that 500 kHz is still allocated to the maritime service so any permanent amateur access in Australia or elsewhere is some way off. It is worthy of note that the I-A-R-U Region 1 and various United States Amateur long wave groups are actively pursuing an experimental allocation at 500 kHz as well. (WIA News)

Thank You Stephen....

Q I have a big radio collection and now my wife has left me, what should I do?

Your wife has probably left you because you have not paid her any attention. You have lots of radios and you spend most of your free time with your radios. You speak to the radios, clean them, take them apart and work on them. Spend most of your weekends away from home at some far away radio rally looking for that hard to get piece that would complete the radio station that you got 5 years ago. Speak on the radio or the phone with friends and other collectors for long periods.

Probably the last straw before she left you was when you moved some radios into the bedroom, only because you didn't have any more room in the house for radios. Need I say more? You have forgotten about your wife.

This is what you should do if it is not too late! Get in touch with me and sell me all your radios. That will clear your house from all the radios. Then redecorate the house and with the money you would make from the sale of the radios, buy a couple of tickets for you and your wife to somewhere romantic. Then when you are away on holiday, tell her how much you love and miss her, or words to that effect. Tell her that you have sold all of your radios because you love her, redecorated your home and swear to her that you have given up your radio hobby forever. That should do it; she should come running back to you at this time.

If she still doesn't come back, all is not lost. You now have a newly redecorated empty house. Find a new woman. Don't tell her you are a radio collector. Show her your nice empty house and then marry her. After you are married pretend that you are getting interested in a new hobby and try to get her involved in it. Take her along to a few radio rallies.

Soon she would realise how boring the radio rallies are and stop coming. Then slowly start collecting radios again. As it takes many years to fill the house with radios again, say 25 years or so, by the time your second wife realises what she has got her self into you would be too old to care!

I hate my wife, how can I make her leave me?

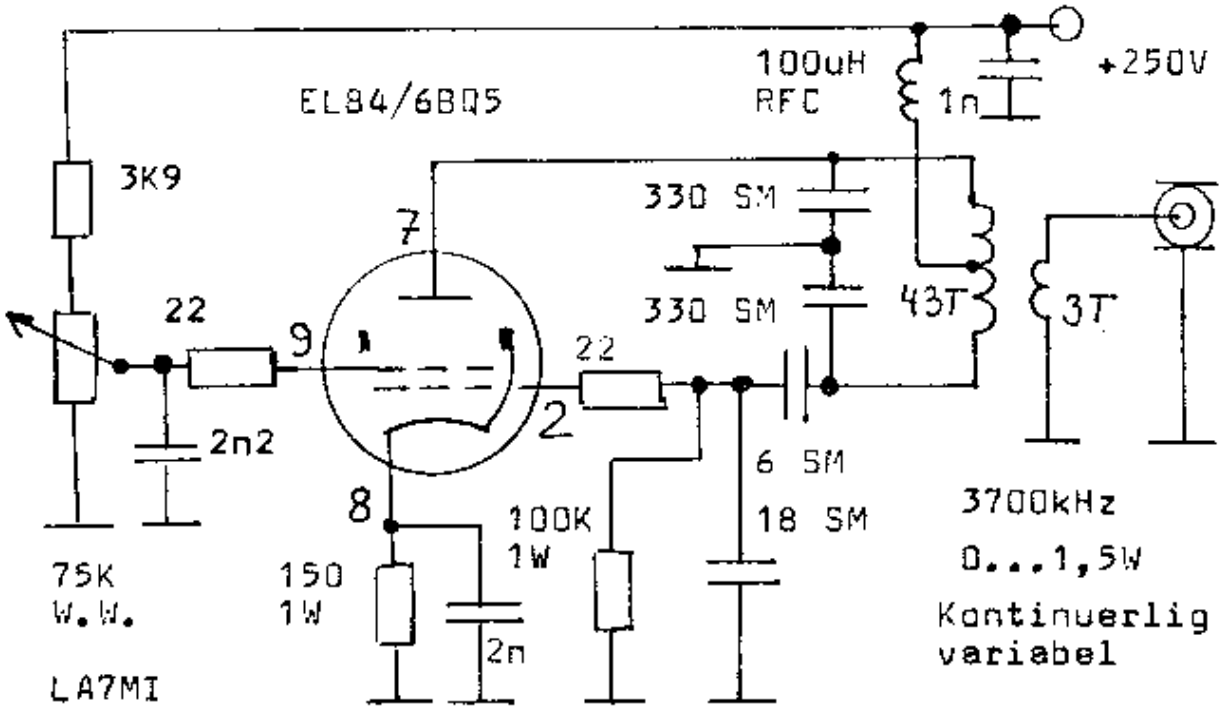
See the above answer and do the exact opposite. Quicker you collect radios, quicker she would leave you. Just think of all that space that you would gain when she leaves you. You can start filling some of that space by getting your radios from me.

Editors Comments & News

The recent 'boot sale' was a well attended success.

80m high level RF signal source

Fig. 32-1. Effektsignalgenerator med EL84 RF outp.: 0–1,5 W for 3,7 MHz.



Understanding broad-band ferrite transformers used in solid state Power Amplifiers

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also read the Motorola application notes, but I am surprised how much is described using obscure references to math which most readers may not understand, it is much easier than he describes, and I do not agree with many of the conclusions made in several articles. It is easier to find important parameters using some practical experiments, this opens for use of inexpensive sources of surplus materials, in particular the Philips core mentioned below has been available at no cost in larger quantities for many of my friends. I've also been to surplus rallies in Los Angeles and London and experienced that a lot of very useful cores have found little interest among the crowd. I am surprised that some readers have not access to curves which are shown in Philips data books as early as 1970, and have drawn the wrong conclusions with a lot of math. If you don't agree or like to exchange opinions I'll be pleased to receive a letter via post, address below.

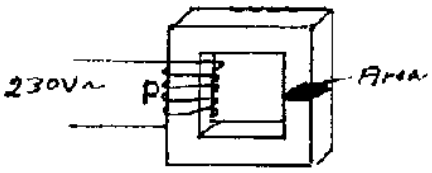
Two types of transformers can be found in linear amplifiers:

The transmission line transformer, and the conventional transformer.

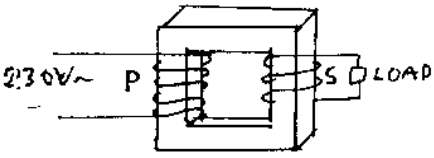
The transmission line transformer is used for large bandwidth ratios (Fmax/Fmin). This transformer is difficult to make. In modern RF-power amplifiers we find the conventional transformer type consisting of primary and secondary windings wound on a ferrite core.

To build a transformer we must know a little about: 1) The turns-ratio to give the wanted impedance transformation 2) loss in the ferrite core due to magnetic field (generates heat) 3) how many µH for minimum operational frequency 4) coupling between primary and secondary to cover maximum operational frequency 5) effect of DC current in the windings 6) how to increase max. operational frequency with capacitive compensation

Ferrite losses Let us start looking at an ordinary mains transformer.



The current in the primary sets up an alternating magnetic field in the core. The loss is the core depends on the strengths of the magnetic field.



When we connect a load to the secondary winding the primary current will increase.

Question: Will the larger primary current set up a stronger magnetic field in the core? <No>..

For all practical purposes the magnetic field is independent of the transferred power. This means we can investigate the loss in a ferrite core by winding a few turns, and connect the winding to a suitable signal source.

80m high level RF signal source (see opposite page)

This 3.7MHz 0-1.5W RF output Colpitts oscillator using 6BQ5/EL84 tube is extremely useful for investigating loss in ferrite cores, and also as a higher level signal source for testing linear power amplifiers. (also see page m3).

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Understanding broad-band ferrite transformers used in solid state Power Amplifiers

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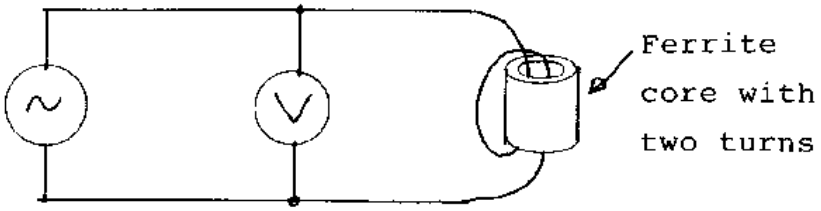
How to test a ferrite core for power loss.

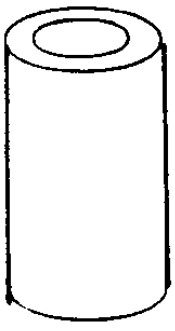


Signal source 3,7 MHz or a higher frequency

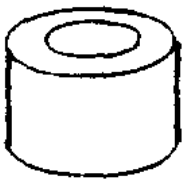
Hf-voltmeter

Increase the level and the temperature in the core will increase. Find the voltage for 20° C temperature increase. Example 8. This core can take 4 volts per turn.

Some actual ferrite cores for 2-30MHz PA's have permeability in the range of 100-1000



10.5 mm OD, 6.9 mm ID, 19.5 Long Philips 3122 134 90783 Ferrite grade 4A4 permeability 500. 4v per turn at 80m band gave 20°C increase. 1 turn = 0.9µH

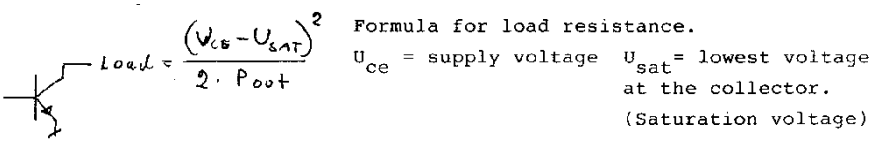


Amidon FB 43-2401 Ferrite grade 43, permeability 850. 1v/turn on 80m band gave 20°C increase. 1 turn = 0.35µH

16W RF Push-pull amplifier

The inductance in the secondary must be: 10µH or more for frequencies down to 3.5MHz, 20µH or more for frequencies down to 1.75MHz. (The reactance must be larger than 200 ohms at the lowest frequency of operation).

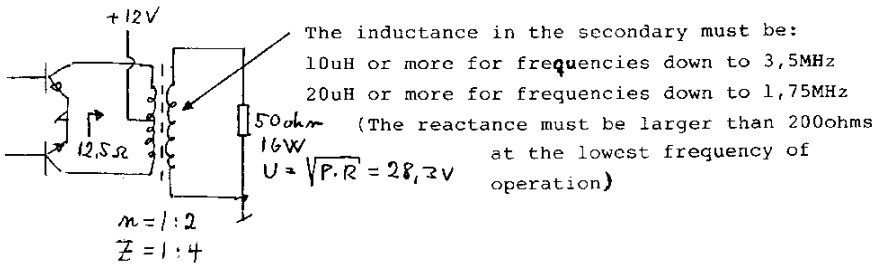
Formula to calculate the load impedance.



8W output and (Uce-Usat) = 10V gives R load = 6.25 ohm. The load resistance of the two transistors in push-pull is two times (not 4 times) the load of a single transistor. A push-pull amplifier with 16W RF from the transistors with 12V supply must see 12.5 ohm load between the collectors. The output transformer in the push-pull stage must transform 12.5 ohm to 50 ohm, the turns-ratio is 2.

Lower frequency limit for a broadband transformer

Without any loss in the ferrite we could be satisfied with 10µH inductance in the secondary (50 ohm load) for operation down to 3.5MHz. In the real transformer we have loss due to the magnetic field. As previously shown this limits the volts per turn. For the 16 watt output rating, we will have 28..3V across the secondary



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Understanding broad-band ferrite transformers used in solid state Power Amplifiers

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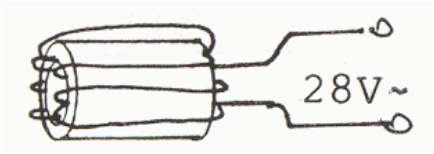
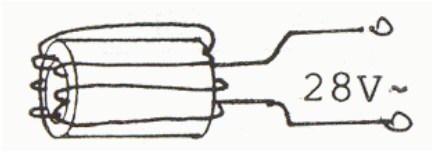
Philips ferrite tube 3122 134 90783 (10.5 mm OD, 6.9 mm ID, 19.5 Long). Let us say max 3.5V per turn. We can use 1, 2, 4 etc number of tubes. (We chosed this type only because it had been available here at very low cost in larger quantites, somewhere else another type is optimum).

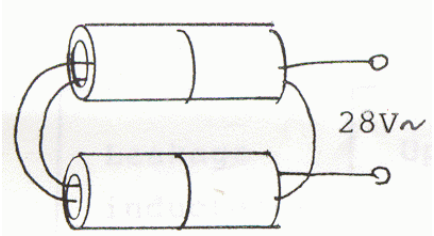
Secondary winding (50 ohm load):



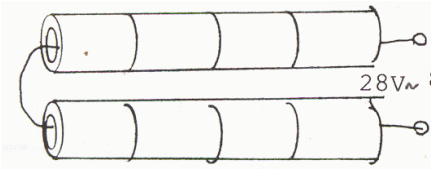
One tube, 8 turns, inductance 0.9 *(8) ² = 28.8µH Lowest useful frequency = 0.6MHz



Two tubes 4turns, inductance (0.9 +0.9) * (4)² = 28.8µH Lowest useful frequency = 1.2MHz



Four tubes, 2 turns, inductance (4x 0.9)2 ² = 14.4µH Lowest useful frequency = 2.4MHz



8 tubes, 1 turn, inductance = 2x 0.9 = 7.2µH this combination gives lowest frequency = 4.8MHz

In the 16w push-pull amplifier we can use two or four tubes in the transformer. The winding wire must not give additional loss due to resistance and skin effect. With 16W RF output the current is 28.3/50 = 0.57A in the secondary winding.

What happens when we double the number of turns?

The transformer can now supply 56V RF. Doubling the voltage gives four times more power (4x 16 = 64W). Since doubling the number of turns gives 4 times greater inductance, the low frequency limit is also divided by 4.

Power dissipation in a broad band transformer

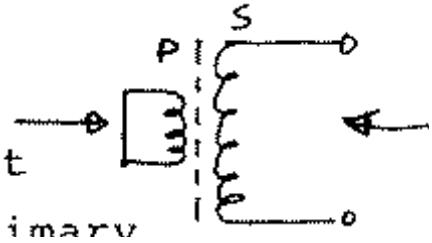
An ideal transformer has zero power dissipation. A real transformer has two types of dissipations: 1) Ferrite losses. Can be reduced by reducing the "volts per turn" rating 2) Ohmic losses in the windings. Can be reduced with heavier wire.

Upper frequency limit for a broadband transformer

In a conventional transformer (not a transmission line transformer) the upper frequency limit is dependent on the coupling between the primary and secondary winding.

How to test a transformer for leakage-inductance?

Short- circuit the primary



Measure the secondary inductance in "µH" = leakage inductance referred to the secondary winding (50 ohm load)

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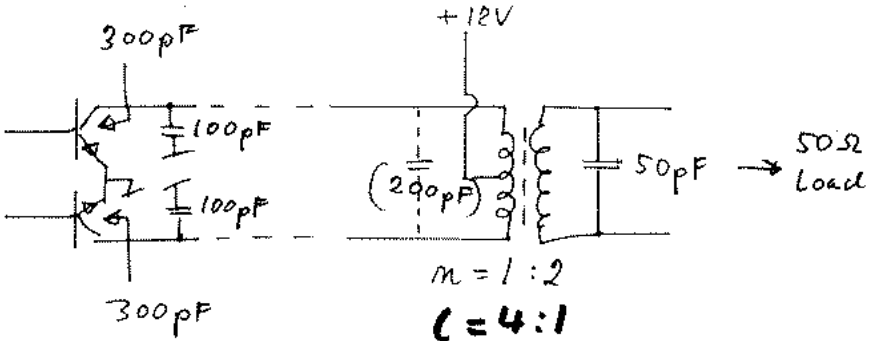
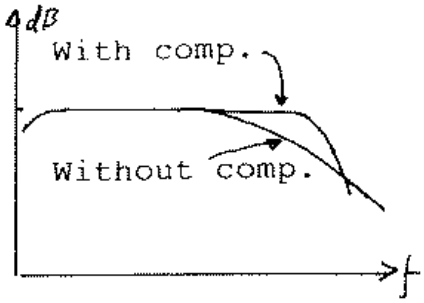
Understanding broad-band ferrite transformers used in solid state Power Amplifiers

(Continued from page 7)

Leakage inductance	Upper frequency limit without capacitive compensation	Upper frequency limit with capacitive compensation	Compensation capacitor across the secondary (pF)
0.125µH	15MHz	60MHz	25pF
0.25 µH	7.5MHz	30MHz	50pF
0.5 µH	3.75MHz	15MHz	100pF

For proper performance we must also put a capacitor across the primary winding. With a turns ration of 1:n this capacitor must be n^2 larger than the secondary capacitor. Note: We must subtract the transistor output capacitance.





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Understanding broad-band ferrite transformers used in solid state Power Amplifiers

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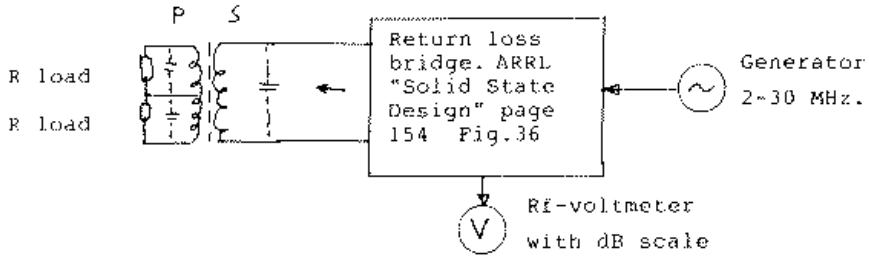


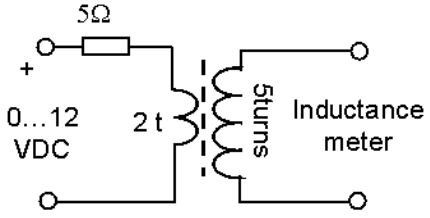
Testing a broad-band transformer by VSWR measurements

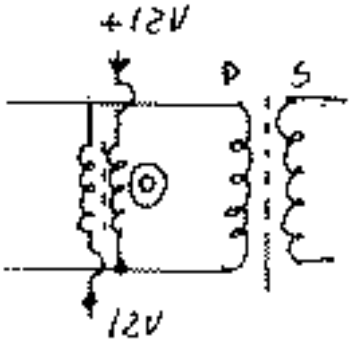
By measuring the return loss (or VSWR) we can optimize a broadband transformer. The primary must be loaded with resistors = load impedance per transistor in the push-pull stage. Try to achieve better return-loss than 17dB or SWR better than 1.3:1.

DC current in a broadband transformer

Feed the supply via a 'centre tapped balun'. This method also improves the waveform at the transistor collectors

DC can reduce the inductance in the windings, it is best to avoid a DC magnetizing component

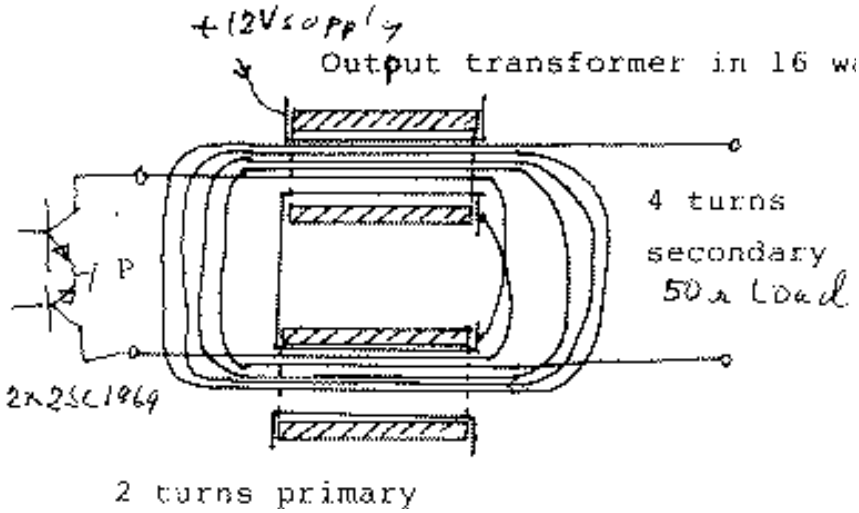




DC-saturation
(how to measure DC saturation in a ferrite core).
For an Amidon FB43-4301 ferrite core the inductance drops by 50% for 1.2At. 3At for 75% reduction. One should keep the DC-current below the value of 0.5A to keep the reduction below 10%. In the example above this rule is used, but the best is to use push-pull arrangement and the DC magnetisation is kept to a minimum level. The inductance reduction is stored and the effect is called remanence, cores used with direct current should have air-gap, and several such cores exists for low frequency power inverter applications.

As an illustration for measuring core saturation this picture could be used. A DC voltage is applied to one side, and an inductance meter to the opposite. Note the DC current voltage needed to reduce the inductance by 10%. Say the DC voltage is 1.25V, the current is 0.25A, and the ampere-turn = 2 * 0.25 = 0.5At (provided voltage drop over the winding is negligible).

Output transformer in the 16W amplifier
Note: No DC magnetic field in



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Understanding broad-band ferrite transformers used in solid state Power Amplifiers

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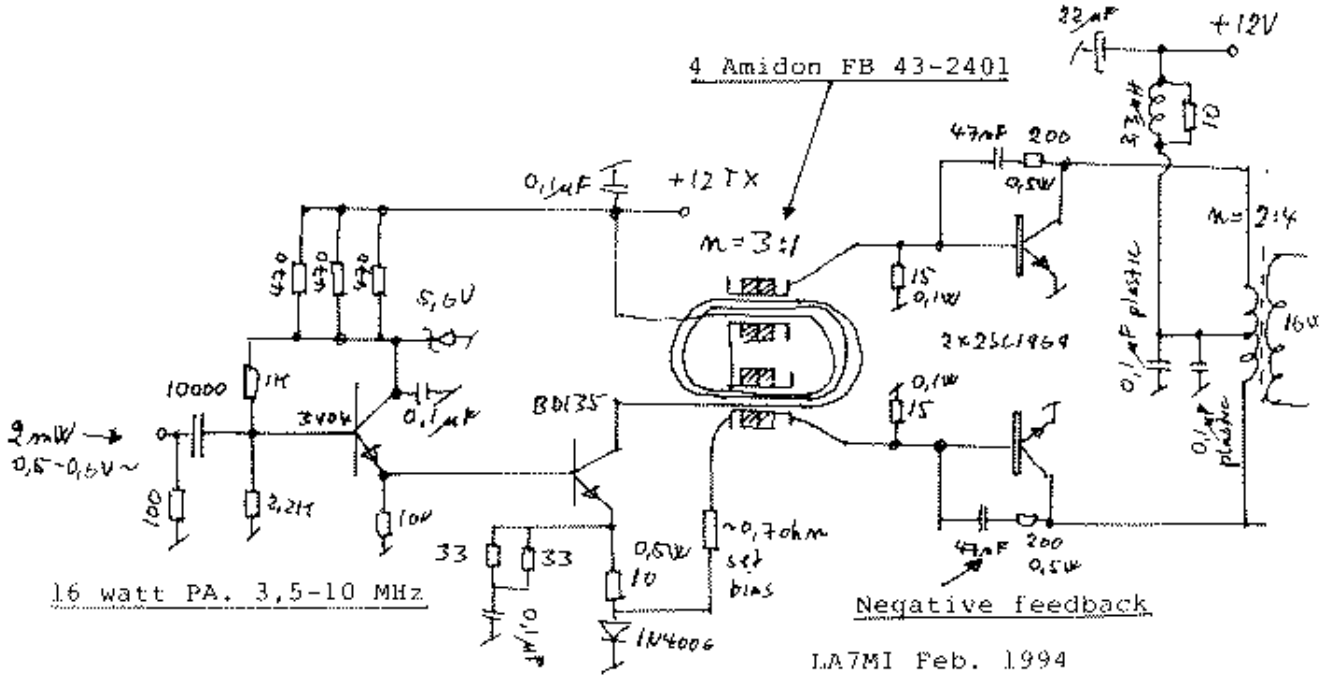
the ferrite core

Un-edited circuit diagram (no available photo program)



The 16W power amplifier covering 3.5-10MHz It is a plate to short circuit the two metal tubes at the left side of the driver transformer

LA7MI in April 2004, and the note about saturation has been added in May, the author has no email, but is reached by telephone nr +47-55-902392. The postal address is: Stein Torp, Tollbodalmenning 34, N-5005 Bergen, Norway

My comments about RF transformers where it is one turn consisting of a brass tube, is this really necessary, could a coax braid be used just as well? The ends could be soldered, and you need no end plates (LA8AK)

See notes about bias regulators and LA7MI 40W FET linear amplifier (n15)

Last update: 2004.06.27

[Taken from the web site. Please visit it for later details.

http://www.noding.com/la8ak/12345/n12.htm]

Document received from

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Bulletins (Sundays at …)
11h15 Start call in of stations
11h30 Main bulletin start

Frequencies
439.000MHz 7.6MHz split
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145,625 MHz (West Rand Repeater)
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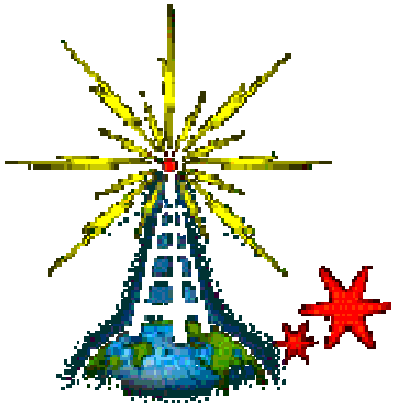
West Rand members - we need your input!

To make this the best ham radio magazine in South Africa we need your input. Please submit articles, comments, suggestions etc.

Please send plain text with no formatting to the email address below.

In July 2003, we re-published an Anode Compendium on CD. It has the issues from July 2000 until June this year. This included the new Adobe reader. It has been updated, check with the chairman for details.



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