Using Electronic Vintage Equipment in a 230V Mains Power Network

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Since „Harmonizing“ of the mains voltages in Europe was conducted in the late 1990ies, problems showed up when using old but valuable electronics equipment, caused by the the new mains voltage, which was elevated in several steps from 220V to 230V. Before, the allowed voltage fluctuation was +/-5% in central Europe (Benelux, Swizerland, Germany, Austria and Denmark). The rest of western Europe allowed for +/10%, eastern Europe countries even more. Now ,the harmonized voltage fluctuation is set to +/-10% for the whole EU. What does this mean to the operation conditions of vintage equipment?

Let's take a look at an Example:

The diagram Fig. 1 on the right shows an old 220V power transformer idling.

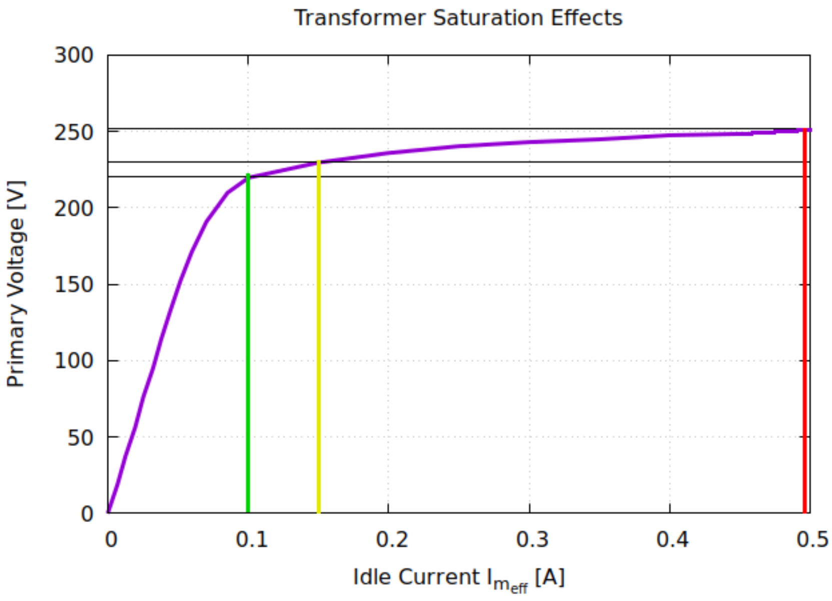

Fig. 1: Transformer Saturation

On a 220V network it's operation point is set by best practice at the sharpest bent section of the magnetizing curve (green), yielding least loss. Here the primary draws an idle current of ~0.1A.

At the upper limit (yellow)of the former mains voltage of 232V the current already increases by 50% to 0.15A, which however was counted for by construction.

Nowadays, the upper limit is 252V, which would drive the transformer far into saturation (red), yielding an idle current of 0.5A! Additional losses in the copper winding and iron core in this extreme case will grow to a level, where the transformer will probably be destroyed in minutes. Under normal circumstances the mains voltage will be much lower, say e.g. between 230V and 240V. But even here the transformer will heat up significantly.

Consequently, Musicians saw their beloved vintage amplifiers burn off and tried many questionable workarounds like series resistors, but the solution came from the scientific sector. Here the urge was strong to keep very expensive equipment like e.g. electron microscopes alive anyway.

Many suggestions to solve the problem were published, from the above mentioned primitive series resistors or even worse series capacitors on one hand to suggestions for complete separated 220V networks on the other extreme. The series resistor approach may give correct voltages under load, but doesn't have much effect on the magnetizing current of the transformer. Worse, during warm up (tubes are still cold) the full voltage is forwarded to the equipment stressing electrolytic capacitors and rectifiers.

So, the only decent solution is simply to provide the correct 220V at all operation conditions to the transformers. Some large scientific institutions indeed installed a separate 220V mains network where needed!

However, there is a solution for single devices which will fulfill almost all mandatory requirements while at the same time being charming inexpensive, low sophisticated and small. This solution is the 'Autotransformer'. It will give idle Voltages well in limits and provide for low voltage degrade under load. Lets take a look at the components involved:

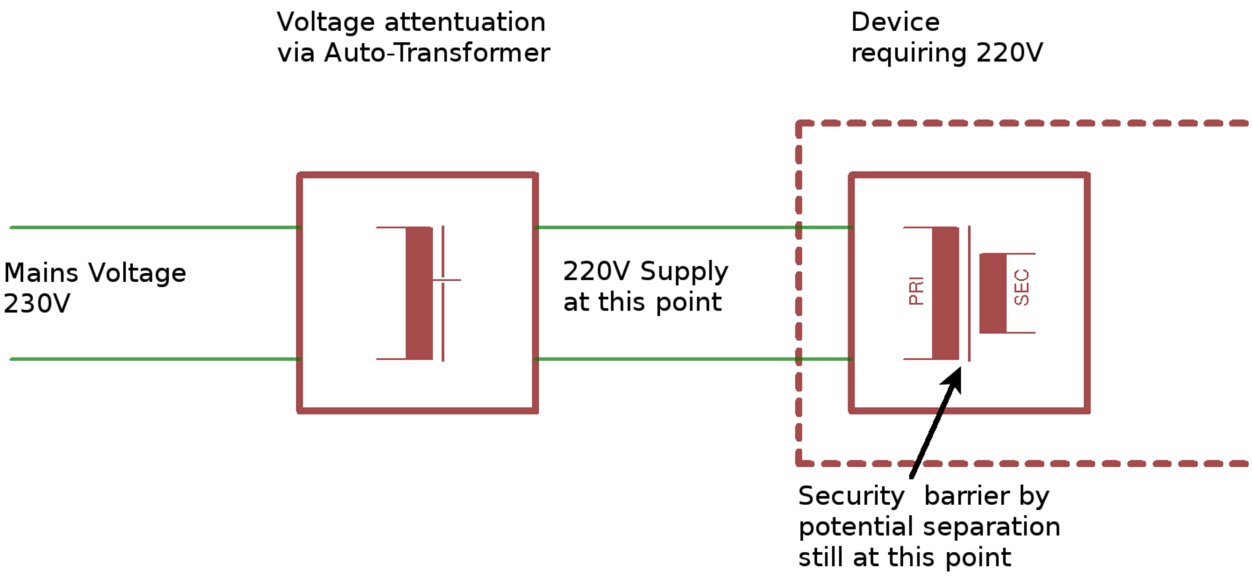

Fig. 2: Autotransformer Arrangement - an Overview

On the left, the new 230V mains voltage enters our arrangement. The Autotransformer block in the middle is supposed to do the work, giving 220V at entry to our vintage device (right).

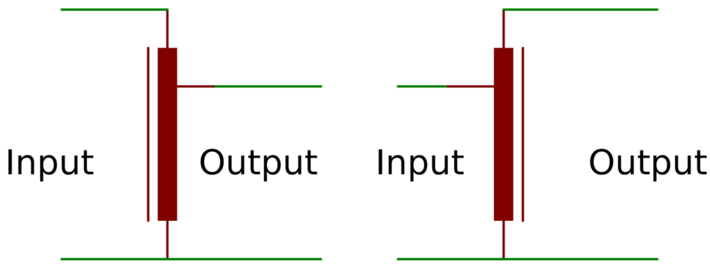

Fig. 3: Autotransformer Step-Up-/Step-Down-Mode

An autotransformer made up by a regular transformer with only one winding with a tap (Fig. 3). There is no potential barrier between input and output. The transformer may be operated in step-down mode (Fig. 3 left), supplying into the whole winding with the tap leading to the output. But reverse step-up operation is also possible, where power goes in the tap and leves via the whole winding (Fig. 3 right).

The tapped winding is not a prerequisite. Instead, series connection of 2 separate windings is perfectly valid and will yield the same result.

Keeping this in mind, let's see, which solutions are feasible.

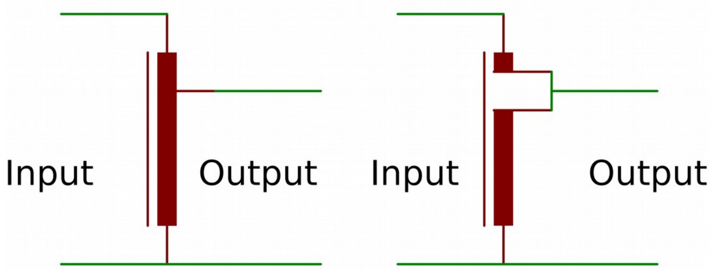

Fig. 4: Autotransformer, 1 and 2 Windings

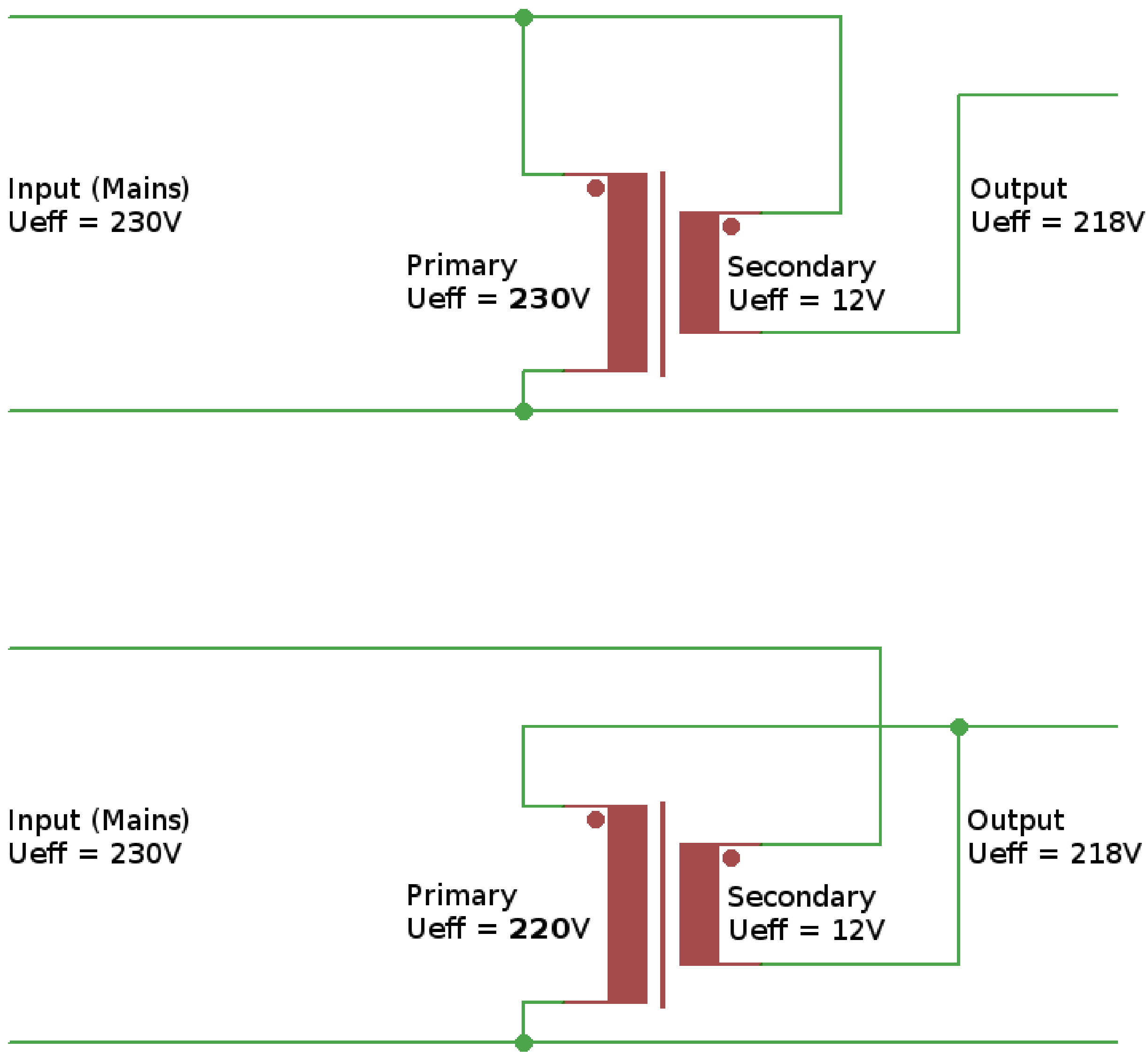

Fig. 5: Two Solution Proposals

The schematic above shows 2 possible solutions, both of which operate a normal transformer in „Autotransformer“ mode.

Doing so will exhibit no security issues, as the mains voltage border is still guaranteed by the original mains transformer of the device. The upper example uses a (modern) 230V/12V transformer, the lower one using a vintage 220V/12V type. However, no matter which solution you prefer, fboth circuits operate the autotransformes well within their specifications.

In upper example the mains voltage is applied directly to the primary side. The secondary is connected in a way, that it's 12V are subtracted from the mains yielding ~218V output.
The lower example shows primary and secondary connected together in true series, now ready to accept 232V mains. With 230V mains a voltage of ~218V is delivered to the output too.

The biggest advantage for the autotransformer solution are the low requirements in respect of isolation and power. For an autotransformer, the magnetic layout is only required to allow for the voltage difference between input and output. E.g. if you whish to drive an old Fender guitar amplifier specified for 220V and a consumption of 250W under load, yielding an effective current of ~ 1.2A. With one of the above solutions and a safety margin of ~10% you need a 12V transformer with an allowed secondary current of at least 1.35A, thus a Power of 12V x 1.35A ~= 16 Watts is necessary. For this power a small M65 transformer will do and you are well on the safe side.