Transformers

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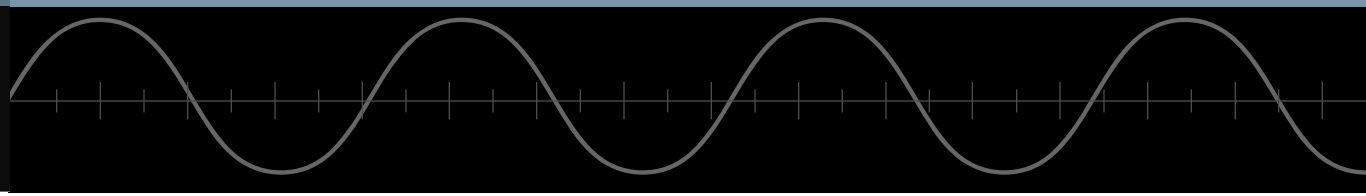


LINEAR TECHNOLOGY

NOW PART OF ANALOG DEVICES

Ideal Transformer Model

- Unlike FETs, inductors and so on, there's no transformer model per say in LTspice. To create one:
  - An inductor must be placed for every transformer winding
  - The inductors must be coupled together magnetically via the mutual inductance (K) statement placed as a Spice Directive on the schematic
    - Ex. K1 L1 L2 L3 1
    - Couple inductors L1, L2 & L3 with a coupling of 1 (ideal transformer)
  - The turn-ratio is specified by setting the inductor values:

$$L_P/L_S = (N_P/N_S)^2$$

  - Inductors called out in a "K" statement will be automatically given a phasing dot if one does not already exist.
  - The "K" directive is specific to a transformer. If more than one transformers are used in a simulation circuit, define a "K" statement for each transformer (K1, K2, …, K_n)

Ideal Transformers - Lab

Hands-on Exercises:

1.) Open up the file “Transformer2windings.asc” and create an ideal transformer with the following characteristics:

- Primary inductance of 100uH
- A Turn-Ratio (primary-secondary) of 1:3
- Polarity inversion between the input and output

2.) Modify the previous transformer to add a third winding (auxiliary) with a 1:2 turn-ratio.

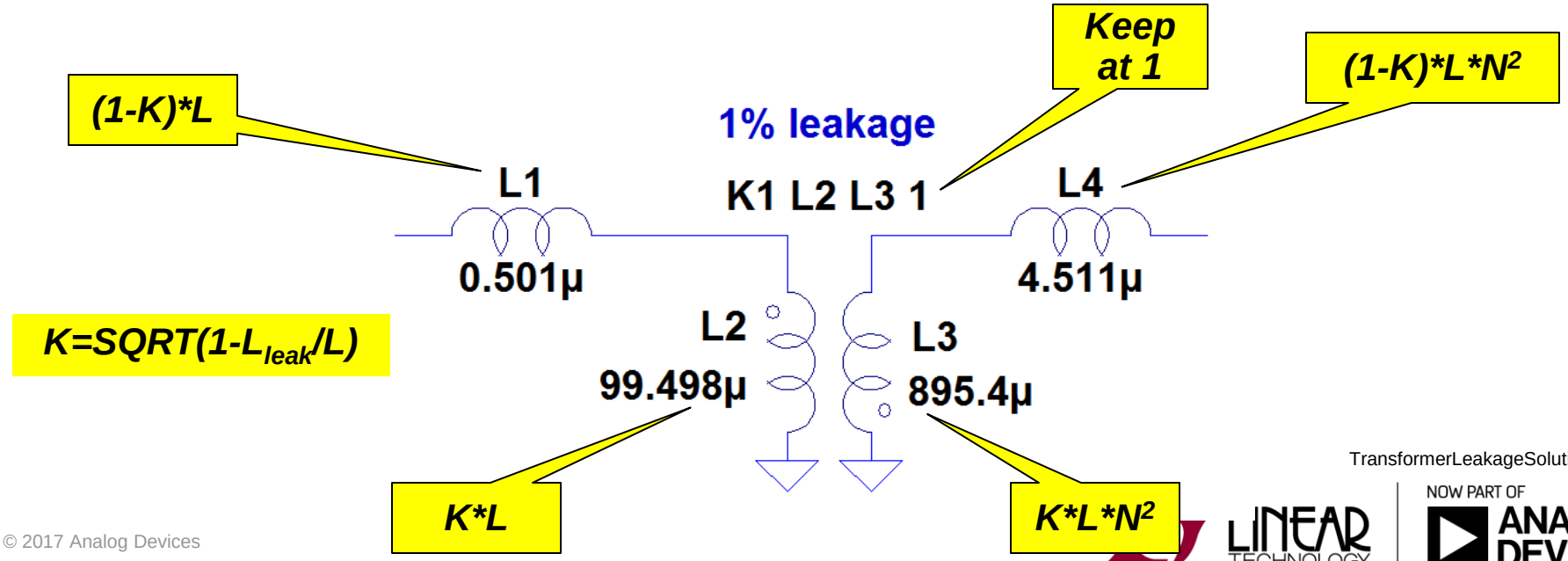
Tip: The use of parameters and equations can simplify the transformer creation process.

TransformerMultiWindingsWithParamsSolution.as

Leakage Inductances – Two Ways to Model

1.) Keep the "K" statement to 1:

- Add a small discrete leakage inductance in series with each winding's coupled inductance
- The leakage inductance for each winding will be (1-K) times the inductance of that winding's inductance.
- Each winding's coupled inductance decreases to K times that winding's inductance
- Where K = SQRT(1 – $L_{leakage}$/L)

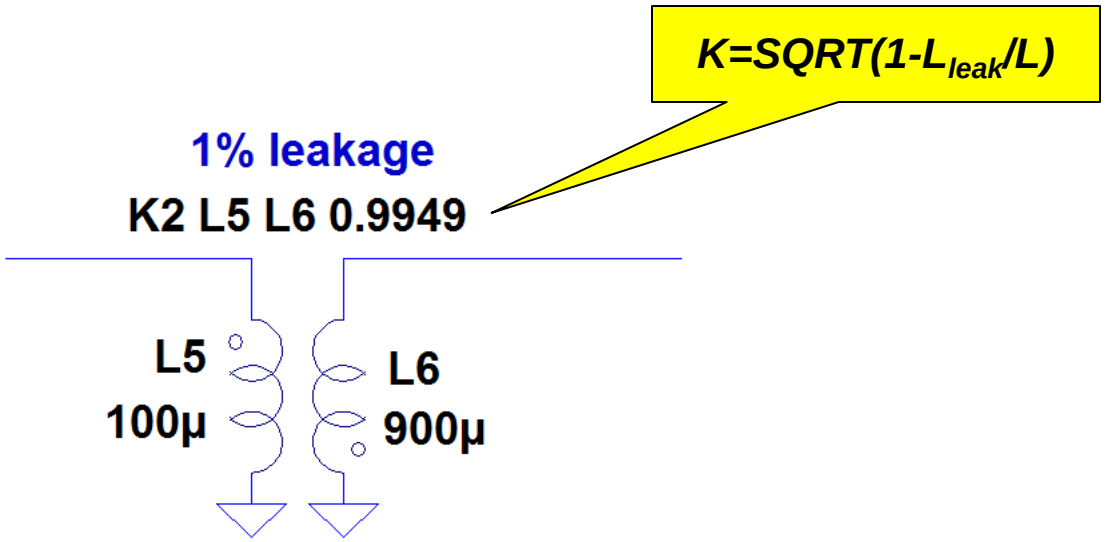


TransformerLeakageSolution.asc

Leakage Inductances – Two Ways to Model

2.) Reduce the coupling factor “K” in the “K” statement:

- Keep the winding’s inductance as if the transformer were ideal
- Change the “K” statement value to SQRT(1 – L_{LK}/L)
- The end result will be the same as adding serial inductances.



TransformerLeakageSolution.asc

Appendix

- LTspice Video channel. “Using transformers” by Gabino Alonso
  - http://www.linear.com/solutions/1079
- LTJournal – September 2006. “Using Transformers in LTspice” by by Mike Engelhardt.
  - http://www.linear.com/docs/39380
- LTwiki.org. “Transformers” page.
  - http://ltwiki.org/?title=Transformers