

Designing Low Noise DC/DC Converters

A presentation from Beta Dyne Power

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Low Noise DC/DC Converter Design Presentation from Beta Dyne Power

Basic parameters, definitions and considerations for a DC/DC converter

- DC/DC Converter:

A component of module that can accept an unregulated DC input voltage and convert it to a different, regulated and often isolated DC output voltage.

- Input Voltage:

Converters are specified in part by their DC input voltage range but may also be specified as a nominal input voltage.

Ex: (9V to 18V) nominal 12Vdc, (18V to 36V) nominal 24Vdc, (36V to 72V) nominal 48V

- Output Voltage Regulation:

Precise output voltage provided regardless of the wide input voltage range.

Basic parameters, definitions and considerations for a DC/DC converter (cont'd)

- Input/Output Isolation: Galvanic Isolation (No Direct Current Path from Input to Output)
Electrical (I/O) separation for safety and signal integrity, protecting users from shock, and preventing interference.
- Pulse width modulation:
Minimizes power loss (improves efficiency) by varying the duty cycle.
- Ripple and Noise:
AC component on the output resulting from the switching action of the converter.
Ripple is typically 0.24% to 10% of its output DC voltage, whereas noise often results from fast current transitions and component parasitics.
- Efficiency (PO/PI): Often specified as a percentage. ($E = PO/PI \times 100\%$).
The higher the efficiency the lower the heat and power loss.

Low Noise DC/DC Converter Designs Utilizing Low Dropout (LDO) Linear Regulators

- Linear regulators (or voltage regulators) are used in DC/DC converters to provide voltage noise reduction and stability for the load.
- They provide a regulated output voltage converted from an unregulated input voltage source.
- Please note, linear regulators are not switching regulators (SR) which are switching circuits designed around a PWM energy-storing element, such as an inductor, capacitor or filter, to step up or step down a voltage source.
- Although switching regulators may offer higher efficiency than linear regulators, they also feature higher voltage ripple.
- When a low ripple is required, the ripple of a switching regulator can be reduced by a linear regulator.

Advantages of the Beta Dyne LDO Regulator designs

Beta Dyne's Low-Noise Series of DC/DC Converters utilize a patented circuit design with Low Drop Out (LDO) linear regulators to:

- Maximize efficiency (up to 93%)
- Minimize noise
- Lower output ripple
- Improved regulation
- Additional (RC) filtering
- Significantly improved transient response
- Resulting in a complete solution for customers



Advantages of the Beta Dyne LDO Regulator designs

Beta Dyne's Low-Noise series of converters also use the patented circuit design to eliminate potential problems with linear regulators, while substantially improving the output ripple.

- The output ripple of a standard DC/DC converter is normally between 0.2% and 10% of its nominal output voltage.
- Linear regulators can be used to reduce a converter's output ripple or noise down to a few mV (millivolts) or even microvolts.

Advantages of the Beta Dyne LDO Regulator designs

Substantially Improves the Transient Response

- A switching regulator transient response for a 50% to 100% to 50% load step, can range from 5 μ S to 5mS.
- The transient response of a linear regulator with the same load step change, ranges from 5 μ S to 50 μ S even when the load switches from no load to full load.

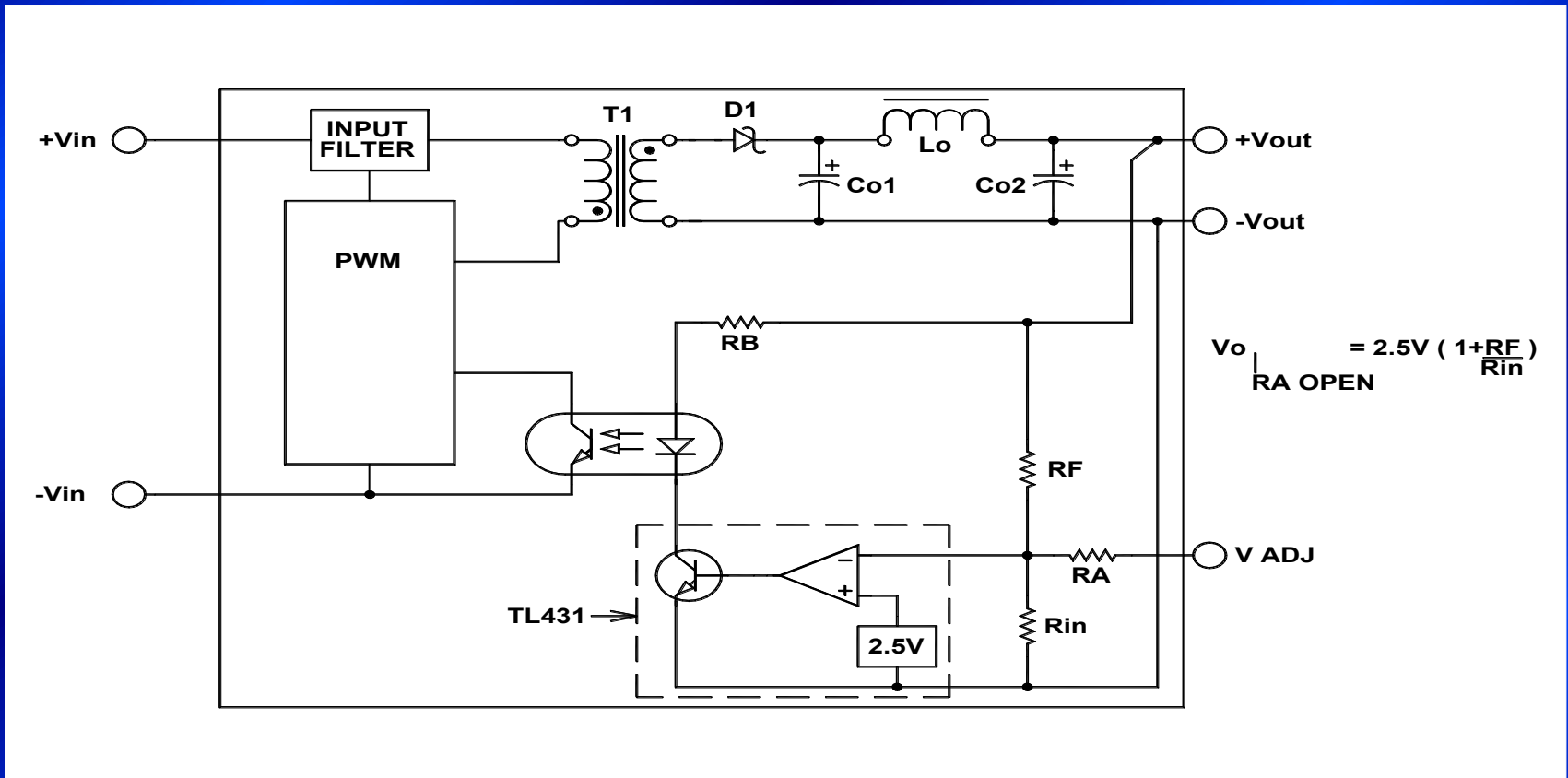


Figure 1. Block diagram of typical flyback DC/DC Converter

At its output, CO1 provides coarse output filtering and energy storage, while LO with CO2 (a low pass filter) perform the fine output filtering.

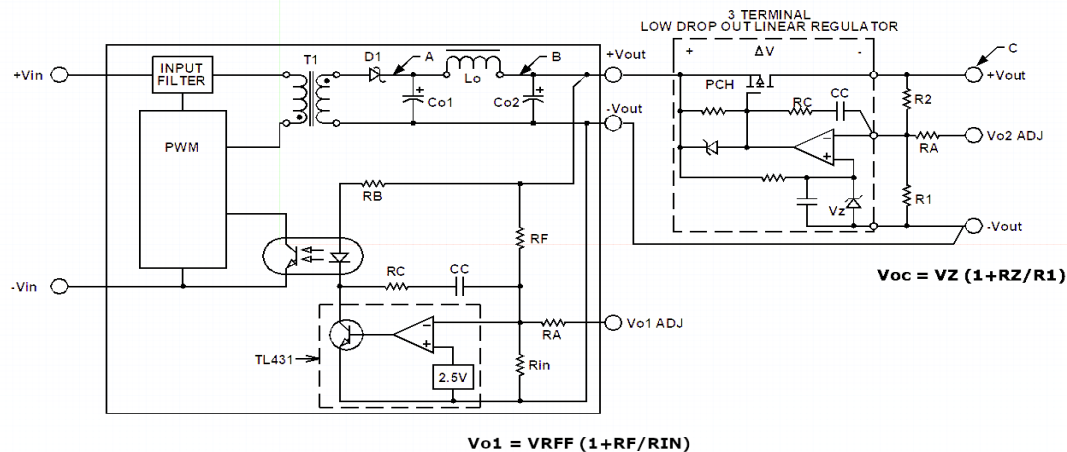


Figure 2.
Converter from Figure 1, followed by a low dropout linear regulator.

- In Figure 2, the output of the linear regulator is lower than the output of the converter by at least the dropout voltage of the linear regulator.
- Also in Figure 2, both DC/DC converters have an output adjust terminal and either one can be used to set the required voltages of VO1, VO2 for proper operation of the system.

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators

- As will be seen in Figures 3 (a,b,c,d) and Figure 4 in the following slides, the linear regulator of a 10W 5VOUT @2A converter offers 2mV to 5mV of output ripple but also reduces the output noise by approximately 12dB.
- The linear regulator acts as a low pass filter and will not attenuate any common-mode noise between the converter's input and output.
- Please note that all the snubbers in the experimental converter were removed and that no high frequency ceramic capacitors were installed across the converter's output terminals.
- Figure 3D shows the results of using a 6.8 μ F capacitor to lower the noise floor by 10dB (compare Figure 3C without the 6.8 μ F to Figure 3D with the 6.8 μ F capacitor).

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators

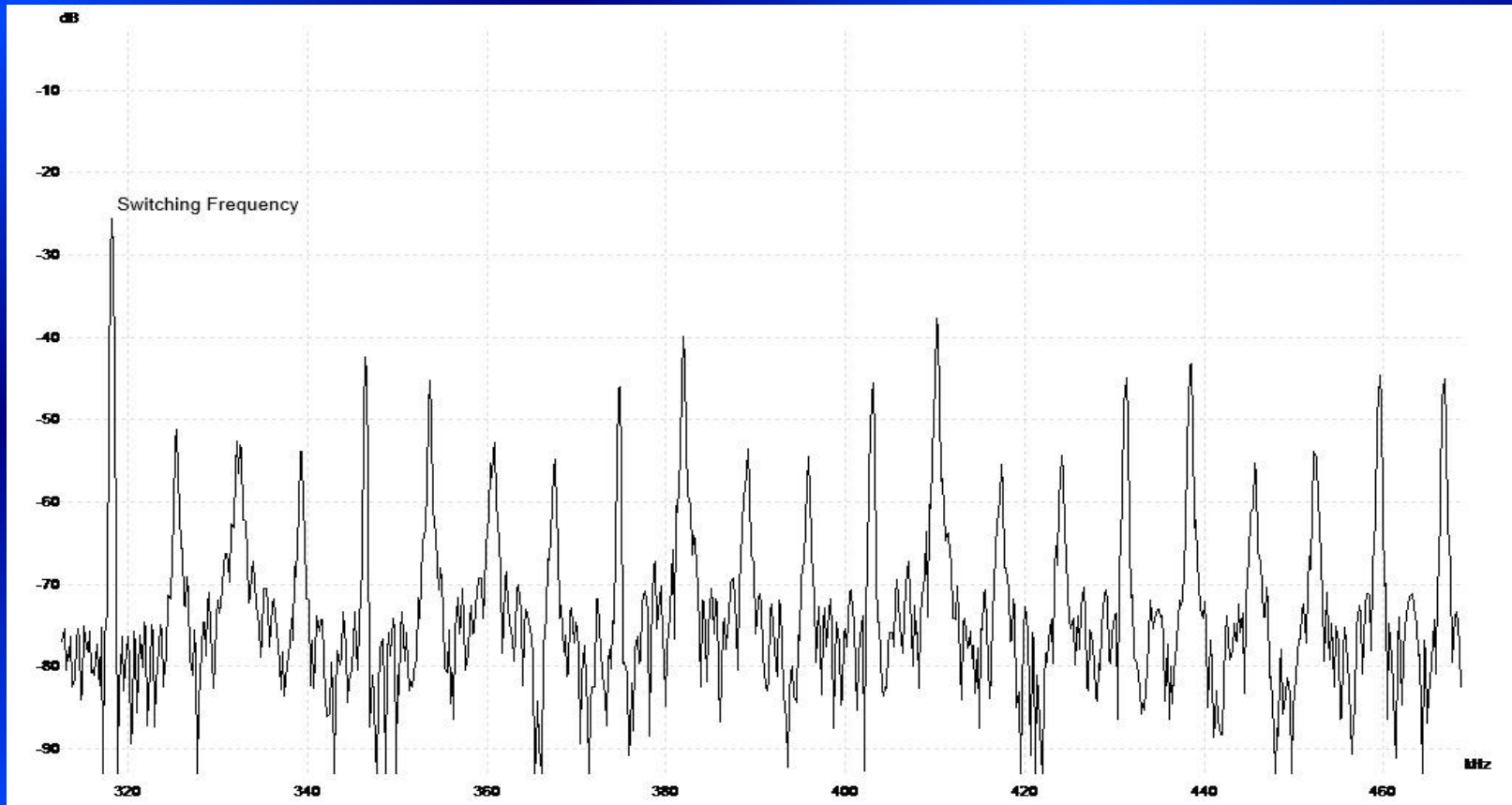


Figure 3A. Spectrum of VOUT at Point A in Figure 2

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators

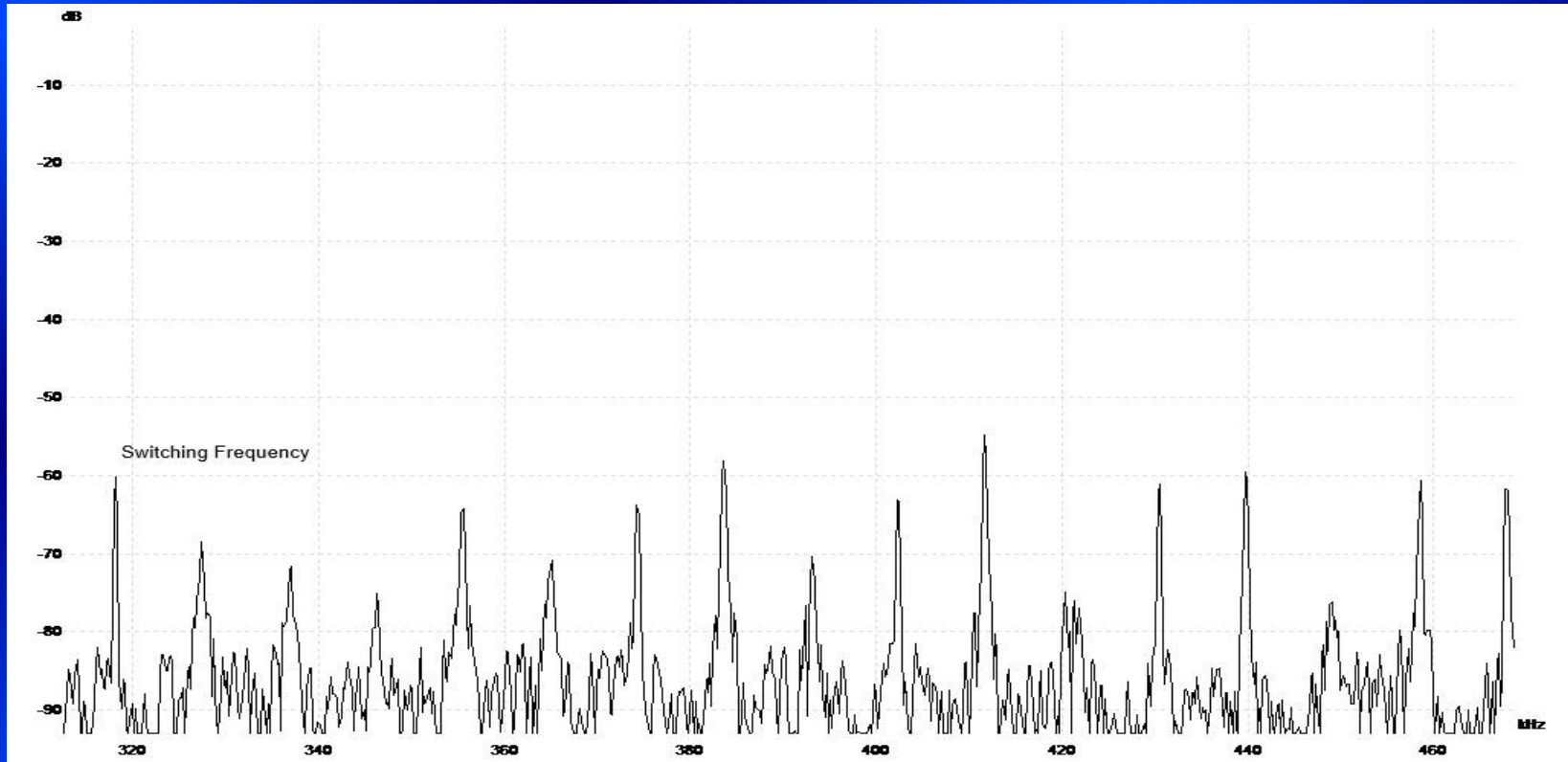


Figure 3B. Spectrum of VOUT at Point B in Figure 2

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators

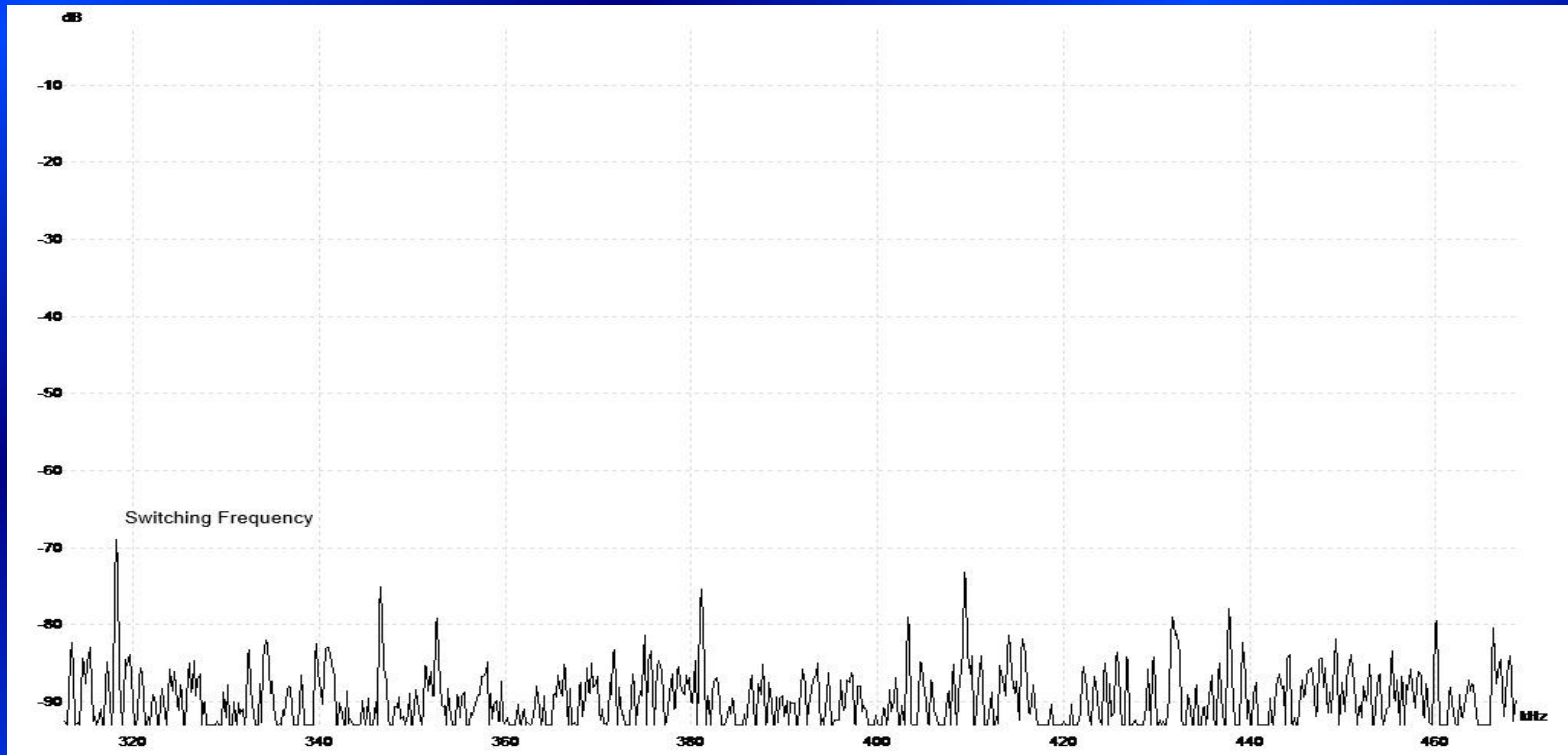


Figure 3C.

Spectrum of VOUT at Point C in Figure 2. Linear regulator output without 6.8 μ F capacitor at the output

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators

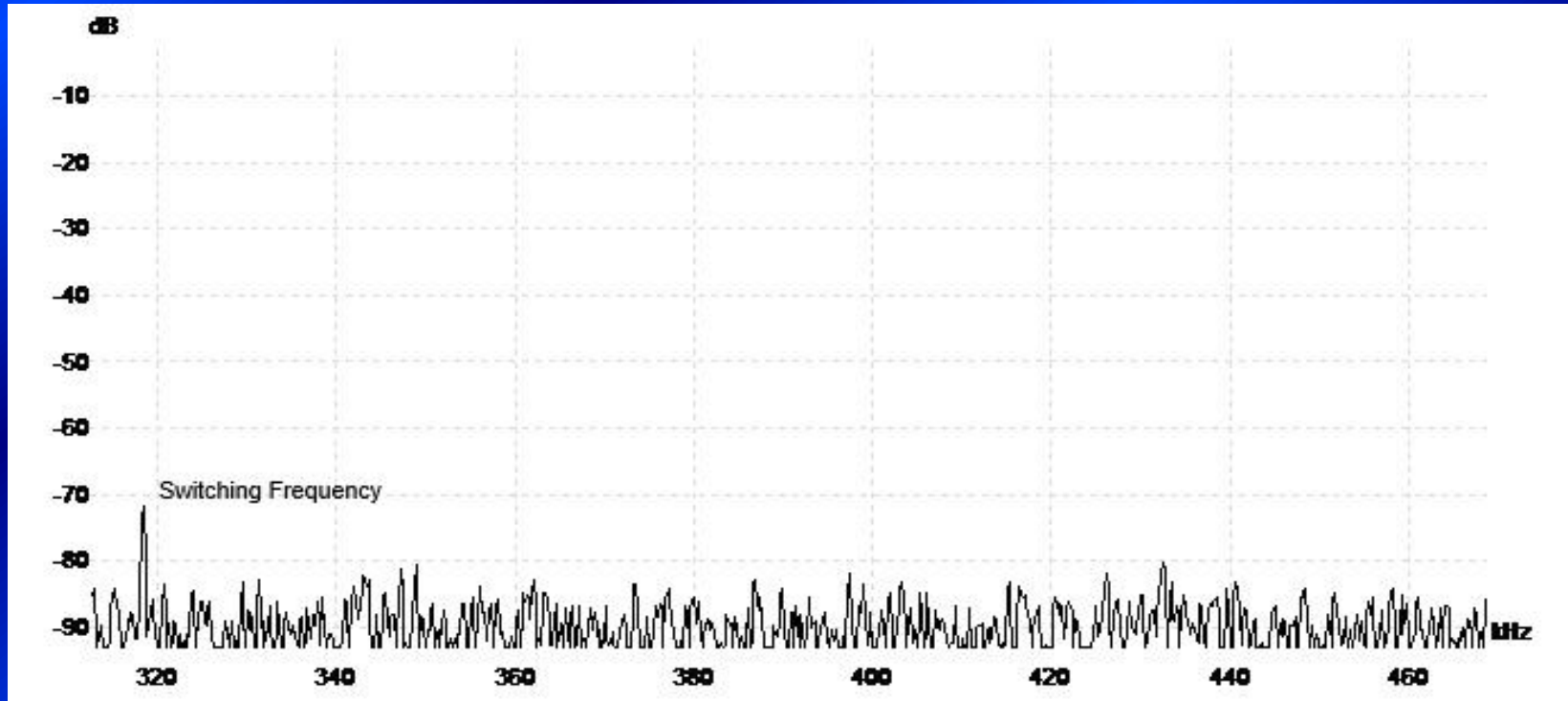
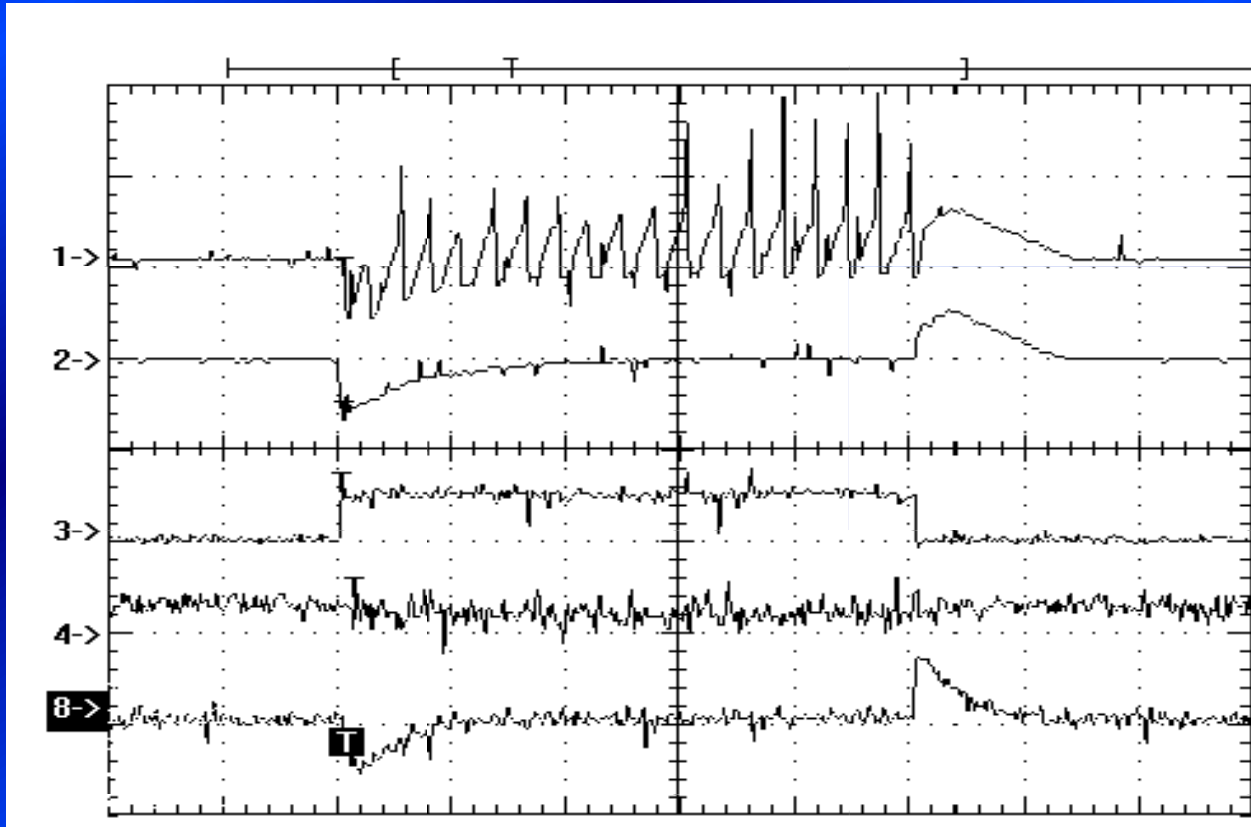


Figure 3D. Spectrum of VOUT at Point C in Figure 2.

Linear regulator with 6.8 μ F capacitor at the output, which lowers the noise floor by 10dB.

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators



- 1) CH1 200mV 2.5mS
- 2) CH1 200mV 2.5mS
- 3) CH1 10mV/A 2.5mS
- 4) CH2 20mV 2.5mS
- 5) CH1 50mV 2.5mS

Ripple at A in Figure 2

Ripple at B in Figure 2

Output current 2A step

LN10S5/48 output (5V@2A, See Figure 2C) 5

Output response at B for 50% FL to FL to 50% FL

Figure 4. Transient response of Model LN10S5/48

Low Noise DC/DC Converter Designs Utilizing Low Dropout Linear Regulators

- As seen in Figures 3 & 4, the linear regulator of a 10W 5VOUT @2A converter offers 2mV to 5mV of output ripple but also reduces the output noise by approximately 12dB.
- The linear regulator acts as a low pass filter and will not attenuate any common-mode noise between the converter's input and output.
- Please note that all the snubbers in the experimental converter were removed and that no high frequency ceramic capacitors were installed across the converter's output terminals.
- Figure 3D shows the results of using a 6.8 μ F capacitor to lower the noise floor by 10dB. Compare Figure 3C without the 6.8 μ F to Figure 3D with the 6.8 μ F capacitor.

Beta Dyne's Ultra Low Noise, Isolated DC/DC Converter Products

The following tables, provide general product information for some of Beta Dynes Ultra Low Noise, Isolated DC/DC Converters - with efficiencies up to 93%.



Beta Dyne's Ultra Low Noise, Isolated DC/DC Converter Products

Model Series	Output Power	Nom. Input, Volts	Input Range, Volts	# Outputs	Output Volts	Isolation	Features	Package
Q5S	5W	24, 48	11-36, 18-72	Single	3.3,5,12,15	1,500VDC	Ultra Low Noise, Wide 4:1 Inputs	DIP
Q5D	5W	24, 48	11-36, 18-72	Dual	+/-5, +/-12, +/-15	1,500VDC	Ultra Low Noise, Wide 4:1 Inputs	DIP
LN10S	10W	5,12,24,48	4.75-9, 9.5-18, 18-36, 36-72	Single	2.5, 3.3, 5, 6, 12, 15	1,500VDC	Ultra Low Noise, Two pinout styles	1" x 2" x 0.4" Module
LN10D	10W	5,12,24,48	4.75-9, 9.5-18, 18-36, 36-72	Dual	+/-5, +/-6, +/-12, +/- 15	1,500VDC	Ultra Low Noise, Two pinout styles	1" x 2" x 0.4" Module
LNB15S	15W	12, 24, 48	9-18, 18-36, 36-72	Single	1.8, 2.5, 3.3, 5, 12, 15	1,500VDC	Low Noise, 2:1 Input	1" x 2" x 0.45" Module
LNB15D	15W	12, 24, 48	9-18, 18-36, 36-72	Dual	+/-5, +/-12, +/-15	1,500VDC	Low Noise, 2:1 Input	1" x 2" x 0.45" Module
LN15S	15W	5, 12, 24, 48	5-9, 9-18, 18-36, 36- 72	Single	3.3, 5, 6, 12, 15	1,500VDC	Ultra Low Noise, High Efficiency	2" x 2" x 0.4" Module
LN15D	15W	5, 12, 24, 48	5-9, 9-18, 18-36, 36- 72	Dual	+/-5, +/-12, +/-15	1,500VDC	Ultra Low Noise, High Efficiency	2" x 2" x 0.4" Module

Beta Dyne's Ultra Low Noise, Isolated DC/DC Converter Products

Model Series	Output Power	Nom. Input, Volts	Input Range, Volts	# Outputs	Output Volts	Isolation	Features	Package
LN15D	15W	5, 12, 24, 48	5-9, 9-18, 18-36, 36-72	Dual	+/-5, +/-12, +/-15	1,500VDC	Ultra Low Noise, High Efficiency	2" x 2" x 0.4" Module
Q25S	25-30W	24, 48	9-36, 18-72	Single	3.3, 5, 12, 15	1,500VDC	4:1 Input Range, Low Noise	1" x 2" x 0.45" Module
Q25D	25-30W	24, 48	9-36, 18-72	Dual	+/-5, +/-12, +/-15	1,500VDC	4:1 Input Range, Low Noise	1" x 2" x 0.45" Module
EBL30	25-30W	12, 24, 48	9-18, 18-36, 36-72	Single	2.5, 3.3, 5, 12, 15	1,500VDC	Ultra Low Noise, High Efficiency	1" x 2" x 0.45" Module
BHE30S	30W	12, 24, 48	9-18, 9-36, 18-36, 18-72	Single	2.5, 3.3, 5, 12, 15	1,500VDC	4:1 Input Range, Low Noise	2" x 1.6" x .4" Module
BHE30D	30W	24, 48	9-36, 18-72	Dual	+/-5, +/-12, +/-15	1,500VDC	4:1 Input Range, Low Noise	2" x 1.6" x .4" Module
EAL50	50W	12, 24, 48	9-18, 18-36, 36-72	Single	3.3, 5, 12, 15	1,500VDC	2:1 Input Range High Efficiency	2" x 2" x .50" Module



Beta Dyne also features a vast library of hundreds of custom DC/DC converters, many of which are low noise and high efficiency solutions.

The following is a sample of some of our custom products.

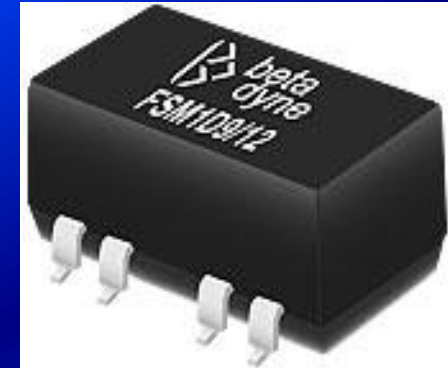
Model Series	Output Power	Nom. Input, Volts	Input Range, Volts	# Outputs	Output Volts	Isolation	Features	Package
ACC1200	12W	12	9.5V-18V	Single	6.5V (12V max.)	1,500VDC	Adjustable voltage and current	2" x 2" x 0.5" Module
BD35003	35W	24	18V-36V	Dual	+/-120Vdc	1,500VDC	Operates with unbalanced loads	2" x 2" x 0.5" Module
BD35004	35W	24	18-36	Single	430Vdc (+/-215Vdc)	1,500VDC	High output voltage	2" x 2" x 0.5" Module
BHE3006	40W	70V	20V-110V	Single	13Vdc	1,500VDC	5:1 input voltage range. Low noise. High efficiency	1.98" x 1.58" x 0.55" Module
LN10028	10W	48	36-72	Single	5.5V	1,500VDC	10mV Ripple and Noise	2" x 1" x 0.395" Module

Other converter products and features from Beta Dyne

- High Input and Output Voltages
- Efficiencies up to 93%
- Adjustable Outputs
- Power levels ranging from 1W to 150W
- Single/Dual/Triple Outputs
- Models are offered in SIP, DIP, and other industry-standard packages and pin-outs
- EMI Filters
- Low Cost



Beta Dyne Power Solutions Products



Beta Dyne Power Solutions

- With over 25 years in the power industry, Beta Dyne, Inc. has developed a wide range of unique and high-performance power products, as well as a reputation for quality and reliability.
- Our combined strengths of in-house design and manufacturing made us a leader in both standard and customized DC/DC converter solutions.
- More information can be found at www.betadynepower.com

