AN-108

How to Use Off-the-Shelf Transformers in DC-DC Power Converters

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Contents

1 Introduction

When confronted with the need to design a power converter, aspects of designing a transformer can be daunting as the engineer seeks to understand all the limiting aspects of winding a reliable transformer. By adopting the pre-designed, but configurable off-the-shelf transformers such as Würth's WE-Flex range the use of a custom transformer may be avoided in many low power DC/DC power supply applications. The WE-Flex transformers come in two configurations: with gapped cores or ungapped cores.

This application note will guide the designer through the use of an off-the-shelf, configurable transformer for flyback converters using gapped cores. By careful adherence to the guidance provided here, it will be possible for design engineers to quickly and confidently design a fully functioning power converter without resorting to custom magnetic design. By following this process, you will be able select the smallest part that meets your application requirements without overheating.

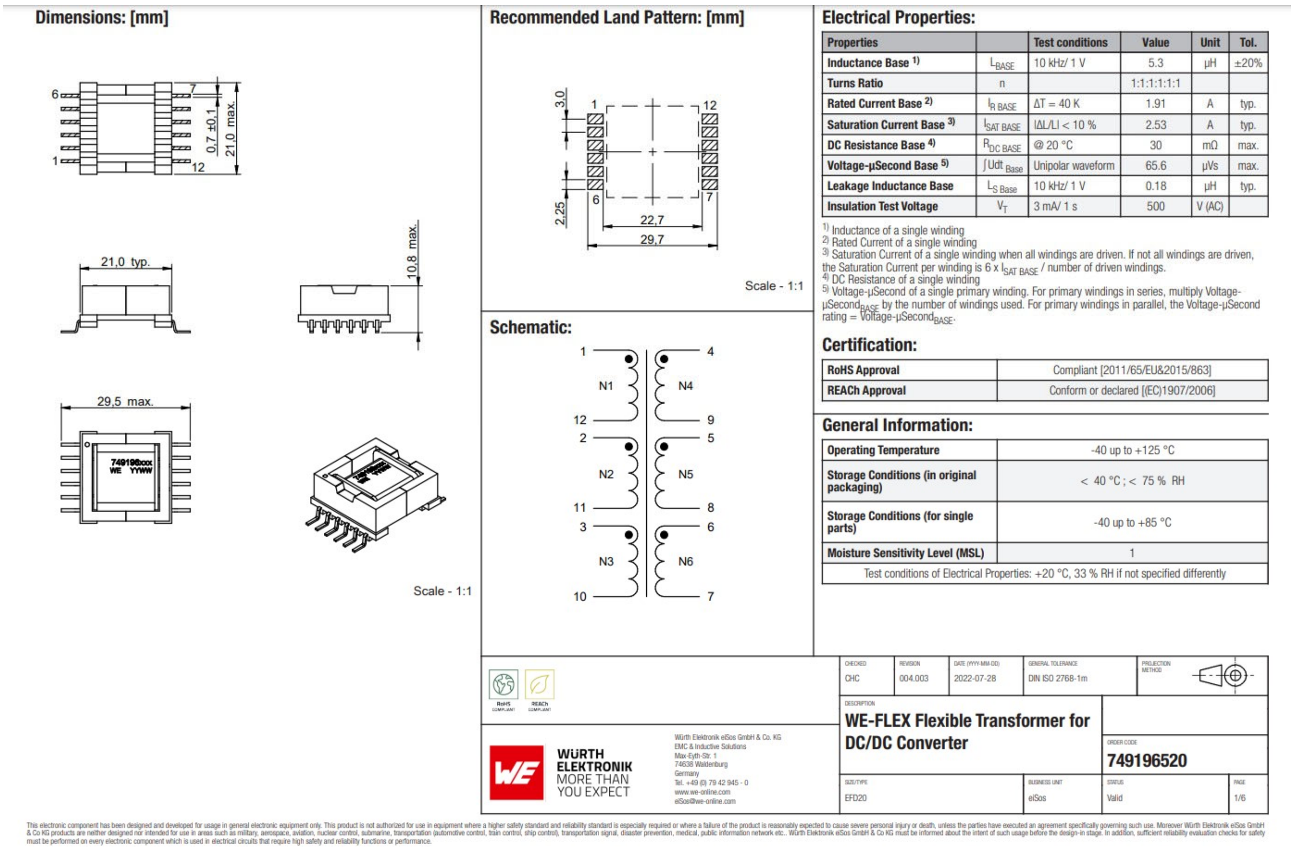
Detailed Step-by-Step design guidelines, rules and equations are given as well as a complete worked example based on a Flyback converter.

Whilst all relevant transformer equations are included in this application note, to make calculations easy a free spreadsheet (Würth WE-Flex Transformer selection spreadsheet) can be downloaded from: www.biricha.com/flex

2 How to Use Würth Flex (WE-Flex) Transformer Range

This is a range of pre-built, ferrite cored transformers that have 6 identical but isolated windings. By careful application of external connections to the transformer, they can be configured to provide multiple combinations of different turns ratios and inductances. Thus, we can design our power supply without resorting to custom wound transformers*.

The datasheets for the transformers describe the wiring and pin connection details, the inductance range for each winding, as well as the current rating for each winding. Using this data allows the designer to quickly create a transformer with a turns ratio and inductance for use in many applications. This is shown in the following figure†:



Electrical Properties:

Properties		Test conditions	Value	Unit	Tol.
Inductance Base 1)	L_{BASE}	10 kHz/ 1 V	5.3	µH	±20%
Turns Ratio	n		1:1:1:1:1:1		
Rated Current Base 2)	$I_{R\ BASE}$	ΔT = 40 K	1.91	A	typ.
Saturation Current Base 3)	$I_{SAT\ BASE}$	|ΔL/L| < 10 %	2.53	A	typ.
DC Resistance Base 4)	$R_{DC\ BASE}$	@ 20 °C	30	mΩ	max.
Voltage-µSecond Base 5)	$\int Udt_{Base}$	Unipolar waveform	65.6	µVs	max.
Leakage Inductance Base	$L_{S\ Base}$	10 kHz/ 1 V	0.18	µH	typ.
Insulation Test Voltage	V_T	3 mA/ 1 s	500	V (AC)	

1) Inductance of a single winding
2) Rated Current of a single winding
3) Saturation Current of a single winding when all windings are driven. If not all windings are driven, the Saturation Current per winding is 6 x $I_{SAT\ BASE}$ / number of driven windings.
4) DC Resistance of a single winding
5) Voltage-µSecond of a single primary winding. For primary windings in series, multiply Voltage-µSecond$_{BASE}$ by the number of windings used. For primary windings in parallel, the Voltage-µSecond rating = Voltage-µSecond$_{BASE}$.

Certification:

RoHS Approval	Compliant [2011/65/EU&2015/863]
REACh Approval	Conform or declared [(EC)1907/2006]

General Information:

Operating Temperature	-40 up to +125 °C
Storage Conditions (in original packaging)	< 40 °C ; < 75 % RH
Storage Conditions (for single parts)	-40 up to +85 °C
Moisture Sensitivity Level (MSL)	1

Test conditions of Electrical Properties: +20 °C, 33 % RH if not specified differently

CHECKED	REVISION	DATE (YYYY-MM-DD)	GENERAL TOLERANCE
CHC	004.003	2022-07-28	DIN ISO 2768-1m

Figure 1: Example Würth WE-Flex-transformer datasheet

We can see that by connecting the windings in different ways we can easily have different turns ratios. However, to design our power supply, we need to work out how changing the winding arrangements

* Note: Whilst the transformer windings are electrically isolated from each other, owing to the configurable nature of the transformer, there is no high voltage insulation between windings. As such, whist the insulation properties of the enamelled copper winding can withstand a relatively high voltage, it is NOT intended for High Voltage (Mains) electrical isolation and safety. For the purposes of this application note only a low voltage isolation is considered.

† https://www.we-online.com/en/components/products/WE-FLEX#749196520

impacts our Rated Current, Saturation Current and Primary and Secondary Inductances. We will describe all of these in the following sections and provide tools to do all the calculations automatically.

2.1 How to connect our windings correctly

If we connect our windings as shown in the following figure, we will have transformer with a turns ratio N of 5:1. Where N is defined as our primary turns (Np) divided by secondary turns (Ns).

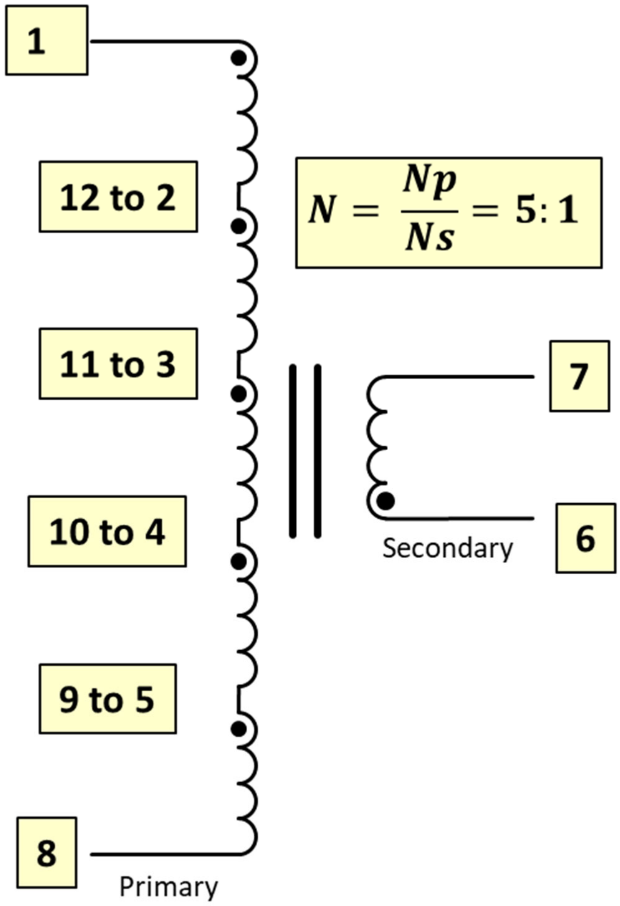


Figure 2: Example of a 5:1 turns ratio transformer connection

Of course, we must always follow the dot convention which marks the start of the winding. For example, you cannot connect your transformer as shown in the following figure:

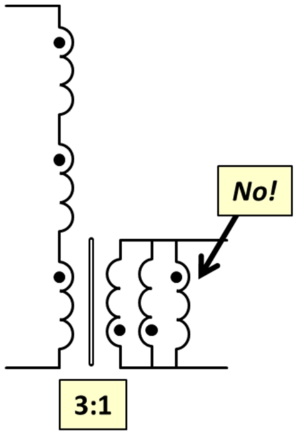


Figure 3: You cannot connect windings with a conflicting dot convention.

This brings us to the first of our six simple rules that we must adhere to in order to be able to use an off-the-shelf transformer as opposed to a custom wound one:

> ***Rule 1: You can connect the windings in different ways for the same turns-ratio, but you must stick to the correct dot convention.***

2.2 How to calculate our rated current for different winding arrangements

Referring to the flex-transformer datasheet shown previously, we can see that our Rated Current Base IR_Base has been defined. For convenience we have reproduced this section of the datasheet:

Electrical Properties:

Properties		Value	Unit
Inductance Base 1)	L_{BASE}	3.4	µH
Turns Ratio	n	1:1:1:1:1:1	
Rated Current Base 2)	$I_{R\ BASE}$	1.91	A
Saturation Current Base 3)	$I_{SAT\ BASE}$	4.18	A
DC Resistance Base 4)	$R_{DC\ BASE}$	30	mΩ
Voltage-µSecond Base 5)	$\int Udt_{Base}$	65.6	µVs
Leakage Inductance Base	$L_{S\ Base}$	0.18	µH
Insulation Test Voltage	V_T	500	V (AC)

Figure 4: Rated Current Base IR_Base of our example transformer

This current figure refers to the maximum RMS current (not Peak!) allowed through just one out of six windings. This is a thermal characteristic. In other words, in the example above, each one of the six windings can have 1.91 A(rms) without dissipating too much heat.

For example, if our transformer had two windings in series on the primary and four windings in parallel on the secondary then our primary RMS rated current, IR_Pri would be 1 x 1.91 A and our secondary RMS rated current IR_Sec would be 4 x 1.91 A. This is shown in the following figure:

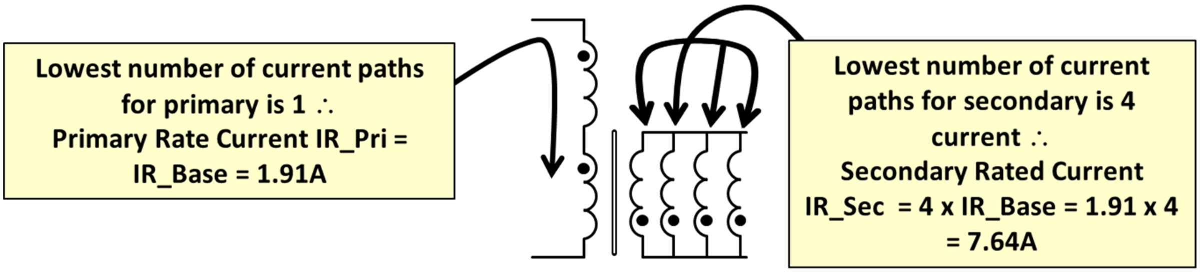


Figure 5: Rated RMS current calculations for series and parallel windings

Please note that paralleled windings on *the same core* are not separate inductances; they are just one inductance with more copper, just like having thicker wire. Therefore, when we parallel our windings in an off-the-shelf transformer, the inductance stays the same but its current rating increases. If we connect our windings in series, then the inductance will indeed increase; we will talk about this later in this application note.

Please also note that we must always use the lowest number of current paths in our primary or secondary for our rated current calculations. In other words, if we have three windings in parallel but they are in series with a single winding, as shown in the following figure, then our rated current is limited by that single winding. This is because IR_Base is a thermal characteristic of the device, and that single winding will get hot.

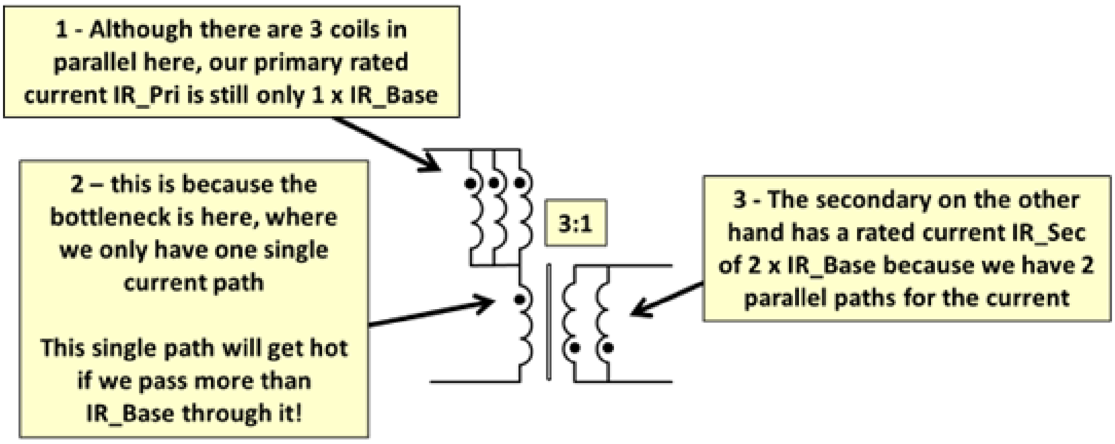


Figure 6: Rated RMS current calculations is based on the minimum number of current paths

This brings to our second important rule:

Rule 2: When you parallel windings, the inductance stays the same, but the rated current is directly proportional to the lowest number complete paralleled current paths.

IR_Pri or IR_Sec = IR_Base x number of parallel paths

You can download our free WE-Flex Transformer selection spreadsheet to quickly make these calculations based on our winding arrangement from www.biricha.com/flex.

2.3 All possible turns ratios that we can have for single output DC-DC power supplies

From the above discussions, it is evident that the best way of paralleling our windings is such that it maximizes our rated current. However, we cannot leave any windings unconnected as this will significantly increase our losses. In other words, even if we need only 5 windings, we still need to somehow connect the 6th one even if it is superfluous leading us to our 3rd rule:

Rule 3: Do not leave windings unconnected as it will increase your losses.

By applying our three rules so far and considering that each transformer has only 6 independent windings we can have 9 winding arrangements which are suitable for single output step-down DC-DC power supplies. We can have 1 version of 5:1, 4:1, 3:1 and 3:2 (1.5:1), 2 versions of 2:1 and 3 versions of 1:1. For completeness, all of these are shown in the following figures:

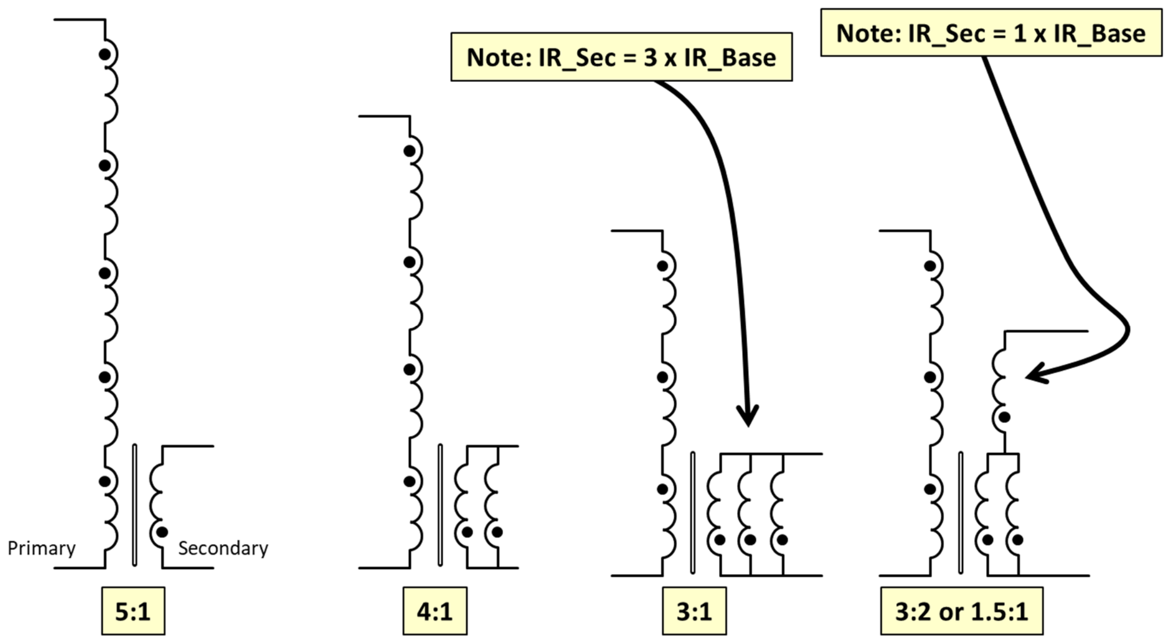


Figure 7: Optimum winding arrangements for turns ratios 5:1, 4:1, 3:1 and 3:2 (1.5:1)

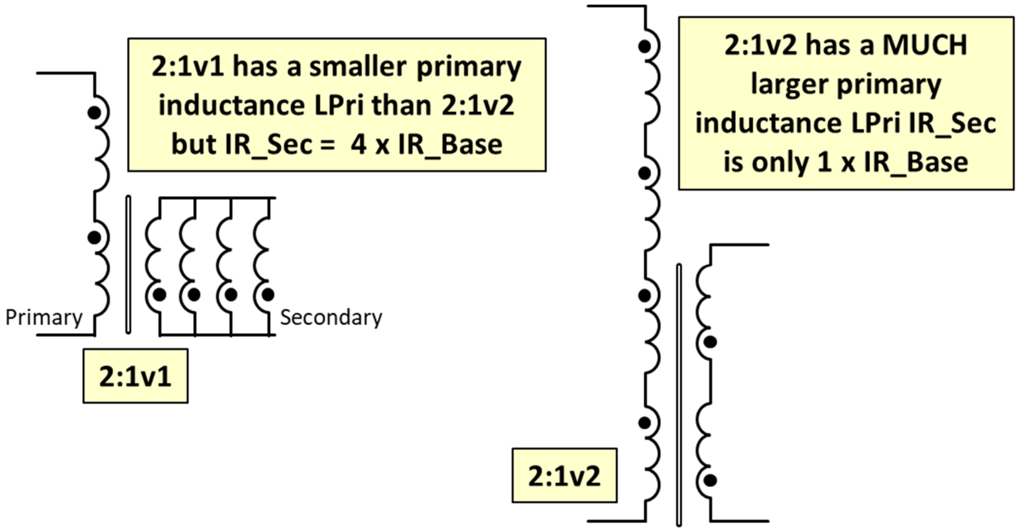


Figure 8: We can have 2 versions of 2:1 turns ratio with different inductances and rated currents

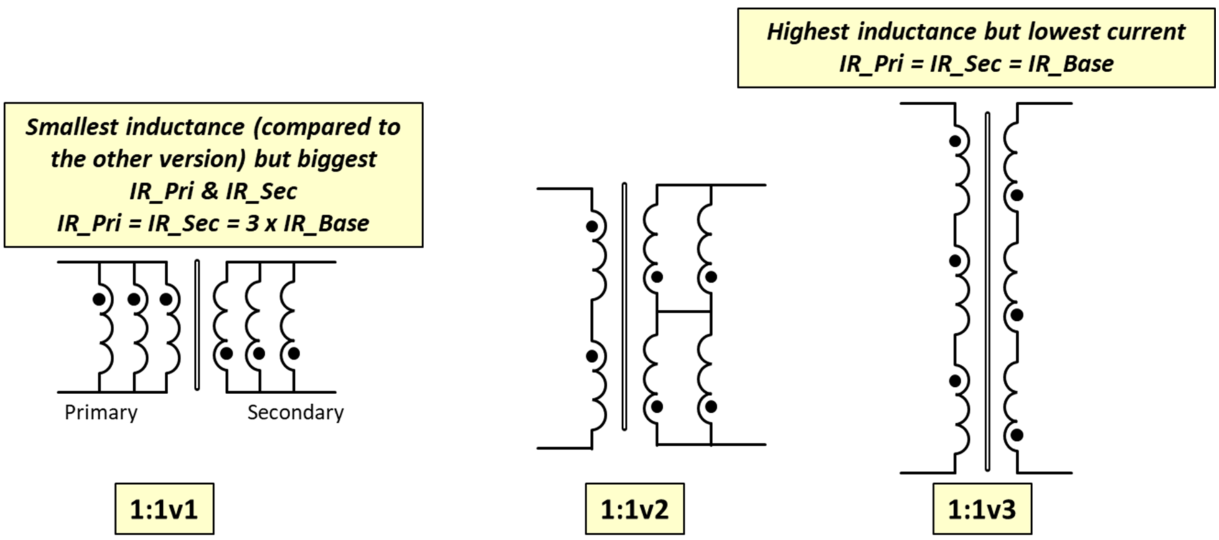


Figure 9: We can have 3 versions of 1:1 turns ratio with different inductances and rated currents

Finally, for step-up applications, we can rotate our transformers, i.e., swap the primary with the secondary in the previously shown figures. Then, we can have 1:5, 1:4, 1:3, 1:1.5, 2 versions of 1:2 and three versions of 1:1.

There are many different ways we can connect these windings, but the above combinations are the most useful for single output applications. In general, we try to parallel the windings in such a way that it will provide us with the maximum number of current paths in either primary or secondary. This is demonstrated in the following figure and leads us to our 4th rule:

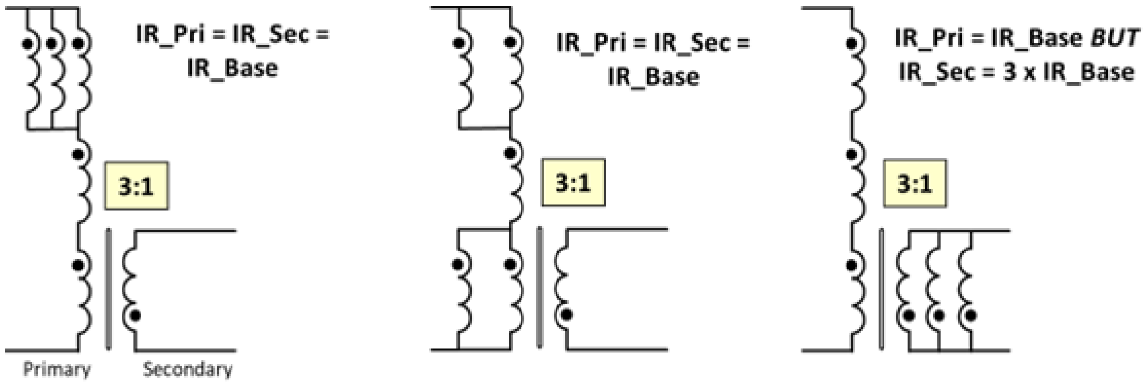


Figure 10: The far-right transformer is the one with the maximum secondary RMS current rating

Rule 4: Parallel the windings to maximize the number of current paths in either primary or secondary. For step down applications maximize the current in the secondary. For step up applications maximize the current in the primary

2.4 How to calculate our primary and secondary inductances with different winding arrangements

You will note from the above diagrams that we are connecting the windings in either series or parallel. As mentioned earlier, connecting windings in parallel will not change their inductances as they are wound on the same core. However, connecting them in series does! In fact, we use this to achieve the inductance that we need for our power supply.

The datasheet of the device specifies the inductance of one winding (L_Base) and we have six identical windings. For convenience this is shown in the following figure:

Electrical Properties:

Properties		Value	Unit
Inductance Base 1)	L_{BASE}	3.4	µH
Turns Ratio	n	1:1:1:1:1:1	
Rated Current Base 2)	$I_{R\ BASE}$	1.91	A
Saturation Current Base 3)	$I_{SAT\ BASE}$	4.18	A
DC Resistance Base 4)	$R_{DC\ BASE}$	30	mΩ
Voltage-µSecond Base 5)	$\int Udt_{Base}$	65.6	µVs
Leakage Inductance Base	$L_{S\ Base}$	0.18	µH
Insulation Test Voltage	V_T	500	V (AC)

Figure 11: Inductance of one winding out of six is specified in the datasheet as L_Base

We know from the equation of the long solenoid that the inductance of a winding, L is proportion to the "square" of the number of turns N‡. This means that if we connect two windings in series, N doubles and therefore our inductance will go up by a factor of 2^2 i.e., a factor of 4. If we connect three windings in series our inductance will go up by 3^2 i.e., factor of 9 and so on. We can therefore present our 5th rule:

Rule 5: Total inductance is given by:
Lpri = L_Base x (Number of primary windings connected in series)^2
Lsec = L_Base x (Number of secondary windings connected in series)^2

By the way of an example, if we were to create a transformer using the transformer of our example datasheet with a turns ratio of 3:1 shown in **Figure *7***, then our primary has three windings in series and our secondary has three windings in parallel. L_Base is 3.4 µH, therefore our primary inductance will be 3.4 µH x 3^2 = 30.6 µH and our secondary will have an inductance of 3.4 µH but three times the rated current. We will provide more numerical examples shortly.

You can download our free WE-Flex Transformer selection spreadsheet to quickly make these calculations based on our winding arrangement from www.biricha.com/flex.

2.5 How to make sure that our transformer does not saturate

Referring to the flex-transformer datasheet shown previously, we can see that our Saturation Current Base ISAT_Base has been defined. As you can see, in our case this is 4.18 A as in the following table which is taken from our datasheet:

Properties		Value	Unit
Inductance Base 1)	L_{BASE}	3.4	µH
Turns Ratio	n	1:1:1:1:1:1	
Rated Current Base 2)	$I_{R\ BASE}$	1.91	A
Saturation Current Base 3)	$I_{SAT\ BASE}$	4.18	A
DC Resistance Base 4)	$R_{DC\ BASE}$	30	mΩ
Voltage-µSecond Base 5)	$\int Udt_{Base}$	65.6	µVs
Leakage Inductance Base	$L_{S\ Base}$	0.18	µH
Insulation Test Voltage	V_T	500	V (AC)

Figure 12: Saturation Current Base is specified in the datasheet as ISAT_Base.

‡ $L = N^2.\mu_0.A/l$ → in our case permeability of free space, μ_0, the area A and length of the solenoid are all constants because all 6 windings are on the same core.

Please note that, unlike "Rated Current" which is a thermal parameter, "Saturation Current" is determined by the maximum flux that our core can handle and therefore, saturation current is determined by our PEAK current and not RMS.

But what happens to ISAT_Base when we connect our windings in series or parallel? Remember from school day physics that our flux is proportional to our Amp-turns[§]. In other words, if our core saturates with 100 A and only 1 turn, we can also saturate with 1 A and 100 turns. We can consider ISAT_Base as the current that will saturate our core when we have the maximum number of turns, i.e., when all six windings are connected in series.

This means that ISAT_Base was measured when we had the maximum number of turns and therefore the minimum amount current[**] (and the same Amp-turns). So, if we connect all six windings in series on the primary, then we have our maximum number of turns and therefore minimum saturation current:

Primary Saturation Current, ISAT_Pri = ISAT_Base

If we have five windings in series on the primary then we have only used 5/6th of our maximum number of turns, therefore we can increase our ISAT_Pri by 6/5; with four windings in series ISAT_Pri goes up by a factor of 6/4 and so on.

To give a numerical example, imagine that we wish to use our flex transformer in a flyback converter. We have worked out that we need a turns ratio of 5:1 and ISAT_Base in datasheet = 4.18 A. Our transformer's primary saturation current limit will be ISAT_Pri = 6/5 x 4.18 A = 5.0 A.

Finally, please note that connecting the windings in parallel will not impact our saturation current as the number of turns stays the same. Therefore, we can now present our 6th and final rule:

Rule 6: Maximum primary saturation current is given by:

$$ISAT\_Pri = \frac{6}{\text{Number of Primary windings in series}} ISAT\_Base$$

The following examples demonstrate the above rule:

[§] Flux ϕ (in Webers) = MMF/S; Where MMF = Magneto-motive Force A·turns and S = Reluctance is in A/Weber

[**] This is for ease of explanation only, in practice it is measured a different way, please consult the datasheet. For our purpose it makes no difference.

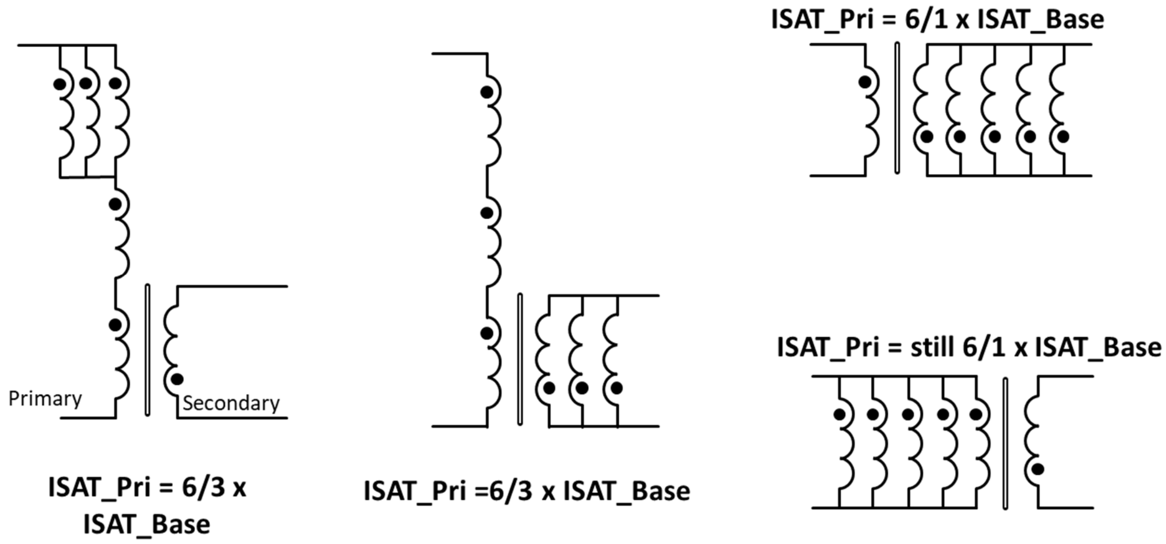


Figure 13: Examples of how to calculate the primary saturation current

This is our final calculation! Again, you can download our free WE-Flex Transformer selection spreadsheet to quickly make these calculations based on our winding arrangement from www.biricha.com/flex.

3 All the Parameters that We Need for Flex Transformer Selection

To select the correct transformer, we need to calculate our:

- Transformer turns ratio, N
- Rated primary RMS current, IR_Pri
- Primary inductance, Lpri
- Rated secondary RMS current, IR_Sec
- Primary saturation current, ISAT_Pri

We then select a transformer that has a higher rating than our calculated ones. Power supply design of course is outside the scope of this short application note and therefore we refer the reader to the numerous excellent books, application notes and design tools that can be found either freely on the internet or available for purchase.

For this application note, we will use Biricha WDS Power Supply Design Software. Biricha WDS will calculate all the parameters for our power supply after which we can use our free WE-Flex Transformer selection spreadsheet to select our transformer.

All attendees to our workshops receive a 1-year free license of Biricha WDS as part of the course fees. An evaluation version is available from: www.biricha.com/wds

WE-Flex Transformer selection spreadsheet is available for free download from www.biricha.com/flex.

Before our full design example let us quickly summarise the rules:

Rule 1: The connection of transformer windings must follow the ‘dot’ notation.

Rule 2: : When you parallel windings, the inductance stays the same, but the rated current is directly proportional to the lowest number complete paralleled current paths:

IR_Pri or IR_Sec = IR_Base x number of parallel paths

Rule 3: Do not leave any unconnected windings – always connect unused windings, normally by paralleling together.

Rule 4: Parallel the windings to maximize the number of current paths in either primary or secondary. For step down applications maximize the current in the secondary. For step up applications maximize the current in the primary.

Rule 5: Total inductance is given by:

Lpri = L_Base x (Number of primary windings connected in series)^2

Lsec = L_Base x (Number of secondary windings connected in series)^2

Rule 6: Maximum primary saturation current is given by:

ISAT_Pri = (6/(Number of Primary windings in series)) × ISAT_Base

4 Step-by-Step Worked Example of a Flyback Converter Using WE-Flex Flex Transformer Selector Tool

For our numerical example we will use an off the shelf WE-Flex transformer to design a low power, continuous conduction mode isolated Flyback converter with the following specifications:

Input Supply	
Maximum	= 52 V
Nominal	= 48 V
Minimum	= 44 V
Output	
Maximum Current	= 1 A
Voltage	= 9 V
Switching Frequency	= 200 kHz

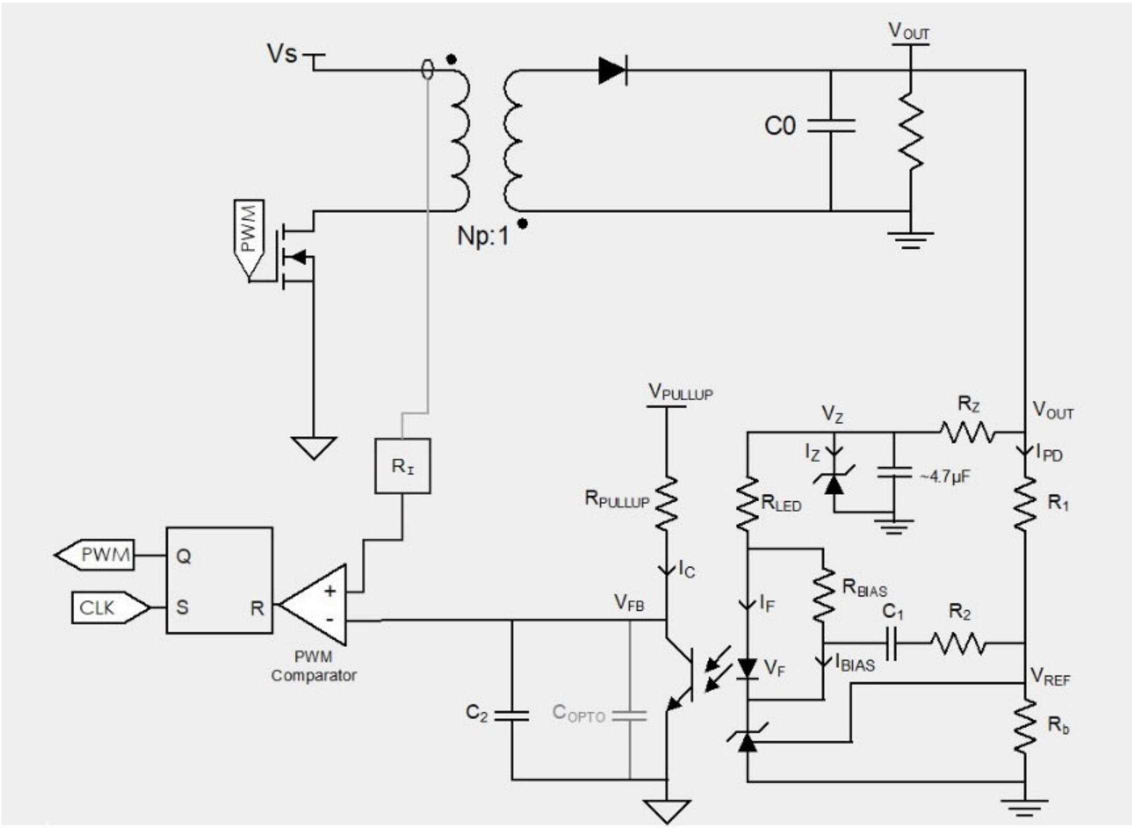


Figure 14: Isolated Flyback converter stage (simplified)

4.1 Step 1: Enter the converter operational parameters in the specification tab of WDS

Complete WDS user guide can be found here: https://www.biricha.com/wds_userguide.html. For completeness we will show the bare minimum needed to select our transformer.

The specification tab of WDS allows us to input these parameters as shown in the following figure; afterwards WDS calculates all that we need in the Transformer tab.

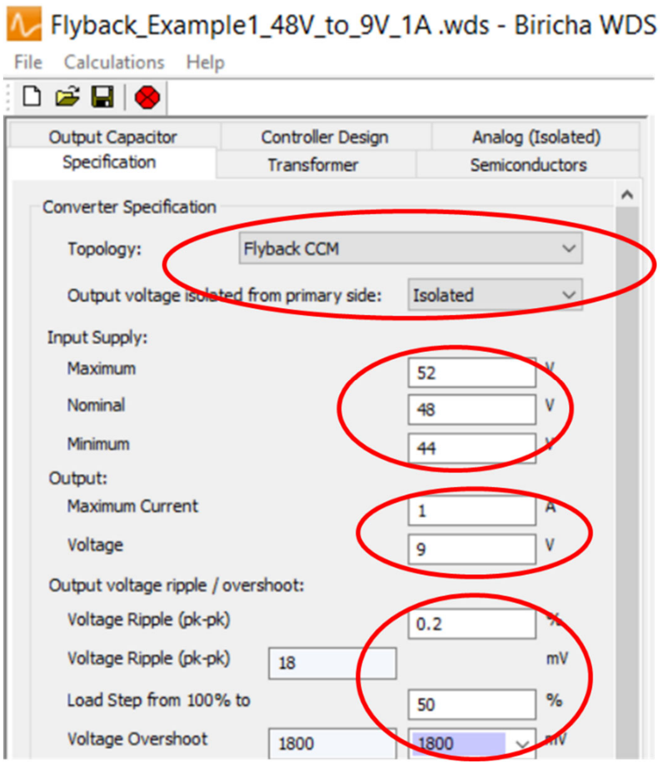


Figure 15: Fill in the Specification tab as shown

You will note that some of the data entry boxes are pre-filled by the WDS Software. These can be overwritten by selecting the parameter and overwriting with the desired value. Parameters on the right-hand column are user adjustable. Once the user has entered the desired specifications in this tab, WDS will calculate the transformer parameters that we need in the Transformer tab.

4.2 Step 2: Obtain the transformer parameters from the Transformer tab

Select the Transformer tab. Based on the parameters of the Specification tab, many of the boxes have already been filled in with optimum values to meet the requirements.

In our example the WDS Software has determined that the recommended Primary turns should be a non-integer number → 4.548, which is clearly not possible. This is shown in the following figure[††]:

[††] Please note that to display turns ratio, WDS uses the Np:1 format, where Np is the primary turns. For example, a turns ratio of 3:2 would be displayed as 1.5:1

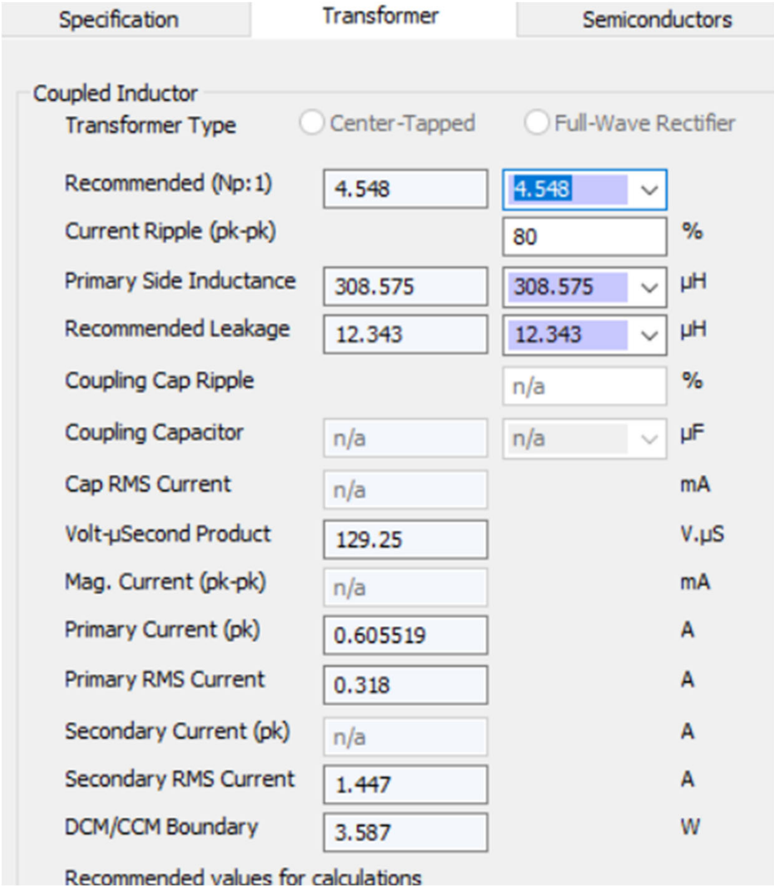


Figure 16: WDS Software Transformer tab with an undesirable turns ratio

This is where the power of the WDS Software comes into its own, as it is possible to continuously iterate the design to achieve the optimum solution. Let us change our desired turns ratio from 4.548 as calculated by WDS to 4:1 so that we can use our Flex range of off-the-shelf transformers. This is shown in the following figure:

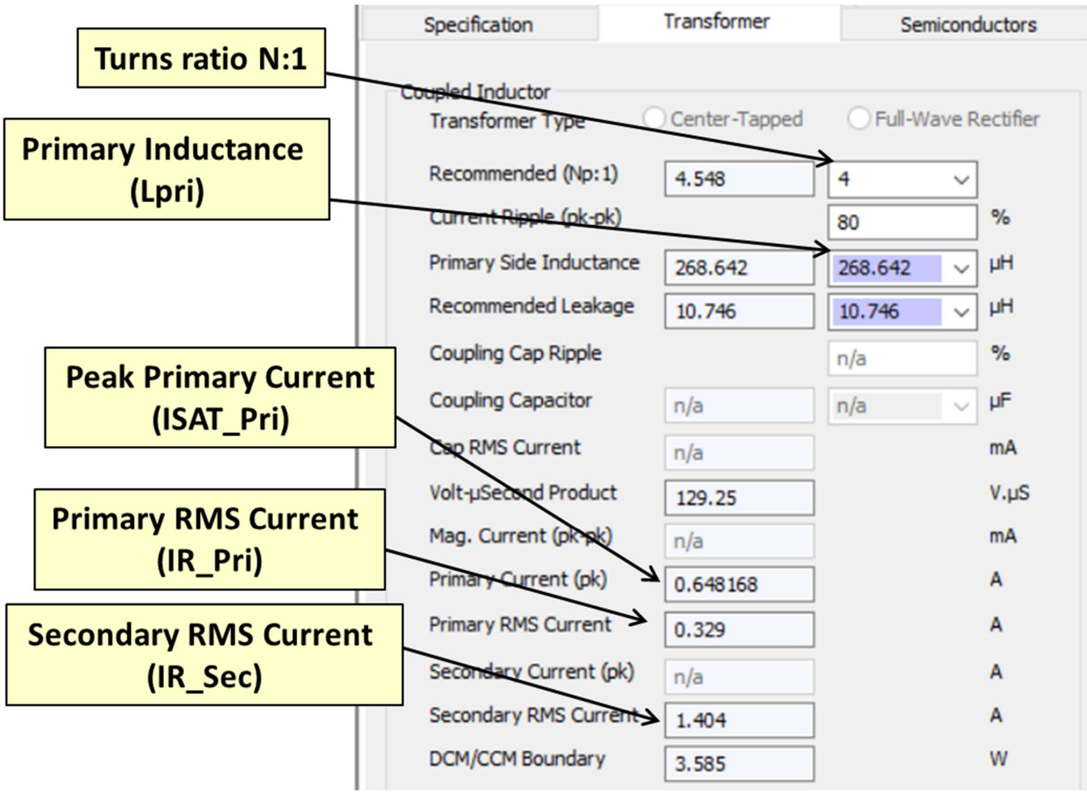


Figure 17: WDS Software Transformer tab with a turns ratio of 4:1

If you compare **Figure 16** with **Figure 17** , you can immediately see that WDS has readjusted all the parameters. Moreover, it has calculated ALL the parameters that we need for our transformer selection as annotated on the figure[‡‡].

We now have all the parameters needed for our transformer selection.

4.3 Step 3: Selecting the best Würth WE-Flex-transformer to meet the design

Open the WE Flex Transformer spreadsheet (you can download from www.biricha.com/flex)

There are a series of sheets at the bottom of the spreadsheet that allow the user to select all pre-defined transformer turns ratios such as Np-Ns = 5-1 (i.e., 5:1), Np-Ns = 4-1 (i.e., 4:1) etc. each of which are pre-populated with turn ratio options to achieve different primary and secondary inductances and current levels similar (but not identical) to the table shown in the following figure.

‡‡ Readers with keen eyes will have noticed that our Magnetising Current (Mag. Current) box is greyed out. This is because we are designing a Flyback converter. For Forward converter type designs, this box will be filled to assist with Flex transformer selection for Forward topologies also.

Lmin	268	uH
Ipeak	0.648	A
Irmsp	0.329	A
Irmss	1.4	A

Order Code	Data-sheet	Lpri(μH)	IR Pri(A)	Primary ISAT(A)	IR Sec(A)
749196228	SPEC	185.6	0.8	1.41	1.6
749196218	SPEC	345.6	0.8	0.72	1.6
749196141	SPEC	136	0.55	1.44	1.1
749196131	SPEC	174.4	0.55	1.095	1.1
749196121	SPEC	235.2	0.55	0.81	1.1
749196111	SPEC	438.4	0.55	0.33	1.1
749196148	SPEC	136	0.5	1.53	1
749196138	SPEC	174.4	0.5	1.2	1
749196128	SPEC	235.2	0.5	0.825	1
749196118	SPEC	438.4	0.5	0.435	1

Figure 18: Biricha WE-Flex-transformer selection spreadsheet set to N=4:1

On the righthand side of the sheet, the winding arrangement has also been given similar to the following figure. It is important to note that all the calculations on the sheet are based on the winding arrangement shown in the spreadsheet.

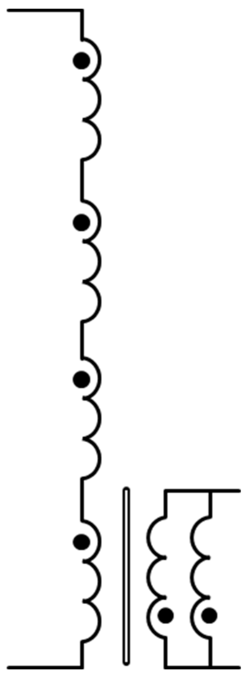


Figure 19: Winding arrangement of the selected 4:1 WE-Flex-transformer

For most single output DC-DC applications you do not need to change anything on these sheets. You only need to select the correct sheet for the correct turns ratio. In our case we have a turns ratio of 4:1. However, if you wish to use a different winding arrangement you need to select the Np-Ns = User_Defined sheet where you will be able to edit the winding setup and turns ratio.

After selecting the turns ratio of 4:1, we need to select the transformer with the correct primary current. Each sheet is already sorted in the correct ascending order to assist quick selection. We can see from **Figure 17** that we need an IR_Pri rating larger than 0.329 A. Cross referencing this against **Figure 18** we can see that all of the transformers have a current rating higher than 0.50 A. However, our choice will soon get more limited as soon as we look for our Primary Inductance.

We can see from WDS that Lpri must be larger than 268.642 µH. By looking at our table, which is sorted by decreasing primary current, meaning the smallest transformer is at the bottom, we look for those that equal or exceed the inductance. Three parts are highlighted in figure 20. These represent the smallest parts that meet the requirements so far.

Lmin	268	uH
Ipeak	0.648	A
Irmsp	0.329	A
Irmss	1.4	A

Order Code	Data-sheet	Lpri(µH)	IR Pri(A)	Primary ISAT(A)	IR Sec(A)
749196228	SPEC	~~185.6~~	0.8	1.41	1.6
749196218	SPEC	345.6	0.8	0.72	1.6
749196141	SPEC	136	0.55	1.44	1.1
749196131	SPEC	174.4	0.55	1.095	1.1
749196121	SPEC	235.2	0.55	0.81	1.1
749196111	SPEC	438.4	0.55	0.33	1.1
749196148	SPEC	136	0.5	1.53	1
749196138	SPEC	174.4	0.5	1.2	1
749196128	SPEC	235.2	0.5	0.825	1
749196118	SPEC	438.4	0.5	0.435	1

Figure 20: All the parts that meet our IR_Pri AND Lpri specifications

Next let us turn our attention to our rated secondary current IR_Sec. Here, from our specification of **Figure 17** we see that we need to have a minimum of 1.404 A. Looking back at **Figure 20**, out of our 3 choices only one (Part number 749196218) meets our IR_Sec requirement.

Finally, we must check to make sure that our transformer will not saturate. We can see from WDS that our power supply's Primary peak current will be 0.648 A. This will have to be less than the primary saturation current of our selected transformer (ISAT_Pri). In our case ISAT_Pri = 0.72 A and therefore this part is suitable. We have found an off-the-shelf transformer for our converter. The datasheet is available by clicking on the SPEC cell of the spreadsheet.

You will see from the figures above that the suitable transformers were already highlighted in green using the conditional formatting function of the spreadsheet. Having carried out the selection process by hand once, we can now use this feature to quickly select the correct transformer.

Referring back to **Figure 18**, all we have to do is to populate Lmin, Ipeak, Primary RMS current (Irmsp) and secondary RMS current (Irmss) based on our calculations and the spreadsheet will automatically highlight the suitable parts in green.

5 What If You Cannot Find a Suitable Flex Transformer?

Please remember that this is an iterative process. If you have some freedom to change perhaps the duty cycle a little, the turns ratio or the switching frequency, then you may be able to find a suitable part. However, if after iterating a few times you cannot find a suitable part, then you have no alternative but to use a custom transformer.

Please note that WDS auto-generates most of the parameters that your magnetics designer needs. You can obtain this from the Summary tab of WDS after which you can send it to your custom transformer designer.

You can contact the custom transformer team at Würth using the following: Customized Transformers & Magnetics (we-online.com)

6 Conclusion

In this application note we have shown how to assess if you can use an off-the-shelf transformer for your DC-DC power supply design quickly and easily.

We have described in detail how the characteristics of a transformer change as you change the winding arrangements, including all the necessary equations, and provided a few rules that you must follow. By following this process, you will be able select the smallest part that meets your application requirements without overheating.

We have given numerous examples of how to use the equations and how to apply the rules with several numerical examples and many diagrams. Finally, we have provided a spreadsheet that contains all the equations and provided a full design example to demonstrate the use of the spreadsheet.

7 Useful Links

The Flex transformer product pages can be found here:

https://www.we-online.com/en/components/products/WE-FLEX

https://www.we-online.com/en/components/products/WE-FLEXHV

https://www.we-online.com/en/components/products/WE-FLEX-PLUS

8 Appendix

Example connection: Connection for EFD 15 & 20 Parts (7491963xx / 7491965xx) only. For other parts please consult the device datasheet. Please see the spreadsheet for latest version.

Important note: copper pour may also be connected to the pins; please take care.

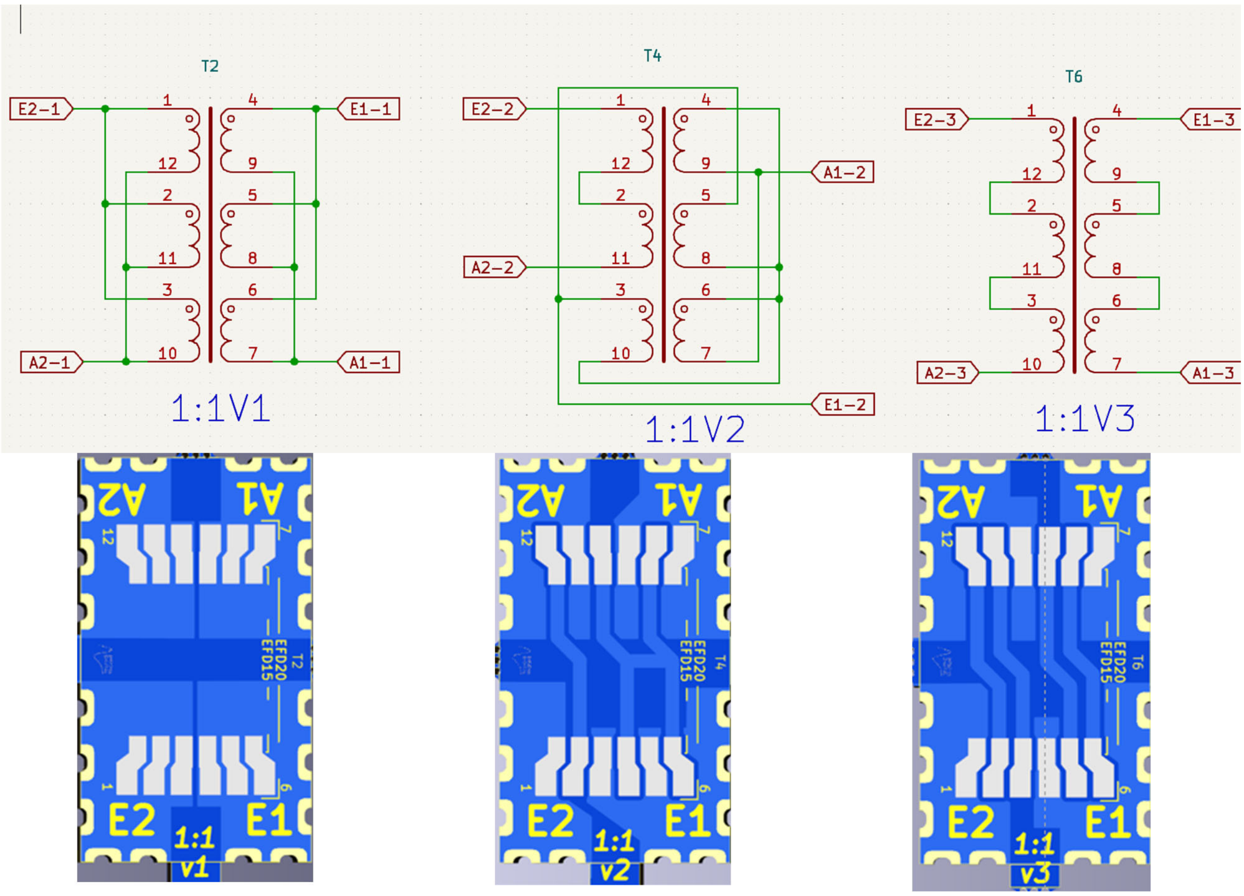


Figure 21: Connections setup for EFD 15 & 20 Parts (7491963xx / 7491965xx) - 1:1

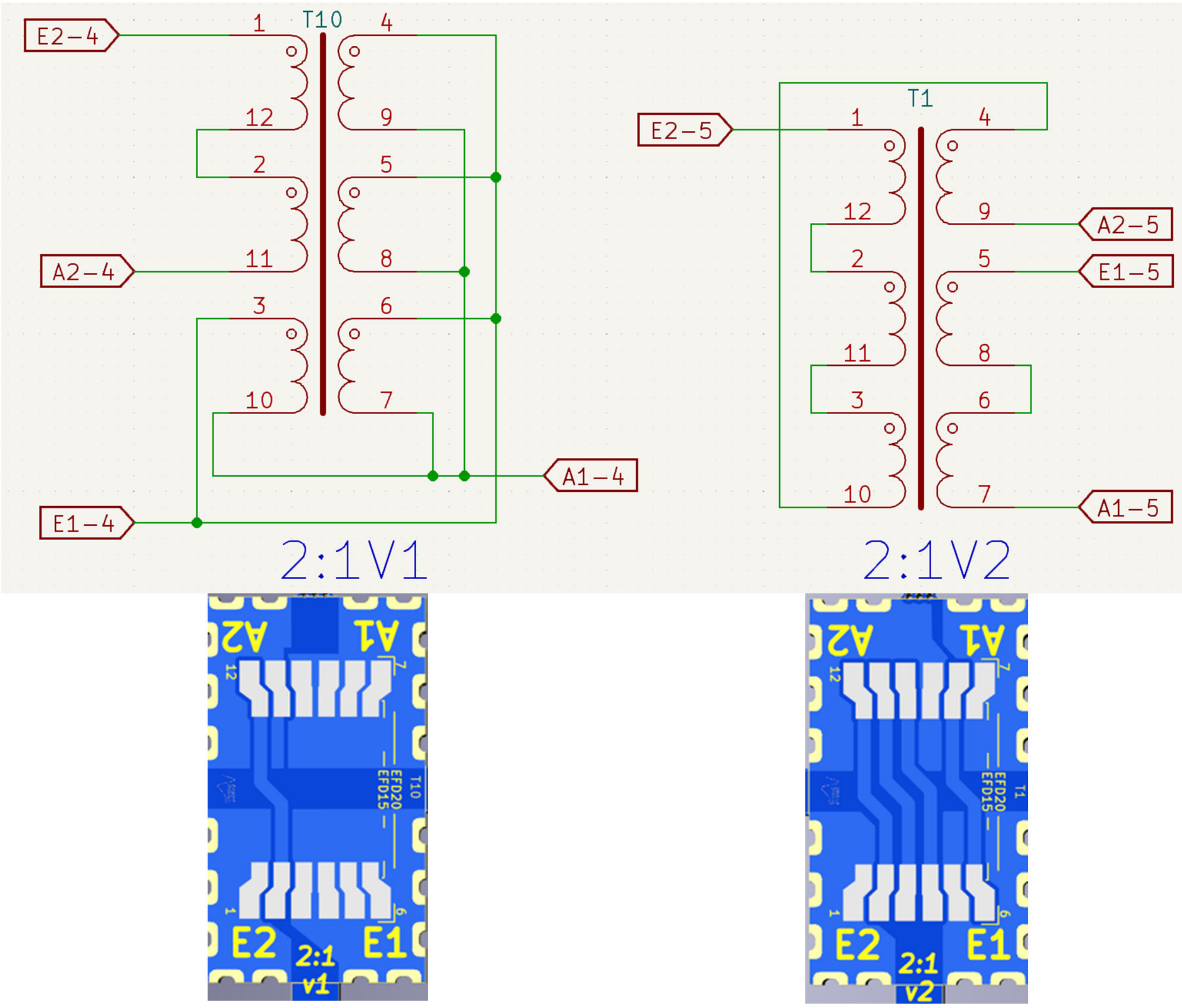


Figure 22: Connections setup for EFD 15 & 20 Parts (7491963xx / 7491965xx) - 2:1

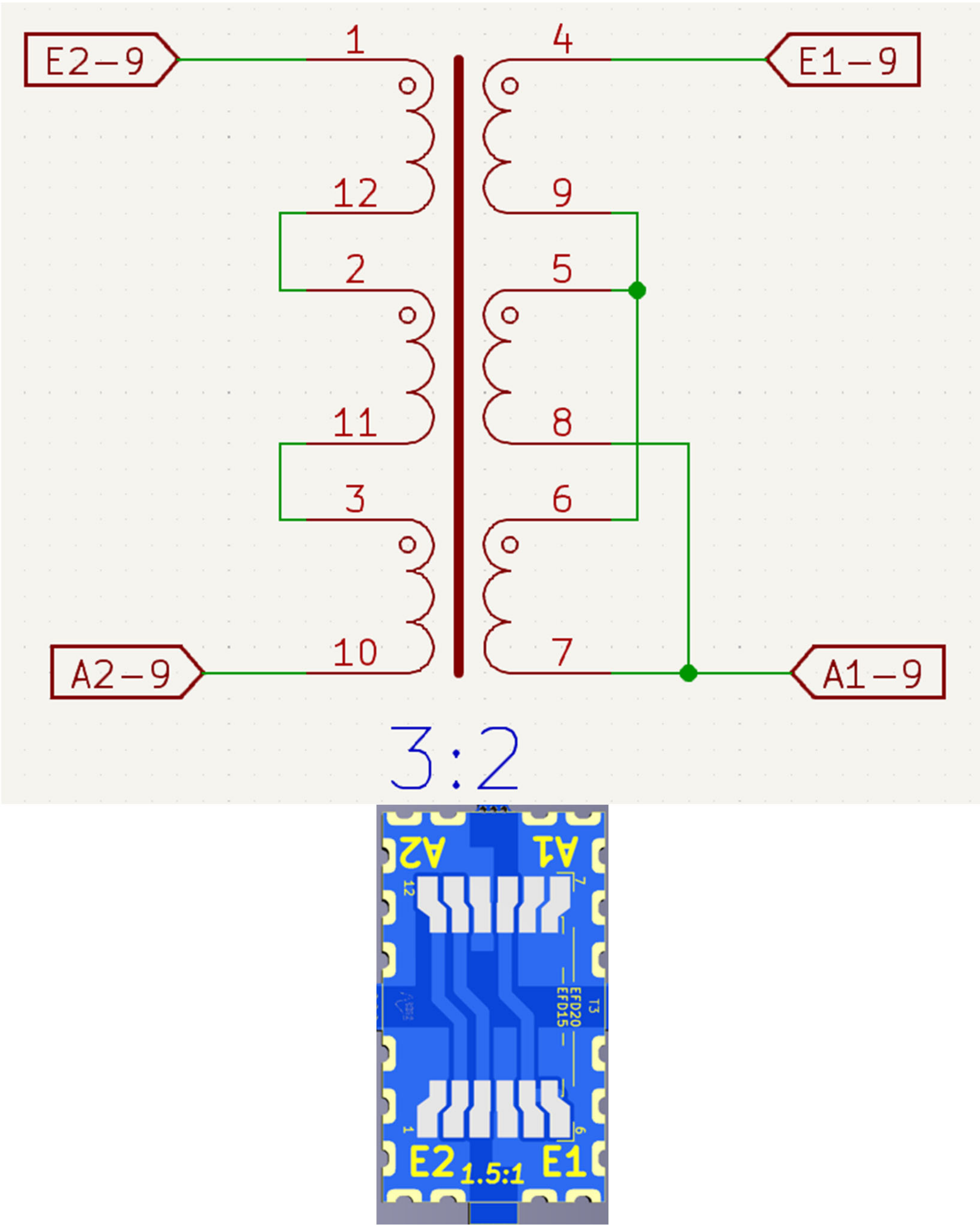


Figure 23: Connections setup for EFD 15 & 20 Parts (7491963xx / 7491965xx) - 3:2

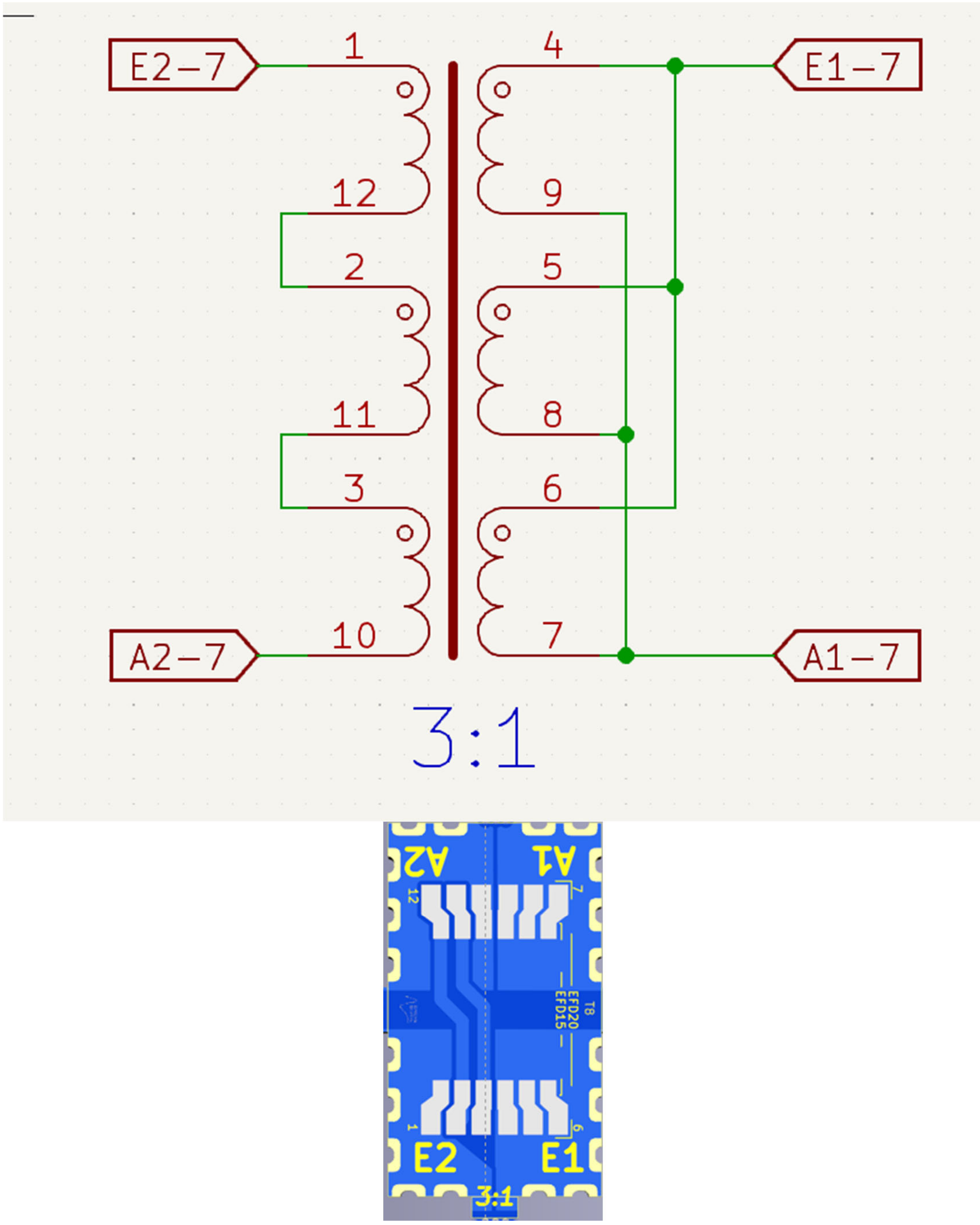


Figure 24: Connections setup for EFD 15 & 20 Parts (7491963xx / 7491965xx) - 3:1

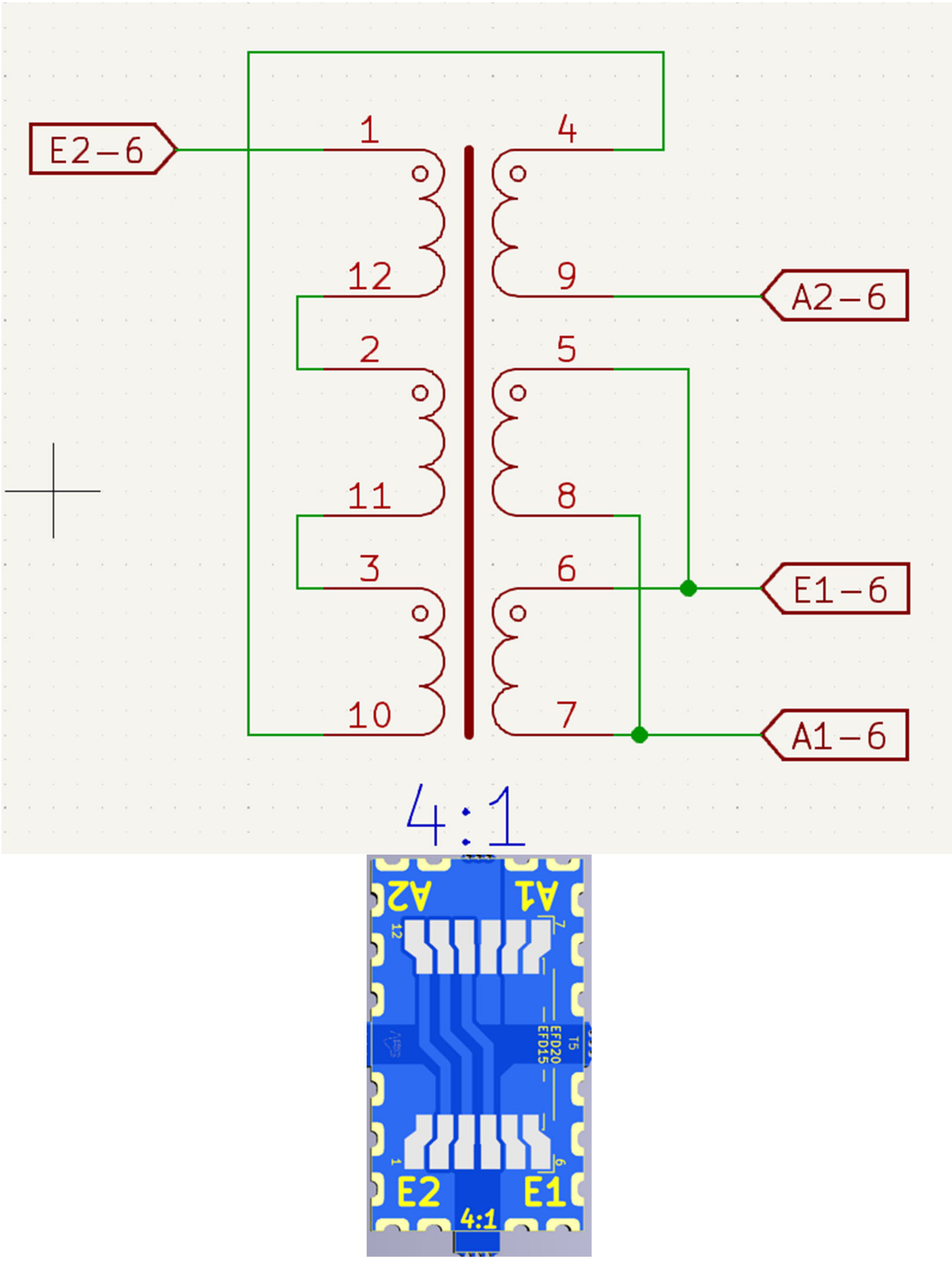


Figure 25: Connections setup for EFD 15 & 20 Parts (7491963xx / 7491965xx) - 4:1

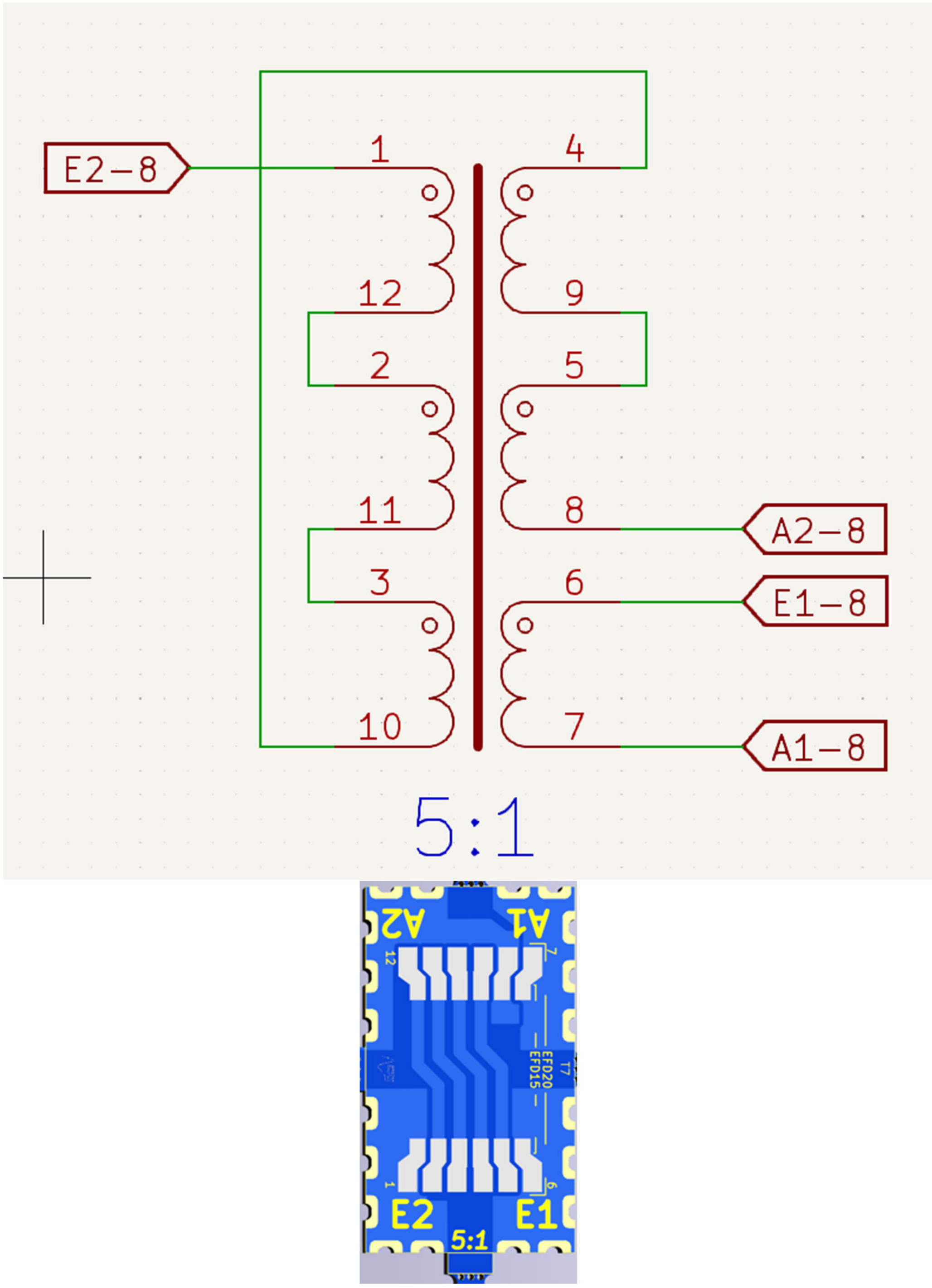


Figure 26: Connections setup for EFD 15 & 20 Parts (7491963xx / 7491965xx) - 5:1

