

Switch-Mode Power Supplies SPICE Simulations and Practical Designs

INTUSOFT/IsSpice Simulation Libraries and Design Templates

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The present Word file describes the content of the INTUSOFT/IsSpice simulation templates available with the release of the book « Switch-Mode Power Supply SPICE Simulations and Practical Designs ». The purpose of these templates is to simplify the design and test of several key topologies among the most popular ones. The files are sorted out by the book chapters where design examples are described. Numerous simulation circuits are given away along with the book (*italic green*), the rest are only available on a set of files separately distributed. Please check <http://perso.orange.fr/cbasso/Spice.htm> for more details on this.

Chapter 1 – dc-dc and regulation theory

Boost converter.dwg: a simple open-loop boost converter

Buck converter.dwg: a simple open-loop buck converter

Buck-boost converter.dwg: a simple open-loop buck-boost converter

Duty-cycle factory PWM mod.dwg: a Pulse Width Modulator

Boost filtering.dwg: EMI signature and filtering of the open-loop boost converter

Regulator 1.dwg: a simplified linear regulator

Regulator 2.dwg: a simplified linear voltage regulator. This is a multi-sheet template:

- **Audio Susceptibility**: the input voltage is ac sweep and the output response is plotted
- **Zout sweep**: the ac output impedance in a closed-loop configuration
- **Stepped Vin**: output response to a stepped input voltage
- **Stepped load**: output response to a step load

RLC filter oscillations.dwg: the stepped response of a RLC filter. This is a multi-sheet template:

- **Damping**: the output voltage response of the damped RLC filter
- **No damping**: the output voltage response of the un-damped RLC filter

RLC filter output impedance.dwg: the output impedance of a RLC filter. This is a multi-sheet template:

- **Damping**: the output impedance of the damped RLC filter
- **No damping**: the output impedance of the un-damped RLC filter

Chapter 2 – Small-signal theory

BCM CM averaged.dwg: a simple BCM CM converter with multiple configuration: **normal** and **step load**

BCM CM cycle-by-cycle.dwg: switched BCM CM boost with multiple configuration: **normal** and **step load**

BCM VM averaged.dwg: a simple BCM VM converter with multiple configuration: **normal** and **step load**

BCM VM cycle-by-cycle.dwg: switched BCM VM boost with multiple configuration: **normal** and **step load**

lossy buck VM: a buck converter featuring the new lossy PWM switch

basic CCM-DCM buck.dwg: basic voltage-mode buck converter

boost PWM Switch CCM small-signal.dwg: the boost converter using the small-signal PWM switch model

boost PWM Switch CCM.dwg: large-signal model used in a boost converter

buck CM k factor.dwg: a simple CM buck converter with multiple configuration: **closed-loop** and **transient**

buck cycle-by-cycle CM transient.dwg: a simple cycle-by-cycle buck in current mode

buck cycle-by-cycle VM transient.dwg: a simple cycle-by-cycle buck in CM: **load step** and **fixed load**

buck VM k factor.dwg: a VM buck with multiple configuration: **AC OL**, **COMP OL** and **transient**

large signal buck.dwg: a simple buck using the large signal model

non-linear diode.dwg: a non-linearly biased diode modulator

small signal buck SSA.dwg: a linearized buck using the SSA process

<PWM Switch collection>

[Boost CM.dwg](#): simple current-mode boost converter
[Boost VM.dwg](#): boost in voltage-mode with multiple configurations : **compensated** and **non compensated**
[Buck CM.dwg](#): current-mode buck converter
[Buck VM.dwg](#): buck in voltage-mode with multiple configurations : **ac OL**, **comp OL** and **transient**.
[Buck-boost CM.dwg](#): buck-boost operated in current-mode, open-loop configuration
[Buck-boost VM.dwg](#): buck-boost operated in voltage-mode, open-loop configuration
[Flyback CM.dwg](#): simple current-mode flyback running in open-loop configuration
[Flyback VM k factor.dwg](#): VM flyback running in open-loop configuration and compensated with the k factor.
[Forward CM k factor.dwg](#): forward in CM with multiple configurations : **ac OL** and **tran step**
[Forward VM k factor.dwg](#): forward in VM with multiple configurations : **ac OL** and **tran step**
[Isolated CUK VM.dwg](#): isolated CUK converter operating in voltage-mode
[Non-isolated CUK.dwg](#): non-isolated CUK converter operating in voltage-mode
[Sepic VM.dwg](#): Sepic operated in voltage mode, open-loop gain
[Tapped boost.dwg](#): tapped-boost circuit
[Tapped buck.dwg](#): tapped-buck circuit
[Weinberg converter.dwg](#): Weinberg small-signal circuit

<CoPEC >

[Boost.dwg](#): an auto-toggling voltage-mode boost converter
[Buck CPM IEEE.dwg](#): a current-programmed buck converter example
[Buck CPM.dwg](#): another current-programmed buck converter example
[Buck.dwg](#): an auto-toggling voltage-mode buck converter
[Buck-boost.dwg](#): an auto-toggling voltage-mode buck-boost converter
[Flyback.dwg](#): an auto-toggling voltage-mode flyback converter
[Flyback2.dwg](#): another auto-toggling voltage-mode flyback converter
[Isolated CUK.dwg](#): an isolated CUK converter operated in voltage-mode
[Non-isolated CUK.dwg](#): a non-isolated CUK converter operated in voltage-mode
[Sepic.dwg](#): a voltage-mode SEPIC

Chapter 3 – Control loop theory

[Buck k factor CM.dwg](#): a current-mode buck converter stabilized using the k factor. This is a multi-sheet template:

Average model :

- **AC OL**: open-loop ac sweep
- **Tran Step**: transient response to a load step
- **Input Step**: transient response to an input step
- **Input ac**: ac sweep to the input

[Buck k factor VM.dwg](#): a voltage-mode buck converter stabilized using the k factor. This is a multi-sheet template:

Average model :

- **AC OL**: open-loop ac sweep
- **Tran Step**: transient response to a load step
- **Input Step**: transient response to an input step
- **Input ac**: ac sweep to the input

[Error amplifier types.dwg](#): a file gathering all possible compensation circuits, type-1 to type-3 with an ac sweep.

[Flyback current mode k factor opto.dwg](#): a flyback converter stabilized with a TL431 and k factor. This is a multi-sheet template:

- **Opto**: the optocoupler is back in the normal path
- **Pole in**: the optocoupler pole is inserted in the path to check its effect

- **Series ac:** the sweep source is inserted in series with the FB path
- **Transient k:** transient response with the k factor
- **Transient fixed:** transient response with fixed components

Flyback voltage mode shunt.dwg: a flyback operated in voltage mode with a shunt regulator (TOPSwitch® like). This is a multi-sheet template:

- **Opto:** the optocoupler is back in the normal path
- **Pole in:** the optocoupler pole is inserted in the path to check its effect
- **Series ac:** the sweep source is inserted in series with the FB path
- **Transient k:** transient response with the k factor

Opto pole.dwg: a simple template to test the optocoupler pole position

Poles-zeros.dwg: a circuit showing the generation of poles or zeroes including a RHPZ

TL431 bias.dwg: checking for a TL431 bias current in a normal configuration

Type 1 dwg: a simple type-1 compensator built around an OPAMP

Type 2 manual TL431.dwg: a type-2 built on a TL431 where the pole and the zero are manually placed

Type 2 manual.dwg: a type-2 compensator built on an OPAMP where the pole and the zero are manually placed

Type 2 TL431.dwg: an automated k factor-based type-2 compensator built with a TL431

Type 2 dwg: a simple type-2 compensator built around an OPAMP

Type 3 manual coincident.dwg: a type-3 compensator built on an OPAMP where the pole and the zero are manually placed

Type 3 manual split.dwg: a type-3 compensator built on an OPAMP where the pole and the zero are manually placed

type 3 TL431 manual split.dwg: a type-3 compensator built with a TL431 where the pole and the zero are manually placed

type 3 TL431.dwg: a type-3 compensator k factor-automated built with a TL431 where the pole and the zero are manually placed

Type 3 dwg: a simple type-3 compensator built around an OPAMP

Chapter 4 – Generic model descriptions

Astable generator.dwg: an astable generator using a hysteresis switch

Buck in CM: a simple cycle-by-cycle buck converter using a generic model

Deadtime generator.dwg: a simple deadtime generator built with AND gates

Fanout source.dwg: a voltage source with a given current capability modeled with an ABM equation

Forward in VM.dwg: a cycle-by-cycle forward converter in voltage-mode

Half bridge w DT.dwg: a half-bridge converter driven by a deadtime generator

Hysteresis SW clock.dwg: a self-relaxing clock circuit with a hysteresis switch

Power VCO LLC.dwg: an open-loop LLC converter using the power VCO subcircuit

Power VCO with DT.dwg: a real Voltage Controlled Oscillator featuring a deadtime generator

Saturable L w hysteresis.dwg: a saturable reactor featuring a hysteresis cycle

Saturable L wo hysteresis.dwg: a saturable reactor without a hysteresis cycle

UC384X OPAMP.dwg: the internal UC384X controller OPAMP

UVLO block.dwg: a simple under voltage lockout subcircuit

Varicap LC.dwg: a voltage-controlled LC tuned filter

Varicap.dwg: an ABM capacitor controlled by voltage

Varicoil.dwg: an ABM inductor controlled by voltage

Chapter 5 – dc-dc design examples

Boost CM ac.dwg: a boost current-mode 2.7 V to 5 V / 1 A. This is a multi-sheet template:

Averaged model :

- **Lossy**: the ac model inclusive of all conduction losses, diode forward drop and MOSFET $R_{DS(on)}$.
- **Compen k**: automated compensation using the k factor
- **Compen man**: manual compensation using pole/zero placement
- **Step load**: step load response with k factor compensation
- **Zin**: input impedance with k factor compensation
- **Compen k filtered**: ac sweep with the compensated EMI filter

Boost CM transient.dwg: a boost current-mode 2.7 V to 5 V / 1 A. This is a multi-sheet template:

Transient model :

- **Normal**: a transient simulation for steady-state analysis
- **Step load**: step load response with k factor compensation
- **Filtered**: a transient simulation for steady-state analysis including EMI filter

Boost VM ac.dwg: a boost voltage-mode 12 V to 48 V / 2 A. This is a multi-sheet template:

Averaged model :

- **Non compensated**: a simple ac sweep to unveil the power stage response
- **Compensated**: compensation using manual type-3 placement
- **Step load**: step load response with a manual type-3 compensation

Buck CM ac.dwg: a buck current-mode 10 V to 5 V / 10 A. This is a multi-sheet template:

Averaged model :

- **Ac OL**: the ac sweep and compensation using the automated k factor template
- **Tran step**: automated compensation using the k factor, transient response
- **Input step**: input step response with k factor type of compensation
- **Input ac**: input rejection ac sweep

Buck CM synchro.dwg: a buck current-mode 10 V to 5 V / 10 A implementing synchronous rectification. This is a multi-sheet template:

Transient model :

- **Transient**: transient response to a load step without input filter
- **Normal**: steady-state analysis a fixed load / input voltage condition
- **Normal**: steady-state analysis a fixed load / input voltage condition with input filter

Buck CM.dwg: a buck current-mode 10 V to 5 V / 10 A. This is a multi-sheet template:

Transient model :

- **Transient**: transient response to a load step without input filter
- **Normal**: steady-state analysis a fixed load / input voltage condition
- **Normal RLC**: steady-state analysis a fixed load / input voltage condition with input filter

Buck VM ac.dwg: a buck voltage-mode 24 V to 12 V / 4 A. This is a multi-sheet template:

Averaged model :

- **Ac OL:** simple open-loop ac sweep to unveil the power stage response
- **Comp OL:** manually compensated ac sweep
- **Transient:** transient response of the manually compensated buck
- **Ac OL filter:** simple open-loop sweep to unveil the power stage response with input filter
- **Input impedance:** input impedance ac sweep for filter interaction
- **Transient:** transient response of the manually compensated buck with input filter

Buck VM transient.dwg : a buck voltage-mode 24 V to 12 V / 4 A. This is a multi-sheet template:

Transient model :

- **Transient:** transient response to a load step without input filter
- **Normal:** steady-state analysis a fixed load / input voltage condition
- **Normal RLC:** steady-state analysis a fixed load / input voltage condition with input filter

Buck-boost CM ac.dwg: a buck-boost current-mode 10 V to -12 V / 2 A. This is a multi-sheet template:

Averaged model :

- **Non compensated:** simple open-loop ac sweep to unveil the power stage response
- **Compensated** : an open-loop ac sweep to show the k factor compensated converter
- **Step load:** transient response to a load step

Buck-boost CM transient.dwg: a buck-boost current-mode 10 V to -12 V / 2 A. This is a multi-sheet template:

Transient model :

- **Step load:** transient response to a load step without input filter
- **Normal:** steady-state analysis a fixed load / input voltage condition

Buck-boost VM ac.dwg: a buck-boost voltage-mode 10 V to -12 V / 2 A. This is a multi-sheet template:

Averaged model :

- **Non compensated:** simple open-loop ac sweep to unveil the power stage response
- **Compensated** : an open-loop ac sweep to show the k factor compensated converter
- **Step load:** transient response to a load step

Buck-boost VM transient.dwg : a buck-boost voltage-mode 10 V to -12 V / 2 A, single sheet template, steady-state simulation.

Chapter 6 – Power Factor Correction circuit examples

BCM 150 W PFC example averaged.dwg: a 150 W PFC operated in BCM current-mode. This is a multi-sheet template:

Averaged model :

- **ABS Vin:** transient response of the PFC when the input is an ABS function of V_{in} (no input bridge)
- **Bridge:** same as above except the ABS function is replaced by standard diode bridge
- **Ac analysis:** small-signal analysis of the BCM current-mode PFC
- **Step load:** step load response of the BCM current-mode PFC after proper compensation

BCM 150 W PFC example bridge version.dwg: a 150 W PFC cycle-by-cycle using a 33262-like configuration. Using a standard diode bridge.

BCM 150 W PFC example cycle-by-cycle.dwg: a 150 W PFC cycle-by-cycle using a 33262-like configuration. Using an ABS function in place of the diode bridge.

BCM CM PFC average model.dwg: a 150 W PFC operated in current-mode borderline mode. This is a multi-sheet template:

Averaged model :

- **ABS Vin**: transient response of the PFC when the input is an ABS function of V_{in} (no input bridge)
- **Bridge**: same as above except the ABS function is replaced by standard diode bridge
- **Ac analysis**: small-signal analysis of the BCM current-mode PFC

BCM CM PFC cycle-by-cycle.dwg: a 160 W BCM PFC using a simplified model representation. This is a multi-sheet template:

Transient model :

- **Normal**: simplified steady-state analysis of the BCM CM PFC circuit
- **Step load**: step load response of the above PFC

BCM CM PFC flyback cycle-by-cycle.dwg: a 100 W BCM flyback PFC operated in voltage-mode. This is a multi-sheet template:

Transient model :

- **Normal**: simplified steady-state analysis of the BCM VM PFC circuit
- **Step load**: step load response of the above PFC

BCM PFC flyback average model.dwg: a 100 W PFC using a flyback architecture and operated in current-mode control. This is a multi-sheet template:

Average model :

- **ABS Vin**: transient response of the PFC when the input is an ABS function of V_{in} (no input bridge)
- **Bridge**: same as above except the ABS function is replaced by standard diode bridge
- **Ac analysis**: small-signal analysis of the BCM current-mode PFC

CCM average CM PFC averaged model.dwg: a 1 kW PFC using a boost architecture and operated in average current-mode control. This is a multi-sheet template:

Average model :

- **Transient**: steady-state simulation using the average model
- **Ac total**: small-signal analysis of the boost, full loop sweep
- **Ac current loop**: small-signal analysis of the boost, current-loop only

CCM average CM PFC cycle-by-cycle.dwg: a 1 kW PFC using a boost architecture and operated in average current-mode control. This is a multi-sheet template:

Transient model :

- **Normal**: simplified steady-state analysis of the BCM VM PFC circuit
- **Step load**: step load response of the above PFC

CCM peak CM PFC average model.dwg: a 1 kW PFC using a boost architecture and operated in peak current-mode control. This is a multi-sheet template:

Average model :

- **Transient**: steady-state simulation using the average model
- **Ac analysis**: small-signal analysis of the boost PFC in peak current mode control

CCM peak CM PFC cycle-by-cycle.dwg: a 1 kW PFC using a boost architecture and operated in peak current-mode control. This is a multi-sheet template:

Transient model :

- **Normal**: simplified steady-state analysis of the BCM VM PFC circuit
- **Step load**: step load response of the above PFC

DCM PFC boost averaged model.dwg: a 100 W boost PFC operated in discontinuous voltage-mode control.

DCM PFC Flyback averaged model.dwg: a 100 W PFC delivering 48 V and using a flyback architecture operated in voltage-mode control. This is a multi-sheet template:

Average model :

- **ABS Vin**: transient response of the PFC when the input is an ABS function of V_{in} (no input bridge)
- **Bridge**: same as above except the ABS function is replaced by standard diode bridge
- **Ac analysis**: small-signal analysis of the DCM voltage-mode PFC

DCM VM PFC Flyback cycle-by-cycle.dwg: a 100 W PFC delivering 48 V and using a flyback architecture operated in voltage-mode control. This is a cycle-by-cycle simulation.

Hysteretic CM PFC cycle-by-cycle.dwg: a 160 W CCM hysteretic boost PFC using current-mode control.

Fullwave doubler.dwg: a diode bridge in a doubler configuration.

Fullwave in-rush.dwg: this template simulates the power-on sequence with a diode bridge

Fullwave mains Z.dwg: this schematic models the mains output impedance

Fullwave rectifier passive PFC.dwg: power factor correction made passive

Fullwave rectifier resistive load.dwg: a simple diode bridge loaded by a resistor

Fullwave rectifier valley-fill PFC.dwg: the valley-fill type of passive PFC

Fullwave rectifier.dwg: a full-wave rectifier loaded by a constant power load

Hold-up time.dwg: the hold-up time simulation on a full-wave rectifier

Chapter 7 – Flyback converters

2SW flyback CM.dwg: 12 V / 360 W generic model 2-switch flyback converter

flyback ac design 1.dwg: ac analysis of a 20 W universal mains flyback operated in current-mode control. This is a multi-sheet template:

Average model:

- **Ac sweep pole**: 20 W DCM ac sweep including the optocoupler pole for compensation
- **Ac sweep no pole**: 20 W DCM ac sweep without optocoupler pole added
- **Transient**: transient response obtained with the ac compensated design

flyback ac design 2.dwg: ac analysis of a 90 W CCM universal mains adapter operated in current-mode control. This is a multi-sheet template:

Average model:

- **Ac sweep pole**: 90 W CCM ac sweep including the optocoupler pole for compensation
- **Ac sweep no pole**: 90 W CCM ac sweep without optocoupler pole added
- **Transient**: transient response obtained with the ac compensated design

flyback ac design 3.dwg: ac analysis of a 35 W BCM universal mains multi-output power supply operated in current-mode control. This is a multi-sheet template:

Average model:

- **Normal LC:** steady-state response using the average model with secondary LC filters
- **Load step LC:** transient response using the average model with secondary LC filters.
- **Opto in:** ac sweep with the optocoupler pole inserted in the ac path

flyback active clamp.dwg: a simple fixed frequency flyback current-mode implementing the active-clamp technique

flyback CM.dwg: a file helpful to compare the ac and transient response of a flyback current-mode operated in either current-mode or voltage-mode. This is a multi-sheet template:

Average model:

- **Ac CCM:** ac sweep when running in the CCM mode
- **Ac DCM:** ac sweep when running in the DCM mode
- **Transient DCM:** transient load step in DCM
- **Transient CCM:** transient load step in CCM

flyback VM.dwg: a file helpful to compare the ac and transient response of a flyback voltage-mode operated in either current-mode or voltage-mode. This is a multi-sheet template:

Average model:

- **Ac CCM manual:** ac sweep when running in the CCM mode, compensated using a manual method
- **Ac CCM k factor:** ac sweep when running in the CCM mode, compensated using the k factor
- **Ac DCM:** ac sweep when running in the DCM mode
- **Transient DCM:** transient load step in DCM
- **Transient CCM:** transient load step in CCM (k factor compensated)
- **Transient CCM:** transient load step in CCM (manual positioning compensated)

flyback CM design 1.dwg: the cycle-by-cycle 20 W DCM converter. This is a multi-sheet template:

Transient model:

- **Normal No LC:** steady-state simulation without secondary LC filter
- **Load step no LC:** load step simulation without secondary LC filter
- **Normal LC filter:** steady-state simulation with secondary LC filter
- **Load step LC:** load step simulation with secondary LC filter

flyback CM design 2.dwg: the cycle-by-cycle 90 W CCM converter. This is a multi-sheet template:

Transient model:

- **Normal No LC:** steady-state simulation without secondary LC filter
- **Load step no LC:** load step simulation without secondary LC filter
- **Normal LC filter:** steady-state simulation with secondary LC filter
- **Load step LC:** load step simulation with secondary LC filter

flyback CM design 3.dwg: the cycle-by-cycle 35 W BCM converter. This is a multi-sheet template:

Transient model:

- **Normal No LC:** steady-state simulation without secondary LC filter
- **Load step no LC:** load step simulation without secondary LC filter
- **Normal LC filter:** steady-state simulation with secondary LC filter
- **Load step LC:** load step simulation with secondary LC filter

Chapter 8 – Forward converters

2SW forward CM 5V Telecom.dwg: a telecom 2-switch forward converter delivering 5 V / 60 A

2SW forward CM generic.dwg: a generic 2-switch forward converter 5 V / 60 A using a generic model

2SW forward design example TRAN1.dwg: cycle-by-cycle simulation of the 12 V / 20 A 2-switch forward converter. TL431-based feedback. This is a multi-sheet template:

Transient model:

- **Normal**: steady-state cycle-by-cycle simulation
- **Tran** : cycle-by-cycle simulation of a step load transient

2SW forward design example TRAN2.dwg: cycle-by-cycle simulation of the 12 V / 20 A 2-switch forward converter. OPAMP-based feedback.

2SW forward design example AC.dwg: average simulation of the two-switch forward converter 12 V / 20 A. This is a multi-sheet template:

Average model:

- **AC OL w opto**: ac sweep with the optocoupler pole included in the feedback path
- **AC OL wo opto**: ac sweep in the normal configuration. Compensation with k factor
- **Tran**: step load response once the converter is compensated

Forw cm demag reso.dwg: a single switch forward converter featuring a resonant demagnetization

Forward ac CM coupled TL431.dwg: a multi-output 5 V / 15 A plus a 3.3 V / 15 A ATX power supply featuring coupled inductors. An average model configuration. This is a multi-sheet template:

Average model:

- **AC OL uncoupled**: the output inductors are not coupled. An ac sweep can be performed.
- **Tran uncoupled**: the transient response when both inductors are un-coupled.
- **AC OL**: the output inductors are coupled with dc transformers. An ac sweep can be performed.
- **Tran coupled**: the output inductors are coupled with dc transformers. A step load can be performed.
- **Tran k coupled**: the output inductors are coupled with a k coupling coefficient. A step load can be performed.
- **AC OL**: the output inductors are coupled with a k coupling coefficient. An ac sweep can be performed

Forward transient CM coupled TL431.dwg: a multi-output 5 V / 15 A plus a 3.3 V / 15 A ATX power supply featuring coupled inductors. A cycle-by-cycle configuration. This is a multi-sheet template:

Transient model:

- **Normal coupled**: both inductors are coupled using dc transformers. A steady-state simulation is performed.
- **Tran coupled**: both inductors are coupled using dc transformers. A load step simulation is performed.
- **Tran uncoupled**: inductors are not coupled. A load step simulation is performed.
- **Normal uncoupled**: inductors are not coupled. A steady-state simulation is performed.
- **k coupled**: both inductors are coupled with a k coupling coefficient. A steady-state simulation is performed.
- **Tran k**: both inductors are coupled with a k coupling coefficient. A load step simulation is performed.

Forward transient CM.dwg: A simple 5 V / 50 A current-mode forward converter using an average model. This is a multi-sheet template:

Average model:

- **AC OL:** open-loop sweep where the feedback is performed with a TL431
- **Tran:** load step response with a compensation made with the k factor.

multi-output forward 12V5V ac sweep.dwg: a multi-output 5 V / 15 A plus a 12 V / 15 A ATX power supply featuring coupled inductors. An average model configuration. This is a multi-sheet template:

Average model:

- **AC OL uncoupled:** the output inductors are not coupled. An ac sweep can be performed.
- **Tran uncoupled:** the transient response when both inductors are un-coupled.
- **AC OL:** the output inductors are coupled with dc transformers. An ac sweep can be performed.
- **Tran coupled:** the output inductors are coupled with dc transformers. A step load can be performed.
- **Tran k coupled:** the output inductors are coupled with a k coupling coefficient. A step load can be performed.
- **AC k coupled:** the output inductors are coupled with a k coupling coefficient. An ac sweep can be performed

multi-output forward 12V5V generic.dwg: a multi-output 5 V / 15 A plus a 12 V / 15 A ATX power supply featuring coupled inductors. A generic model configuration with a TL431. This is a multi-sheet template:

Transient model:

- **Normal coupled:** both inductors are coupled using dc transformers. A steady-state simulation is performed.
- **Tran coupled:** both inductors are coupled using dc transformers. A load step simulation is performed.
- **Tran uncoupled:** inductors are not coupled. A load step simulation is performed.
- **Normal uncoupled:** inductors are not coupled. A steady-state simulation is performed.
- **k coupling normal:** both inductors are coupled with a k coupling coefficient. A steady-state simulation is performed.
- **Tran k:** both inductors are coupled with a k coupling coefficient. A load step simulation is performed.

multi-output forward 12V5V UC3844.dwg: multi-output forward 12V5V generic.dwg: a multi-output 5 V / 15 A plus a 12 V / 15 A ATX power supply featuring coupled inductors. A UC3844 model configuration. This is a multi-sheet template:

Transient model:

- **Normal coupled:** both inductors are coupled using dc transformers. A steady-state simulation is performed.
- **Tran coupled:** both inductors are coupled using dc transformers. A load step simulation is performed.
- **Tran uncoupled:** inductors are not coupled. A load step simulation is performed.
- **Normal uncoupled:** inductors are not coupled. A steady-state simulation is performed.
- **k coupling normal:** both inductors are coupled with a k coupling coefficient. A steady-state simulation is performed.
- **Tran k:** both inductors are coupled with a k coupling coefficient. A load step simulation is performed.