#EM-07/08 Precision Spark Generator

DESCRIPTION

The EM-07 Precision Spark Generator supplies the high-voltage, short duration pulses needed for spark recording. The generator supplies these pulses at nine precise frequencies, obtained by digitally dividing the power line frequency. The intrinsic frequency stability of the line voltage makes it an economic and always available time reference. Two CMOS decimal dividers divide the frequency; the required division is selected by a front panel switch. A push button switch on a cord controls the spark.

Spark recording is the most convenient way of obtaining a permanent record of the position of a moving object as a function of time. Every time the generator delivers a pulse, the spark jumps from the body through the spark paper to the ground plane, marking the paper with the path of the object. Air Track and Air Table experiments can be accurately and conveniently recorded with spark recording.

The digital division of the power line frequency is not the same for the 60Hz and the 50Hz versions of this instrument. The front panel is different as well, reflecting the resulting output frequency. The available outputs are shown in the following table.

Switch Position	EM-07/60Hz Frequency Hz	EM-08/50Hz Period ms
1	60	20
2	30	40
3	15	60
4	10	80
5	5	100
6	4	200
7	3	400
8	2	600
9	1	1000

WARNING

The voltage provided at the output of this device, while not normally dangerous to a healthy person, are capable of causing considerable discomfort. When operating, take care to avoid accidental contact with the high voltage output.

NO STATEMENT OF SPARK SAFETY IS MADE OR IMPLIED IN CONNECTION WITH THE USE OF THIS DEVICE.

Turn off the spark before making any adjustments. The operator of the spark should make the adjustments, so that a co-worker doesn't accidentally turn on the unit while adjustments are being made. Since the spark will not operate without the push button connected, it can be used as a safety lock by removing it when adjustments are being made.

SINGLE SPARK OPERATION

1. Connect the Precision Spark Generator to a line power outlet with a grounded receptacle. It is important that the ground pin in the line cord be attached to a good ground for reliable operation. The 60 Hz and the 50 Hz versions of this instrument use different digital divisions of the power frequency and have a different front panel showing the appropriate frequencies or periods between spark points.

2. Connect the alligator clip on the black wire of the generator to the ground side of the experiment. For an air track, connect this clip to the track.

3. Connect the alligator clip on the red wire of the output to the spark wire on the air track.

4. Attach a strip of spark paper to the air track in the slot provided for it on the opposite side of the air track from the meter tape. The spark paper should have the white side facing out.

5. Place a Glider on the air track and adjust the Glider wire so that it is close to the spark wire and the spark paper on the track. The manual for the Spark Wire Kit EA-14 describes the assembly of the spark wire on the Glider in more detail. There should be a 2 mm gap between the wire at both ends.

6. Insert the 1/4" phone plug on the end of the push button cord into the front panel jack. The generator operates when the button is pushed.

7. Make sure no one is touching the spark wire, the track itself is at ground potential and represents no hazard. Turn on the front panel switch. Press the push button and observe the spark. It should make a clear mark on the spark paper.

8. When the spark is properly adjusted, select the desired frequency and proceed with the experiment.

CAUTION! Do not set the spark gaps too wide. The total length of all gaps should be less than 10 mm. Excessive gaps may cause skips in the spark recording or internal breakdown within the instrument, possibly causing permanent damage.

9. The EM-07 Precision Spark Generator can be synchronized with the start of an air track experiment, if using the Daedalon EA-04 Glider Release to hold the Glider. The Glider Release has an electromagnet that mounts on the air track end stop. When powered, the magnet holds the steel bumper spring of the Glider. A cord connected to the Glider Release box replaces the trigger push button. When the *RELEASE* button is pressed, the power is removed from the magnet coil and a *START* signal is sent to the Spark Generator. The Spark Generator operates as long as the *RELEASE* button is depressed. In this way, the spark starts at the moment of release of the Glider, giving a clear start to the recording, thus facilitating data reduction.

DOUBLE SPARK RECORDING

When recording collisions on an Air Track for conservation of momentum experiments, it is necessary to use two spark wires to record the motion of both Gliders. This requires the use of two spark wire mounted on the Air Track. A single Spark Generator can service both spark wires by connecting the spark gaps in series. In this setup, the Air Track itself is not at ground potential. Consequently, the student must stay away from the Track during the recording process.

The Track can be kept at ground potential by the use of a second Spark Generator. An EM-07 Precision Spark Generators can be connected to an EM-01 Spark Generator or a second EM-07 so that their output is synchronized. The newest version of the EM-07 Precision Spark Generator is provided with a rear panel jack to control a second EM-01 or EM-07.

1. Install two spark wires on the Air Track. The second wire with its tensioning spring is attached to the unused hole in the spark wire support insulator attached to the end stops on the Track.

2. Bend the trolley wire from one Glider so that it is close to the lower wire and the spark paper. Bend the trolley wire from the second Glider close to the upper spark wire and the spark paper. It takes a little care to get them both right, so don't rush. Arrange the trolley wire ends near the spark paper are separated and will leave separate, non-overlapping tracks.

3. Clip the black wire output lead from the Master EM-07 to the Air Track end stop. The red lead connects to the upper spark wire. Connect the black wire of the Slave EM-01/07 to the end stop and the red wire to the lower Spark Wire.

4. Set the frequency on the Slave EM-01/07 to 60Hz. Set the frequency of the Master EM-07 to the desired frequency, typically 10Hz.

5. Insert the Push-button into the *TRIGGER* jack on the front panel of the Master EM-07. Connect the rear panel jack on the Master EM-07 to the *TRIGGER* jack on the Slave EM-01/07 with a connecting cable terminated with single circuit phone plugs, such as the Daedalon EM-05 Connecting Cable.

6. Turn on the Master Spark first and then turn on the Slave Spark. If the Slave is turned on first it will run continuously until the Master is turned on.

7. Place the Gliders on the Air Track with the air turned off and test the spark gaps by pressing the Trigger button attached to the Master Spark. Both Gliders should spark at the set rate, i.e., 10Hz. If the gaps are not right make adjustments and test again. Turn off the Sparks while making adjustments to avoid accidents while adjusting the gap.

8. Tape a strip of spark paper to the Track and perform the experiment. Both Gliders should leave separate tracks before and after the collision.

The experiment must be set up so that one of the Gliders does not reverse direction. This is a small limitation in general but should be observed. If a heavy Glider collides with a lighter Glider moving in the same direction, neither Glider will change direction. If a light Glider strikes a heavier Glider, it will reverse direction. When a Glider velocity direction reverses, the spark points fall on top of the earlier track and are difficult or impossible to decipher.

OTHER CONSIDERATIONS

Spark recording does radiate a considerable amount of electromagnetic interference, which may affect other equipment in the laboratory. Digital equipment, such as computers or electronic counters, is particularly susceptible to this sort of impulse noise. Normally, no permanent damage is done, but use of the equipment is impossible during spark recording, and stored programs may be spoiled.

To minimize this interference, use the spark equipment with a grounded outlet, which will ground the instrument case, eliminating much of the interference. In addition, set the spark gap as short as practical for the particular experiment to reduce radiation and give the best accuracy of the data as well.

The accuracy of the data points obtained from a spark recording depends primarily upon the wander of the spark between the spark wire and the

ground plane. Anyone who has watched a lightning bolt during an electrical storm knows that the discharge does not travel in a straight line. What is true for lightning is also true for these small sparks. Several successive sparks do not strike the ground plane at the same point. The easiest way to minimize this spread is to make the spark very short. By using a short gap, there is little opportunity for the spark points to spread.

CALIBRATION

There are no internal adjustments in the Precision Spark Generator. Circuit operation is digital, using high reliability CMOS circuits.

Take considerable care when working on this circuit. Many of the voltages are very high and dangerous if encountered accidentally. If you have any question about your ability to repair high voltage circuits, please don't attempt it. Return the instrument to Daedalon with a description of the trouble and we will repair it safely for you.

TYPICAL EXPERIMENT

A simple introductory experiment using Spark recording is the measurement of acceleration of a Glider down an inclined Air Track. This experiment illustrates the acceleration of a body by a constant force and is a useful introduction to Newton's Second Law of Motion.

1. Set up the Air Track with an EA-04 Glider Release mounted to the end stop at the base end, and level it by adjusting the leveling screw until a Glider set on the middle of the Track remains there without drifting to either end.

2. Raise the end of the Track by inserting one of the EA-15 Riser Blocks under the end of the leveling screw. From the thickness of the Block and the separation between the support feet (1m nominally), students can determine the slope of the Track.

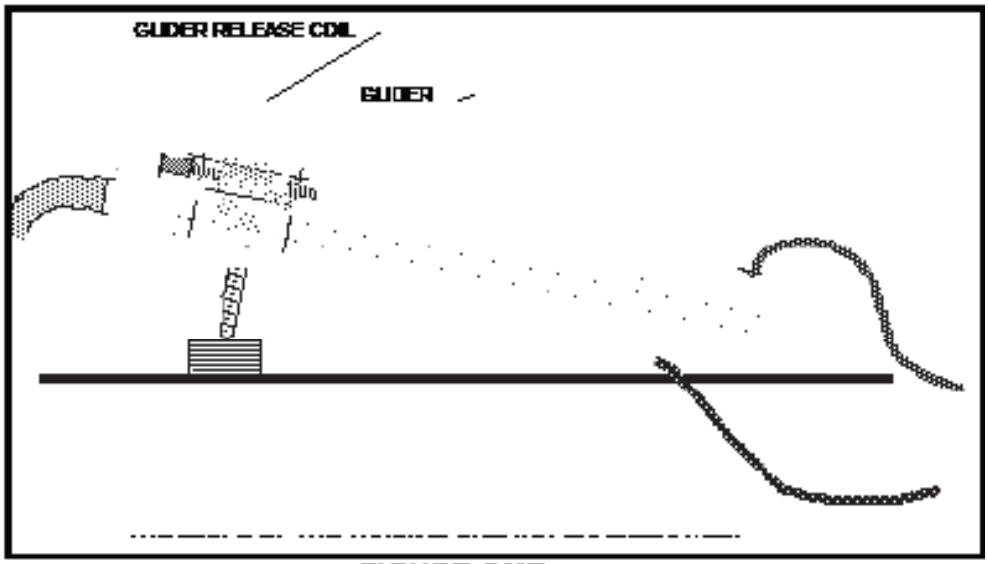

FIGURE ONE

3. Connect the Glider Release to the Spark Generator and turn them both on. Move the Glider up to the coil so that its bumper spring is held by the magnet.

4. Place a strip of spark paper in the groove on the side of the Track (the far side in the above Figure). Adjust the transfer wire on the Glider so that it is about 2mm away from the spark wire and about 2mm above the spark paper.

5. Set the Spark Frequency to 10Hz.

6. With the Spark Generator turned off, run a test to make sure the Glider starts when the "Release" button is depressed. The remanence in the magnet core and spring will sometimes cause the Glider to hang on the coil after the current is cut off. This can be corrected by putting one or two layers of masking tape between the bumper spring and the coil core, the thickness required depends upon the force pulling the Glider.

7. When the Glider starts reliably, replace it at the end of the coil and turn on the Spark Generator. Keep your hands clear of the spark wire and press and hold the "Release" button. The Spark will start and the Glider will accelerate down the Air Track. Hold the button down until the Glider approaches the lower end stop and release it before it reaches the stop to insure that the spark recording ends before the Glider bounces off the end stop. Alternatively, use masking tape to cover the air holes for the last 10 cm of the Track. The Glider will slow to a stop on these covered holes.

8. Turn off the Spark Generator and remove the spark paper strip from the Track. Identify the recording with the name of the experiment, your name, date, Spark frequency, and the Riser Block height. Unidentified recordings are of no use in a very short time.

The Spark Recording you have made should look something like this:

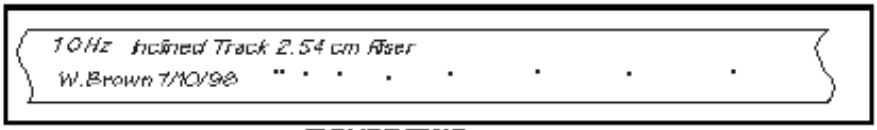

FIGURE TWO

The points wander slightly from a straight line due to the variable spark path through the air. If you keep the spark gap short, your data will be more accurate than this sample.

These points represent the position of the Glider each 0.1s after the start of the experiment. There is necessarily some uncertainty in the start, since the time base is not synchronized with the "Release" button. The very small error can be removed in data processing.

From these points, the displacement versus time, velocity versus time, and acceleration versus time curves can be determined. For best measurement accuracy, tape the recording down to a table beside a centimeter scale. Place a square on the edge of the scale and slide it to the spark point.

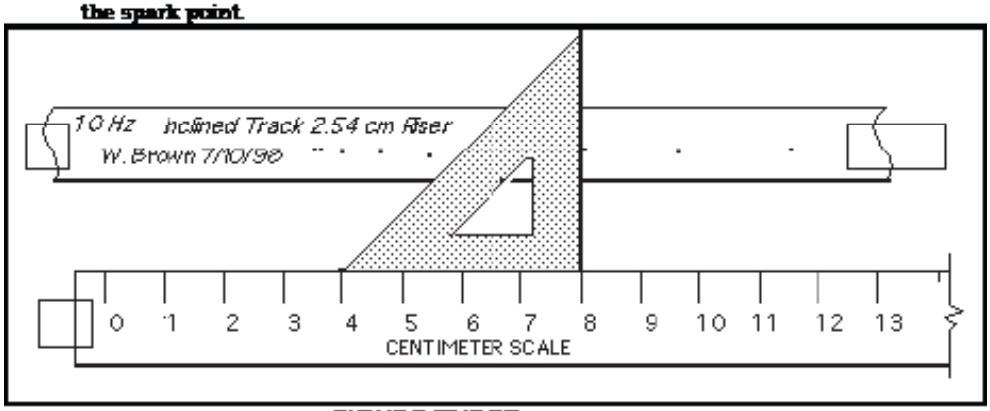

FIGURE THREE

This summarizes the basic data reduction procedure for spark recording. It can be applied to virtually all Air Track experiments. Measurement of collisions between Gliders requires the use of two spark wires. Additional details for setting up an Air Track for Spark Recording can be found in the EA-14 Spark Wire Kit manual.

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Specifications

Frequencies	Eight: 60,30,15,10,5,3,2,1 Hz for 60 Hz Line Eight: 20, 40, 60, 80, 100, 200, 400, 1,000 ms Period for 50 Hz line.
Stability	Typically ±0.05%
Spark Voltage	Approximately 30 kV Depends upon the gap length Spark normally jumps a 15 mm gap.
Connections:	
High Voltage	Color coded 1.2 m long w/alligator clips
Trigger	Push Button on a 1 m cord.
Fuse	3AG-3 Slo Blo or MDL-3 Internal Draws .4 A at 60 Hz, and .14 A at idle.
Dimensions	9.5 h x 28 w x 22 d cm (3.8 x 10 x 8.5 in)
Weight	3.5 kg (7.7 lbs) net.