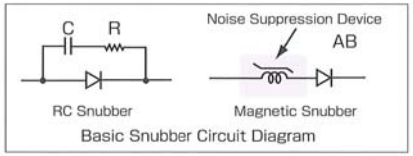
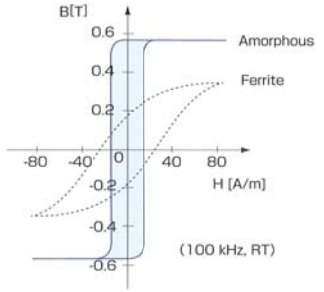
2. Noise Suppression Devices AMOBEADS®

An amorphous noise suppression device is unique and completely different from conventional noise filters. Conventional noise prevention products focus on somehow minimizing the noise after it's been created, by typically trying to absorb the noise, and so their effectiveness in noise reduction is directly influenced by frequency of the circuit. Amorphous noise suppressing devices, on the other hand, focus on the source of the noise and work to prevent or minimize the noise before it has a chance to develop. The source of the electronic circuit noise is the rapid change of current or voltage, and the effectiveness of the amorphous cores in eliminating this noise is independent of frequency.

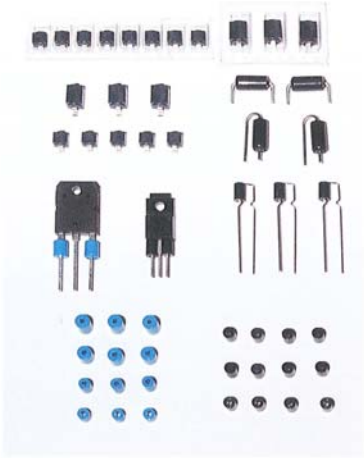
An amorphous noise suppression device is a product that takes full advantage of the unique magnetic characteristics of the cobalt based amorphous alloy. Toshiba Materials offers two noise suppression devices, "AMOBEADS®" and "SPIKE KILLERS®". AMOBEADS®" deliver excellent noise suppression results and are convenient to use by simply being slipped over the leads of the semiconductor device. "AMOBEADS®" are also available with a lead thru and in a surface mount configuration. "SPIKE KILLERS®", which are larger in size than "AMOBEADS®", most often are wire wound and are effective in eliminating or minimizing higher noise levels.



Basic Snubber Circuit Diagram

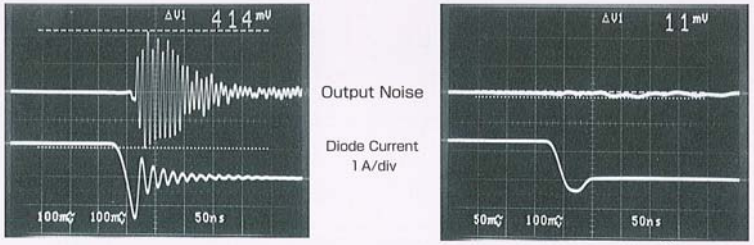


B-H Curve (typical)



Example for Noise Suppressing Effect (Chopper Converter)

With an excellent saturable characteristic, "AMOBEADS ® suppress the reverse recovery current of the diode and decrease the noise that was occurring. When the current for diode reverses and tries to go into the recovery condition, the "AMOBEADS®" displays a large inductance and oppose the generation of the recovery current. In this instance, a soft recovery is possible for core material with a smaller coercive force.



Without Countermeasure

With AMOBEADS®
(AB4×2×8W)

AB/LB Series

RoHS compliant products

Standard Specifications

AMOBEADS®

W series

Type No.	Finished Dimensions [mm]			Core Size [mm]*1			Total Flux*2	AL value*3	Insulating Cover	Packing Unit
	O.D. max	I. D. min	H.T. max	O.D.	I. D.	H.T.	φc[μWb] min	L[μH] min		
AB3X2X3W	4.0	1.5	4.5	3.0	2.0	3.0	0.9	3.0	PBT case Blue	2,000 [pcs/box]
AB3X2X4.5W	4.0	1.5	6.0	3.0	2.0	4.5	1.3	5.0		
AB3X2X6W	4.0	1.5	7.5	3.0	2.0	6.0	1.8	7.0		
AB4X2X4.5W	5.0	1.5	6.0	4.0	2.0	4.5	2.7	9.0		
AB4X2X6W	5.0	1.5	7.5	4.0	2.0	6.0	3.6	12.0		
AB4X2X8W	5.0	1.5	9.5	4.0	2.0	8.0	4.8	16.0		

DY series (low price) (Recommend for big demand, 10,000pcs/lot)

Type No.	Finished Dimensions [mm]		Total Flux*7	Insulating Cover	Packing Unit
	O.D.	H.T.	φc[μWb]		
AB2.8X4.5DY	4.0±0.2	5.7±0.3	0.9min	PBT case Black	10,000 [pcs/bag]

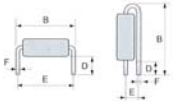
※Inner diameter can pass through a 1.2X0.7mm lead.


W series DY sereis

AMOBEADS®with lead

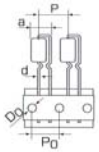
Bulk type

Type No.	Finished Dimensions [mm]				Current*4	Total flux*2	AL Value*3	Insulating Cover	Packing Unit
	B	D	E	F	[A]	φc[μWb]	L[μH]		
LB4X2X8F	16.0max	4.2±0.5	14.0±1.0	φ1.25±0.1	(8.0)	4.8 min	16.0 min	PBT case Black	1,000 [pcs/box]
LB4X2X8U	20.0max	4.0±0.5	5.0±1.0	φ1.25±0.1					


LB4X2X8F LB4X2X8U

Radial taping

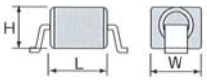
Type No.	P [mm]	Po [mm]	Do [mm]	a [mm]	d [mm]	Current*4 I [A]	Total Flux*7 φc[μWb]	Packing Unit
LB2.8X4.5U	12.7	12.7	φ4.0	9.0max	φ0.8	(5)	0.9min	3,000 [pcs/box]

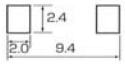


SMD Type AMOBEADS®

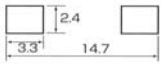
Type No.	Finished Dimensions [mm]			Lead	Io*4	Total Flux*2	AL value*3	Insulating Cover	Packing Unit [pcs/reel]
	width	length	height	width x thickness	[A]	φc[μWb]	L[μH]		
AB3X2X3SM	5.0±0.3	5.0±0.3	4.0±0.3	(1.8×0.35)	(6.0)	0.9 min	3.0	LCP case Black	2,000
AB4X2X6SM	6.0±0.3	8.0±0.3	5.0±0.3	(1.8×0.52)	(9.0)	3.6 min	12.0		1,000

Recommended Land Pattern (mm)





AB3X2X3SM



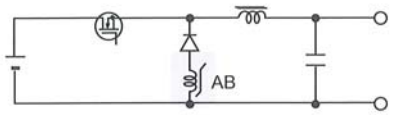
AB4X2X6SM

*1 Reference Value *2 Minimum Guarantee on Measuring Condition : 50kHz、80A/m(sine wave), R.T.
*3 Measuring Condition : 50kHz, 1V, 1turn, R.T.
*4 Typical Value, using a cross section of lead
*5 Measuring Condition : 100kHz, 80A/m (sine wave), R.T. *6 Tolerance ±0.2 [mm]
*7 Converted from Inductance Value L_1 at 1kHz、100mA(sine wave)、R.T.
$\phi c(\mu Wb) = 0.282 \times L_1(\mu H)$

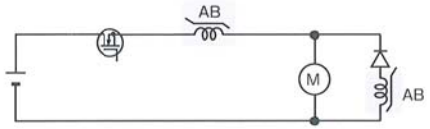
☆"AMOBEADS® " sample kits are prepared. Please ask to sales department.
☆"AMOBEADS® " and "SPIKE KILLER® " : Registered trademarks of TOSHIBA MATERIALS Co., Ltd.
☆"AMOBEADS® " and "SPIKE KILLER® " : Resistered in U.S.A., France, Germany, U.K., Japan.

Examples of Applied Circuits and their Characteristics

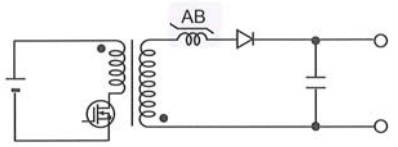
Application of Amorphous Noise Suppression Devices



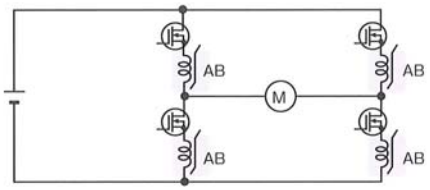
Chopper Converter



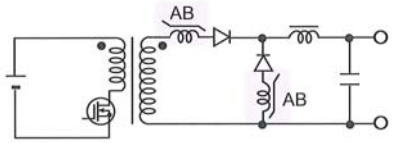
Control Circuit for Motor



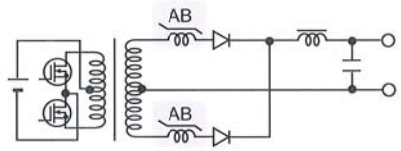
Flyback Converter



Motor Driving Circuit

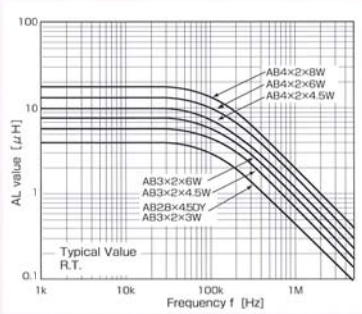


Forward Converter

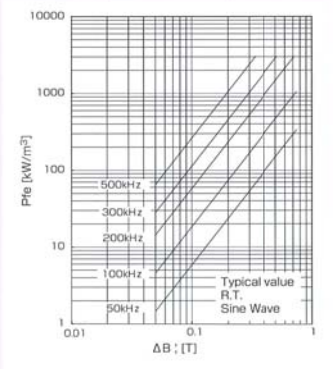


Push-pull Converter

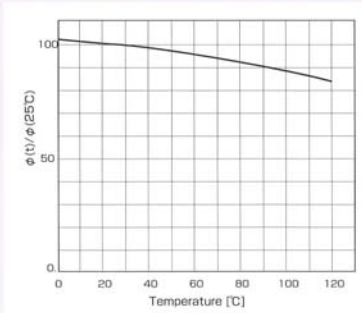
Characteristics (Typical value)



Frequency Characteristics of Inductance



Coreloss Characteristic [AMOBEADS®]



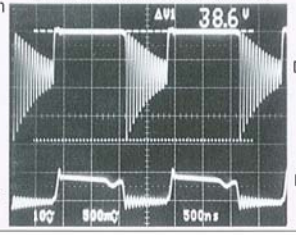
Flux(φ) Decline Ratio vs. Temperature

Effects of Noise Suppression by AMOBEADS®

Spike Voltage Suppression

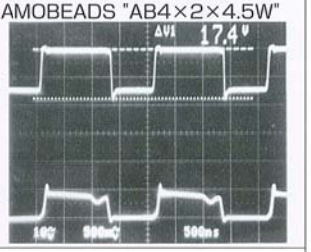
Spike voltage can be reduced and ringing phenomena can also be prevented by AMOBEADS, and also Schottky barrier diode (SBD) can be protected from over withstand voltage.

Frequency : 500kHz
Output Voltage - Current
: 5V-20A



Diode Voltage
VD
10V/div

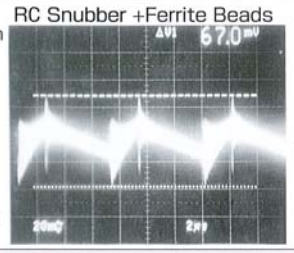
Diode Current
ID
5A/div



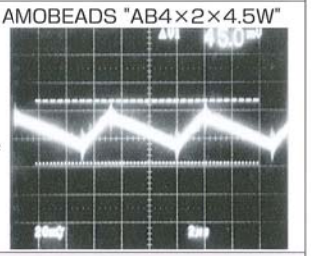
Output Noise Reduction

When the ferrite replaced to AMOBEADS at the secondary output diode (FRD) of the forward converter circuit, the output noise can be tremendously reduced, not only noise peak level but also amplitude range.

Frequency : 150kHz
Output Voltage - Current
: 15V-10A



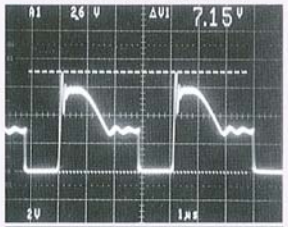
Output Noise
VN
20mv/div



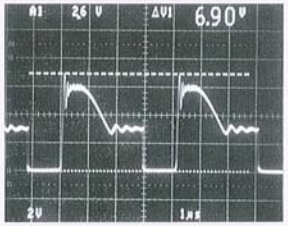
Primary Surge Voltage

When the ferrite replaced to AMOBEADS at the secondary output diode (SBD) of the forward converter circuit, the output noise and harmful influence to the primary stage can be reduced. These effects are based on the inclination of the actual BH curves between amorphous and ferrite materials.

Frequency : 250kHz
Output Voltage - Current
: 5V-15A

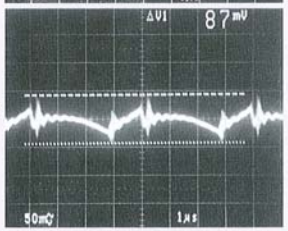


MOS-FET
Drain-Source
Voltage
VDS
200V/div

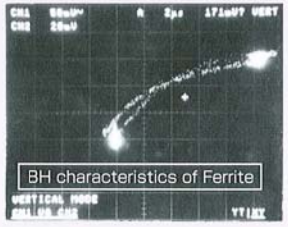


Output Noise

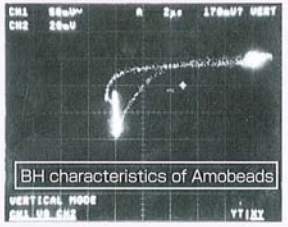
Output Noise
VN
50mv/div



Actual BH Curve



B
H



How to Select the Proper Size "AMOBEADS®"

Reference

The proper size "AMOBEADS" core is selected by calculating the necessary voltage times the time in seconds (=flux). From its operating theory, there is a need to increase the voltage used in the calculation by that which develops during the reverse recovery period of diode. The multiple of the voltage and time (voltage times second) is equal to the operating flux. Therefore, the magnetization $\Delta\phi$ns necessary to suppress the noise is calculated by the voltage Ec[V] and time for reverse recovery of diode, that is added to "AMOBEADS"

$$\Delta\phi_{ns}\,[Wb] = Ec \times trr\ [V \times Sec]$$

A good result is achieved when the voltage Ec added to "AMOBEADS" is close to voltage added to diode. Please select the "AMOBEADS" that have a larger core magnetization ϕc than the voltage times seconds that was calculated here. However, the actual noise suppression result for "AMOBEADS" on real circuit may differ from the calculated value due to the peculiar recovery characteristics of the diode used or the circuit structure. So please confirm the effect by performing examination. "AMOBEADS" can be also affected by things like a CR snubber, so please perform evaluation under condition without any effect of a snubber.

Since "AMOBEADS" have high circuit voltage, sometimes an insufficient result is obtained when the reverse recovery time is long and has minimal magnetization. Under this condition, please consider a wire wound type "SPLIKE KILLER"

Example of "AMOBEADS" Selection

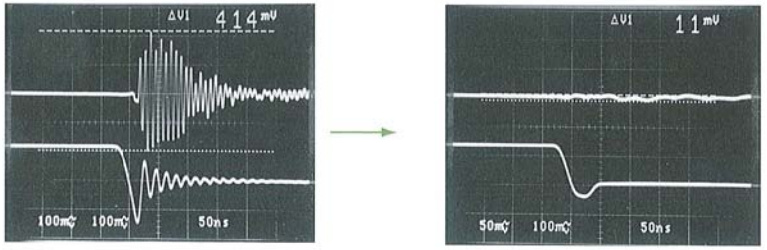
Forward Converter

	Output Voltage				
trr	3.3V	5V	12V	15V	24V
35nsec	AB3×2×3W	AB3×2×4.5W	AB3×2×6W	AB4×2×4.5W	AB4×2×6W
60nsec	AB3×2×4.5W	AB3×2×6W	AB4×2×4.5W	AB4×2×6W	SPIKE KILLER

Flyback Converter

	Output Voltage				
trr	3.3V	5V	12V	15V	24V
35nsec	AB3×2×3W	AB3×2×3W	AB3×2×4.5W	AB3×2×6W	AB4×2×4.5W
60nsec	AB3×2×3W	AB3×2×4.5W	AB3×2×6W	AB4×2×4.5W	AB4×2×6W

Example of Noise Reduction



Without Countermeasure

With AMOBEADS
(AB4×2×8W)

Principle of the Noise Suppressing Device

Reference

We will explain the behavior of "AMOBEADS" when slipped over the lead of a switching power supply output diode.

Period I ,O(When Diode is On)

During period I, which is when the diode is in the "ON" condition and the forward current is running, the "AMOBEADS" are in the saturated magnetic condition "I". There will be almost no inductance under this condition. (Inductance is proportional to the slope of the B-H curve.)

Period Ⅱ(When Diode is Turn Off)

During period Ⅱ, which is when the diode current starts to turn off and the current decreases heading towards zero, the "AMOBEADS" magnetization curve will change like "Ⅱ" in a condition of almost no inductance until the current crosses zero. Since there is no inductance during this period Ⅱ, the angle or slope of the diode current during turn off is constant, a unique characteristic of the "AMOBEADS". If materials such as ferrite is used, inductance will occur during this period Ⅱ and the angle or slope of current during the turn off period will change and this will lead to increased of diode loss.

Period Ⅲ(Reverse Recovery Period)

During period Ⅲ, a reverse recovery current tries to flow in a direction opposite to the normal direction of current flow of the diode and as a result, the magnetization curve of the "AMOBEADS" change like "Ⅲ" and the inductance increases rapidly. At this time, the large inductance of the "AMOBEADS" intercepts and opposes the recovery current and converts the current into a soft recovery condition. Thus by converting the sharp reverse recovery to a soft recovery condition by decreasing the rate of the current change (di/dt), the "AMOBEADS" minimize the rapid change of current (High di/dt) and suppress the noise in the circuit.

Period Ⅳ(After Reverse Recovery Ends)

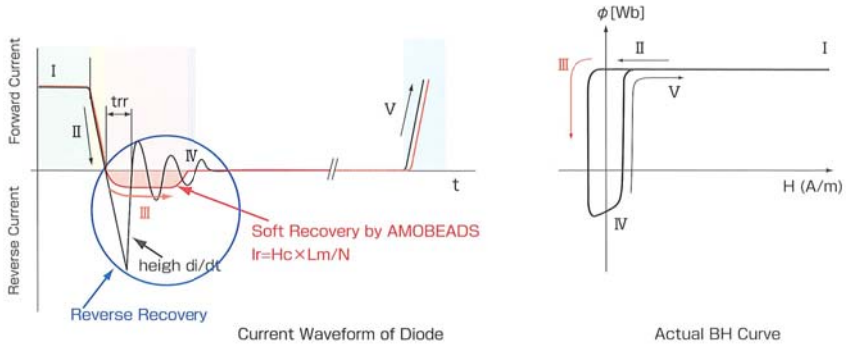
During period Ⅳ, when the reverse recovery of the diode ends, the magnetization of the "AMOBEAD" will move parallel to the vertical axis of the magnetization curve as shown in period "Ⅳ".

Period V (When Diode is Turn On)

The "AMOBEADS" magnetization will change as shown in "V" of the magnetization curve and go back to a saturation condition. At this point, the diode will turn on and after a slight delay of the start up of current, the next current pulse will develop and the cycle described above from Period I thru V will repeat itself.

As the complete cycle repeats itself at the circuit operating frequency, the "AMOBEADS" repeatedly suppress circuit noise during period Ⅲ of the cycle by eliminating the rapid change in the reverse recovery current of the diode, which is the cause of noise.

"AMOBEADS" use a cobalt based amorphous alloy with a small coercive force under frequency and this results in excellent noise suppression.



Current Waveform of Diode

Actual BH Curve

3. Noise Suppression Devices SPIKE KILLER® RoHS compliant products

Standard Specifications

SPIKEK KILLER®

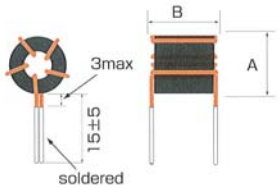
Type No.	Finished Dimensions *1 [mm] O.D.	I.D.	H.T	Core Size [mm] *2 O.D.	I.D.	H.T	Effective core cross section Ae[mm²] *2	Mean Flux Path Length Lm [mm] *2	Total Flux φc[μWb]min *3	Coercive Force Hc[A/m] *3	Rectangular Ratio Br/Bm[%] *3	Insulating Cover
SS7X4X3W	9.1	3.3	4.8	7.5	4.5	3.0	3.38	18.8	3.15	22max	90min	PET case Black
SS10X7X4.5W	11.5	5.8	6.6	10.0	7.0	4.5	5.06	26.7	4.73			
SS14X8X4.5W	15.8	6.8	6.6	14.0	8.0	4.5	10.1	34.6	9.46			

*1 Tolerance ±0.2 [mm] *2 Reference value
*3 Measuring condition : 100kHz、80A/m (sine wave), R.T.

☆ "SPIKE KILLER® " : Registered trademarks of TOSHIBA MATERIALS Co., Ltd.
☆ "SPIKE KILLER® " : Resistered in U.S.A., France, Germany, U.K., Japan.

Wired SPIKE KILLER® and AMOBEADS®

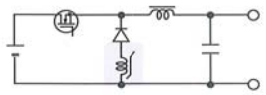
Type No.	Core No.	Current*1 [A]	Wire Dia. [φmm]	N [turn]	Flux*2 [uWb]	Dimensions[mm] A max	B max
AB44DY0305	AB4x2x4.5DY	0.5	0.3	5	13.5	7	9
AB44DY0307	AB4x2x4.5DY	0.5	0.3	7	18.9	7	9
SS07S0309	SS7x4x3W	0.5	0.3	9	28.3	12	8
AB34DY0402	AB3x2x4.5DY	1.0	0.4	2	2.6	6	9
AB34DY0403	AB3x2x4.5DY	1.0	0.4	3	3.9	6	9
AB44DY0402	AB4x2x4.5DY	1.0	0.4	2	5.4	7	9
AB44DY0403	AB4x2x4.5DY	1.0	0.4	3	8.1	7	9
AB44DY0404	AB4x2x4.5DY	1.0	0.4	4	10.8	7	9
SS07S0507	SS7x4x3W	1.5	0.5	7	22.1	12	8
SS07S0510	SS7x4x3W	1.5	0.5	10	31.5	12	8
SS07S0515	SS7x4x3W	1.5	0.5	15	47.3	12	8
SS10S05105	SS10x7x4.5W	1.5	0.5	5	23.7	14	10
SS10S05107	SS10x7x4.5W	1.5	0.5	7	33.1	14	10
SS10S05110	SS10x7x4.5W	1.5	0.5	10	47.3	14	10
SS10S09110	SS10x7x4.5W	5	0.9	10	47.3	15	11
SS14S09108	SS14x8x4.5W	5	0.9	8	75.7	20	11
SS14S09205	SS14x8x4.5W	10	0.9x2	5	47.3	20	11



Type of wire : 1UEW

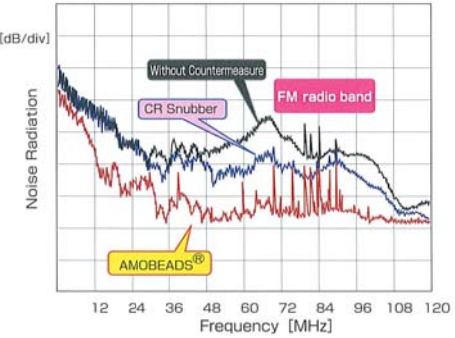
*1: Typical Value, using a cross section of winding wire
*2:Total Flux of core × turn

Example of applied circuit and it's characterisitic



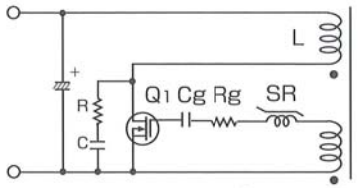
Chopper Converter

Testing Condition of Radiant Noise Measurment	
Input	20[V]
Output	12[V]/2[A]
Frequency	90kHz
Rectifier	FRD
Detector	Simple Loop Antenna



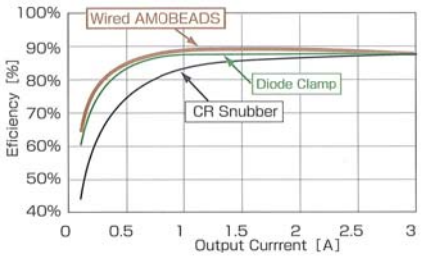
Examples of Applied Circuits and Effects of Noise Suppression

Example Circuit : Self-Exiting Single Flyback(RCC)



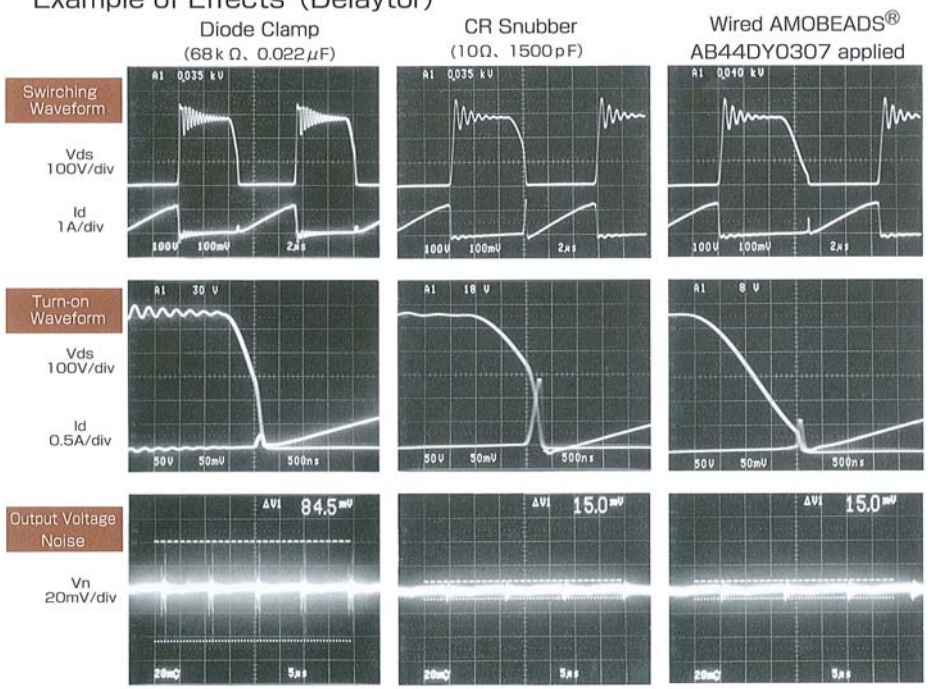
SR : Wired AMOBEADS ®

JPN.P. No. 3190775 Toshiba Materials Co. Ltd.
USP No. 5745353 〃



Power Supply Efficiency (Vin:DC140V, Vo:24V)

Example of Effects (Delaytor)



Wired AMOBEADS delay the turn-on time of the MOSFET when they are inserted between the gate of the MOSFET and drive winding on the primary side of the self-exiting single flyback (RCC). The wired AMOBEADS reduce both noise, due to surge current and switching loss by turning on the switching element at the point when the voltage of the transformer becomes low, utilizing the the LC resonance phenomenon induced by inductance L of the primary winding of the transformer and a snubber capacitor C.

Note : The diode clamp circuit has a tenency to increase the out put noise.