Analysis of Pulsed DC Ionizer Measurement Procedures with a CPM Using ESDA RP 3.11-2006

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Abstract **–** The purpose of this research was to model the Pulsed DC ionizer with a Charge Plate Monitor (CPM) and to compare the results with the actual performance of a CPM measuring a Pulsed DC ionizer. The motivation for the study was that measurement of ionizers using a CPM as defined by ESDA RP3.11 - 2006 produce results which seem to vary dramatically. In a previous study [1]. it was shown that corona ionizers exhibit drift caused by movement of conducting objects in proximity to the ionizer. The most dramatic conductor is the operator himself. Having taken that effect into account, the CPM measurement continues to show large fluctuations in measuring swing and balance voltage as defined by the R.

I. The Model

The composite system is modeled by the diagram below.

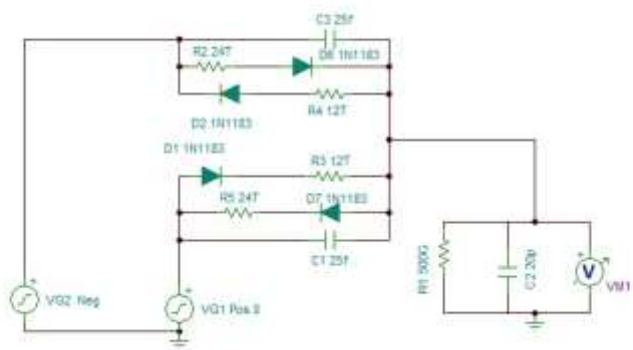

Figure 1. Schematic of simulation model of a pulsed ionizer and CPM system.

The system shown in Figure 1 was modeled in SPICE [2][3] (*Simulation Program with Integrated Circuit Emphasis.)* Here the 20 pF capacitor represents the CPM. The two voltage generators represent the positive and negative emitter points. The Tera-Ω resistors represent the air column from the points to the CPM and the leakage path from one point to the other. The 500 GΩ resistor represents the air column from the CPM plate to ground. The incredibly low 25 fF capacitors represent the capacitance between the emitter points and the CPM plate. The resistance of the column–, set by R_3 and R_4 was determined to achieve a discharge time of 20 seconds, typical of many uses of the ionizer. The values of R_2 and R_5 were selected to make the current between the emitters points half of the current delivered to the target. The capacitance between the points and the column was adjusted to cause the "glitch" at the beginning of the transition to match CPM-oscilloscope measurements reported previously [4]. This very small coupling turns out to be significant as can be seen in the data below. The shunt resistance of the plate forms the second half of a voltage divider which sets the swing voltage of the CPM, This reisitance was chosen to make the swing voltage ±50 V, nominal for typical pulsed DC ionizers.

II. Simulation Results

Figure 2 shows the result of a simulation with an ionizer ON time of one second and an initial ionizer value of zero. Figure 3 shows an oscilloscope trace of the analog output from a Monroe 288B CPM operating under an Ion Systems 5285e pulsed DC ionizer. The shapes of the curves in these two figures are strikingly similar, lending confidence to the accuracy of the SPICE simulation.

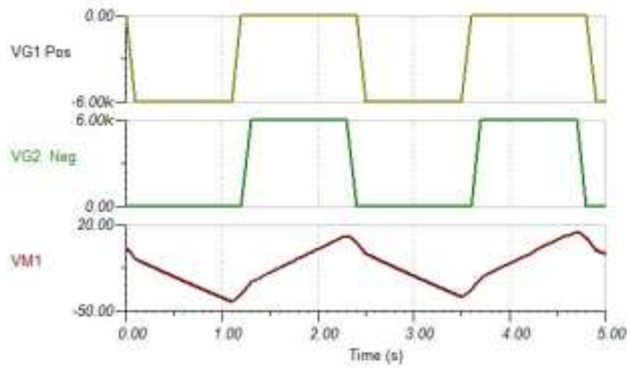

Figure 2. Results of a SPICE simulation of a pulsed DC ionizer. ON times are 1 second and transition times are 200 milliseconds.

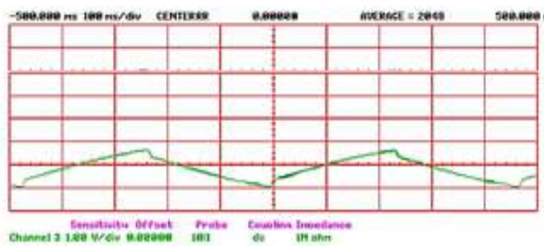

Figure 3. Analog output of the Monroe 288B in the field of a pulsed DC ionizer (Ion Systems 5285e) operating with 1 second ON times.

Figure 4 shows a SPICE simulation of a discharge from -1000 V to less than -100 V and the time is quite repeatable even if the phase of the ionizer is varied with respect to the beginning of the discharge. This validates the discharge time procedure as specified by ESDA 3.11-2006.

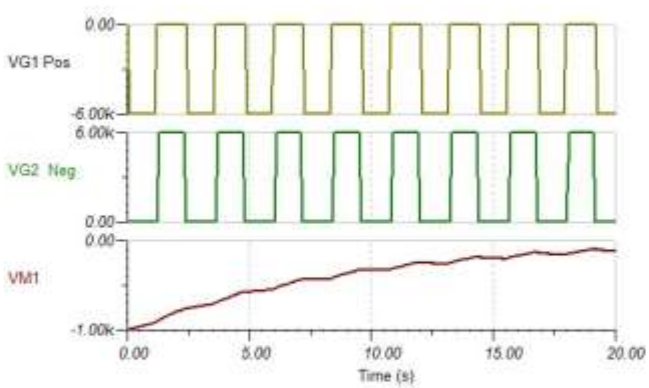

Figure 4 SPICE simulation of a CPM measurement of the Discharge Time of the pulsed DC ionizer shown in Figure 1.

The same validation was not found for the Swing and Balance measurements as specified in the recommended practice. Figure 5 shows a 20 second simulation with an ionizer ON time of 1 sec. The first cycle appears to be out of line with subsequent cycles.

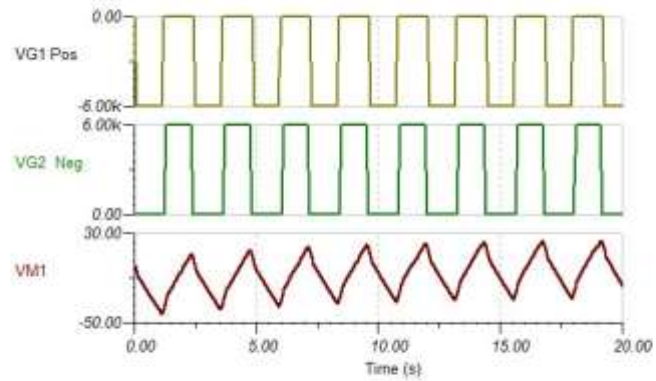

Figure 5. SPICE simulation of a CPM measurement of Balance and Swing setting the initial value on the CPM to 0 V.

To make this more obvious to the eye, 1 second ionizer cycle times were used with a total of 100 seconds of simulation. Figure 6 shows the results for the case where the ionizer starts with a positive excursion first and Figure 7 shows the same conditions for negative first. Note that since the ionizer operates asynchronously to the CPM, any phase between the two limiting cases of Figures 6 and 7 is possible for any measurements using a CPM to make this measurement.

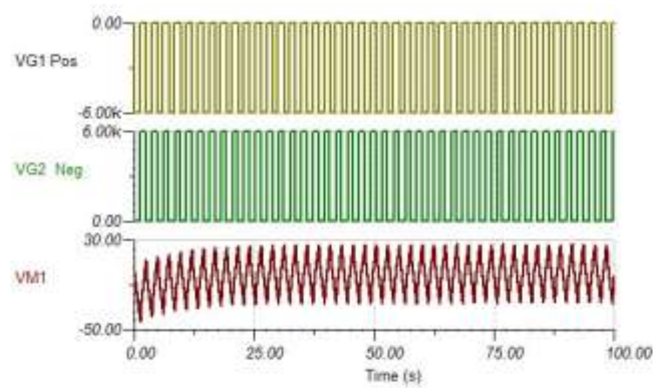

Figure 6. 100 seconds of a SPICE simulation of a CPM measurement of Balance and Swing setting the initial value on the CPM to 0 V. Negative ionizer pulse at the start of the measurement.

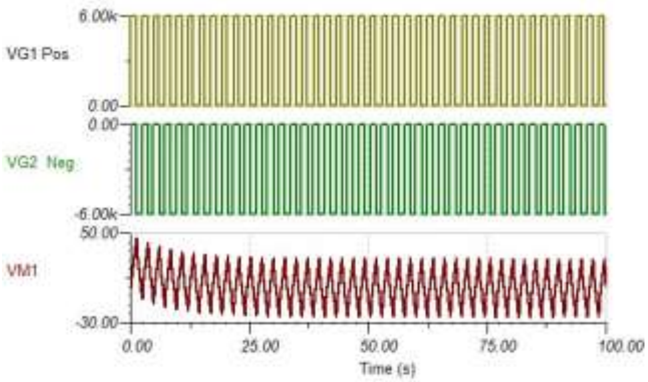

Figure 7. 100 seconds of a SPICE simulation of a CPM measurement of Balance and Swing setting the initial value on the CPM to 0 V. Positive ionizer pulse at the start of the measurement.

The initial transient is obvious in the two traces (Figures 6 and 7). One starts negative and settles to a steady state and the other starts positive and settles to the same steady state. Unfortunately, conventional measurements as suggested by the RP specify the most positive voltage and the most negative voltage and that is what is reported by the CPM. See Figure 8.

It is clear that the swing voltage (max - min) and the Balance Voltage ([max - min]/2) as reported have a variability that is due to the transient response of the system.

It is clear that the measurement should commence two to three time discharge times after the plate has been released to swing positive and negative. Using this measurement technique eliminates the remaining fluctuation issue seen in calibration of ionizer systems.

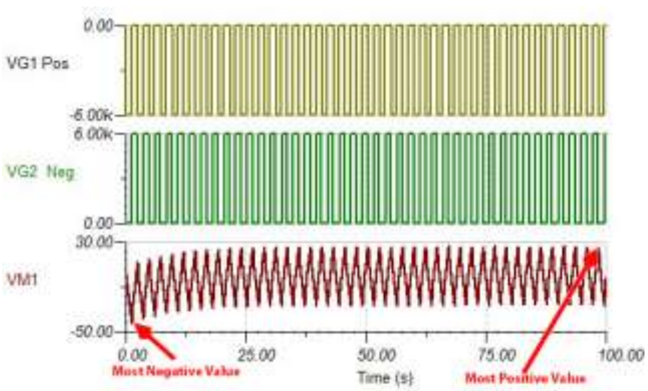

Figure 8. This figure shows what is reported by a CPM following the test procedure in ANSI/ESDA3.1-2006.

The Monroe 288B CPM now has a feature to allow Max, Min and Ave data to be reset by the user so that the data are collected by the CPM after a user selected period of time after the plate is released from 0 V. Working with the CPM using this feature dramatically reduces the variability of offset measurements and makes them very repeatable. Without the delay, a measurement with a maximum offset of ~100 V (±100 V balance) typically has shot- to-shot variations of ±50 V of the Average parameter (max – min)/2 measurement to measurement. With the delay, results typically match to within 10 V.

III. Conclusions

The work above makes it clear that an addition to the standard test procedure for making balance tests, specifying a wait time after the CPM releases its plate to acquire and then follow the ionizer signal would be wise. It will account for the transient response of the CPM/ionizer system and make measurements more reproducible. To confirm the validity of this new procedure with a CPM, a reseat feature has been added to the instrument. The technician performs a balance test as previously done but presses the peak reset button after 30 seconds. The resulting positive and negative excursions measured by the 288B are reproducible and very consistent, thus validating the recommended procedural change.

References

[1] Larry Levit and Geoff Weil. Environmental Effects on Corona Ionization, Proceedings of the IEST ESTECH Conference, San Antonio TX, May 13, 2014 - May 16, 2014

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[4] Lawrence Levit and Geoff Weil, Evaluation of the Performance of Corona and Hybrid Ionizers in Nitrogen, ESD Symposium on Factory Issues, November 7-8, 2012. TÜV SÜD PSB Pte. Ltd., 1 Science Park Drive, Singapore, 118221, Paper 2B.3.