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Technical Report ARMET-TR-18002

SMALL-SCALE DETONATION VELOCITY TEST REPORT

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U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND ARMAMENTS CENTER

Munitions Engineering Technology Center

Picatinny Arsenal, New Jersey

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14. ABSTRACT

Detonation velocity is a critical performance measure for any explosive that is dependent on density of a material. At the research and development level, there is not enough material available to measure the performance parameters of explosives. The U.S. Army Combat Capabilities Development Command Armaments Center, Picatinny Arsenal, NJ, has developed a method that measures detonation velocity using a small amount – less than 2 g. This paper describes the test method and detonation velocity values of secondary explosive and its formulations such as PAX-22, PBXN-9, 3,3′-diamino-4,4′-azoxyfuraz (DAAF), and HATOAF.

15. SUBJECT TERMS

Detonation velocity PAX-22 PBXN-9 3,3′-diamino-4,4′-azoxyfuraz (DAAF)
Methylene-bis-aminonitrofurazan (MBANF) PAX46 HATOAF

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(continued)

INTRODUCTION

There is tremendous interest in producing replacements for initiating explosives that are environmentally undesirable such as lead azide, lead styphnate, and mixtures of these lead-based explosives. The synthesis of lead-free explosives is usually done in small quantities, sometimes milligram batches. Therefore, a method for measuring detonation velocity (DV) of these lead-free explosives was developed for using energetic materials on a small scale. Only a few grams of material are needed for these measurements.

The DV of a new explosive material will be very useful in determining its performance capabilities when compared to the standard explosives currently being used in detonators and primers. The DV for lead azide is 5.5 mm/us at 3.8 g/cm^3, and the DV for triazine triazide is 5.68 mm/us at 1.18 g/cm^3, 6.65 mm/us at 1.41 g/cm^3, and 6.94 mm/us at 1.49 g/cm^3.

This report provides the test method, test equipment, and test setup used to measure small-scale DV for new explosive material: PAX-22 ED01, PAX-22 ED02, PBXN-9 ED01, PBXN-9 ED02, 3,3′-diamino-4,4′-azoxyfurazan (DAAF), methylene-bis-aminonitrofurazan (MBANF) PAX46, and HATOAF.

The formulations for PAX-22 and PBXN-9 are listed in the following bullets:

- PAX-22 ED01: 92% (2µm) CL-20, 3.2% cellulose acetate butyrate (CAB), and 4.8% bis(2,2-dinitropropyl)acetal/formal (BDNPAF).
- PAX-22 ED02: 69% (2µm) CL-20, 23% Class 5 - 1,3,5,7-Tetranitro-1,3,5,7-tetrazocane (HMX), 3.2% CAB, and 4.8% BDNPAF.
- PBXN-9 ED01: 51% Class 1 HMX, 41% Class 5 HMX, 2% Hytemp 4454, and 6% dioctyl adipate (DOA).
- PBXN-9 ED02: 69% (2µm) CL-20, 12.7% Class 1 HMX, 10.3% Class 5 HMX, 2% Hytemp 4454, and 6% DOA.

DESCRIPTION

The instrumentation used in the small-scale DV test consists of the firing system and the measurement system as shown in figure 1. The firing system consists of a Reynolds FS-43 fire set that is made up of a control chassis and a capacitor discharge unit (CDU) module. The CDU module is located next to the explosive chamber that contains the loaded brass cylinders. It is charged up by the control chassis to 3.8 KV to fire the RP87 detonator used to initiate the explosive under test. The control chassis is located in an adjoining room and sends an electrical pulse to fire the firing module. It also sends a trigger pulse to the LeCroy digital storage oscilloscope. The electrical circuit used to measure DV consists of two switches, a two channel pulse forming circuit, and a LeCroy digital storage oscilloscope. The switches are made by twisting magnet wires together and placing them on the top and bottom of the lower test cylinder in line with the explosive material. When the reaction reaches the switch wires, it shorts them and allows capacitors in the pulse circuit to discharge through a load resistor generating timing pulses that are sent to the LeCroy digital storage oscilloscope. Figure 2 is the circuit diagram of the timing pulse circuit. Figures 3 through 6 are pictures of the various components that make up the DV test system.

DISCUSSION

Figure 7 shows the explosive chamber, and figure 8 shows the CDU and DV pulse circuit used to measure small-scale DV. Figure 9 shows trigger and timing pulses from a test explosive as displayed on the screen of the LeCroy digital storage oscilloscope. The pulses generated by the circuit are decaying exponentials that result from discharging the sense capacitors through the shorted switches and a resistive load. They are well defined and timing data is obtained by measuring the time between the peaks of the positive and negative pulses as indicated by arrows. The small-scale DV test results for the new explosive material are summarized in table 1, and the timing data are shown in figures 10 through 20.

CONCLUSIONS

The test results showed that PAX-22 and PBXN-9 have the highest velocity from 8.1684 to 8.5082 mm/us, then 3,3′-diamino-4,4′-azoxyfurazan and methylene-bis-aminonitrofurazan PAX46 from 7.1335 to 7.6616 mm/us, and HATOAF with the lowest velocity of 5.9989 mm/us.

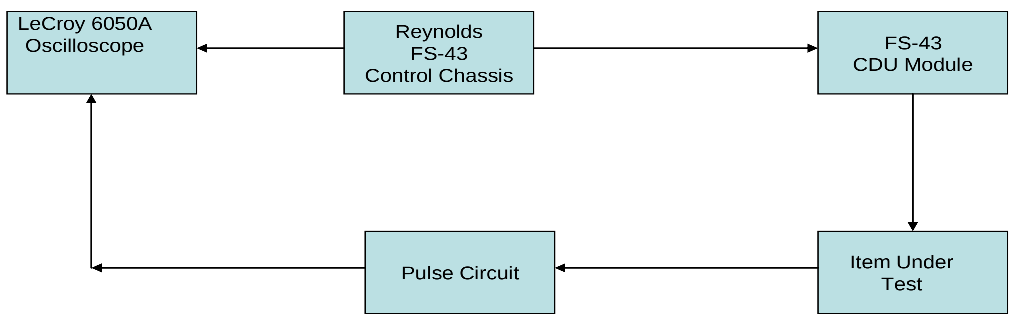

Figure 1
Small-scale DV instrumentation block diagram

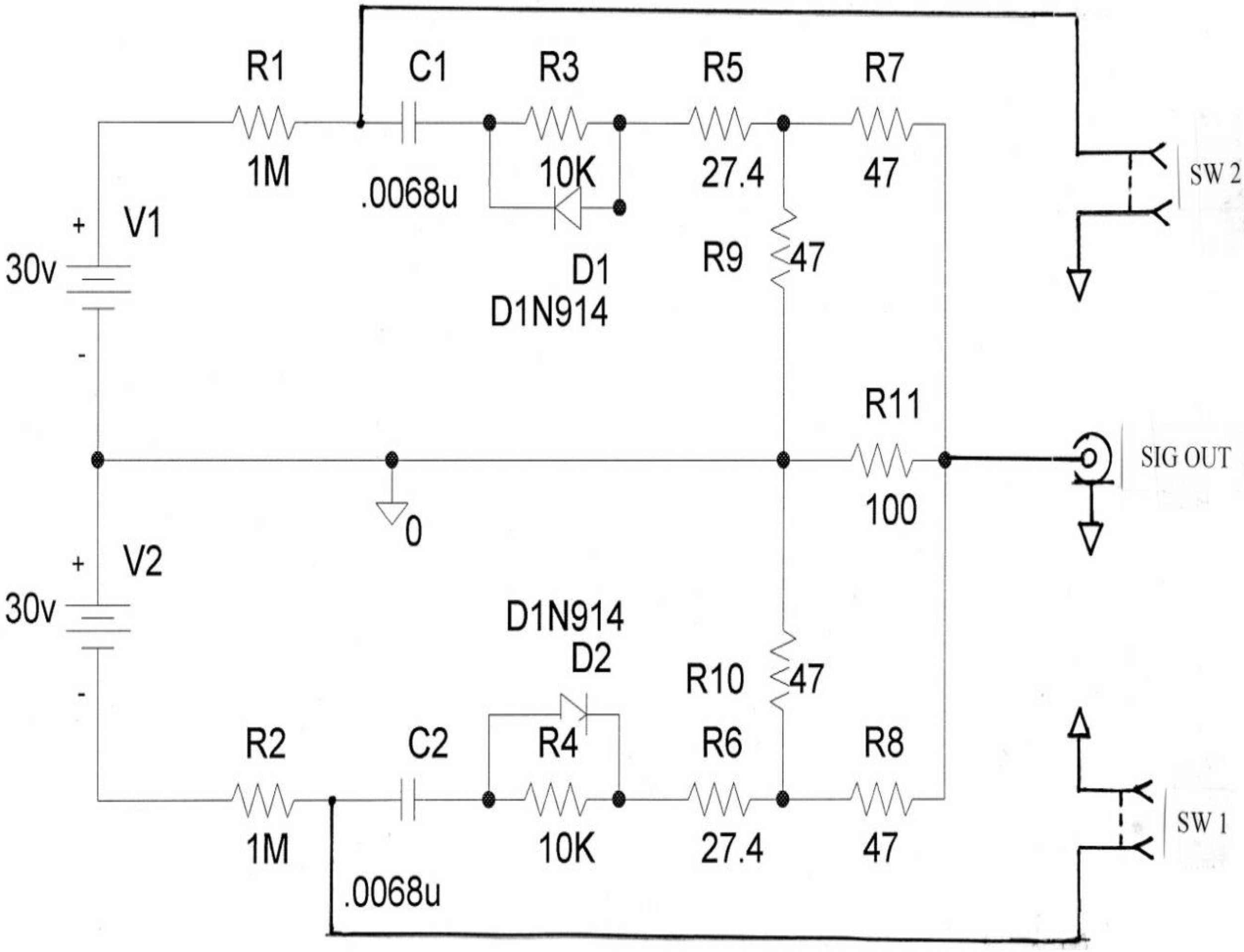

Figure 2
Small-scale DV pulse circuit

Figure 3
Small-scale cylinders and witness plate

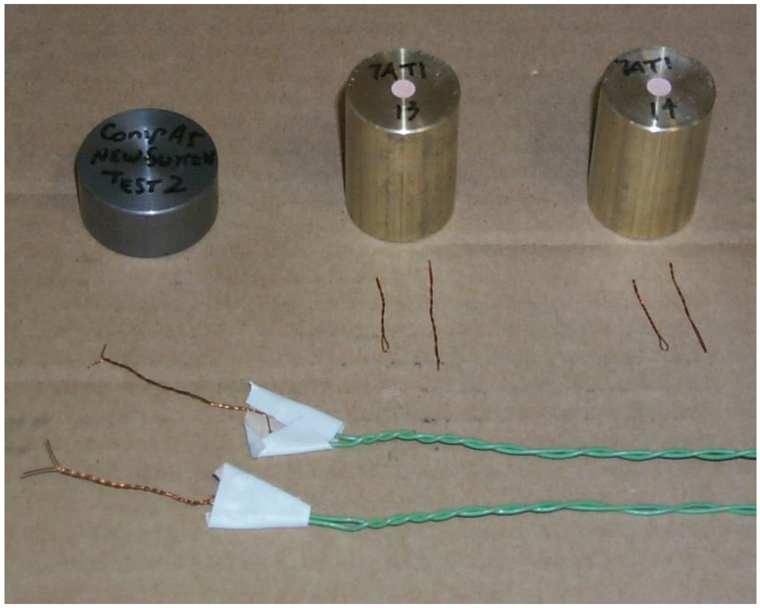

Figure 4
Cylinders, witness plate, cylinder spacers, and switches

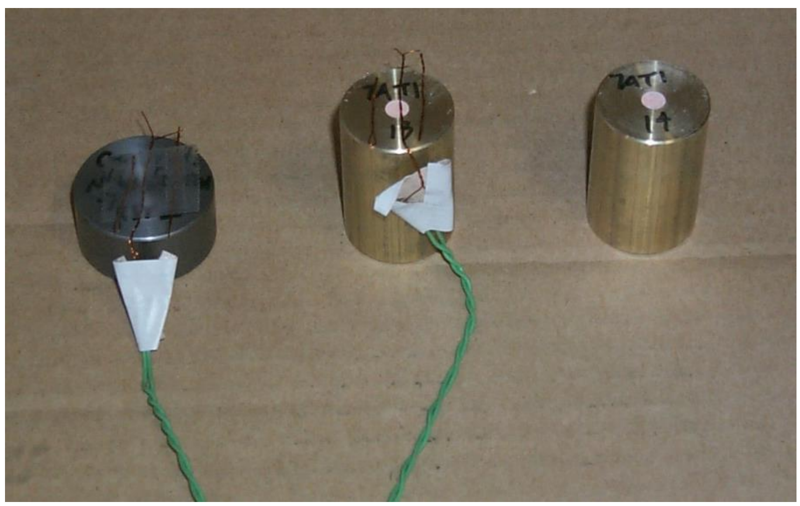

Figure 5
Switches assembled to cylinder and witness plate

Figure 6
Assembled cylinders and witness plate

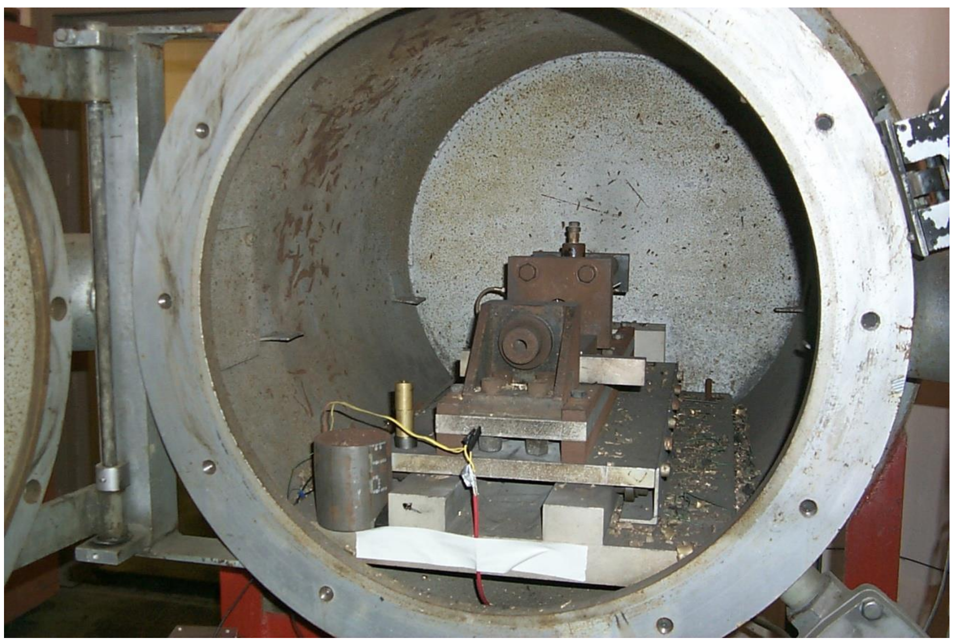

Figure 7
Explosive chamber

Figure 8
CDU and DV pulse circuit

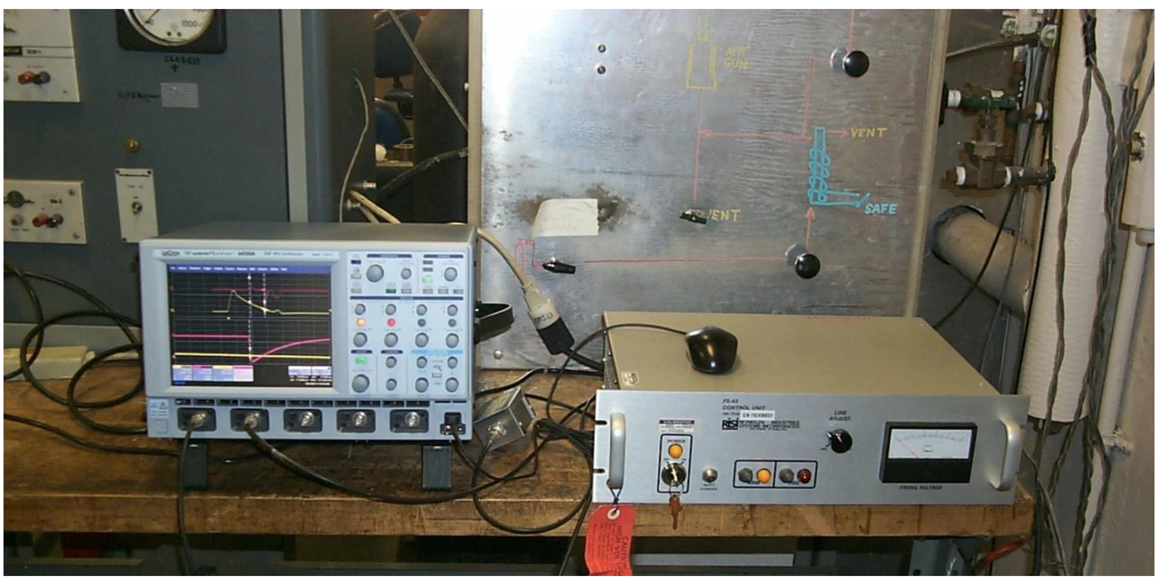

Figure 9
LeCroy digital storage oscilloscope and small-scale DV instrumentation

Table 1
Small-scale DV test result

Sample	Force (lbf)	Empty cylinder weight (g)	Loaded Cylinder weight (g)	Material weight (g)	Loaded Height (in)	loaded height (mm)	Time from scope (us)	Density (g/cc)	DV (mm/us)	Volume (cc)	Figure
PAX-22 ED01 - 1	1120	156.5635	158.0056	1.4421	1.5020	38.1508	4.4840	1.8650	8.5082	0.7733	A
PAX-22 ED01 - 2	1120	156.1904	157.6103	1.4199	1.5040	38.2016	4.5620	1.8338	8.3739	0.7743	B
PAX-22 ED02	1120	156.5605	157.9915	1.4310	1.5110	38.3794	4.5380	1.8396	8.4573	0.7779	C
PBXN-9 ED01 - 1	960	156.1734	157.5729	1.3995	1.5110	38.3794	4.6400	1.7991	8.2714	0.7779	D
PBXN-9 ED01 - 2	960	156.2673	157.6570	1.3897	1.5000	38.1000	4.5640	1.7996	8.3479	0.7722	E
PBXN-9 ED02 - 1	960	156.1844	157.6384	1.4540	1.5190	38.5826	4.5386	1.8593	8.5010	0.7820	F
PBXN-9 ED02 - 2	960	156.1790	157.6248	1.4458	1.5010	38.1254	4.6674	1.8710	8.1684	0.7727	G
DAAF - 1	480	156.1933	157.4720	1.2787	1.5000	38.1000	5.3410	1.6559	7.1335	0.7722	H
DAAF - 2	480	156.2018	157.4714	1.2696	1.5000	38.1000	5.2638	1.6441	7.2381	0.7722	I
MBANF PAX46	1000	156.2137	157.5724	1.3587	1.5100	38.3540	5.0060	1.7478	7.6616	0.7774	J
HATOAF with A5 Booster	1000	156.2963	157.6038	1.3075	1.4950	37.9730	6.3300	1.6988	5.9989	0.7696	K

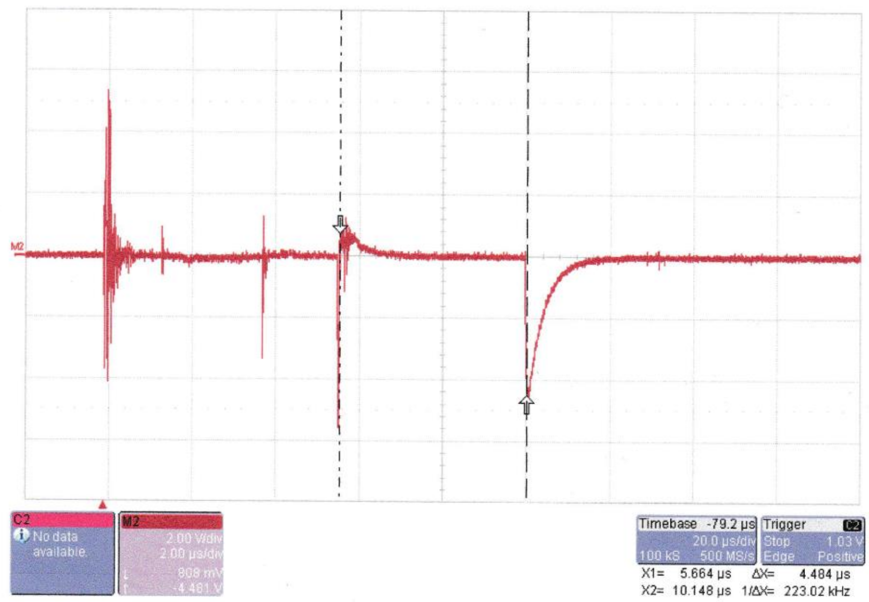

Figure 10
PAX-22 ED01-1

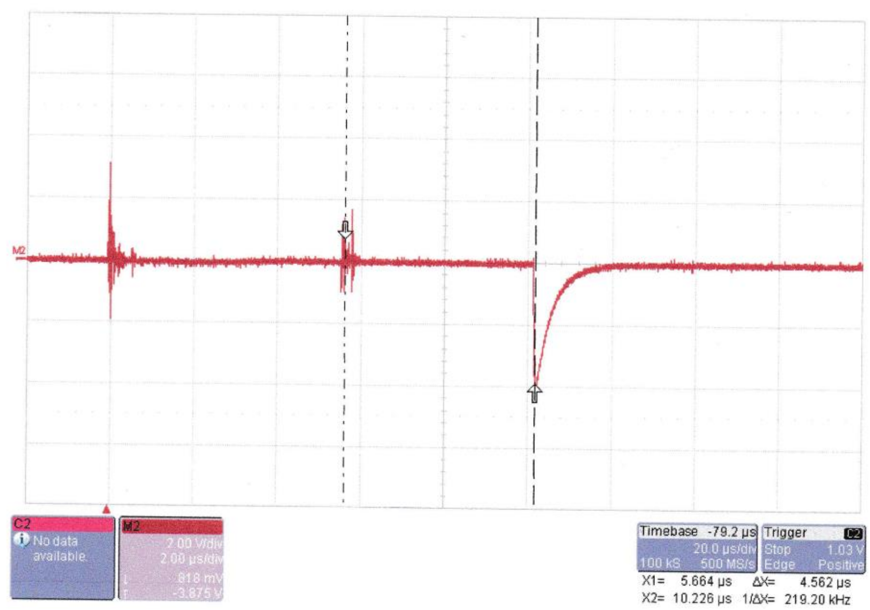

Figure 11
PAX-22 ED01-2

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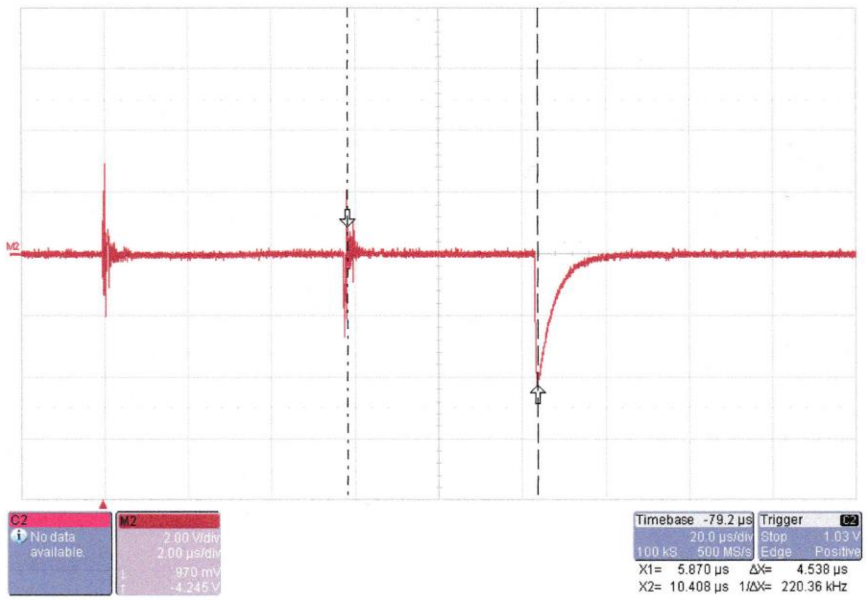

Figure 12
PAX-22 ED02-2

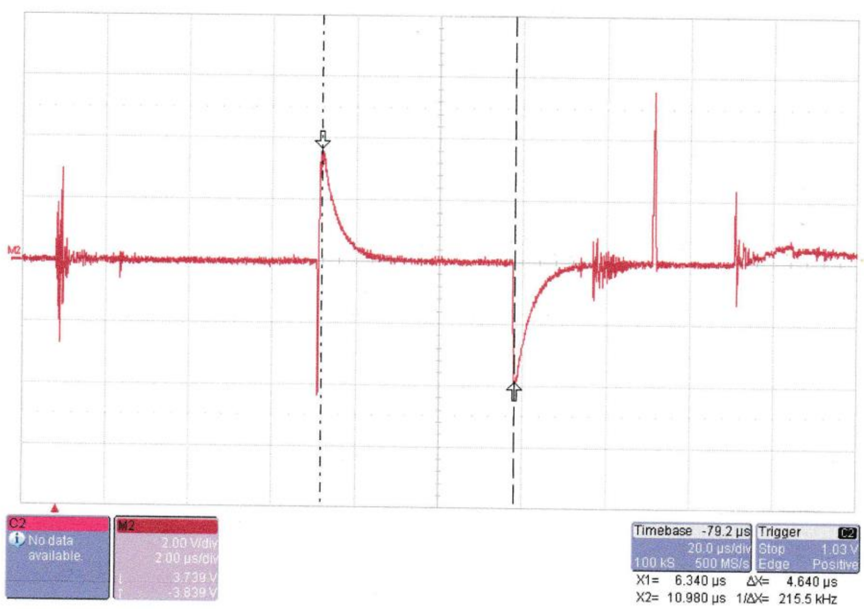

Figure 13
PBXN-9 ED01-1

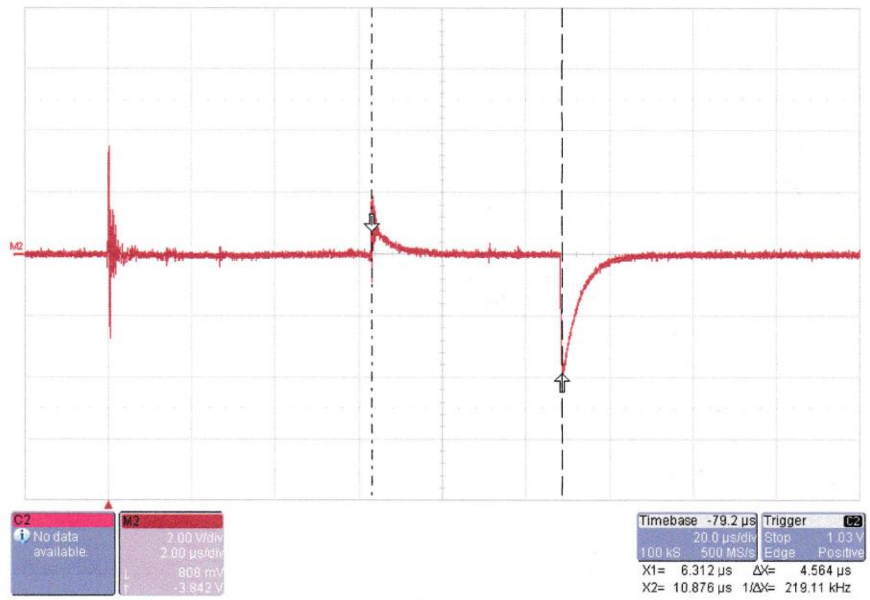

Figure 14
PBXN-9 ED01-2

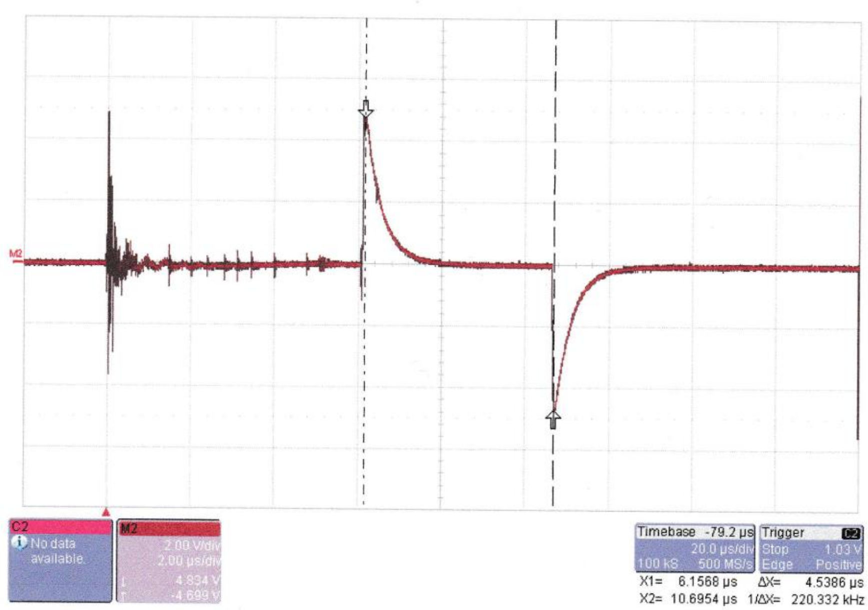

Figure 15
PBXN-9 ED02-1

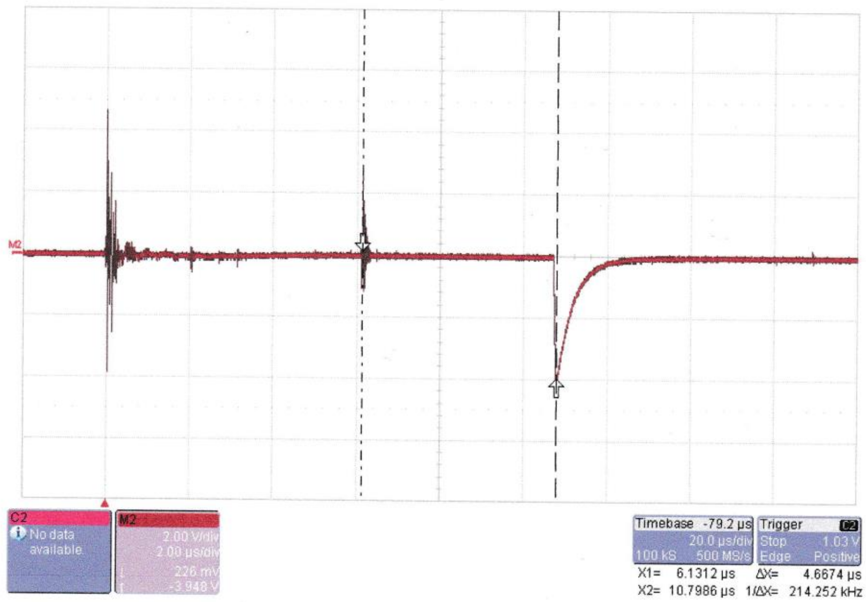

Figure 16
PBXN-9 ED02-2

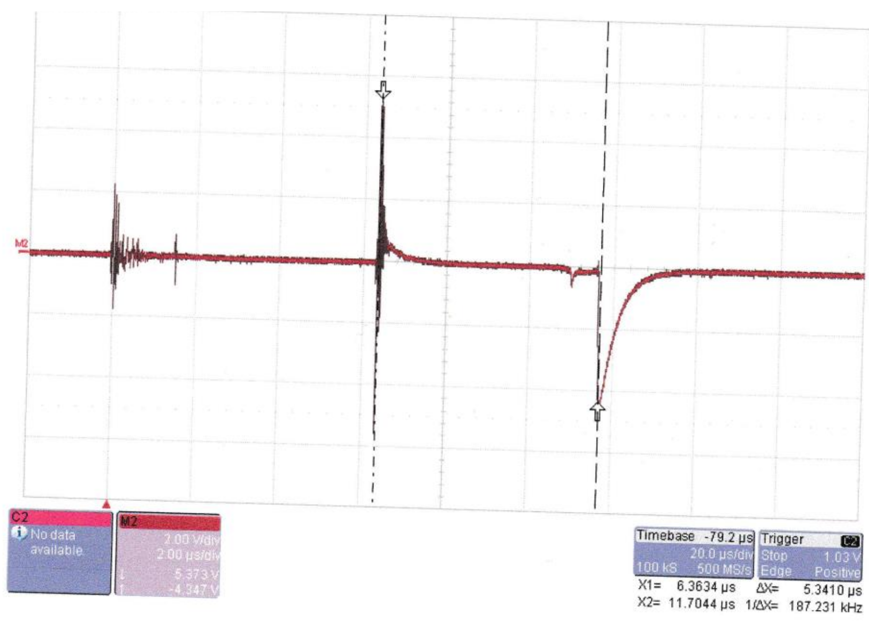

Figure 17
DAAF-1

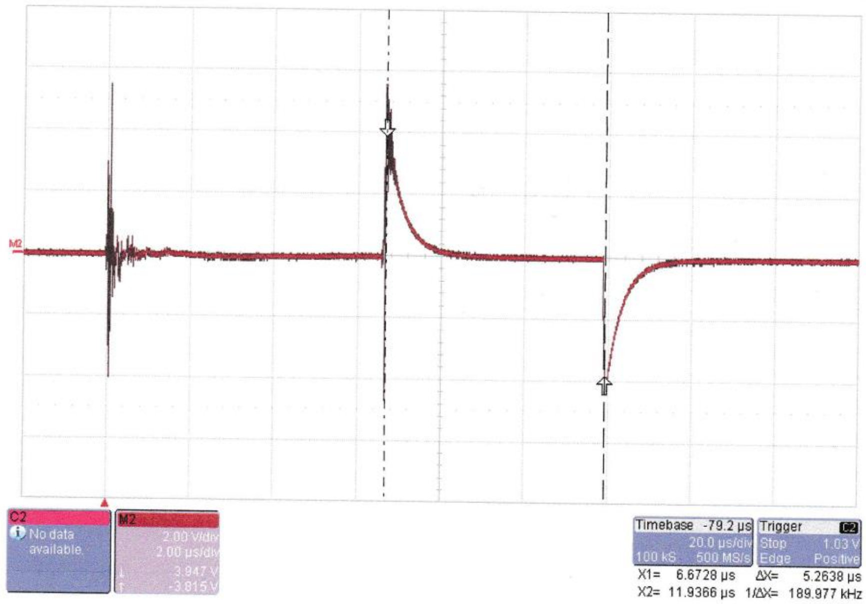

Figure 18
DAAF-2

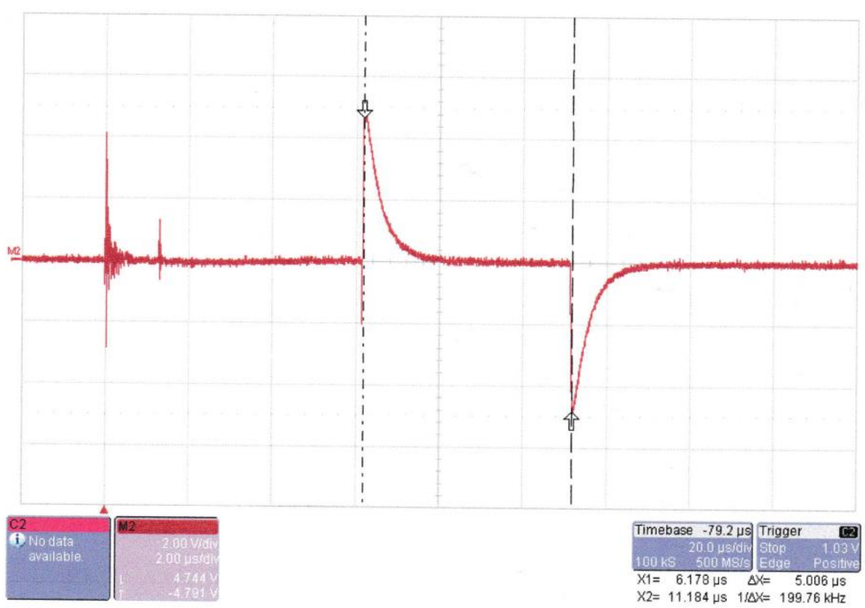

Figure 19
MBANF PAX46-2

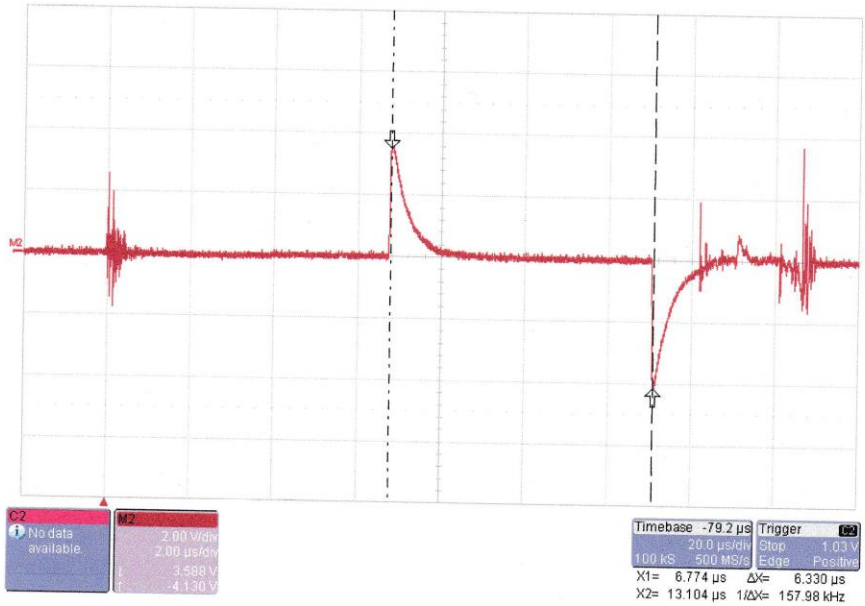

Figure 20
HATOF with A5 booster

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