AN070710 : Coil Transient Suppression Test – Worked Example.

This document looks at typical data from the coil transient suppression test (CTSP) and how to interpret and optimise it.

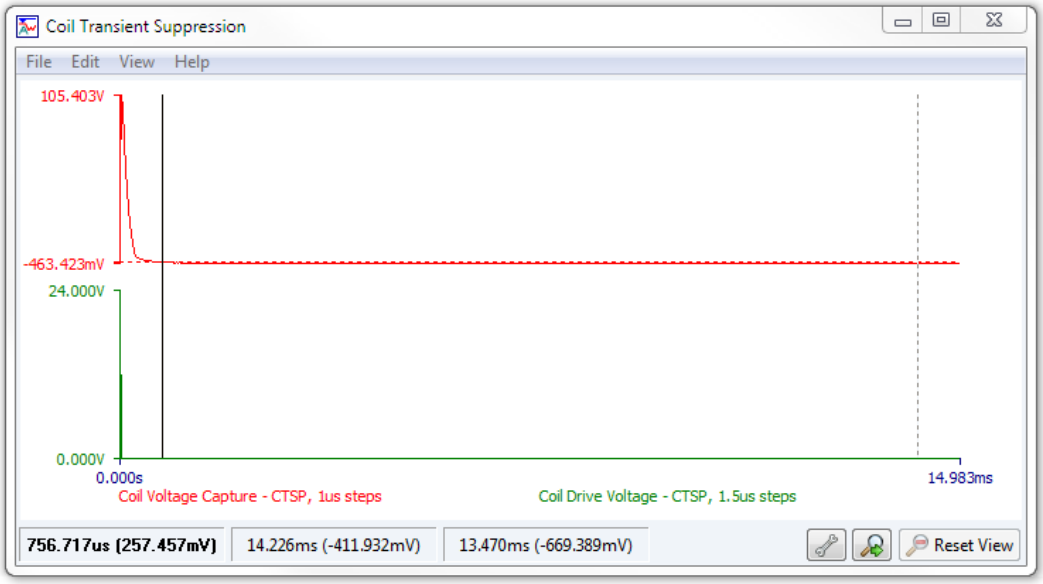
Setting up the test.

This example is connecting to a 1.3k coil device, nominal voltage 24V and it presently has no coil suppression. You can leave the 'resolution' parameters set to zero and the system will work out suitable values for you when the test is run:

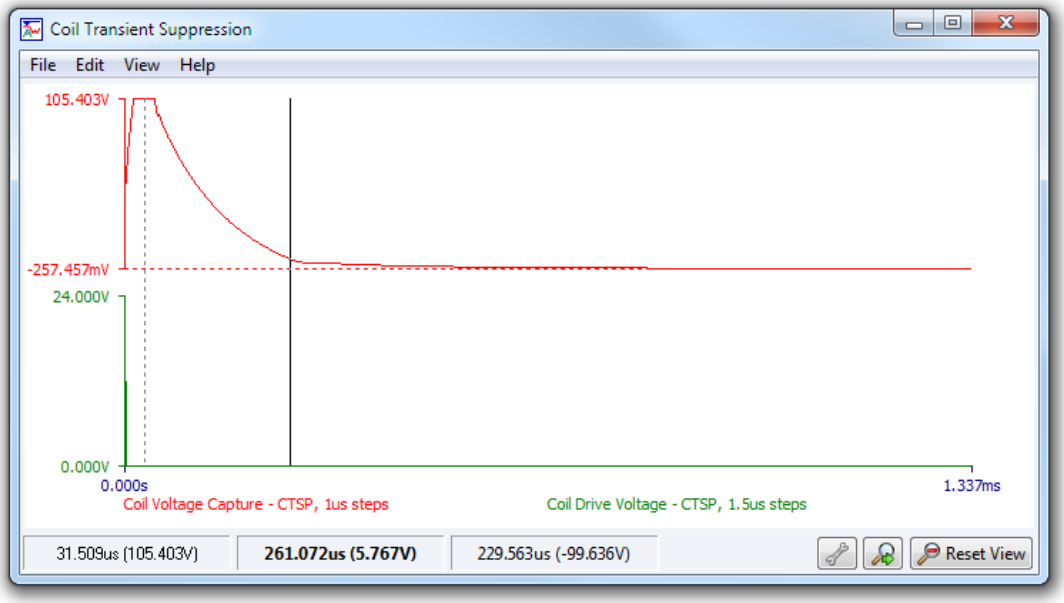
```
7 [P] Coil Transient Suppression            Back Emf: 105.403 V
 CONDITION LIST
  C121                            Device Coil Format          = As monostable A+
  C201  [     /     ]              # Voltage default          =    5.000  V
  C301  [     /     ]              # Current default          =  100.000 mA
  C401  [     /     ]              # RCoil default            =    1.300 kR
  C501  [     /     ]              # TStable default          =   15.000 ms
  C122                            Coil selected              = Coil-A (Monostable
  C210  [     /     ]             Voltage to apply           =   24.000  V
  C310  [     /     ]             Current to apply           =   20.000 mA
  C510  [     /     ]             Settling time              =   15.000 ms
  C531  [     /     ]             Test duration              =   15.000 ms
  C532  [     /     ]             Coil drive resolution      =    0.0 us
  C533  [     /     ]             Coil capture resolution    =    0.0 us
  C252  [     /C253 ]             VMeasured Min limit        =    0.100  V
  C253  [C252 /     ]             VMeasured Max limit        =  500.000  V
  C901                            Graphic script             =
 RESULT LIST
  R1                              Test step passed           = Yes
  R2                              Test Status                = Test OK
  R101  [C252 /C253 ]             Diode reverse voltage      =  105.403  V
 HANDLER BIN Fail:0, Pass:0
 RESULT SUMMARY Back Emf: 105.403 V
 TOTALS THIS STEP 40% Batch[P:4,T:10,F:6] Seq[P:1,T:1,F:0]
 JUMP    Never [False] to <End> ELSE <Continue>
```

Results showing No Coil Suppression.

When the above test is run, the following display is seen:



By manually zooming-in, this next display shows the first 1ms or so of the above plot...

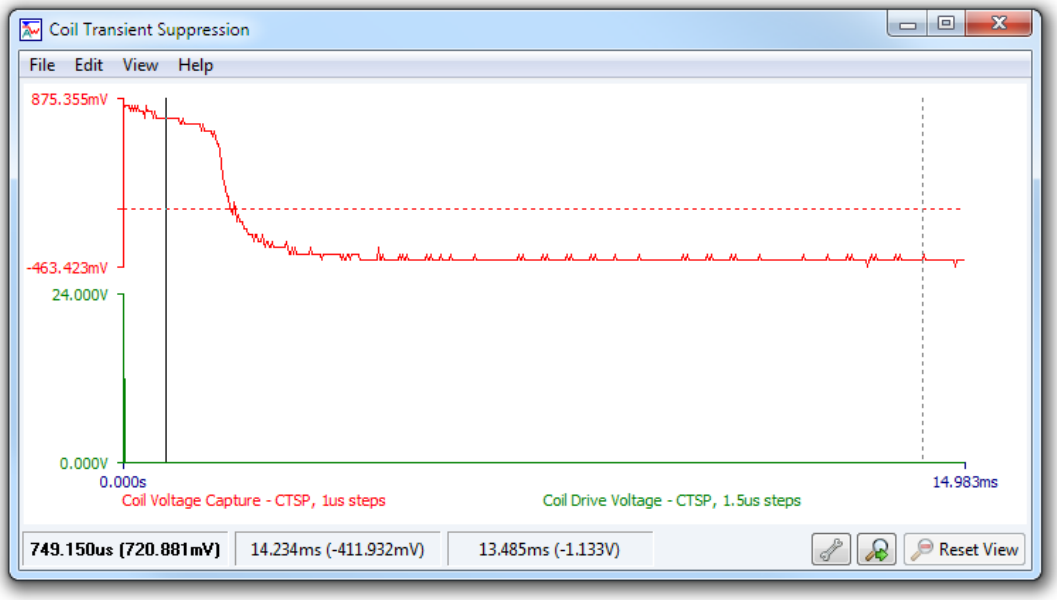


You can see that the lack of coil suppression leads to a large (105V) reverse voltage when the coil is released.

Note that as the coil transient dies away, it is tangential to a small negative voltage rather than zero. This is because the hardware sense amplifier circuitry 'steals' a small amount of current from the open coil terminal to perform its sensing and this in turn leads to a non-zero 'floor'. In fact this has no actual consequence because the test is looking for the absolute value of the positive peak, and this is not affected by the final 'floor' value.

Results showing a diode fitted.

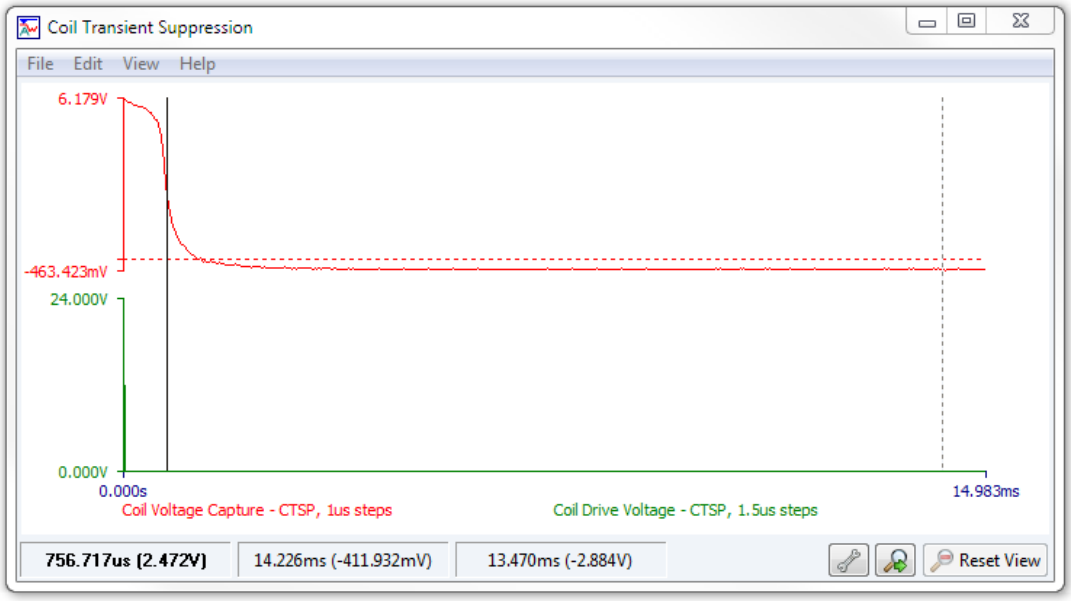
With a diode is fitted to suppress the relay coil the trace looks similar to the following:



Now the non-zero 'floor' mentioned above can be more clearly seen at around -460mV but the diode clamping action is visible at around 0.875V indicating a correctly functioning diode. It is also usual to see some high-frequency noise appear on the trace due to fixturing and cabling pickup. This can be ignored as long as it is not significant compared to the limit being examined.

Results showing a Zener diode fitted.

In many relays a zener diode is used for the clamping action to speed up the release time of the relay. The plot below shows this with a 5.1V zener diode in series with a conventional signal diode as a clamp, limiting the coil back-EMF to around 6.1V. You can clearly see that the coil energy is dissipated in around half the time on the diode-only case above.



Optimising the test for speed.

Since the test involves a short action (the back-EMF 'spike') and potentially numerous data capture samples, there is scope for improving the execution time of the test without adversely affecting the measured data.

The test above can have two major improvements made to it:

- Reduce the test duration from 15 ms (the default) to 2 ms - This saves some 13 ms of test time, but more importantly it reduces the number of captured data samples from around 10,000 to 1,500, speeding up the test time by about 7x.
- Increase the coil capture duration from 0 (the default) to 10 us. With a value of '0', the actual sample interval was around 1us - changing this to 10us has little effect on the captured wave shape but further reduces the time taken to transfer the data by a factor of 10x.

These improvements are shown highlighted below and the resulting test can be made to complete in little more than 100 ms with an output as shown below.

```
7 [P] Coil Transient Suppression          Back Emf: 6.333 V
 CONDITION LIST
  C121                          Device Coil Format          = As monostable A+
  C201  [     /     ]            # Voltage default          =    5.000  V
  C301  [     /     ]            # Current default          =  100.000 mA
  C401  [     /     ]            # RCoil default            =    1.300 kR
  C501  [     /     ]            # TStable default          =   15.000 ms
  C122                          Coil selected               = Coil-A (Monostable
  C210  [     /     ]           Voltage to apply            =   24.000  V
  C310  [     /     ]           Current to apply            =   20.000 mA
  C510  [     /     ]           Settling time               =   15.000 ms
  C531  [     /     ]           Test duration               =    2.000 ms
  C532  [     /     ]           Coil drive resolution       =    0.0 us
  C533  [     /     ]           Coil capture resolution     =   10.0 us
  C252  [     /C253 ]           VMeasured Min limit         =    0.100  V
  C253  [C252 /     ]           VMeasured Max limit         =  500.000  V
  C901                          Graphic script              =
 RESULT LIST
  R1                            Test step passed            = Yes
  R2                            Test Status                 = Test OK
  R101  [C252 /C253 ]           Diode reverse voltage       =    6.333  V
 HANDLER BIN Fail:0, Pass:0
 RESULT SUMMARY Back Emf: 6.333 V
 TOTALS THIS STEP 66% Batch[P:14,T:21,F:7] Seq[P:1,T:1,F:0]
 JUMP    Never [False] to <End> ELSE <Continue>
```

Advanced capture analysis using the 'Graphics Script' parameter.

The parameter C901 is normally left blank with the result that the R101 'Diode Reverse Voltage' is calculated from a simple maximum of the captured samples.

If C901 is set to a graphics script string, R101 can be made to take on a special value based on the execution of the graphics script. For more details see Graphics Scripting.