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Application Note

How to bias the LL1667 / LL1668

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It possible to use the Lundahl plate chokes at higher DC current, if the maximum AC voltage, for which the choke is made, is not required in the application. This is very beneficial in situations with low AC voltage across the choke, because in that case a lower DC Specified choke can be exceeded. This means for instance in some practical applications, a 15mA choke can be replaced by a 7mA choke, which has more than 2x the inductance. So the filtering of the choke will be twice as good.

In data sheets, a choke is specified for the maximum DC current and maximum AC Voltage at the same time. However this leads often to over specifiying the choke in terms of DC current. That is a pity, because such chokes have lower inductance. So we are giving away what we were trying to achive in the first place, and that is: ***Inductance***.

For all magnetic devices, there is the situation with “core saturation” which represents the limit to what the device can be used. Core saturation just means, if you exceed the maximum magnetisation (specified in TESLA), the choke will stop being a choke, and it becomes a copper wire resistor.

A magnetic core can be saturated by DC current alone, or by AC signal alone. With chokes however, there is always DC current and AC signal together. Each of which contributes to core magnetisation to a large part.

The maximum AC voltage for Lundahl chokes is extremely high. This is a useful feature for so called choke input rectifier circuits, but it is not needed in many other cases.

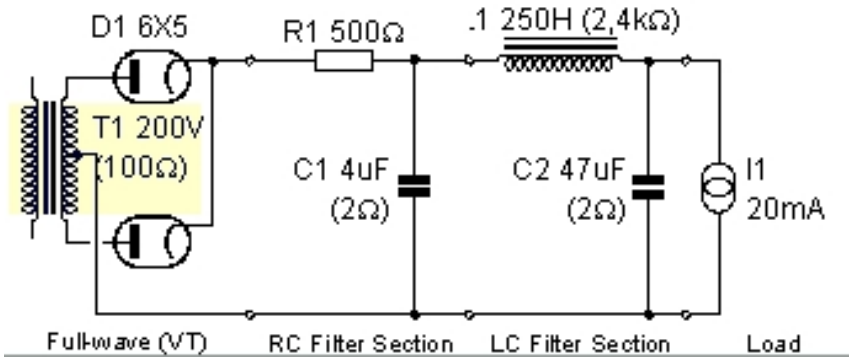
So we have two ways to select a choke from the Lundahl palette. The one is, the user does not know the AC voltage across the choke. In that case, there is no other way as simply choose a choke which can do the required DC current. This will result in LL1667-15mA when the DC current is 11mA.

A better way to select a choke, is when the AC Voltage is known. There will be many cases where the AC Voltage is low. This means, the AC part of the magnetisation is lower as maximum, and then it becomes allowed to choose the DC part higher as maximum. For this the following tables can be used.

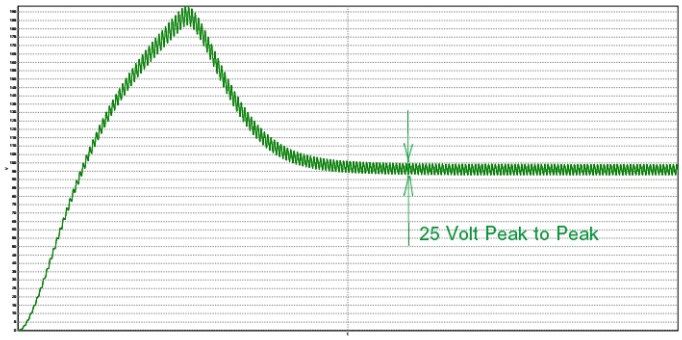
DC Current (mA) LL1667					**Max Signal**
LL1667/5	**LL1667/7**	**LL1667/10**	**LL1667/15**	**LL1667/25**	LL1667
810H	**580H**	**405H**	**270H**	**168H**	(AC Volt, RMS)
5,0	7,0	12,5	15,0	25,0	390
5,3	7,4	13,2	15,8	26,3	359
5,5	7,8	13,8	16,6	27,7	327
5,8	8,2	14,6	17,5	29,1	293
6,1	8,6	15,3	18,4	30,7	257
6,5	9,0	16,1	19,4	32,3	220
6,8	9,5	17,0	20,4	34,0	180
7,1	10,0	17,9	21,4	35,7	139
7,5	10,5	18,8	22,6	37,6	95
7,9	11,1	19,8	23,8	39,6	49
8,3	11,7	20,8	25,0	41,7	3

DC Current (mA) LL1668					Max Signal
LL1668/5	**LL1668/7**	**LL1668/10**	**LL1668/15**	**LL1668/25**	LL1668
500H	**367H**	**250H**	**167H**	**100H**	(AC Volt, RMS)
5,0	7,0	10,0	15,0	25,0	235
5,2	7,3	10,5	15,7	26,2	216
5,5	7,7	11,0	16,5	27,5	196
5,8	8,1	11,5	17,3	28,8	176
6,0	8,4	12,1	18,1	30,2	154
6,3	8,9	12,6	19,0	31,6	131
6,6	9,3	13,3	19,9	33,1	107
6,9	9,7	13,9	20,8	34,7	82
7,3	10,2	14,6	21,8	36,4	56
7,6	10,7	15,3	22,9	38,2	29
8,0	11,2	16,0	24,0	40,0	2

Example1. 20mA Power Supply for a pre amplifier with LL1667.



It is obvious, such a circuit must work as hum-free as possible. This means, a too large first capacitor would cause stray hum by too large current peaks throughout the whole circuit, and also from the tube itself. A too large second capacitor can cause saturation problems of the choke at start up, resulting in unwanted effects.



The above chart shows the voltage across the choke, including start up effect, showing the voltage over the choke is larger at the beginning. (This results from initial charge of C2) This is normal, and the Choke DC resistance is a current limiting element. After start up, the AC voltage across the choke is only 25 Volts peak to peak, which is appr 9 Volts RMS, and it can be seen it doesn't exceed this value during start up. So we can safely say, this choke needs to be specified only up to 9 Volts AC. This is very little compared to the full 390Volts RMS of the LL1667, and this gives us the possibility to exceed the DC current specification of the choke.

Theoretically we need to take the 25mA choke as it is the closest higher value to 20mA. The 25mA version would be a 168H choke. In the table for LL1667 we can see the 15mA version can actually do 23.9 mA at 49Volt AC, which is even more than we need, and this is already a 270H choke. If the output current would be 19.8mA, we could even use the LL1667-10mA which is a 405H choke. Let's not design totally on the edge, and we say the LL1667-15mA is a safe choice here, even though output current is 20mA.

Example2: Single Ended Triode application with 11mA and 49 Volts AC (RMS), comparing the use of with LL1667 or LL1668.

Theoretically, the next higher value choke above 11mA, is the 15mA version. For the LL1667 that would be a 270 Henry choke, capable of 390 Volts AC. This reserve in AC voltage, we can now use to exceed the DC current. In the above table, you can see at 49 Volts AC, LL1667-10mA can be used up to 15.8mA and even LL1667-7mA can be used up to 11.1mA. This box is marked yellow, for this example. Since LL1667-7mA has a stunning 580 Henry, this is definitely the better choice in case Inductance comes first.

In the same example, LL1668 would result in the LL1668-10mA, the according box in the table is marked green. LL1668-10mA has still 250 Henry.

In case you prefer LL1668 for this application, the reason for doing so, It would be for the lower copper resistance and lower windings capacitance. R-Copper is 680 Ohm for LL1668, versus 2400 Ohms for LL1667. For Audio, the copper resistance should be low, but for power supplies it gives extra filtering. Yet between LL1668 and LL1667 there is great overlap and often you can take both. I would advise LL1667 if there is need for simply highest inductance, and use LL1668 for Audio when you have enough inductance.

Conclusion: Looking back to what happened in the above SE amplifier example:

Requirement: 11mA and 49 Volts AC (RMS).

1) Without AC considereation: Use LL1667-15mA, which has 270Henry
2) With AC consideration: Use LL1667-7mA, which has 580 Henry
3) With AC consideration: Use LL1668-10mA, which has 250 Henry

Hidden Reserve: All Lundahl chokes have a hidden reserve in the DC specifications, which reserve should not be compromised by the user. The reserve allows the user to go to the design limit, without having to worry about headroom. So even if you go to the design limit, you are still safely away from distortion level. For this reason, the hidden reserve is not officially specified by Lundahl.

Note: Many of the types in this table are specially made versions, as this is needed to make the best choice. At jacmusic we have these versions either on stock, or we can supply them to you at no extra cost.

Moreover for a quick overview of DC current and inductance of those special types, please use the jacmusic pricelist for this. All chokes are sorted first by DC current, and then by Henry, allow a quick orientation.

This method of exceeding DC current is approved by Per Lundahl to publish on the jacmusic website.