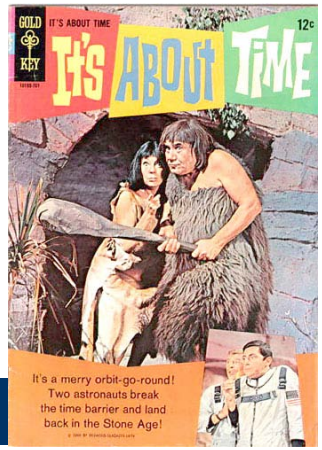
Radiation Effects…

- *Parts issues are well managed by other experts and there is not much I can add other than the fact that there are not many substitutes for some of the key devices. The design and test approach should allow for graceful degradation.*
- *LET and associated upsets need to be carefully manages since a crash of the control circuitry can truly result is a catastrophic failure.*
- *The many excellent dielectrics make charging in the space environment a more interesting issue although one that can typically be managed.*
- *Radiation effects on insulators are usually not a problem since the dose rates need to be really high. However, there are cases such as cables where the surface and penetrating effects need to be carefully evaluated.*
- *The one area worth some discussion is the ability to both partition designs and use potting or other insulators as a radiation shield. The components in the transformer, multiplier and filter are not strongly radiation sensitive. Thus, the shield can be substantially less in these areas.*

"Shrinking" a Design…

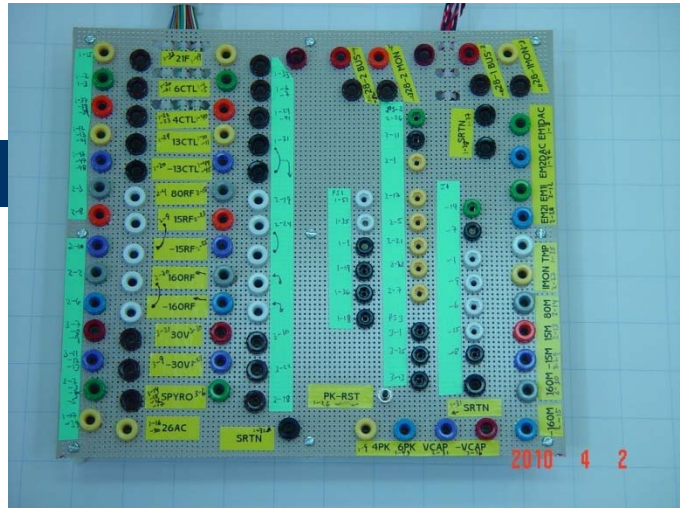


…"*It's about time, it's about space it's about, strange people in the strangest place"…*

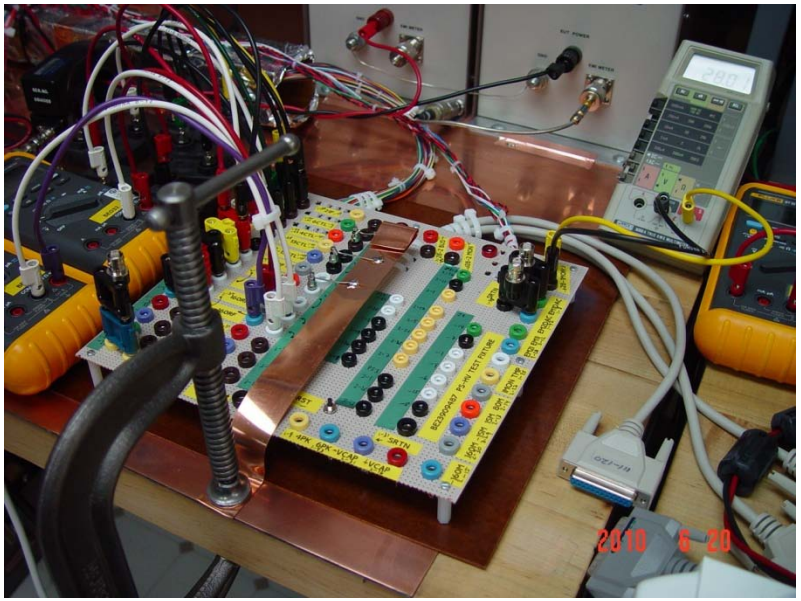
- *People can make up all the requirements they want, but engineers must consider the physics of failure when trying to make a high voltage system substantially more compact than allows for using standard design factors.*
- *The key driver in an optimal design will always be about managing the time dependent dielectric failure mechanism.*
- *The 4 way trade will be between complexity, field spacing (volume), density and operating life.*
- *My approach is to first attack the requirements and then attack the key elemental drivers such at the magnetics or multipliers that can be subjected to accelerated testing.*

Make your GSE simple enough that a 4th grader and (possibly) even your manager can run a test on flight hardware!

GSE Design… 1



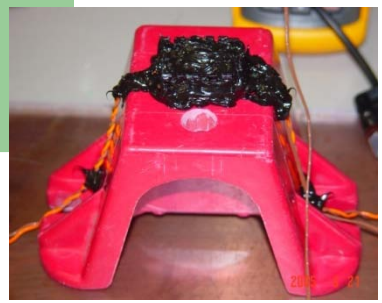
- *GSE design is a place where institutional preferences come into play.*
- *Since I am often asked to resurrect old brassboards or test units many years after their production, I greatly prefer simple "direct connect" designs that have no active circuits or intermediate electronics between the unit and the test equipment.*
- *This approach is dependent on maintaining a "standard" test bench setup but does allow for full visibility in order to fully understand everything that happens during the test activity.*



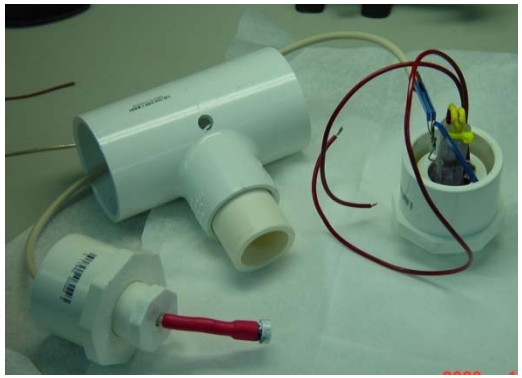
GSE Design… 2

- *A secondary advantage of a direct connect GSE approach is that you also achieve a simple and clean test setup that is easy to analyze and validate prior to connecting the flight hardware.*
- *I always certify the test setup prior to use including performing secondary calibration on the key measurement equipment.*
- *One important lesson learned over many years is to maintain continuity in the test setups. I store every test setup and maintain it for future use.*

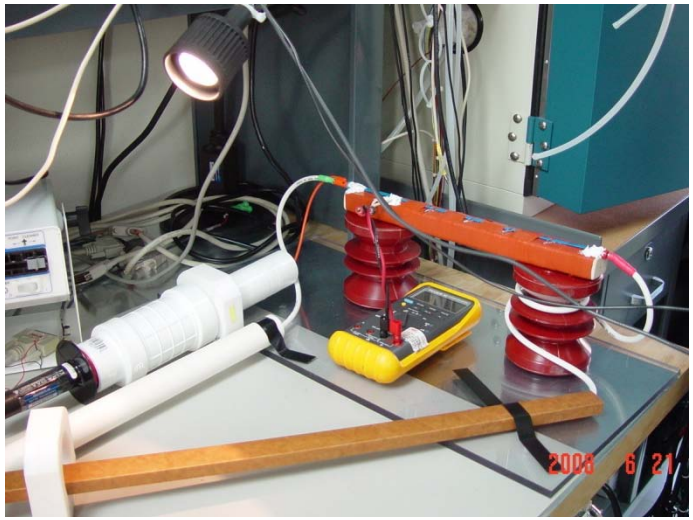
The test problem can still be hard even when the GSE is simple. But, at least you will know the problem is with the hardware!

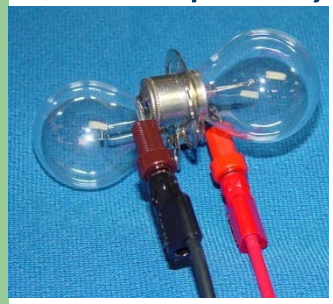


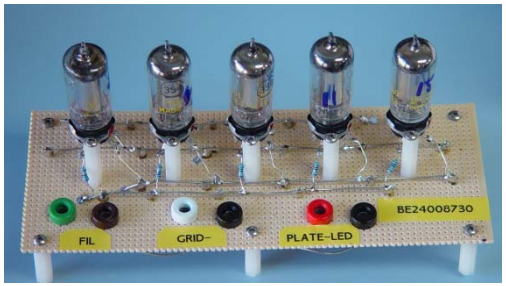
Simulator Design…



- *Simulators for high voltage systems can come in all shapes and sizes.*
- *I find that building simulators and then certifying them for the application is actually the most fun part of the overall job.*
- *Keep your simulator simple and robust.*
- *Test your simulator carefully and completely.*

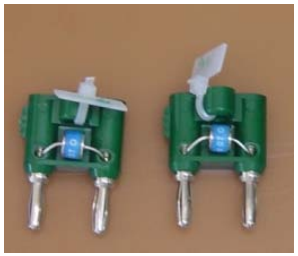




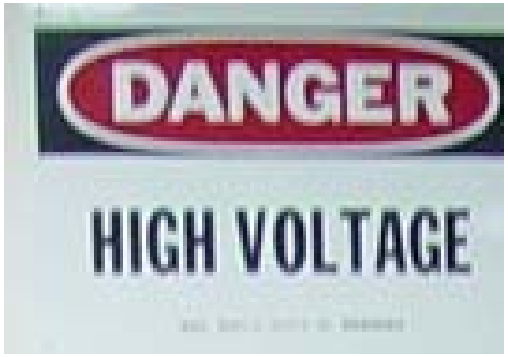


Tools of the Trade…

Use gas tube "equipment savers to protect your equipment!



- *It is important to recognize the "real work" happens in the early stages of design when the various elements are laced together as a proof of concept.*
- *Having a big junk box of insulators, wires, spacers etc. enables rapid setups and investigations.*
- *Also don't overlook the value of the "the equipment saver". Gas tubes are a great way to protect the input to your meters and other sensitive equipment.*



Safety is Always First… 1

- *These notes are simply a supplement to your Institutional Safety Standards. Make sure you are familiar with them and that they are consistent with proper operation of the flight hardware.*
- *Safety considerations are part of the engineering process and should be incorporated into the design.*
- *If the work area has a mixed use, barriers and marking should be employed to assure the area is safe and free of distractions.*
- *Support equipment should be certified and clearly marked.*
- *Only people with proper training in the fundamentals of safe high voltage operation should be in proximity to equipment.*

Safety is Always First… 2

- *Proper grounding is essential. I prefer floating setups with clear simple point grounding paths to a facility ground bar.*
- *I use mats and heel straps rather than wrist straps to keep metal away from the work area.*
- *We have already discussed arc protection and V/10 design approaches. Safe fault-tolerant methods for ON/OFF switching operational control should also be implemented.*
- *Units, test equipment and procedures should also be consistent with safe operation and test.*

Summary Thoughts…

- *By now you have probably concluded that you know the engineering and understand the physics. That is why I have been trying to teach the "art".*
- *You have also figured out the approach I have been trying to teach where there are three fundamentals to developing reliable high voltage systems:*
  - ***Push back on requirements in order to find the optimal middle.***
  - ***Own every element of the design, process and product.***
  - ***Adapt proven and reliable techniques to successfully solve new problems.***
- *Thanks again for your time and your patience. I hope to see you in October at JPL!*

30 MINUTE Q & D SESSION

UNTIL WE MEET AGAIN!