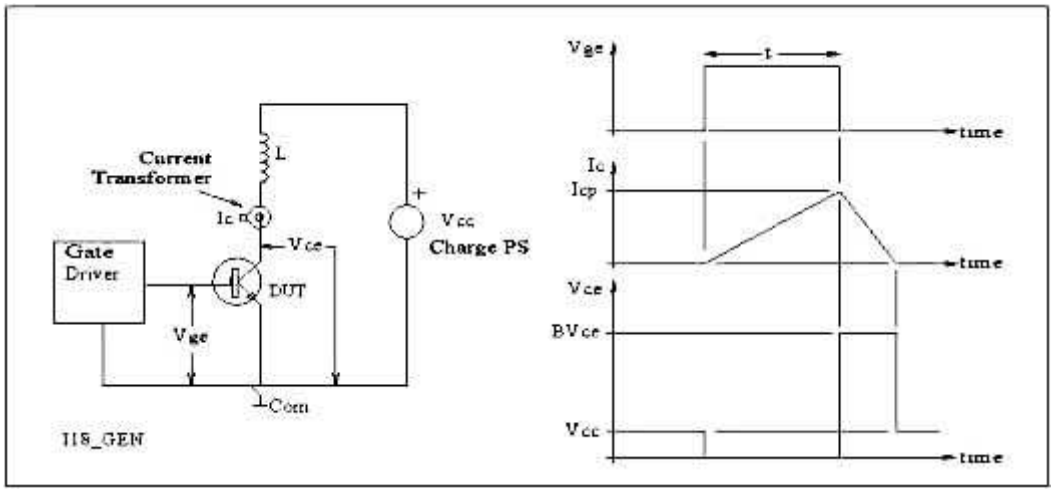
Introduction to the IST-1:18 Energy Absorption Tester

Many semiconductor device types require **testing for their energy absorption capability**. There are many variations of test circuit on a basic theme. Bipolars have their “Sustaining Voltage” test, power-fets have their “Unclamped Inductive Load” test, Igbts their “Clamped Inductive Load” tests, some diode types their “Avalanche Energy” tests and so on.

All rely on charging an inductor of known value to a required current then interrupting the current flow to allow the inductor to produce its “fly-back” voltage. The discharge of this voltage into the DUT or its clamp will produce the fixed energy pulse used for this test.

The basic test circuit used in all these test types is described in MIL-STD-7500 Method 3470. This example uses an NPN Igbt for the DUT but the basic principle applies for all.

The basic circuit and simplified waveforms obtained are shown below;



The DUT is switched on for a required time by the gate driver and the Inductor L charges up to a current set by;

$$I = Vcc \times t / L \quad \text{where } t = \text{the set gate ON time.}$$

(This equation is derived from the usual $V = -L.\ di/dt$ the negative sign denotes the voltage generated will be inverted).

The DUT is switched off. The coil will discharge into the DUT or the lowest voltage available. The discharge energy is fixed by the charge-up parameters and the lowest breakdown voltage found. Assume the DUT breaks down at BVce.
To calculate the energy on discharge, a simplified diagram of the turn-off is now shown.
The discharge voltage is assumed to have a “flat-top”.

Energy = volts x current x time.

= (BVce x Icp x td) / 2

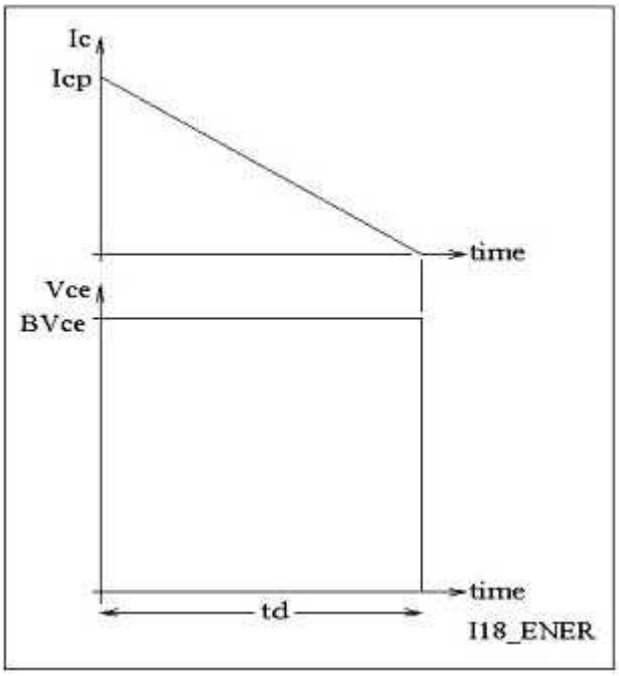
assuming the current discharge is linear the BVce shape is rectangular and td is the discharge time.

The current fall rate is controlled by the inductor value L and the voltage across it (BVce) ;

BVce = L x Icp / td

Therefore substituting BVce into the Energy equation,

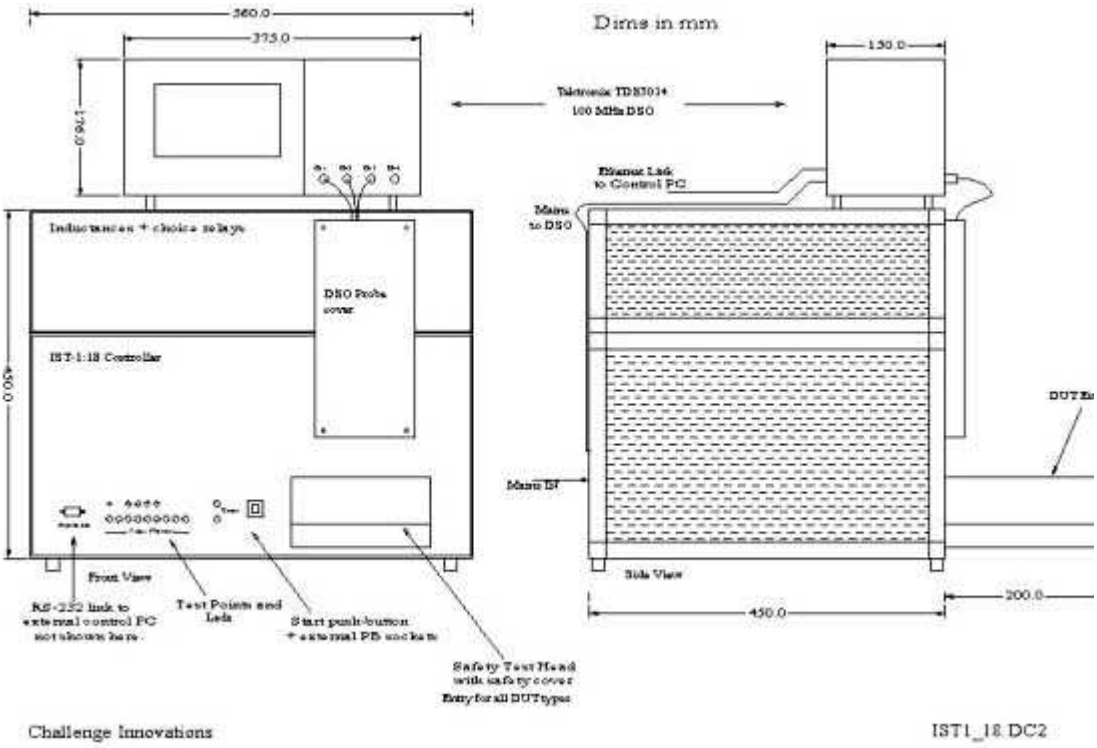
Energy = ½(L x Icp x Icp) the classical equation.



This simplified explanation hides many complex details. Testers have to confront these details and provide the best compromise possible for the range of DUT required to test.

Challenge Innovations have been building Avalanche Absorption Testers since 1982. The IST-1:18 is a general purpose unit that brings together all the functions required to test a broad range of DUTs.

The IST-1:18 enclosure is;



Note that the external control PC and its peripherals are not shown. These are “Standard” units running “Windows” based software and include a suitable printer. Challenge Innovations provides the software to run within the “Windows” environment. The “Standard” PC package can be supplied by Challenge Innovations or by the customer.

The test circuitry uses the basic MIL-STD method 3470 circuitry but refined in major ways. Each section of this Tester is now described.

IST-1:18 Controller contains all the circuitry including;

- - Gate driver provides the gate turn-on and turn-off levels for a given time (t). The ON time is determined by the software. Levels are programmed from +/-5V to +/-20V in 1V steps. Rise and fall times are approx. 30nsec with a drive capability of > 20A peak. This is needed to charge and discharge the gate capacitance of the larger DUT. The gate driver circuitry is easily changed for different DUT types

- - Gate series resistors, both ON and OFF, are situated under the DUT Safety Test Head right next to the DUT socket.

- - The charge power supply (Vcc) is a choice of 30V or 100V suitable to provide the requirement of charging the largest coil at the longest time. The software makes the voltage choice.

- - Charge current (Icp) is set from 0.1 to 99.9 Amps in 0.1A steps. The current is chosen or set by the software.

- - Vge and Vce are measured using standard /10 and /100 voltage probes connected to the DSO.

- - Icp is measured using a current transformer (Pearson or similar) terminated with a 50R on the DSO. This gives a conversion of 0.05V/Amp. These transformers do not have a significant delay between the actual current flowing and the displayed waveform.

- - The DSO (Tektronix TDS 3014 or similar) on top of the unit will display the collector current Icp (Ch 3), the collector voltage Vce (Ch 2) and the gate voltage Vge (Ch 1) for the turn-off part of the test pulse. The time base is set to a suitable value by the software. The DSO is controlled by the external control PC and its software, via the Ethernet link. At the end of each test pulse, all 3 channels are downloaded via this link to the PC and its software where;
  1. there is a choice of loading all 3 channels into an EXCEL compatible file. This can be manipulated by Challenge Innovations supplied or customer written macros to produce suitable test reports,
  2. 2. the supplied software will determine if the DUT is a PASS or FAIL using algorithms which interrogate the waveforms,
  3. 3. determine if the test sequence parameters (Vge, Icp etc.) have been correct.

  There is the option for manual control of the DSO without the download so that special waveform areas can be investigated.

- - On the top of the Controller is a removable box carrying the inductances. They provide 0.01 to 159.99 mH. Up to 99.99 mH in 0.01mH steps then in 0.1mH steps. The inductances are chosen by relays, also in this box, controlled from the software. Inductances are air cored to 99.99 mH then special toroidal-

cored types. This change is made to keep the sizes of the coils to a manageable level.

- On the front panel of the controller is the Safety Test Head. This is made to best suit the DUT packages requested by the customer. They can range from surface mounted devices to the large Igbt modules used in traction control. The working voltage of the DUT collector is 3kV max.. As most testing is made at room temperature, there is no heater block provided. A temperature controlled (ambient to 200oC) can be added if required.

- Plug-in option to add a high voltage Igbt/power-fet to generate a required energy pulse for a diode or similar DUT. The current (Icp) monitor is changed to the diode circuit.

- Plug-in option to perform a “Clamped Inductive Load” test on a DUT.

- Internal high energy capability voltage clamp to 3kV.

- Software controlled limit to the Energy requested. To date this is 1.0 mJoules to 50.0 Joules. These values can be changed.

All items are controlled by internal micro-computer programmed in C code. It includes a calibration check at switch-on / on demand. During the test sequence, it checks all the parameters are correct.

External PC software package includes;

EDITOR section;

- sets up one or a sequence of up to 100 Energy pulses with a programmable delay in between each.
- Each pulse set up by a choice of 2 parameters from current (Icp), Inductance (L) or Energy. The software calculates and displays the third parameter.
- Test Upper/Lower limits operating on choice of Energy or Voltage (Vce)
- Facility for entering comments and Engineers name, date entered automatically.
- Facility to save, re-load, print-out, save in text format the test file.

RUN TIME section;

- displays the numerical result of each test on the parameter chosen,
- Large PASS/FAIL/ERROR legend for each test and in total,
- facility to download the test results into an EXCEL compatible file.

Software features are continually being added. Any reasonable customer’s request will be considered.

Please contact **Challenge Innovations** or their Agent for price and delivery details.