FRANKLIN
APPLIED PHYSICS

explosives and pyrotechnics

The Newsletter of explosives, pyrotechnics and their devices

Volume 47 ~ Number 2 **February 2014**

TESTING EEDS FOR MICROWAVE SENSITIVITY

It is always important to know the sensitivity of the electro explosive devices (EEDs) with which we work. That is, we should know what level of stimulus will make them fire, as well as what level of stimulus will not cause them to fire. When the stimulus is microwave energy, we must use special equipment to test EED sensitivity. These tests are worth doing, because microwave energy, for example from a nearby wireless network, is common. We will describe some of the special equipment that we use:

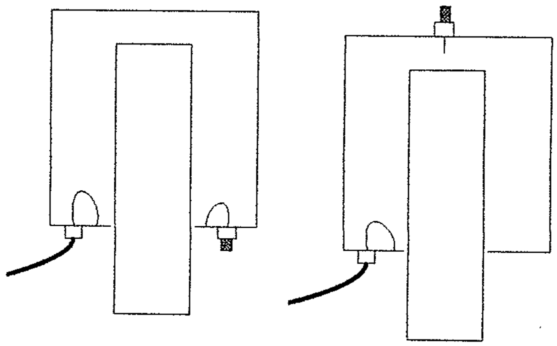
We make special mounts to hold the EED under test. A mount is a microwave cavity, resonant at the frequency of operation. A mount must match the impedance of the EED mode (pin-to-pin or pins-to-case), at the operating frequency. Another requirement is that the EED mount must be strong enough to withstand the shock when an EED fires. We show the general design in Figure 1 on the next page. This is a reentrant microwave cavity with a tuning post or plunger in the center. The optimum length, for the plunger height inside the cavity, is about one-quarter wavelength. The ratio of the cavity diameter to the plunger diameter determines the input impedance.

To the left, in Figure 1, is a pin-to-pin mount. We see the hollow, right circular cylindrical cavity, made of brass. The top is closed. The bottom plate of the cavity is pierced in the center; the solid brass post or plunger penetrates into the cavity. The plunger rides on fine screw threads; we can turn the plunger, to raise it or lower it. In this way, we change the resonance frequency of the cavity. In other words, we tune the cavity to the operating frequency. On the bottom plate of this cavity, to the left, is a small coaxial fitting that terminates in a loop. This is for input power. The coaxial cable from our RF power source plugs into this fitting – we can see the cable at lower left. On the opposite side of the plunger is a second coaxial fitting which also terminates in a loop, for power output to the EED. This is a low-impedance connection, and it therefore is useful for the pin-to-pin firing mode, because the pin-to-pin resistance of the EED is only about one ohm. In the second fitting, one lead wire of the EED goes to the center conductor of the coaxial fitting; the other lead wire is grounded along with the EED case. When we drive this cavity with RF power, RF magnetic fields go around the plunger, intersecting both the input loop and the output loop. RF power transfers from the input to the output and dissipates in the pin-to-pin mode of the EED, i.e. in the bridgewire.

Published twelve times a year by FRANKLIN APPLIED PHYSICS, INC.
98 Highland Avenue, P.O. Box 313
Oaks, Pennsylvania 19456-0313
Tel.: (610) 666-6645, Fax: (610) 666-0173
Email: info@FranklinPhysics.com

Edited by James G. Stuart, Ph.D.
Subscription: $47.50 per year
$51.50 outside USA
$5 single copy

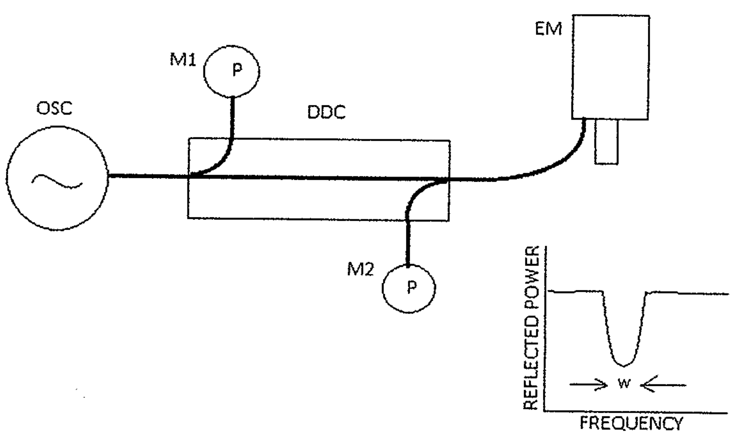
Figure 1: P-P and P-C EED Mount



To the right, in Figure 1, is a pins-to-case mount. The hollow, right circular cylindrical cavity, and the tuning plunger, and the input loop, are the same as we described above. At the top of the mount is a coaxial fitting, with its center conductor extending into the cavity. When we drive this cavity with RF power, a powerful vertical electric field appears at the top of the plunger, in the area of the second fitting. This is a high-impedance connection, and thus it is useful for the pins-to-case mode, because the pins-to-case impedance of the EED is high. We connect both lead wires of the EED to the center conductor of the coaxial fitting; the case of the EED goes to ground. RF power transfers from the input to the EED where it dissipates in the pins-to-case mode.

We calibrate the mount in two ways: by frequency, and by efficiency. We described above how we can tune the mount to the operating frequency, by moving the plunger in and out. Efficiency is a different concept. Efficiency is the ratio of RF power that dissipates in the EED to total RF power in. Some of the RF power dissipates in circulating currents in the walls of the microwave cavity that is the EED mount; we must take these currents into account.

Figure 2: EED Mount Calibration Apparatus



A simplified diagram of the apparatus that we use for mount calibration appears as Figure 2. The RF power source is OSC; the dual directional coupler is DDC; the EED mount is EM; meter M1 indicates forward power, and M2 indicates reflected power. First, we look for a dip in reflected power when we achieve resonance in the EED mount. We do this by adjusting the plunger height. At the bottom of the dip, our EED mount is tuned to the operating frequency. Next, we adjust OSC to sweep it over a narrow band that includes the operating frequency; we write down the value of reflected power at each point of the sweep, and we draw the graph that we see at the lower right-hand corner of Figure 2. We measure the width of the dip, which we call W.

In a microwave cavity, the power dissipation is proportional to the width of the resonance. We express this in Equation 1, and we define a constant of proportionality α.

Equation 1: Power Dissipation Proportional to Width

$$P \sim W$$

$$P \equiv \alpha W$$

We start by taking the EED out of the mount entirely. We measure W_1, the resonance width due to power dissipation in the mount P_{mnt}. Equation 2 shows this.

Equation 2: Power Dissipated in Mount

$$P_{mnt} = \alpha W_1$$

Next, we put the EED back into the mount. Now we measure W_2, the resonance width due to power dissipation in the EED, P_{EED}, combined with power dissipation in the mount P_{mnt} , as in Equation 3.

Equation 3: Power Dissipated in Mount and in EED

$$P_{EED} + P_{mnt} = \alpha W_2$$

The efficiency, or the fraction of total power that goes to the EED, is in Equation 4.

Equation 4: Efficiency

$$Efficiency = \frac{P_{EED}}{P_{EED} + P_{mnt}} = \frac{W_2 - W_1}{W_2}$$

We will measure resonance widths, and calculate the power transfer efficiency, using Equation 4, for each mount. When we know the actual power dissipated in the EED, we can make statements about its sensitivity.

UPCOMING MEETINGS

The **10th** biennial **Cartridge Actuated Devices / Propellant Actuated Devices** (CAD/PAD) **Technical Exchange Workshop** will be held 20-22 May 2014 at Joint Base Andrews, Maryland USA. The workshop is dedicated to enabling and promoting a better understanding of new initiatives, and recent and emerging requirements. It offers a constructive interchange among technologists, designers, and engineers involved in new technology and development applications, as well as program managers and sustainment experts addressing program and user needs.

Power point presentations will be on the following suggested topics:

*Engineering	*Energetic materials – processing & disposition
*Manufacturing	*Environmental, occupational, safety & health issues
*Performance requirements	*Government and industrial base
*Simulation	*Hazards of electromagnetic radiation to ordnance (HERO)
*Testing	*Technology implementation
*Packaging	

If you have questions about the workshop, email IHDIV_CAD_PAD_TEW@navy.mil; you can find information on abstract submittal, registration (available in February), and other relevant information at the website http://www/navsea.navy.mil/nswc/indianhead/TEW/tew.aspx

COURSE OFFERED

Intercontinental Development Corporation – Precision Blasting Services (IDC-PBS) of Montville, Ohio USA has scheduled another seminar for this spring:

Safety for Blasting & Explosives Use March 18-20, 2014

A course outline and additional information can be sent by e-mail. Please contact them at 440-474-6700 or info@idc-pbs.com

MEETINGS, COURSES, AND OTHER ACTIVITIES

Activity	Venue	Date(s)	E&P Issue
17th International Seminar (NTREM 2014) "New Trends in Research of Energetic Materials"	Pardubice,Czech Republic	9-11 Apr. 2014	Sep. 2013
10th CAD/PAD Technical Exchange Workshop	Joint Base Andrews, Maryland USA	20-22 May 2014	this issue
Tenth International Symposium on Special Topics in Chemical Propulsion	Poitiers, France	2-6 June 2014	Sep. 2013
11th Workshop on Pyrotechnic Combustion Mechanisms	Colorado Springs, CO	12 July 2014	Sep. 2013
40th International Pyrotechnics Seminar	Colorado Springs, Colorado USA	13-18 July 2014	May 2013
Courses:			
Rock Blasting & Overbreak Control		4-6 Mar. 2014	Jan. 2014
Fundamentals of Ballistics		10-14 Mar. 2014	Dec. 2013
Safety for Blasting & Explosives Use		18-20 Mar. 2014	this issue
Introduction to the Technology of Explosives		24-28 Mar. 2014	Dec. 2013
Fundamentals of Shaped Charges		25-27 Mar. 2014	Dec. 2013
Underwater Blasting		8-10 April 2014	Jan. 2014
Electroexplosives: Functioning, Reliability, and Hazards	Oaks, Pennsylvania USA	28 Jul-1 Aug 2014	Jan. 2014