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US Army Research Laboratory

A Circuit for Firing 50 M6 Blasting Caps in Series

by Mark V Ware

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14. ABSTRACT
In May 2016, engineers from the US Army Research Laboratory were tasked to design and build a circuit to detonate 50 M6 blasting caps wired in series as a functional or lot acceptance test. A constant-current circuit was built and tested successfully. This circuit replaced a previously designed capacitive discharge circuit and a commercial unit, both of which did not produce the correct test output.

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M6 blasting cap, constant current, demolition, lot acceptance test, fire circuit

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1. Background/Introduction

In May 2016, engineers from the US Army Research Laboratory (ARL) at the Adelphi Laboratory Center (ALC) in Adelphi, Maryland, were asked by Dan Perciballi, the lead engineer for the Grenades and Demolitions Branch at Picatinny Arsenal, New Jersey, to design a circuit to detonate 50 M6 blasting caps wired in series in support of a functional or lot-acceptance test. The fire circuit is required to generate a 1.4- to 1.6-A pulse for 1.5 to 1.6 ms as an output to the caps, and a successful test occurs if all 50 caps detonate. Personnel at Aberdeen Proving Ground (APG), Maryland, had built a capacitive discharge circuit for this purpose, but it did not produce a pulse of the required current that lasted for 1.5 ms. A commercial unit bought for this purpose also did not produce the correct output. It was decided to build a constant-current circuit to replace the capacitive discharge circuit, preferably one that could fit in the existing firing box.

2. Electrical Design

Damian Urciuoli of the Power Conditioning Branch at ARL-ALC suggested that a suitable way to generate a high-voltage pulse for the intended application would be to use a power field-effect transistor (PFET) biased within its linear region. The resulting circuit design is shown in Fig. 1. The LM317 regulator produces the bias voltage for the gate of PFET Q1. U2 is a driver and buffer for the output of U3, a one-shot circuit, which produced the desired output pulse width. The firing box produces a pulse, which is isolated by U4. Since the output of U4 is a negative-going pulse, U5 is used to invert it and produce a positive-going pulse to trigger the one-shot circuit. The firing line is connected at F.L.+ and F.L.–.

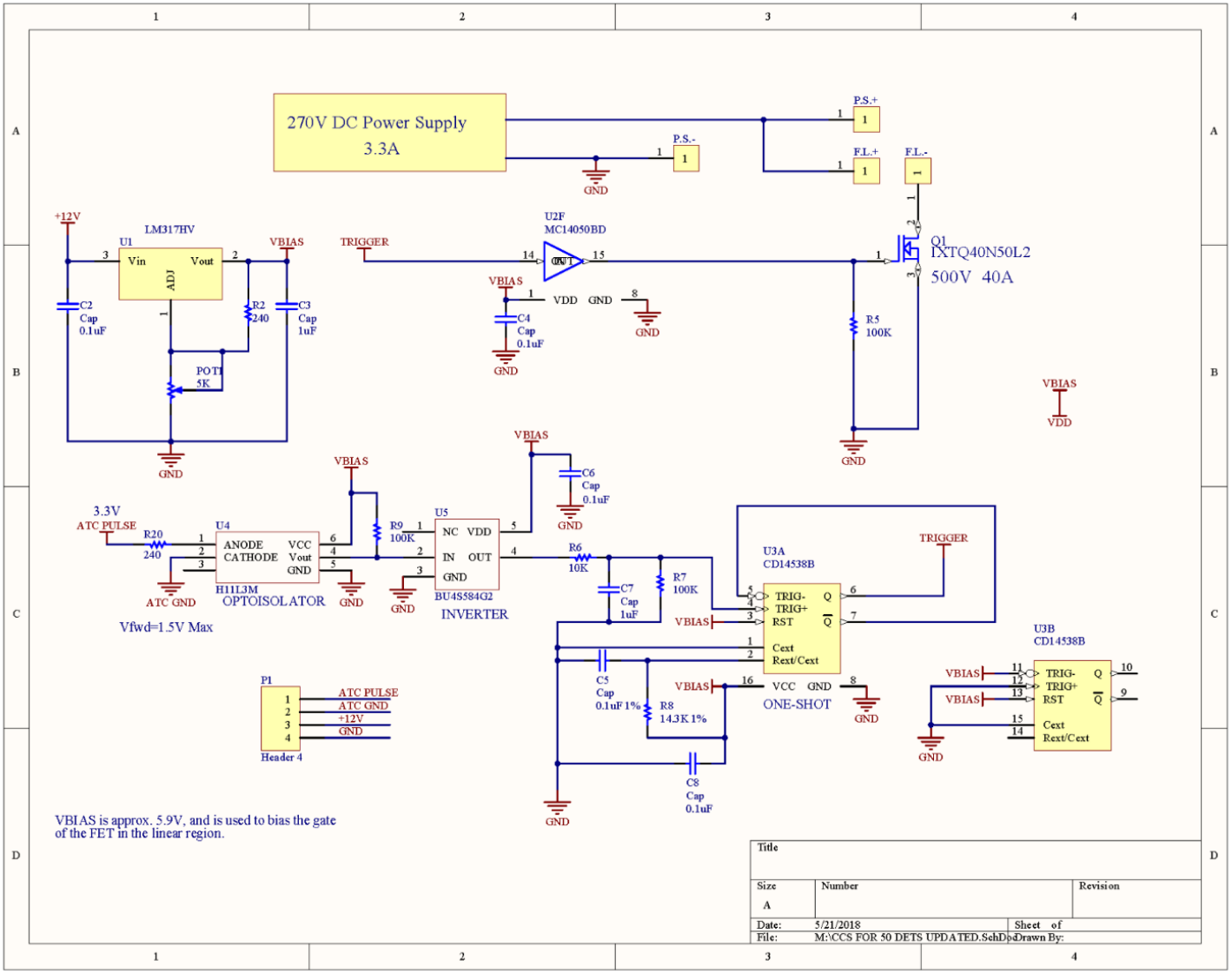

Fig. 1 Schematic of the constant-current circuit

Given the total series resistance of the 50 blasting-cap bridges is approximately 80 Ω to start and rises to approximately 160 Ω as the bridges heat up before detonating the caps, it was calculated, using Ohm's Law, that approximately 240 V would be needed to produce a current of 1.5 A. A 270-V custom power supply, from Acopian, was procured for this purpose after determining from functional tests that the power supply could produce the necessary current without its output sagging. The circuit was breadboarded and tested at ALC using 300 ft of firing line and 50 inert blasting caps wired in series. These blasting caps contained the resistance wire bridge, which normally heats up to detonate the cap but not the explosives. The resulting current waveform produced during this test is shown in Fig. 2. The fire circuit was then built as a custom printed circuit (PC) board. APG personnel integrated the circuit and the Acopian power supply into the existing firing box.

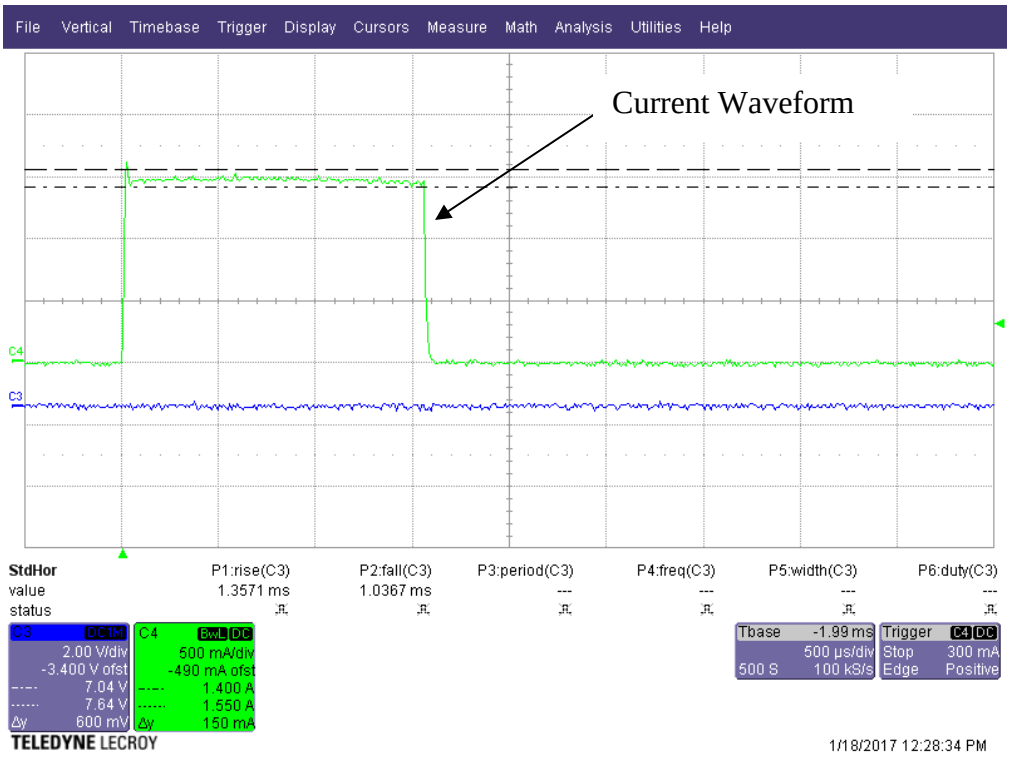

Fig. 2 Current waveform produced from the test of 50 inert caps in series

The new fire circuit was tested successfully on August 24, 2017, at APG with 50 blasting caps wired in series. All 50 blasting caps detonated. A plot of the waveform produced by the circuit during this test is shown in Fig. 3.

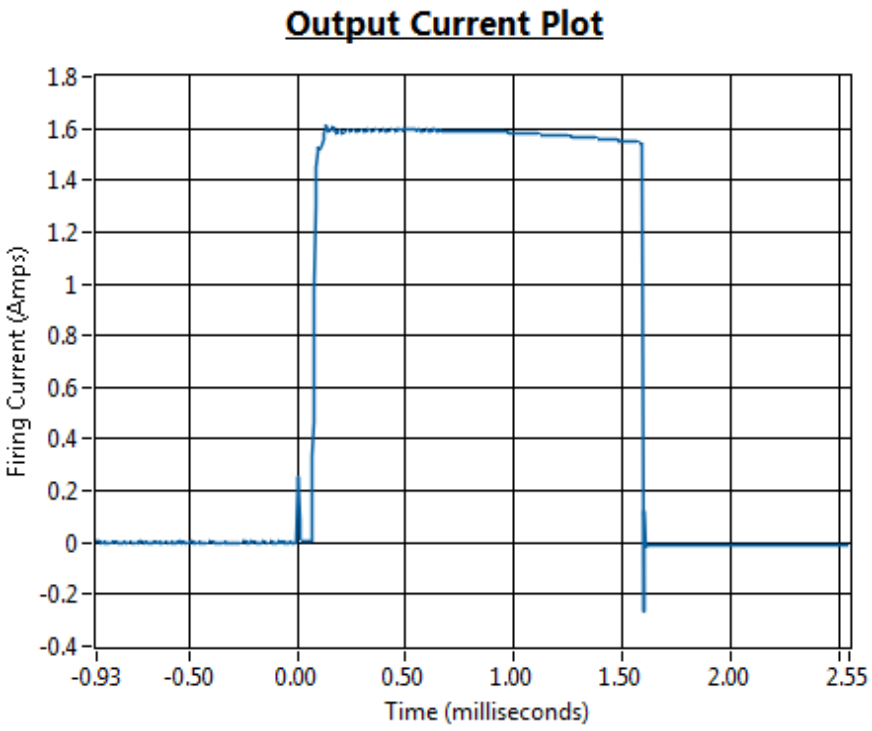

Fig. 3 Current waveform produced from the test of 50 M6 caps in series

3. Conclusion

Engineers from ARL successfully designed, built, and tested a constant current circuit for detonating up to 50 M6 blasting caps wired in series. This new design provides engineers from Picatinny Arsenal with an Army-built circuit for verifying the function of 50 series caps and is more reliable than currently available commercial systems. This new tester will be used by Picatinny to perform lot-acceptance testing during procurement and production of this common blasting cap.

List of Symbols, Abbreviations, and Acronyms

ALC	Adelphi Laboratory Center
APG	Aberdeen Proving Ground
ARL	US Army Research Laboratory
PC	printed circuit
PFET	power field-effect transistor

1 (PDF)	DEFENSE TECHNICAL INFORMATION CTR DTIC OCA
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