System Simulation & Design Creation Tool
(Transformer, BOM and IC Parameters)

Single-Stage PFC Flyback Dimmable Constant-Current Controller

ICL8105
.dp digital power 2.0

About this document

Scope and purpose
This document is a guide to using the Infineon ICL8105 system simulation and design creation tool. It enables users to generate transformer, bill of materials (BOM) and IC parameter designs based on the system simulation/calculation output.

The Infineon ICL8105 is a digital controller for high-performance single-stage flyback converter, targeting LED lighting applications.

Intended audience
This document is intended for anyone wishing to evaluate the performance of the Infineon ICL8105 for their own application tests or to use it as a base/reference for a new Infineon ICL8105-based development.
Table of contents

About this document .................................................................................................................. 1

Table of contents ...................................................................................................................... 2

1 Key features ............................................................................................................................... 3
  1.1 System simulation/calculation .............................................................................................. 3
  1.2 System design creation .......................................................................................................... 4
  1.2.1 Auto-generated transformer drawing .............................................................................. 4
  1.2.2 Auto-generated BOM and IC parameters ........................................................................ 5

2 Overview .................................................................................................................................... 6
  2.1 Software and version ............................................................................................................. 6
  2.2 Worksheets ............................................................................................................................ 6
  2.3 Cell protection and legend ..................................................................................................... 6
  2.4 Cell comments ....................................................................................................................... 6
  2.5 Expand/collapse button and status bar ................................................................................. 7
  2.6 Other important notes ............................................................................................................ 7

3 User guide .................................................................................................................................... 8
  3.1 STEP 1 – System simulation and transformer design ............................................................ 8
  3.1.1 Project specification input ............................................................................................... 8
  3.1.2 Transformer electrical spec. input .................................................................................... 9
  3.1.3 Input capacitor and MOSFET parasitic capacitor values input ........................................ 10
  3.1.4 IC timing parameters input ............................................................................................. 11
  3.1.5 Simulation output: Primary average input current curve ............................................... 12
  3.1.6 Non-dimming system switching behavior estimation ....................................................... 14
  3.1.7 Vcc supply source selection and minimum output current estimation .......................... 15
  3.1.8 Maximum output ripple, worst case startup time estimation ......................................... 16
  3.1.9 Primary aux turns ratio and Vcc circuit design calculation ............................................ 17
  3.1.10 Secondary aux turns ratio and IEC60929-compliant 0-10 V circuit design (with CDM10V) .................................................................................................................. 17
  3.1.11 MOSFET Vds_max, output diode Vr_max estimation ....................................................... 18

  3.2 STEP 2 – Transformer construction (optional) ..................................................................... 19
  3.2.1 Core and bobbin selection input ...................................................................................... 19
  3.2.2 Transformer electrical spec. (read-only information) ......................................................... 20
  3.2.3 Skin depth and max wire size (read-only information) .................................................... 21
  3.2.4 Wire type, minimum wire size and insulation tape thickness input ................................. 22
  3.2.5 Maximum flux density and current density input (fine-tuning) ..................................... 22
  3.2.6 Calculation output for number of winding turns ............................................................. 24
  3.2.7 Winding turns ratio check and comparison ..................................................................... 25
  3.2.8 Estimated transformer losses .......................................................................................... 25
  3.2.9 Auto-generated transformer drawing .............................................................................. 26

  3.3 STEP 3 – Finalize system design ......................................................................................... 27
  3.3.1 CS resistor preference input ............................................................................................. 27
  3.3.2 Transformer leakage inductance percentage input .......................................................... 28
  3.3.3 Output bleeder selection input .......................................................................................... 28
  3.3.4 Dim-to-off setting input .................................................................................................... 28
  3.3.5 CS pin-related design calculation ..................................................................................... 29
  3.3.6 ZCD pin-related design calculation .................................................................................. 30
  3.3.7 Primary RCD snubber design calculation ....................................................................... 30
  3.3.8 Output bleeder design calculation .................................................................................... 31
  3.3.9 Auto-generated BOM & IC parameters .......................................................................... 33

Revision History ......................................................................................................................... 36
Key features

1.1 System simulation/calculation

Single-stage PFC Flyback is the most cost-effective topology for lighting applications which have low output power and require isolation. However, system optimization of such a topology is not so straightforward as it mostly requires trade-off with other performance factors. For instance, increasing output capacitance will reduce output current ripple but the trade-off could be a longer startup time at low dimming. Therefore, the system simulation and calculation with this tool is intended to help ICL8105 customers when creating a board design with overall-balanced performance profiles which fit best to their requirements.

Below is a list of system simulation and calculation outputs generated by the tool:

- Normalized primary average current curve simulation for iTHD optimization (see example in Figure 1)
- Controller operating mode (quasi-resonant /discontinuous conduction/ continuous conduction) during non-dimmed operation
- Minimum and maximum on-times during non-dimmed operation
- Minimum and maximum switching frequencies during non-dimmed operation
- Maximum primary peak current, primary rms current, secondary rms current calculations
- Output current estimation at minimum dimming
- Maximum output current ripple estimation
- Maximum startup time estimation
- Maximum MOSFET drain voltage and output diode reverse voltage estimation
- Transformer conduction loss, core loss estimation at minimum and maximum input voltages
- Minimum and maximum value selection for passive components (capacitors & resistors)
- Maximum power loss estimation of selected values of ICL8105 CS pin resistor, ZCD pin resistors and bleeder resistor.

![Simulation Output](image)

**Figure 1** Example of normalized primary average current curve simulation (for iTHD optimization)

*Note: iTHD refers to input current harmonics distortion.*
1.2 System design creation

A full system design with ICL8105 can be achieved easily with this tool as it is highly interactive, providing design tips and detecting any errors or warnings based on user inputs in each step. Upon completion of the 3 main design steps in the tool without any error, the transformer drawing, bill of materials (BOM) and IC parameters are automatically generated.

1.2.1 Auto-generated transformer drawing

Below is a list of transformer drawing outputs generated by the tool:

- Wire size and type of each winding
- Parallel wires used in each layer of winding
- Number of turns and layers for each winding
- Winding layers sequencing based on “sandwich-winding” construction

An example of an auto-generated transformer drawing is shown in Figure 2.

Figure 2 Example of auto-generated transformer drawing
1.2.2 Auto-generated BOM and IC parameters

The ICL8105 is a high-performance digital controller which allows custom parameterization by designers or end users. For instance, the ICL8105 allows changes to non-dimmable output current settings on the same board without any change in hardware. There are a total of 69 IC parameters which can be configured using a GUI called .dpVision.

Based on the design inputs of each step, the tool will recommend the minimum and maximum values of parameters and components dimensioning in order to guide users in selecting appropriate values. After completing the final step with no error detected, BOM and IC parameters will be automatically generated – as shown in Figure 3.

![Figure 3](image-url)

**Figure 3** Example of auto-generated BOM and IC parameters
2 Overview

This section provides general information about the tool.

2.1 Software and version

- Software name: Microsoft Excel
- Software version: 2010 or later
- Excel file format: *.xlsm (macro-enabled Excel sheet)

2.2 Worksheets

There are 3 worksheets in this Excel tool by default.

- The “SCH” worksheet shows a schematic of the auto-generated BOM
- The “Wire” worksheet shows wire table used in the calculation of the auto-generated transformer drawing
- The “Simulation & Design” worksheet is the tool itself with which users can enter design inputs and where the simulation output/system design will be generated

Note: “SCH” and “Wire” worksheets are for reference only. The workbook structure is protected by password.

2.3 Cell protection and legend

The “Simulation & Design” worksheet is protected by password. Users can only enter or modify values in the design input cell, which is light-green-coloured, as shown in Figure 4.

![Figure 4](image)

Cell legend of “Simulation & Design” worksheet

2.4 Cell comments

Comments are available to provide explanations or give guidance on every design input and calculation output. For an example, refer to Figure 5.

![Figure 5](image)

Example of a cell comment explanation
Overview

2.5 Expand/collapse button and status bar

Each design step and generated output can be expanded or collapsed according to the user’s preference. The expand/collapse button is available on the left side (See Figure 6).

Also, the status of each step will be shown in the status bar on the right side (See Figure 6):

- “OK” means that no error or warning has been found.
- “WARNING” means that a warning, but no error has been found. The user should pay attention to the warnings.
- “ERROR” means an inappropriate design input has been found. The user should adjust the design input.

![Figure 6 Expand/collapse button and status bar](image)

2.6 Other important notes

- The Excel macro must be enabled to use the tool when opened and must be saved in *.xlsm format.
- The Excel zoom level setting should be set to a minimum of 90% for proper content display.
- The user can click the “Optimize View” shortcut button for the best view settings (zoom level: 110%, full screen, formula bar disabled). To exit full-screen mode, press the “ESC” key.
- Press the “Enter” key on the design input cell whenever its value is modified. This will ensure that the output results are updated with the calculation based on the new modified value. Depending on the CPU resources, the output results update could take up to 3 seconds.
3 User guide

This section provides a detailed guide on each of the 3 main design steps given below:

- Step 1: System simulation and transformer design
- Step 2: Transformer construction
- Step 3: System design finalization

3.1 STEP 1 – System simulation and transformer design

In this step, the system design outlined below is based on the simulation/calculation output:

- Transformer design (primary inductance, turns ratios of all windings)
- Maximum switching frequency parameter setting
- Output and input OVP-related parameters setting
- Minimum dimming level-related parameters setting
- Input and output capacitor values
- HV pin series resistor value
- Vcc supply source selection
- Voltage regulator circuit design (if necessary)
- Vcc capacitor value
- Secondary 0-10V dimming circuit design (if necessary)
- MOSFET and output diode voltage rating

![Figure 7](image)

3.1.1 Project specification input

The first half of the step 1 main design input (as circled in red in Figure 8) is related to project specification, so is straightforward to fill in.

- \( V_{in} \): AC input voltage range
- \( V_o \): Output load voltage range (LED forward voltage range) at non-dimming
- \( I_{out\_set} \) setting: Non-dimmed \( I_{out} \) setting by IC parameterization
- \( V_{out\_OV} \) setting: Output OVP level setting by IC parameterization (based on typ. value)
- Efficiency: System efficiency estimation
- \( I_{out\_Dimming?} \): Output dimming (No / Primary side Dimming / Secondary 0-10V dimming)
- \( EN\_OVP\_In \) setting: Input OVP enabled/disabled setting by IC parameterization
**V_inOV setting:** Input OVP level setting by IC parameterization (based on typ. value)

If necessary, please refer to the cell comments or to the “Tips and Interactive Info” section for guidance and details.

<table>
<thead>
<tr>
<th>Step 1: System Simulation &amp; Transformer Design</th>
<th>Main Design Input</th>
<th>Tips &amp; Interactive Info</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vin (Vrms)</strong></td>
<td>min</td>
<td>typ</td>
</tr>
<tr>
<td>Vo (V)</td>
<td>90</td>
<td>230</td>
</tr>
<tr>
<td>V_outOV setting (V)</td>
<td>18.0</td>
<td>20.0</td>
</tr>
<tr>
<td>I_out_set setting (A)</td>
<td>46.0</td>
<td>48.4</td>
</tr>
<tr>
<td>Efficiency (%)</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>I_out Dimming?</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>EN_OVP_in setting</td>
<td>Enabled</td>
<td></td>
</tr>
<tr>
<td>V_inOV setting (V)</td>
<td>305.0</td>
<td>328</td>
</tr>
<tr>
<td>L_p (µH)</td>
<td>344.0</td>
<td>344.0</td>
</tr>
<tr>
<td>Cl, Input capacitor (µF)</td>
<td>0.220</td>
<td>0.220</td>
</tr>
<tr>
<td>MOSFET Co(tr) (µF)</td>
<td>68.0</td>
<td>68.0</td>
</tr>
<tr>
<td>f_sw_max setting (kHz)</td>
<td>180.80</td>
<td>180.80</td>
</tr>
<tr>
<td>N_DCM_MOD_GAIN setting</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>L_on_min setting (µs)</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Normalized Ipri_avg simulation #1</td>
<td>Perfect Sine</td>
<td></td>
</tr>
<tr>
<td>Normalized Ipri_avg simulation #2</td>
<td>Vin_typ, Vo_max</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 8**  Project specification (Step 1 Main design input)

### 3.1.2 Transformer electrical spec. input

**Np/Ns selection** refers to the turn ratio of primary main winding turns to secondary main winding turns. Based on quasi-resonant (QR) constant on-time operation, higher Np/Ns values give lower iTHD. However, please take note that MOSFET drain voltage will increase with higher Np/Ns values and it should not exceed the MOSFET drain voltage rating.

**L_p** is the primary main winding inductance of the transformer. Too high a value could force the system to enter CCM protection mode, while too low a value could cause discontinuous conduction mode (DCM) high-switching frequency operation at non-dimming level and high output current at min-dimming level.

Tips are available in the “Tips and Interactive Info” section to help users to find the right Np/Ns and L_p values by dynamically calculating a recommended value range based on project specification input (as shown in the red-highlighted text in **Figure 9**). It is recommended (but not mandatory) to follow the tips given there.
The ICL8105 flyback transformer $L_p$ and $Np/Ns$ selection have to consider many factors relating to performance, such as the power factor, optimized iTHD (Section 3.1.5), optimum switching frequency range (Section 3.1.6), minimum dimming current (Section 3.1.7) and voltage rating of the MOSFET/output diode (Section 3.1.11). By referring to the system simulation/calculation output of these performance factors in this step, the user can find the optimized values for these 2 design inputs.

Of course, it is important to take note that whatever design is finalized in step 1 can only be valid provided the transformer inductance and all numbers of winding turns can fit in the transformer construction with the desired core/bobbin size (decided by the board form factor) and acceptable losses (conduction and core loss). Such transformer construction checks can be carried out easily with step 2 afterwards.

### 3.1.3 Input capacitor and MOSFET parasitic capacitor values input

**Cin, input capacitor** refers to the DC capacitor placed after the bridge rectifier. Higher Cin values give better EMI but worse power factors, and vice versa. However, please take note that different values here could have a slight impact on the minimum dimming level.

**MOSFET Co(tr)** refers to the MOSFET time-related effective output capacitance. It is mainly used to estimate the LC resonant period for more precise QR frequency estimation. As a start, please refer to the cell comment for a list of Co(tr) values based on Infineon MOSFETs.

Tips are available in the “Tips and Interactive Info” section to help the user to get the rough values of these inputs (as shown in the red-highlighted text in Figure 10)
3.1.4 IC timing parameters input

**f_sw_max setting** refers to the controller maximum switching frequency parameterization. As shown in the tips (see red highlighted text in Figure 11), the maximum configurable value is limited according to the maximum operating junction temperature.

The lower f_sw_max setting could give better iTHD in most cases, particularly during high input voltage, because the system will shift more of its operating point over the half-sine wave period from quasi-resonant (QRM) to discontinuous conduction mode (DCM). For more details, please refer to Section 3.1.5 or Figure 13.

**N_DCM_MOD_GAIN setting** refers to the modulation gain of the maximum allowable switching frequency over a half-sine wave period. Its main purpose is to improve light quality when dimming with DCM switching. Furthermore, it also helps to improve the iTHD in most cases. User can adjust the modulation gain as following:

- Select “8” for maximum modulation gain
- Select “16” for medium modulation gain
- Select “32” for minimum modulation gain
- Select “0” for no modulation

*Note: “0” setting option is only available if Iout dimming is set to “No” in step 1 main design input.*

The lower N_DCM_MOD_GAIN setting (except value “0”) could give better iTHD in most cases, particularly during high input voltage, because the system will shift more of its operating point over the half-sine wave period from quasi-resonant (QRM) to discontinuous conduction mode (DCM). For more details, please refer to Section 3.1.5 or Figure 13.

**t_on_min setting** refers to the ICL8105 controller minimum on-time. Please use lower value to achieve a lower dimming level. However, if it is set too low, please beware that it could result to current steps while dimming. The setting range is shown in the tips (see red highlighted text in Figure 11).
3.1.5 Simulation output: Primary average input current curve

For low iTHD, the primary average input current curve should be as close as possible to the shape of a positive half-sine waveform. Based on the step 1 main design input, this tool will simulate the normalized primary average input current curve across a half-sine wave period for iTHD optimization. The simulation output is shown in the blue area on the right side of Figure 12.

The input and output voltage (Vin, Vo) conditions of the current curve simulation are based on checkpoint #1 and #2 in the main design input of step 1, as shown in the red circled box in Figure 12. Users can select any of the following for each simulation checkpoint:

- Perfect Sine
- Vin_min, Vo_max
- Vin_min, Vo_min
- Vin_typ, Vo_max
- Vin_typ, Vo_typ
- Vin_typ, Vo_min
- Vin_max, Vo_max
- Vin_max, Vo_typ
- Vin_max, Vo_min

Note: All checkpoints are based on a non-dimmed condition.

A practical use case example for users would be to choose either of the following options:

- Simultaneously simulate 2 current curves with different Vin, Vout conditions OR
- Simulate 1 current curve while having the other checkpoint set as “Perfect Sine” for reference/comparison.

In the example shown in Figure 12, the user is comparing the primary average input current curve at “Vin_typ, Vo_max” (typical input voltage, maximum output voltage) with the “Perfect Sine” reference.
Figure 12  Normalized primary average current curve simulation checkpoint (for iTHD optimization)

It is possible to improve iTHD especially at high input voltages with the ICL8105 by reducing the \texttt{f\_sw\_max} setting or \texttt{N\_DCM\_MOD\_GAIN} setting as this will increase the DCM operating area across the current curve (see the example in Figure 13 & Figure 14).

However, please take note that there could be an impact on the efficiency if the DCM operating area increases too much (QR operating area reduces too much).
3.1.6 Non-dimming system switching behavior estimation

In step 1 section I, there will be a simulation/calculation of the system switching behavior with non-dimming at the peak of the input voltage sine wave (as shown in Figure 15).

<table>
<thead>
<tr>
<th>Simualtion/Calculation Output</th>
<th>L. Non-dimming System switching behaviour at peak of input voltage sine wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.0</td>
<td>0</td>
</tr>
<tr>
<td>45.0</td>
<td>0.35</td>
</tr>
<tr>
<td>18.0</td>
<td>0.18</td>
</tr>
<tr>
<td>20.0</td>
<td>0.39</td>
</tr>
<tr>
<td>45.0</td>
<td>0.35</td>
</tr>
<tr>
<td>18.0</td>
<td>0.15</td>
</tr>
<tr>
<td>20.0</td>
<td>0.17</td>
</tr>
<tr>
<td>45.0</td>
<td>0.31</td>
</tr>
</tbody>
</table>

**Figure 15** Non-dimming system switching behavior (Step 1 Simulation/calculation output)

t-valley1 refers to the timing between the end of demagnetization and the first QR valley. It is just a rough estimation based on the half-resonant period of L_pri & MOSFET Co(tr). In Section 3.1.3, the suggestion is to enter a MOSFET Co(tr) value based on the MOSFET datasheet – but keep in mind that other parasitics are not yet considered, which could affect the accuracy of this calculation output.
User guide

System Simulation & Design Creation Tool (Transformer, BOM and IC Parameters)

3.1.7 Vcc supply source selection and minimum output current estimation

In step 1 section II, the user has to select a Vcc supply source for the design and check the estimated minimum output current (see red-circled boxes in Figure 17).

There are 2 possible choices, as shown below.

- External: The Vcc supply is not from the flyback AUX winding (e.g. external standby power circuit)
- Flyback AUX: The Vcc supply source is from the flyback AUX winding

If Vcc supply source = “Flyback AUX”, the minimum output current estimation can be lower than compared to Vcc supply source = “External” due to energy being drawn from the transformer via the AUX winding for the Vcc supply.

As shown in Figure 17, there are other design inputs that can be adjusted if needed. These design inputs are placed in this section because they mainly affect the output current at minimum dimming.

EN_ABM setting refers to an IC parameterization input that enables or disables the active burst mode (ABM). If disabled, the controller will only operate in quasi-resonant (QR) mode and discontinuous conduction mode (DCM).

f_sw_min_DCM setting refers to an IC parameterization input that sets the minimum DCM switching frequency. The configurable range is 3 ~ 20 kHz. Lower minimum output current can be achieved with lower f_sw_min_DCM setting but please beware of audible noise if configured to be less than 18 kHz.
**ΔV of Vo_min @ min dim** is a design input that defines the change percentage of Vo_min at minimum dimming. The selectable value is 0%, -5%, -10%, … , -25%. This input is needed because Vo_min (step 1 main design input) is defined for a non-dimmed condition; therefore the LED voltage at minimum dimming should be lower than Vo_min by a certain percentage. For instance, if Vo_min = 18 V and ΔV of Vo_min @ min dim is -10%, it means the voltage of a minimum number of LEDs is approx. 16.2 V at the l_out_dim_min setting.

**I_out_dim_min setting** refers to an IC parameterization input that sets the controller target output current at minimum dimming. The configuration range here is from 10 mA to I_out_set setting. It is highly recommended not to set this value too low to have reasonable output accuracy and startup time (see Est. Worst Case Startup Time calculation in Section 3.1.8).

**Est. System Iout_min** refers to the simulation output of the estimated system output current at the minimum dimming level. This value should be same or close to the I_out_dim_min setting for good output accuracy. If Iout Dimming is set to “No” in step 1 main design input, Est. System Iout_min will show “No Dimming”.

**Dynamic resistance for each series LED @ I_out_set** is the design input that specifies the dynamic resistance of a single LED at I_out_set setting which can be calculated from the I-V curve in the LED datasheet. The multiplication of this value with NLED in series @ Vo_min will be used to simulate Est. Max Iout ripple.

**ΔV of Vo_max @ min dim** is the design input that defines the percentage change of Vo_max at minimum dimming. The selectable value is 0%, -5%, -10%, … , -25%. This input is needed because Vo_max (step 1 main design input) is defined for the non-dimmed condition; therefore the LED voltage at minimum dimming should be lower than Vo_max by a certain percentage. For instance, if Vo_max = 45 V and the selected value is -10%, the voltage of the maximum number of LEDs is approx. 40.5 V at I_out_dim_min setting. The selected value here should be the same as ΔV of Vo_min @ min dim else there will be a warning.

**R_HV setting** refers to the design input of the resistor value connected in series with the ICL8105 HV pin and it is also an IC parameterization value. This value only has an effect on the startup time but not on the output.
ripple. The configurable range is dependent on the main design input. If the user inputs an out-of-range value, an error will pop up along with the configurable range.

**Est. Max Iout Ripple** is the simulation output that estimates the maximum output current peak-to-peak ripple percentage and it is likely at the Vo_min, I_out_set condition.

**Est. Worst Case startup** is the simulation output that estimates the worst case startup time and is likely at the Vin_min, Vo_max, lout_min condition (for non-dimming designs, it is based on I_out_set setting instead).

![Figure 18](image)

**Figure 18**  Max output ripple, worst startup time estimation (Step 1 Simulation/calculation output III)

### 3.1.9 Primary aux turns ratio and Vcc circuit design calculation

In step 1 section IV, the user has to decide on the Vcc cap value and primary auxiliary winding turns ratio, **Na/Ns selection** based on the calculation output of min Vcc cap, min Na/Ns and max Na/Ns (see red-circled boxes in Figure 19).

Please take note that changing Vcc cap value would have an effect on the Est. Worst Case Startup Time in Section 3.1.8.

For the Vcc circuit design, the tool will also check and output whether Pri Aux winding Vcc regulator needed applies in the design based on the step 1 main design input and selected Vcc supply source in section II.

If Pri Aux winding Vcc regulator needed is “Yes”, the tool will calculate the Vcc reg. min input cap value as well.

![Figure 19](image)

**Figure 19**  Primary aux turns ratio and Vcc circuit design (Step 1 Simulation/calculation output IV)

### 3.1.10 Secondary aux turns ratio and IEC60929-compliant 0-10 V circuit design (with CDM10V)

In step 1 section V, the user has to decide on the secondary auxiliary winding turns ratio, **Nsec_aux/Ns selection** based on the calculation output of Min Nsec_aux/Ns and Max Nsec_aux/Ns (see red-circled boxes in Figure 20).

CDM10V is a fully integrated 0-10V dimming interface IC from Infineon which transmits secondary side analog voltage based signals from 0-10V dimmer to primary side, by driving an external opto-coupler with a 5mA current based PWM signal. The secondary auxiliary winding is necessary to supply the operating voltage of CDM10V. For more details about CDM10V, please visit Infineon website: [http://www.infineon.com/cdm10v](http://www.infineon.com/cdm10v)

Therefore, please note that this section is only necessary if the Iout dimming option selected in step 1 main design input is “Secondary side 0-10 V Dimming”.
3.1.11 MOSFET $V_{ds\_max}$, output diode $V_{r\_max}$ estimation

Similar to any flyback transformer design, the maximum MOSFET drain voltage, MOSFET $V_{ds\_max}$ and maximum output diode reverse voltage, Output diode $V_{r\_max}$ have to be calculated. Therefore, in step 1 section VI, the user has to check if these calculation outputs are ok for the component selection (see red-circled box in Figure 21).

The calculation will be based on 2 kinds of conditions, as shown below:

- $V_{in\_max}$, $V_{out\_OV\_Max}$ (Output over-voltage protection at maximum input voltage)
- $V_{in\_OV\_max}$, $V_{out\_max}$ (Input over-voltage protection at maximum output voltage)

Note: If input over-voltage protection, $EN\_OVP\_In$ setting is “disabled”, calculating condition $V_{in\_OV\_max}$ above will be replaced by $V_{in\_max}$ instead.

For output over-voltage protection condition, if $V_{ds\_max}$ is 800–900 V, there will be a warning; if it exceeds 900 V, there will be an error. For input over-voltage protection condition, if $V_{ds\_max}$ exceeds either 800 V or 900 V, there will only be a warning.

As shown in Figure 21, there are other design inputs that can be adjusted if needed. These design inputs are placed in this section because they mainly affect the MOSFET $V_{ds\_max}$ and output diode $V_{r\_max}$.

**MOSFET $V_{ds\_spike}$** refers to the spike voltage (due to leakage inductance) on the MOSFET. As a rule of thumb, it should be at least 45% of $V_{in\_max}$. For example, If $V_{in\_max}$ = 300Vac, the minimum value will be 135 V.

**Output Diode $V_{r\_spike}$** refers to the spike voltage on the output diode. As a rule of thumb, it should be at least 40% of ($V_{reflect\_sec} + V_{out\_OV\_max}$). $V_{reflect\_sec}$ is the secondary winding reflection voltage when flyback MOSFET is switched on. $V_{out\_OV\_max}$ refers to maximum output over-voltage level.

If the MOSFET $V_{ds\_max}$ is too high, the user can either reduce $Np/Ns$ selection (Step 1 main design input) or MOSFET $V_{ds\_spike}$, but there is a risk of exceeding $V_{ds\_max}$ in the actual board test if MOSFET $V_{ds\_spike}$ is set too low.

If the Output Diode $V_{r\_max}$ is too high, the user can either increase $Np/Ns$ selection (Step 1 main design input) or reduce Output Diode $V_{r\_spike}$, but there is a risk of exceeding $V_{r\_max}$ in the actual board test if Output Diode $V_{r\_spike}$ is set too low.
3.2  STEP 2 – Transformer construction (optional)

In step 2, the user can construct the transformer with suitable wires, core and bobbin for the board design. Upon completion without error in both step 1 and step 2, the transformer drawing is auto-generated.

However, step 2 is optional and can be skipped if not needed, which means that the user can still possibly proceed to complete step 3 for BOM and IC parameters generation despite an error/warning in step 2.

3.2.1 Core and bobbin selection input

Based on the Bobbin Isolation Type (Functional/Reinforced) and Bobbin Mounting Type (THT/SMD) design input by the user, the Core Bobbin Selection dropdown box will be updated and a list of suitable cores and bobbins will be shown (see Figure 23). THT and SMD refer to through-hole and surface mount, respectively.

Users can check the core and bobbin properties of the selection, as circled in red in Figure 24.

- Bobbin height, width, length
- Bobbin window, depth, perimeter
- Core effective cross sectional area, \(A_e\) and core volume
- Primary margin tape

---

**Figure 22**  STEP 2 – Transformer construction (optional)

**Figure 23**  Core and bobbin selection (Step 2 Main design input)

**Figure 24**  Selected core and bobbin properties display
Alternatively, users can define the core and bobbin properties by selecting “Others” in Core Bobbin Selection if the desired part is not in the list. A small table will appear on the right (circled in red in Figure 25), which allows the user to enter self-defined property values. There will be errors beside the table at first but once the table is filled up, these errors will disappear (as shown in Figure 26).

![Figure 25](image.png)

**Figure 25**  Self-defined core and bobbin properties by selecting “Others”

![Figure 26](image.png)

**Figure 26**  Example of inserting values of self-defined core and bobbin properties

Note: The user is not required to enter the bobbin height, width and length if “Others” is selected because these dimensions will only affect the board form factor but not the transformer winding construction itself.

### 3.2.2 Transformer electrical spec. (read-only information)

Apart from primary inductance and all turn ratios, the following step 1 calculation output will be passed to the step 2 design input (as circled in red box of Figure 27) for transformer construction calculation:

- **Ipri_pk_max**: Maximum primary peak current  
  \( \text{Vin_min, Pout_max} \)
- **Irms_pri_max**: Maximum primary rms current  
  \( \text{Vin_min, Pout_max} \)
- **Irms_sec_max**: Maximum secondary rms current  
  \( \text{Vin_min, Pout_max} \)
- **Max average switching freq**: Maximum average switching frequency  
  \( \text{Vin_max, Pout_max} \)

Users cannot modify these values because they are read-only information in step 2. Therefore, it is very important to complete step 1 with no errors before proceeding to step 2.
3.2.3 Skin depth and max wire size (read-only information)

AC electric current flows mainly at the "skin" of the conductor, between the outer surface and a level called the skin depth. Based on the average maximum switching frequency (at Vin_max, Pout_max condition), the skin depth will be calculated based on copper material at 100 °C.

This tool will then select the maximum wire size (AWG) based on the calculated skin depth. This is to avoid selecting wires with a high skin effect. This max wire size (AWG) is applied to the primary wire and TIW-type secondary wire while the max wire size for the TEX-E type secondary wire will also be shown in the “Tips & Interactive Info”. Please refer to Section 3.2.4 for details about the wire type.

The skin depth and max wire size information is shown in the red box in Figure 28.

**Figure 27** Transformer electrical spec. (read-only information in Step 2)

**Figure 28** Skin depth and maximum wire size (read-only information of Step 2)
3.2.4 Wire type, minimum wire size and insulation tape thickness input

The Primary wire type is fixed as “MW Grade 1”, which means a magnet wire single insulation wire. 2 types of triple insulation wire can be selected for Secondary wire types:

- TIW (more common wire type, but the wire diameter is generally larger than TEX-E)
- TEX-E (preferred wire type if available because the wire diameter is generally smaller than TIW)

There is generally a limitation on using overly thin wire in transformer manufacturing. Therefore, the Primary Wire minimum size and Secondary Wire minimum size have to be specified. Users are recommended to follow the tips suggesting AWG34 for primary wire and AWG38 for secondary wire (as shown in Figure 29) or else it is also possible to select other wire size, according to their transformer supplier requirement.

Insulation tape is typically applied after each winding layer so it is necessary to specify the insulation tape thickness. Please follow the recommended value of 0.03 mm. Otherwise, the user can also specify the desired value within the range of 0.0254 ~ 0.06mm.

![Figure 29 Wire type, min. wire size and tape thickness (Step 2 Main design input)](image)

3.2.5 Maximum flux density and current density input (fine-tuning)

Maximum Flux Density input is required to calculate the number of turns needed for each winding. More turns are needed if the Maximum Flux Density input is lower, and vice-versa. The recommended value will be between 0.27 ~ 0.33 teslas. Maximum value is 0.35 teslas. These design inputs are shown in the red box in Figure 30.

Based on the Pri Winding Current Density and Sec Winding Current Density input, this tool will find the best combination of the following outputs from the wire tables (as shown in the “Wire” worksheet) that fits the calculated numbers of turns of each winding with the minimum bobbin depth usage.

- Wire Size
- Parallel Wire Number (total)
- Parallel Wire Number (for each layer)

Note: This wire information is shown in the red box in Figure 30.
In general, the depth usage or winding thickness will be higher if the current density input is lower and vice versa. As a rule of thumb, it is recommended to select a value < 7 A/mm². To start, the user can set the following as an initial check to see if the selected core/bobbin could fit the design.

- Maximum flux density = 0.35 teslas
- Both primary winding current density and secondary winding current density = 7 A/mm²

If an error shows that the build is too thick, the user should consider selecting a larger core/bobbin or reduce L_p in step 1.

If the initial check is ok, the user can fine-tune these 3 design inputs to further optimize the transformer design based on the following guide information generated by the tool (See red-circled parts a, b, c and d in Figure 31)

- **Bobbin Depth and Window Usage Percentage**
  
  For each primary and secondary winding, the bobbin depth and window usage percentage will be calculated (see red-circled part a in Figure 31). It is suggested to maximize window usage (best case up to 100%).

- **Manufacturability Check**
  
  Based on the total wire and tape layers of each winding with corresponding wire and tape thickness, the total build thickness is calculated. If it is less than the bobbin depth, the manufacturability check shows “OK”, else “NG” (see red-circled part b in Figure 31). Please note that this manufacturability check is just based on theoretical calculation, so it is important to confirm the manufacturability in actual production environment with the transformer supplier based on the auto-generated transformer drawing (see section 3.2.9)
**Build Information**

If the manufacturability check is “OK”, the unused depth (in mm and percentage of bobbin depth) will be shown (see red-circled part c in Figure 31). If the manufacturability check is “NG”, for example, if the build thickness is 5 mm but the bobbin depth is 4 mm, the build information will show “ERROR! Build too thick (120% of Bobbin Depth used)”. For an optimized transformer design, the unused bobbin depth should not be too high.

**Conduction and Core Loss Percentage**

The flux density and current density input fine-tuning should minimize the conduction and core losses of part d in Figure 31. This calculation does not include losses from other main components like the MOSFET and diode.

---

### Figure 31  Guide information for fine-tuning of maximum flux density and current density

3.2.6  **Calculation output for number of winding turns**

In step 2 section I (see Figure 32), the number of winding turns for \( N_p \) is calculated using the equation below:

\[
N_p = \frac{L_p \ast Ipri_pk_max}{Ae \ast B_{max}}
\]

Where

- \( L_p \): Primary inductance
- \( Ipri_pk_max \): Maximum primary peak current
- \( B_{max} \): Maximum flux density

---

### Table 3.2.6 Calculation Output for Number of Winding Turns

<table>
<thead>
<tr>
<th>Calculation Output</th>
<th>Manufacturer Check OK</th>
<th>Build (mm): 3.132</th>
<th>Unused depth: 0.050mm/mil</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. Winding turns number calculation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( N_p ) (Turns)</td>
<td>58</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

---

**Diagram**

- a: Pri winding thick = 0.050mm (Depth usage = 25%)
- b: Sec winding thick = 1.560mm (Depth usage = 50%)
- c: Percent Use %
- d: Conduction Loss / Core Loss (%)
Ae: Effective core area

The absolute number of winding turns for \( Ns, Na \) and \( Nsec\_aux \) will then be calculated based on the \( Np/Ns, Na/Ns \) and \( Nsec\_aux/Ns \) selection from step 1.

**Figure 32  Calculation of number of winding turns (Step 2 Calculation output I)**

### 3.2.7 Winding turns ratio check and comparison

Despite using the step 1 design input turns ratio to calculate the absolute number of winding turns for \( Ns, Na \) and \( Nsec\_aux \) in the calculation output section I, the ratios of turns (based on the step 2 transformer construction) might vary due to limited ratio combinations. Therefore, the ratios of winding turns can be checked and compared in calculation output section II, as shown in **Figure 33**.

**Figure 33  Check and compare ratio of winding turns (Step 2 Calculation output II)**

### 3.2.8 Estimated transformer losses

The transformer losses are calculated for the following two conditions:

- \( \text{Vin}_\text{min}, \text{Pout}_\text{max} \)  (calculation output section III in **Figure 34**)
- \( \text{Vin}_\text{max}, \text{Pout}_\text{max} \)  (calculation output section IV in **Figure 34**)

**Figure 34  Estimated transformer losses (Step 2 Calculation output sections III & IV)**

The following calculated outputs are generated for each section or condition.

- Primary winding estimated conduction loss

\[
L_{pri\_rms}^2 \times Rd_{pri}(100^\circ C) \quad \text{[unit: W]}
\]

\[
Rd_{pri}(100^\circ C) = \frac{\rho_{\text{copper}(100^\circ C)} \times l_{pri}}{N_{\text{total(pri)}} \times A_{\text{wire(pri)}}} \quad \text{[unit: } \Omega\text{]}
\]

where:

\[
\rho_{\text{copper}(100^\circ C)} = 2.22 \times 10^{-8} \quad \text{[unit: } \Omega\text{m}]\]

\[
l_{pri} = Np \times \{\text{bobbin perimeter} + \text{(bobbin depth} \times 4)\} \quad \text{[unit: m]}\]
System Simulation & Design Creation Tool (Transformer, BOM and IC Parameters)

User guide

\[ N_{\text{total pri}} = \text{number of primary parallel wires in total} \]
\[ A_{\text{wire pri}} = \text{conductor cross section area of each primary parallel wire} \text{ [unit: m}^2\text{]} \]

Secondary winding estimated conduction loss
\[ = \text{\(I_{\text{sec}}\text{rms}^2 \times R_{\text{dc sec}}(100°C)\)} \text{ [unit: W]} \]
\[ R_{\text{dc sec}}(100°C) = \frac{\rho_{\text{copper}}(100°C) \times l_{\text{sec}}}{N_{\text{total sec}} \times A_{\text{wire sec}}} \text{ [unit: } \Omega\text{]} \]
Where:
\[ \rho_{\text{copper}}(100°C) = 2.22 \times 10^{-8} \text{ [unit: } \Omega\text{m}] \]
\[ l_{\text{sec}} = \text{Ns} \times \{\text{bobbin perimeter} + (\text{bobbin depth} \times 4)\} \text{ [unit: m]} \]
\[ N_{\text{total sec}} = \text{number of secondary parallel wires in total} \]
\[ A_{\text{wire sec}} = \text{conductor cross section area of each secondary parallel wire} \text{ [unit: m}^2\text{]} \]

Estimated total conduction loss
\[ = \text{\(I_{\text{pri}}\text{rms}^2 \times R_{\text{dc pri}}(100°C)\)} + \text{\(I_{\text{sec}}\text{rms}^2 \times R_{\text{dc sec}}(100°C)\)} \text{ [unit: W]} \]

Estimated total core loss
\[ = P_{\text{c}v100°C,\text{PC44}} \times \text{core volume} \text{ [unit: W]} \]
\[ P_{\text{c}v100°C,\text{PC44}} = \frac{1}{\pi} \times \int_{\theta=0}^{\pi} 6.674 \times 10^{-7} \times f_{\text{sw}}(\theta)^{1.412} \times B(\theta)^{2.567} \ d\theta \]
where:
\[ f_{\text{sw}}(\theta) = \text{switching frequency of AC input sine phase angle} \]
\[ B(\theta) = \text{flux density of AC input sine phase angle} \]

Total loss percentage over \(P_{\text{out max}}\)
\[ = \frac{\text{Est. conduction loss + core loss}}{P_{\text{out max}}} \times 100% \]

3.2.9 Auto-generated transformer drawing

If no error is found in both steps 1 and 2, a transformer drawing will be generated, as shown in Figure 35. Please note that it is still necessary for the user to input the transformer pin assignment (see the light-green cells in Figure 35) based on the board schematic and PCB layout design to finalize the transformer drawing.
3.3 **STEP 3 – Finalize system design**

In this last step, the user has to finalize the system design as outlined below:

- CS shunt resistor selection and maximum power loss estimation
- ZCD series and shunt resistor selection and maximum power loss estimation
- Primary RCD snubber design
- Output bleeder (active/passive) design

Upon completion of steps 1 and 3 without error, the BOM and IC parameters are auto-generated, as shown in Figure 36.

### 3.3.1 **CS resistor preference input**

The **CS Resistor Preference** allows users to select either one of the options shown below:

- **Higher output accuracy**
  
  This selection allows higher resolution of the primary peak current measurement but higher power dissipation with a higher resistance value.

- **Lower power dissipation**
  
  This selection allows lower power dissipation but lower resolution of the primary peak current measurement with a lower resistance value.
### 3.3.2 Transformer leakage inductance percentage input

The **Transformer Leakage Inductance** (in percentage) over primary inductance needs to be input by the user for RCD snubber design calculation (see **Section 3.3.7**). The value of a typical design would be around 1%. The user can select a value of 0.5%, 1.0%, 1.5%, 2.0%, 2.5% or 3.0%.

### 3.3.3 Output bleeder selection input

Selection of an output bleeder is mandatory for flyback primary side control to ensure the output will not be over-charged under no-load condition (e.g. LED not connected). There are two options available:

- **Active (auto-discharge circuit)**

  An output will only be discharged by the bleeder resistor when transformer switching is stopped (e.g. during AC-off or dim-to-off). The component count is higher but there is no drop in efficiency and fast discharge occurs with low bleeder resistances.

- **Passive (dummy resistor)**

  An output will be always discharged by a dummy resistor connected in parallel with output LEDs. The component count is the lowest but there is a slight drop in efficiency and slow discharge with high bleeder resistances.

### 3.3.4 Dim-to-off setting input

The ICL8105 allows dim-to-off operation but it requires an active voltage source to exit from dim-to-off.
The **EN_DIM_TO_OFF setting** allows users to enable/disable such operations but it is strongly recommended to enable it only when the application design is for primary side dimming and an external Vcc supply. Therefore, step 3 will show a warning if this setting is enabled but the step 1 design inputs (**Iout Dimming** and **Vcc supply source**) do not meet these two requirements.

![Figure 40 Dim-to-off setting (Step 3 Main design input)](image)

### 3.3.5 CS pin-related design calculation

In step 3 section I, the user has to decide on an **R_CS Selection** or CS shunt resistor selection (see red-circled part in **Figure 41**). The selection value should be between the calculation outputs for **Min R_CS** and **Max R_CS**.

**I_OCP1** refers to transformer primary winding current which triggers input overcurrent protection level 1. It is automatically set to the maximum of **Ipri_pk** (from Step 1 calculation output section I).

If **CS Resistor Preference** is set to “higher output accuracy”,

\[
\text{Min } R_{\text{CS}} = \frac{0.98}{I_{\text{OCP1}}} \quad \text{Max } R_{\text{CS}} = \frac{1.08}{I_{\text{OCP1}}} \quad \text{[unit: } \Omega \text{]}
\]

\[
V_{\text{OCP1}} = R_{\text{CS Selection}} \times I_{\text{OCP1}} \quad \text{[unit: V]}
\]

\[
V_{\text{OCP2}} = 1.6 \quad \text{[unit: V]}
\]

If **CS Resistor Preference** is set to “lower power dissipation”,

\[
\text{Min } R_{\text{CS}} = \frac{0.49}{I_{\text{OCP1}}} \quad \text{Max } R_{\text{CS}} = \frac{0.54}{I_{\text{OCP1}}} \quad \text{[unit: } \Omega \text{]}
\]

\[
V_{\text{OCP1}} = R_{\text{CS Selection}} \times I_{\text{OCP1}} \quad \text{[unit: V]}
\]

\[
V_{\text{OCP2}} = 0.8 \quad \text{[unit: V]}
\]

**Note:** **V_OCP1** refers to the CS resistor voltage threshold setting for input overcurrent protection level 1. **V_OCP2** refers to the CS resistor voltage threshold setting for input overcurrent protection level 2.

**R_CS Selection Max Power Loss** refers to the maximum power loss calculation based on the R_CS Selection input by the user. The equation is as shown below:

\[
P_{\text{loss, max}(R_{\text{CS}})} = I_{\text{pri rms}}^2 \times R_{\text{CS Selection}} \quad \text{[unit: W]}
\]
3.3.6 ZCD pin-related design calculation

In step 3 section II, the user has to decide on the R_ZCD_1 selection and R_ZCD_2 selection (see the red-circled part in Figure 42).

R_ZCD_1 Selection should be between the calculation outputs for Min R_ZCD_1 and Max R_ZCD_1, which are based on the equations below:

$$\text{Min } R_{ZCD,1} = \frac{(V_{in,max} \times 107\%) \times \sqrt{2} \times N_a}{3 \times N_p} - 0.22 \text{ [unit: kΩ]}$$

$$\text{Max } R_{ZCD,1} = \frac{(V_{in,max} \times 107\%) \times \sqrt{2} \times N_a}{1.9 \times N_p} - 0.15 \text{ [unit: kΩ]}$$

Note: The highest value for Max R_{ZCD,1} is 100 kΩ. If input OVP is enabled, Vin_max in the equations will be replaced by V_inOV typical value.

R_ZCD_2 Selection should be between the calculation outputs for Min R_ZCD_2 and Max R_ZCD_2, which are based on the equations below:

$$\text{Min } R_{ZCD,2} = \frac{R_{ZCD,1 \text{ Selection}}}{(V_{outOV,max} \times N_a \times \frac{N_s}{N_p} + 1.9) - 1} \text{ [unit: kΩ]}$$

$$\text{Max } R_{ZCD,2} = \frac{R_{ZCD,1 \text{ Selection}}}{(V_{outOV,max} \times N_a \times \frac{N_s}{N_p} + 2.3) - 1} \text{ [unit: kΩ]}$$

R_ZCD_1 Selection Max Power Loss refers to the maximum power loss calculation based on the R_ZCD_1 Selection input by the user.

3.3.7 Primary RCD snubber design calculation

In step 3 section III, the user has to decide on the Csn Selection for the primary RCD snubber (see red-circled part in Figure 43). The primary RCD snubber is to clamp the MOSFET spike voltage, caused by the transformer leakage inductance. Generally, higher Csn values will result in lower Rsn values needed in the RCD snubber design. Please choose a standard capacitor value for Csn Selection within the range of 2200 ~ 47000 pF.
L_p_lk is calculated by multiplying the L_p and Transformer leakage inductance percentage inputs.

MOSFET Vds_spike is read-only and refers to the MOSFET drain voltage spike based on the step 1 section VI input.

Recommended Initial Rsn for the primary RCD snubber is calculated based on the equation below:

\[ R_{sn} = \frac{t_{\text{discharge}}}{C_{\text{sn Selection}} \cdot \ln\left(\frac{\Delta V_{\text{CSN}}-V_{\text{ds_spike}}}{V_{\text{ds_spike}}}\right)} \]

where:

\[ t_{\text{discharge}} = \frac{1}{f_{\text{sw}}(V_{\text{in max}}, P_{\text{out max}})} - \frac{\pi}{2} \cdot \sqrt{L_{p} L_{p lk} C_{\text{sn}}} \]

\[ \Delta V_{\text{CSN}} = V_{\text{ds max}} - \sqrt{V_{\text{ds max}}^2 - \frac{L_{p} L_{p lk} I_{pri pk}(V_{\text{in max}}, P_{\text{out max}})^2}{C_{\text{sn}}}} \]

\[ V_{\text{ds max}} = V_{\text{in max}} \cdot \sqrt{2} + \frac{N_{p}}{N_{s}} \cdot V_{\text{out max}} + V_{\text{ds_spike}} \]

Figure 43  Primary RCD snubber design calculation (Step 3 Calculation output III)

3.3.8 Output bleeder design calculation

Based on the output bleeder selection in the step 3 main design input, the user has to make a bleeder resistor selection.

As shown in Figure 44, there are also design inputs that can be adjusted if needed. These design inputs are placed in this section because they mainly affect the output bleeder design calculation.

- **Reaction_OVP_Vout setting:**
  IC parameterization to set the reaction of the output over-voltage protection (selectable value is “Auto-Restart” or “Latch”)

- **t_auto_restart setting:**
  IC parameterization to set the auto restart time for all protections with reaction = "Auto-Restart" and speed of reaction = "Slow" (selectable value is t_auto_restart_fast ~ 10 sec)

- **t_auto_restart_fast setting:**
  IC parameterization to set the auto restart time for all protections with reaction = "Auto-Restart" and speed of reaction = "Fast" (selectable value is 0.2 ~ 10 sec)

- **Speed_OVP_Vout setting:**
  IC parameterization to set the speed of reaction for the output over-voltage protection (selectable value is “Slow” or “Fast”)
The calculation output below will then be generated:

- **Vout OVP auto-restart time:**
  
  Output over-voltage protection auto-restart time based on the IC parameterization above.

- **Max Bleeder Resistance:**
  
  Maximum bleeder resistance calculation output. **Bleeder resistor Selection** should not exceed this value.

![Figure 44: Output bleeder design calculation (Step 3 Calculation output V)](image)

**Table 1** Calculation output of column M&N based on conditions

<table>
<thead>
<tr>
<th>Reaction_OVP_Vout setting</th>
<th>Calculation output (column M&amp;N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-restart</td>
<td>Bleeder Resistor Selection Est. OVP Vout drop after auto-restart time</td>
</tr>
<tr>
<td>Latch mode</td>
<td>Bleeder Resistor Selection Est. OVP Vout drop after 3-sec. discharge</td>
</tr>
</tbody>
</table>

In the column O calculation output (See Figure 44), the estimated loss of the bleeder resistor selection is calculated based on the **Reaction_OVP_Vout setting** and the highest loss condition, as shown in **Table 2**.

**Table 2** Calculation output for column O based on conditions

<table>
<thead>
<tr>
<th>Reaction_OVP_Vout setting</th>
<th>Est. Loss of Bleeder Resistor Selection</th>
<th>Calculation Output (Column O)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OVP auto-restart</td>
<td>Normal Operation</td>
</tr>
<tr>
<td></td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td></td>
<td>Lower</td>
<td>Higher</td>
</tr>
<tr>
<td>Latch mode</td>
<td>Not applicable</td>
<td>Any value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bleeder Resistor Normal Operation Est. Loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bleeder Resistor OVP auto-restart Est. Loss</td>
</tr>
</tbody>
</table>
3.3.9 Auto-generated BOM & IC parameters

If the user has completed step 2 with the desired core and bobbin without errors, please select generate option for T1 as “AUTO GENERATE BASED ON STEP 2” (see Figure 45).

Otherwise, please select “MANUAL KEY IN” which requires the user to enter Np manually (see Figure 46).

Note: T1 refers to the reference designator of flyback transformer

ERROR CHECK here will detect if there are any errors in each of the steps. If detected, it will show in which step the error is located and the user should resolve the error or errors accordingly (as shown in Figure 45 with “NO ERROR FOUND”). This is to ensure that the generated BOM and IC parameters are correct.

WARNING CHECK here will detect if there are any warnings in each of the steps. If detected, it will show in which step the warning is located. It is recommended to resolve the warnings (as shown in Figure 45 with “NO WARNING FOUND”) but this is not mandatory. The BOM and IC parameters can still be generated with warnings.

Figure 45  Flyback transformer, T1 parameter-generating option (“AUTO GENERATE BASED ON STEP 2”)

Figure 46  Flyback transformer, T1 parameter-generating option (“MANUAL KEY IN”)

Figure 47 shows an example of the generated BOM and IC parameters.

The BOM reference designators are based on the schematic of ICL8105-CDM10V Reference Design. For easy reference, the schematic is available in the “SCH” worksheet of the excel tool.

By opening the ICL8105 parameterization file (*.csv) with the GUI called .dpVision, user can enter the generated IC parameters from the excel tool and burn these parameters into the IC, using the .dp Interface Board Gen 2.

Please note that there are a few IC parameters which could not be calculated but require fine-tuning at system level. These parameters are as shown in the green-highlighted cell in the IC parameters table in Figure 47. Please refer to the “ICL8105-CDM10V 40W Reference Design Application Note” for the fine-tuning guide.

Also, there are a few IC parameters which are each generated with an initial default value as shown below, instead of dynamically adapted based on the input or output from the design steps before. If necessary, user can adjust each of these parameter values later in .dpVision according to the application needs.

- Output current dimming curve, C_DIM: Quadratic (default) or Linear
- Enable output under-voltage protection, EN_UVP_Vout: Enabled (default) or Disabled
- Enable maximum average output current protection, EN_Iout_max_avg: Enabled (default) or Disabled
- Enable maximum peak output current protection, EN_Iout_max_avg: Enabled (default) or Disabled
- Auto restart speed for output current protection, Speed_OCP_Iout: Slow (default) or Fast
- Enable input under-voltage protection, EN_UVP_In: Enabled (default) or Disabled
Auto-generated BOM

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Rating</th>
<th>Supplier</th>
<th>Part Number/Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>1.5 µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BXM155T0800M10075605N104</td>
</tr>
<tr>
<td>IG1</td>
<td>4.7 µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>SS155T0800M10075605N104</td>
</tr>
<tr>
<td>G1</td>
<td>4 µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>SS155T0800M10075605N104</td>
</tr>
<tr>
<td>D1-V3</td>
<td>1k</td>
<td>800V</td>
<td>FAIRCHILD</td>
<td>2SN6501A</td>
</tr>
<tr>
<td>C5</td>
<td>0.22 µF</td>
<td>±0.1%</td>
<td>NITAL</td>
<td>SPP0220000000208000000</td>
</tr>
<tr>
<td>C6</td>
<td>10k</td>
<td>63V</td>
<td>NITAL</td>
<td>SPP0220000000208000000</td>
</tr>
<tr>
<td>R1-H100</td>
<td>1k</td>
<td>±10%</td>
<td>NITAL</td>
<td>SPP0220000000208000000</td>
</tr>
<tr>
<td>R11</td>
<td>510kΩ</td>
<td>±10%</td>
<td>NITAL</td>
<td>SPP0220000000208000000</td>
</tr>
<tr>
<td>R12</td>
<td>220kΩ</td>
<td>±10%</td>
<td>NITAL</td>
<td>SPP0220000000208000000</td>
</tr>
<tr>
<td>R13</td>
<td>10kΩ</td>
<td>±10%</td>
<td>NITAL</td>
<td>SPP0220000000208000000</td>
</tr>
<tr>
<td>D4</td>
<td>±0.394</td>
<td>±1%</td>
<td>INFINET</td>
<td>BTP08240001001000000</td>
</tr>
<tr>
<td>D10</td>
<td>1300V</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BDJ135050200000500</td>
</tr>
<tr>
<td>D16</td>
<td>0.22 µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>D20</td>
<td>±0.22</td>
<td>±1%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>C21</td>
<td>4.7µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>C24</td>
<td>4.7µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>C26</td>
<td>2.2µF</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R21</td>
<td>10kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R22</td>
<td>1kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R24</td>
<td>4kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R26</td>
<td>2kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R32</td>
<td>2kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R33</td>
<td>4kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
<tr>
<td>R36</td>
<td>1kΩ</td>
<td>±10%</td>
<td>WINTRON</td>
<td>BST1605031020001000</td>
</tr>
</tbody>
</table>

Figure 47  Auto-generated BOM and IC parameters (end of Step 3)
System Simulation & Design Creation Tool (Transformer, BOM and IC Parameters)

User guide

Figure 48  Schematic for the auto-generated BOM (Refer “SCH” Worksheet in the excel tool)
## Revision History

**Major changes since the last revision**

<table>
<thead>
<tr>
<th>Page or Reference</th>
<th>Description of change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>