Optimizing and Determining ADX LPF Efficiency and Power Out (Simplified)

The efficiency of the ADX class E power amplifier is impacted by the bias applied to the BS170's by the LPF. The value of this bias can most easily be adjusted by varying the inductance of L2. Adjusting the winding spacing of L2 using the original number of turns or after reducing the number of turns by one turn will results in better performance. For most there will be no need to reduce the L2 turns, with good results possible from adjusting L2 winding spacing with the original number of turns.

A few simple adjustments to the L2 winding spacing can have a significant impact on the efficiency and power out from the ADX.

It is recommended that you adjust the winding spacing of L2 on the LPF for each band to achieve the best possible efficiency and optimize the power out from the ADX. You will typically see 3-4 Watts on the lower bands and 2.5 to 3W on the higher bands. This will ensure that the BS170's do not overheat and potentially get damaged as a result. It is also important that the ADX transmits into a resonant 50 Ohm antenna system to prevent overheating and damage to the BS170's.

The following is one way of adjusting the LPF to achieve maximum efficiency and power output. The aim is to achieve the maximum power out with and efficiency greater than 70%. If you must choose between maximum power and maximum efficiency, choose the maximum efficiency to be on the safe side.

Equipment Needed:

You will need the following equipment to perform this process:

- An ADX and associated LPF's
- A stable regulated power supply
- An accurate ammeter
- A 50 Ohm dummy load
- A power meter capable of accurate measurement of the ADX output power (or a method of calculating the output power by measuring the output voltage from the BS170's).

In my own testing I used the Barb-A-Watt and its associated 50 Ohm dummy load, together with a Lab Power Supply as shown in the following photograph:

Efficiency Calculation

The efficiency of the PA section is calculated as follows:

PA Efficiency = Power Out / Power In to the PA section

Power Out is recorded by the RF power meter in Watts

Power In is calculated by observing the power consumed during transmit (Voltage * Current) – the power consumed by the circuitry within the ADX during the transmit cycle (excluding the PA section)

The power consumed by the ADX during the transmit cycle can be established by removing the LPF and observing the supply voltage and current consumption when pressing the Tx button. This will show all power consumed by the ADX during Tx without the PA section, as 12v is only supplied to the BS170's when the LPF is inserted.

It is recommended that you set up a spreadsheet as an aid to this process along the following lines for each LPF that you set out to optimize:

Test	Band	V_{in}	Tx Current No LPF mA	Non PA Pwr (W)	TX Current (mA)	P_{out} W	Tx P_{in} W	Eff %	Heat Loss (W)	Changes Made
1	40	12	72	0.864	340	2.6	3.216	80.85	0.616	Base state with even L2 windings
2	40	12	72	0.864	320	2.2	2.976	73.92	0.776	record changes made here eg: expanded L2 windings to Max Spacing
3	40	12	72	0.864		3.5	-0.864	-405.09	-4.364	
4	40	12	72	0.864		3.5	-0.864	-405.09	-4.364	
5	40	12	72	0.864		3.2	-0.864	-370.37	-4.064	
6	40	12	72	0.864		3.2	-0.864	-370.37	-4.064	
7	40	12	72	0.864		3.2	-0.864	-370.37	-4.064	
8	40	12	72	0.864		3.2	-0.864	-370.37	-4.064	
9	40	12	72	0.864		3.2	-0.864	-370.37	-4.064	
10	40	12	72	0.864		3.2	-0.864	-370.37	-4.064	

A blank copy of this sheet is available at my github page here:

Cowtown-ADX-Project/Blank LPF Testing Spread Sheet.xlsx at main · VK2ARH/Cowtown-ADX-Project

Method for Optimizing (For each band):

1. Your test setup should have the ADX connected to a 50 Ohm dummy load and record the power out whilst observing the input voltage and current.

2. Establish the non-PA power consumption by removing the LPF from the ADX and observing the voltage and current consumed when the TX button is pressed.

   

   There will be no power output from the ADX, but you will see an increase in the power consumption from the receive state as additional components are now consuming power.

   Record the power consumption as this will be deducted from the power consumption during transmit with the LPF inserted to determine how much power is being supplied to the PA section.

3. Reinstall the LPF and ensure that the ADX is set to the desired band.

4. Press the Tx button again (Tx into a 50 Ohm Dummy Load) and observe the RF power out, and the input voltage and current.
5. Subtract the power consumption observed in step 2 from the input power in step 4 to determine how much power is being consumed by the PA section of the ADX.
6. Determine efficiency by dividing the RF power out by the PA power consumption. This is done automatically in the supplied spreadsheet if you are using that. Eg:

Test	Band	V_{in}	Tx Current No LPF mA	Non PA Pwr (W)	TX Current (mA)	P_{out} W	Tx $P_{in\,W}$	Eff %	Heat Loss (W)	Changes Made
1	40	12	72	0.864	420	2.6	4.176	62.26	1.576	Base state with even L2 windings

7. Now adjust the L2 inductance by varying the spacing on the windings. Record what change you made (eg: spread the windings a little further apart) and then repeat steps 4 to 6 and record the new result.
8. Continue to adjust the L2 windings until you reach your optimized state. You should be targeting efficiency greater than 70% with the maximum power out you can achieve this good efficiency.
9. I adjust the colour of the cells in the efficiency and heat loss column of the spreadsheet to provide a visual indication of the LPF performance. The colour coding is shown in the sample spreadsheet on the GitHub page.

	Tx Efficiency above 70%	
		Heat loss suitable for WSPR without additional cooling (less than 1.5W)
		Heat buildup in BS170's suitable for FT8 but exercise caution with WSPR (2 min Tx Cycle) may need additional cooling (1.5 - 2W)
		Heat loss not suitable for operation without additional PA cooling (> 2W)

10. Undertake this test for each of the LPF's you wish to use.

Good luck 😊

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