ISCE

The Institute of Sound and Communications Engineers

Engineering Note 19.2

Optimum number of turns for an AFILS loop

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1. Basic measurements

Assuming that the amplifier specification is unknown or unreliable, connect a 2 Ω ±5% non-inductive resistor of adequate power rating to the loop terminals and measure the voltage V_1 across it with a 1 kHz signal, set so that the output waveform is just not clipped. The voltmeter must be connected directly across the resistor (so neither lead can be 'earth') , but the oscilloscope can be connected between the signal common of the amplifier and the 'hot' output terminal, and not (ever) to the 'cold' output terminal.

Repeat the test but with a load resistor of 0.1Ω ±5%, and start with the loop drive control at zero. Increase the drive until the waveform is just not clipped and then measure the voltage V_2. (Let's hope that the amplifier has efficient short-circuit protection. Go carefully! If it doesn't have protection, maybe choose another amplifier.)

The maximum output voltage is thus V_1 volts and the maximum output current can be taken as $10V_2$ amps (since few loops indeed are less than 0.1 Ω at the upper full-current frequency (between 1.5 and 2.5 kHz, usually).

So, the load impedance that just runs the amplifier out of voltage and current simultaneously is $V_1/10V_2$ Ω. Any other impedance prevents the amplifier giving as much as it can. We want the loop to present this impedance at the upper full-current frequency.

2 Current-drive amplifiers

We also want as little voltage as possible wasted in the wire resistance, so the loop inductive reactance should be much larger than the resistance. Suppose we set the upper full-current frequency at 2 kHz, then:

$$2\pi.2000L = V_1/10V_2$$

$$\text{So } L = V_1/20000\pi V_2 \text{ henrys}$$

$$= V_1/20\pi V_2 \text{ mH}$$

If the loop is a square of side a metres, the inductance of 1 turn is 8a μH, and we can take the inductance of n turns as $0.007an^2$ mH (7 instead of 8, to allow for less than 100% coupling between turns).

Thus:

$$0.007an^2 = V_1/20\pi V_2$$

$$\text{giving } n = \sqrt{(V_1/0.44aV_2)}$$

For example, if V_1 = 4.7 V and V_2 = 0.32 V, with a = 0.25 m,

n =11.6 turns, say 12 turns.

3 Voltage-drive amplifiers

These days, voltage-drive should be considered only for very small loops, such as neck loops. The loops in portable AFILS with quasi-vertical loops need too much drive volt-amps for voltage-drive to be acceptably efficient. With voltage drive, we have to have a loop resistance equal to $V_1/10V_2$ so that we don't run into current limiting at low frequencies. Normally, it isn't practicable to get the required resistance by using thin wire; a fixed series resistor is used. Also, in order to have adequate high frequency response, we need equal loop resistance and inductive reactance at 5 kHz or above. Choosing 5 kHz, we get :

$$2\pi.5000L = V_1/10V_2$$

Comparing with the previous calculations, we can go straight to:

$$L = V_1/50\pi V_2 \text{ mH, and thus:}$$

$$n = \sqrt{(V_1/1.1aV_2)}$$