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Application Note AN281197
Creating linked relay test steps to achieve a custom device test.

1 Contents.

2 Introduction.

This note discusses how to achieve a custom relay device test by linking ramp and contact resistance tests such that the coil control timing and drive levels act as if a single custom test had been created.

An example is shown of measuring contact resistance's related to the measured operate and release voltage of the device.

3 An example device test requirement.

Consider an example requirement to make the device test measurements shown in Fig 1. Here, an operate voltage ramp determines the 'just operated voltage' Vop and after a saturate level, a contact resistance measurement is required on closed NO contacts using a voltage related to the measured operate voltage by the expression Vcrno = Vop * 0.8. A second saturate voltage is followed by a ramp to determine the release voltage Vrel with a final contact resistance measurement made on closed NC contacts at a voltage Vcrnc = Vrel * 1.2.

Implementing this requirement by using the standard test steps of an RT90 / RT290 test program will illustrate techniques of

1. Separating operate and release voltage ramps.
2. 'Connecting' the coil drive between ramp tests and contact resistance.
3. Using expressions to create 'run-time' parameters.

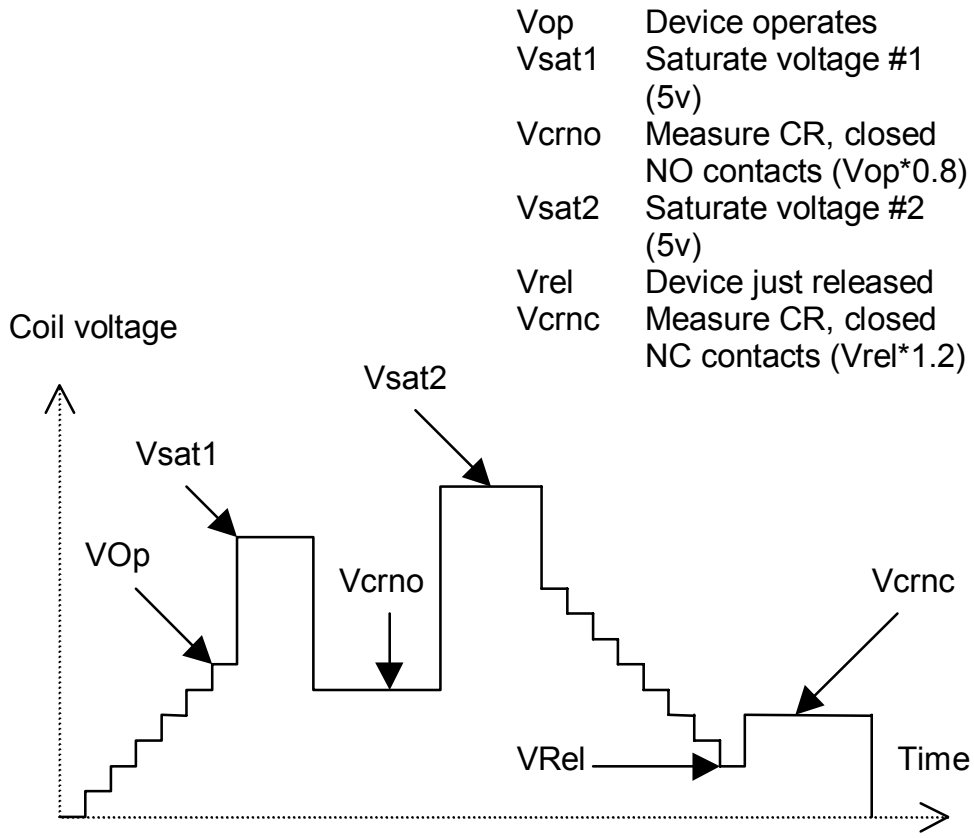

Figure 1 – Coil drive profile of the desired device test.

4 Implementing this on the RT90 / RT290.

The first task is to design the outline of the test and how it will be built from the basic tests available in the RT90/290. For example it can be built from

1. An operate and release voltage ramp test (Vramp type)
2. Two contact resistance tests (CR type).

The challenge is to use them together in such a way as to implement the desired coil drive shape shown above. One way of achieving this is to 'segment' the operate and release test into two parts, inserting a contact resistance test into the 'middle' after the operate ramp and appending a second CR test at the end after the release ramp.

4.1 Segmenting the 'Vramp' operate and release test.

For maximum use by default, the 'Vramp' operate and release voltage test is

implemented on the RT90/290 with a combined operate and release ramp shape as follows:

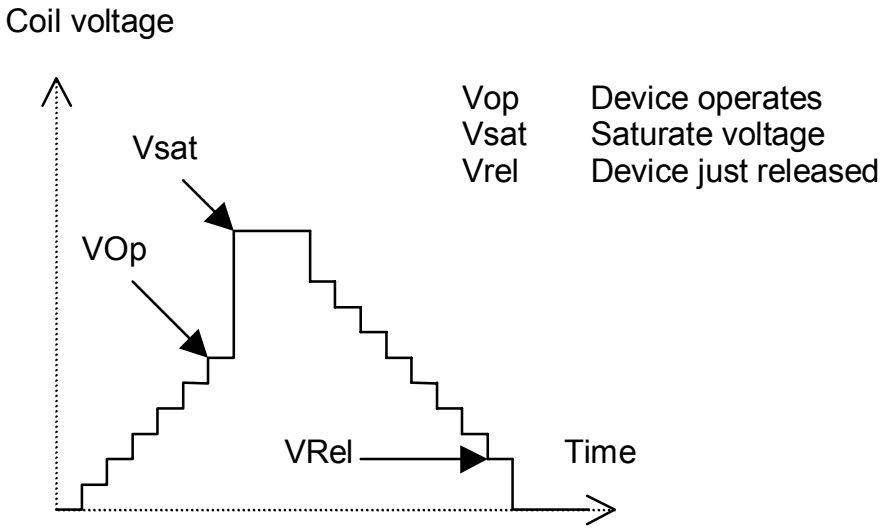

Figure 2 – Coil drive profile of the standard RT90/290 'Vramp' operate / release voltage test.

The operate ramp commences with a start voltage, increasing until the device operates at 'Vop'. The coil drive moves to a saturate voltage 'Vsat' followed by a release ramp decreasing until the device releases at 'Vrel'.

This profile is very useful for many test situations but there are others where only the operate (or release) part of the ramp is required. For example such a situation would occur where it was required to measure the contact resistance of the 'just operated' contacts before continuing to make the release ramp.

To make this possible the Vramp test is programmable as two test 'segments', one for 'operate' and the other for 'release' – allowing the test to provide only one of the segments if required. Programmed as individual segments in this way, the coil drive profile is shown as in Fig 3.

A key additional point of this programming is that the saturate voltage is optional – the saturate voltage only occurs if the saturate time is non-zero - and that it 'belongs' to both the operate and release segments. This makes it possible to provide only an operate ramp followed by a saturate voltage, or only a release ramp *preceded* by a saturate voltage – exactly what is required by the desired test profile in Fig 1.

The default coil activity at the end of Vramp test is to return to zero since this ensures that there is maximum independence of one test from the next allowing test steps to be moved around freely. This return to zero activity is not acceptable for our desired test profile because we wish to measure contact resistance at a voltage just above the operate voltage without the coil voltage returning to zero after the device operates. Fortunately we do not need to program this since if the test is segmented it is assumed that the user wishes to have the coil drive stay at its final level and to have control over the subsequent coil activity – this is shown in Fig 3.

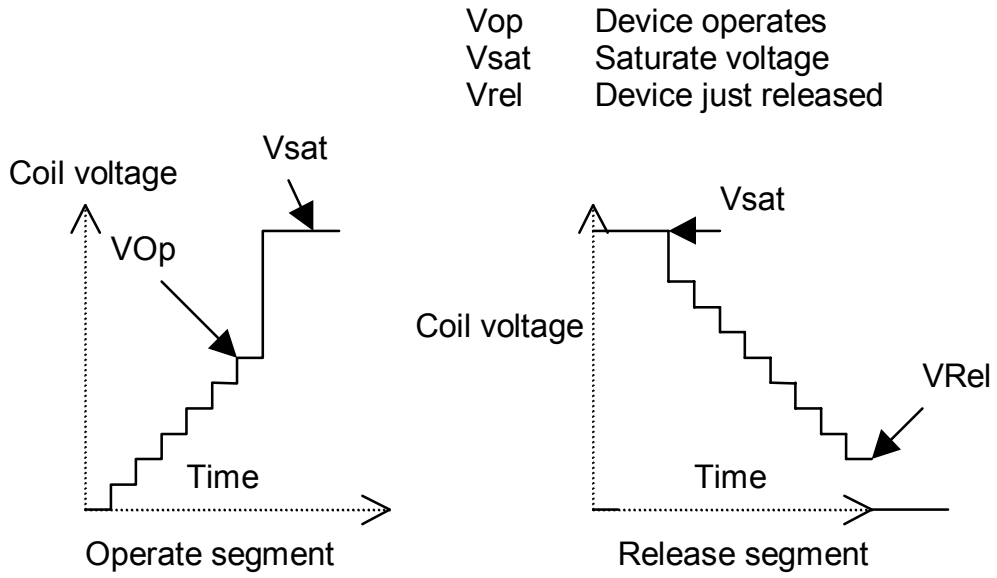

Figure 3 – Coil drive profile of the RT90/290 'Vramp' operate / release voltage programmed in two 'segments'.

For example the condition used to obtain only an operate segment is shown highlighted in Fig 4. The release segment is obtained in the same way, with C701 (operate segment) set to 'skip segment' and C702 (release segment) set to 'normal'. (If required, see the complete test program in section 6).

```
2 [-] Measure VOperate                  ------
CONDITION LIST
  C121 Device coil format                          = As monostable A+
  C101 Device contact format                       = 2PCO   (Sets 1,2)
  C102 Contacts to test                            = C,C,X,X,X,X,X,X
  C201  # Voltage default                          =    5.000  V
  C301  # Current default                          =    0.000 mA
  C401  # RCoil default                            =    0.000 kR
  C501  # TStable default                         =    0.000 ms
  C124 Device coil suppression                     = Network #1
  C510 Settling time                               =   10.000 ms
  C211 Saturate voltage                            =    4.000  V
  C511 Saturate time                               =   50.000 ms
  C310 Current to apply                            =  100.000 mA
  C701 Operate segment mode                        = Keep drive and exit
  C222  Operate ramp start voltage                 =    0.500  V
  C223  Operate ramp step voltage                  =    0.200  V
  C224  Operate Min must operate       [   /225]   =    2.000  V
  C225  Operate Max must operate       [224/   ]   =    5.000  V
  C226  Operate Min must release       [   /211]   =    0.000  V
  C227  Operate Max must release       [   /211]   =    3.750  V
  C228  Operate Max unstable region    [   /211]   =    1.500  V
  C702 Release segment mode                        = Skip segment
  C242  Release ramp start voltage                 =    5.000  V
  C243  Release ramp step voltage                  =    0.050  V
  C244  Release Min must release       [   /245]   =    0.000  V
  C245  Release Max must release       [244/211]   =    3.000  V
```

```
  C246  Release Min must operate      [   /211]   =    0.500  V
  C247  Release Max must operate      [   /211]   =    4.000  V
  C248  Release Max unstable region   [   /211]   =    1.500  V
```

Figure 4 - Conditions used to obtain only the 'operate' segment.

5 Integrating the contact resistance tests

To complete the required device test profile of Fig 1 we need to add two contact resistance tests, one after the operate ramp and another after the release ramp. To ensure that its voltage level is integrated with the existing voltage from the ends of the ramps we program its ‘Device coil format’ condition to ‘VI Changes only’ as shown in Fig 5. This instructs the test that an existing coil drive is present and that the contact resistance test should only change the levels of voltage and current instead of setting up brand new coil drive conditions based on device type and polarity.

A key requirement in the desired test profile of Fig 1 is that the contact resistance be measured at 80% of the operate voltage. This can be achieved by setting C210 (‘Voltage to apply’) to an expression instead of a fixed value. Expressions can be used for any numeric condition with the convention that parameters are named as

<TestName>.<RefNum>

Where <TestName> is the name of a specific test step with embedded spaces removed and <RefNum> is the reference of the parameter. For example in this test we wish to obtain 80% of the R110 result in the test ‘Measure Voperate’. We can therefore set the parameter C210 (the contact resistance drive voltage) to the expression:

MeasureVOperate.R110 * 0.8

After the operate ramp is complete and results in a value of (say) 5V for R110 (the just operated voltage) this expression will be evaluated to 5*0.8=4 and the coil voltage will be set to 4V to measure the contact resistance.

```
CONDITION LIST
  C121 Device coil format                          = VI Changes only
  C101 Device contact format                       = 2PCO   (Sets 1,2)
  C102 Contacts to test                            = C,C,X,X,X,X,X,X
  C201  # Voltage default                          =    0.000  V
  C301  # Current default                          =    0.000 mA
  C402  # RContact default                         =   0.0000  R
  C401  # RCoil default                           =    0.000 kR
  C501  # TStable default                         =    0.000 ms
  C124 Device coil suppression                     = Network #1
  C103 Contact side to measure                     = Normally open
  C212 VClamp                                      =   50 mV
  C104 Contact load                                = CA0 (as gen and clamp)
  C210 Voltage to apply        =    2.800  V [MeasureVOperate.R110 * 0.8]
  C310 Current to apply                            =  100.000 mA
  C510 Settling time                               =   15.000 ms
  C410 CR Measurement range                        = 1R
  C411 CR measurement precision                    = 80ms 25Hz
  C412 Min RContact pass limit          [   /413]  =   0.0000  R
  C413 Max RContact pass limit          [412/   ]  =   0.1000  R
```

Another copy of this test is used – suitably programmed – to make the contact resistance measurement of the closed normally-closed contacts after the release ramp – see the listing of the full test.

6 Additional features.

There are some features that would normally be part of the test sequence that are missing from this test program.

1. Normally, the test would include an adaptor check to ensure that the device is correctly connected. This should be inserted at the start of the test sequence.

2. To make the test program more proof against faulty device operation, the JUMP statements can be programmed to skip to the end of the test program if any test parameters fail during this test sequence.

7 The complete program.

This section shows the complete test program that achieves the desired device test in Fig 1. The key conditions that are specially programmed are shown in bold. If required, a machine-loadable version if the test program can be obtained by loading the file AN281197.R90.

The actual coil drive profile obtained on an RT290 with this test is shown in Fig 5. (Note that on an RT90, the short 500us settling time may result in a slower ramp rate due to the lower speed of the system. In this case, increase both the step voltage and the settling time in the same ratio to achieve the desired ramp).

1 Operate ramp start voltage. (VOP.C222, 0.5v)
2 Operate ramp (VOP.C223 5mV and C510 500us)
3 Device operate voltage (VOP.R110)
4 Saturate voltage (VOP.C211 4V and VOP.C511 100ms)
5 Measure CR NO contacts (based on 80% of VOP.R110)
6 Saturate voltage (VREL.C211 5V and VREL.C511 100ms)
7 Release ramp (VREL.C243 5mV and C510 500us)
8 Device releases (VREL.R114)
9 Measure CR NC contacts (based on 120% of VREL.R114)
10 Negative spike at removal of coil drive

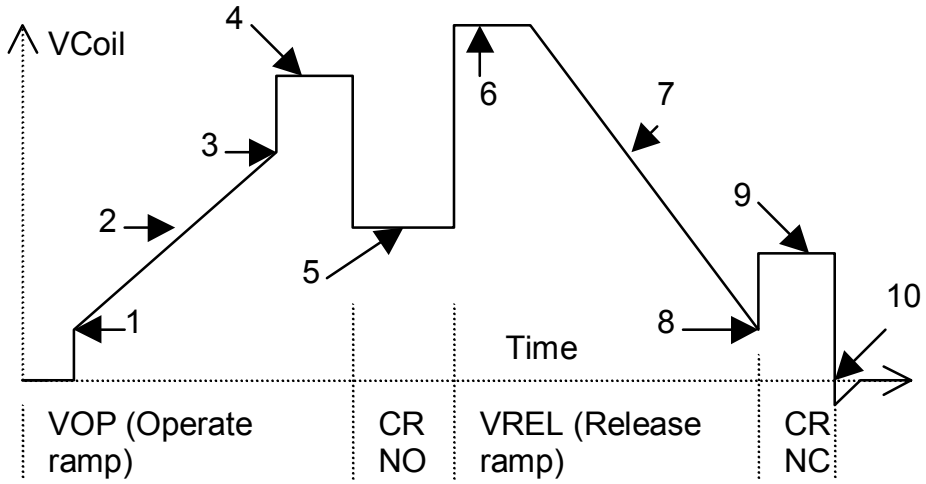

Figure 5 – Coil drive profile when running this test on an RT290.

```
[ ------------------------------------------------- ]
[ Printed from   : RT290 SOFTWARE, V1.02c 28/11/97   ]
[ Description    : Immediate print of test sequence  ]
[ Date and time  : 09:57:26, Monday, 1st December 1997 ]
[ Test file path : 'an281197.R90'                    ]
[ File reference : 'A demonstration composite test'  ]
[ ------------------------------------------------- ]
```

```
 1 [P] Batch definition                A demonstration composite test
 CONDITION LIST
   C1   Part Number                 = No part number
   C2   Device Type                 = No Device Type
   C4   Operator                    = No operator
   C5   Batch                       = No batch
   C6   Lot                         = No lot
   C7   Sample Plan                 = No sample plan
   C20  Device routing              = None specified
 RESULT LIST
   R1   Last test run at            = 09:56:35, Monday, 1st December 1997
   R2   Tester Name                 = RT290
   R3   Software Name               = RT290 SOFTWARE
   R4   Version Name                = V1.02c 28/11/97
```

```
  R5   File reference             = A demonstration composite test
DATALOG True [Always]
PRINT   True [Always]
--------------------------------------------------------------------------------
2 [P] Measure VOperate                 Op:   3.435  V, Rel:   0.000  V
CONDITION LIST
  C121 Device coil format                          = As monostable A+
  C101 Device contact format                       = 2PCO   (Sets 1,2)
  C102 Contacts to test                            = C,C,X,X,X,X,X,X
  C201  # Voltage default                          =    5.000  V
  C301  # Current default                          =    0.000 mA
  C401  # RCoil default                            =    0.000 kR
  C501  # TStable default                         =    0.000  s
  C124 Device coil suppression                     = Network #0
  C510 Settling time                               =  500.000 us
  C211 Saturate voltage                            =    4.000  V
  C511 Saturate time                               =  100.000 ms
  C310 Current to apply                            =  100.000 mA
  C701 Operate segment mode                        = Keep drive and exit
  C222  Operate ramp start voltage                 =    0.500  V
  C223  Operate ramp step voltage                  =    0.005  V
  C224  Operate Min must operate      [   /225]    =    2.000  V
  C225  Operate Max must operate      [224/   ]    =    5.000  V
  C226  Operate Min must release      [   /211]    =    0.000  V
  C227  Operate Max must release      [   /211]    =    3.750  V
  C228  Operate Max unstable region   [   /211]    =    1.500  V
  C702 Release segment mode                        = Skip segment
  C242  Release ramp start voltage                 =    5.000  V
  C243  Release ramp step voltage                  =    0.050  V
  C244  Release Min must release      [   /245]    =    0.000  V
  C245  Release Max must release      [244/211]    =    3.000  V
  C246  Release Min must operate      [   /211]    =    0.500  V
  C247  Release Max must operate      [   /211]    =    4.000  V
  C248  Release Max unstable region   [   /211]    =    1.500  V
RESULT SUMMARY Op:   3.435  V, Rel:   0.000  V
TOTALS THIS STEP 100%% Batch[P:1,T:1,F:0] Seq[P:1,T:1,F:0]
RESULT LIST
  R1   Test status                                 = Test OK
  R110 Opr: just operated             [224/225]    =    3.435  V
  R111 Opr: just released             [226/227]    =    2.865  V
  R112 Opr: unstable region           [   /228]    =    0.570  V
DATALOG True [Always]
PRINT   True [Always]
HANDLER BIN Fail:1, Pass:0
JUMP    False [Never] to <End> ELSE <Continue>
--------------------------------------------------------------------------------
3 [P] Measure CRNO                     MaxCRNO:  0.0222  R
CONDITION LIST
  C121 Device coil format                          = VI Changes only
  C101 Device contact format                       = 2PCO   (Sets 1,2)
  C102 Contacts to test                            = C,C,X,X,X,X,X,X
  C201  # Voltage default                          =    0.000  V
  C301  # Current default                          =    0.000 mA
  C402  # RContact default                         =   0.0000  R
  C401  # RCoil default                            =    0.000 kR
  C501  # TStable default                         =    0.000  s
  C124 Device coil suppression                     = Network #0
  C103 Contact side to measure                     = Normally open
  C212 VClamp                                      =   50 mV
  C104 Contact load                                = CA0 (as gen and clamp)
  C210 Voltage to apply          =    2.748  V [MeasureVOperate.R110 * 0.8]
  C310 Current to apply                            =  100.000 mA
  C510 Settling time                               =  100.000 ms
  C410 CR Measurement range                        = 1R
  C411 CR measurement precision                    = 1 (best stability)
  C412 Min RContact pass limit        [   /413]    =   0.0000  R
  C413 Max RContact pass limit        [412/   ]    =   0.1000  R
RESULT SUMMARY MaxCRNO:  0.0222  R
```

```
TOTALS THIS STEP 100%% Batch[P:1,T:1,F:0] Seq[P:1,T:1,F:0]
RESULT LIST
  R1   Test status                                = Test OK
  R499 CR: Max this test              [412/413]   =   0.0222  R
  R491 CR: Contact #1                 [412/413]   =   0.0219  R
  R492 CR: Contact #2                 [412/413]   =   0.0222  R
DATALOG True [Always]
PRINT   True [Always]
HANDLER BIN Fail:1, Pass:0
JUMP    False [Never] to <End> ELSE <Continue>
--------------------------------------------------------------------------------
4 [P] Measure VRelease                 Op:   0.000  V, Rel:   0.995  V
CONDITION LIST
  C121 Device coil format                       = As monostable A+
  C101 Device contact format                    = 2PCO   (Sets 1,2)
  C102 Contacts to test                         = C,C,X,X,X,X,X,X
  C201  # Voltage default                       =    5.000  V
  C301  # Current default                       =    0.000 mA
  C401  # RCoil default                        =    0.000 kR
  C501  # TStable default                      =    0.000  s
  C124 Device coil suppression                  = Network #0
  C510 Settling time                            =  500.000 us
  C211 Saturate voltage                         =    5.000  V
  C511 Saturate time                            =  100.000 ms
  C310 Current to apply                         =  100.000 mA
  C701 Operate segment mode                     = Skip segment
  C222  Operate ramp start voltage              =    0.500  V
  C223  Operate ramp step voltage               =    0.050  V
  C224  Operate Min must operate      [   /225]   =    2.000  V
  C225  Operate Max must operate      [224/   ]   =    5.000  V
  C226  Operate Min must release      [   /211]   =    0.000  V
  C227  Operate Max must release      [   /211]   =    3.750  V
  C228  Operate Max unstable region   [   /211]   =    1.500  V
  C702 Release segment mode                     = Keep drive and exit
  C242  Release ramp start voltage              =    5.000  V
  C243  Release ramp step voltage               =    0.005  V
  C244  Release Min must release      [   /245]   =    0.000  V
  C245  Release Max must release      [244/211]   =    3.000  V
  C246  Release Min must operate      [   /211]   =    0.500  V
  C247  Release Max must operate      [   /211]   =    5.000  V
  C248  Release Max unstable region   [   /211]   =    1.500  V
RESULT SUMMARY Op:   0.000  V, Rel:   0.995  V
TOTALS THIS STEP 100%% Batch[P:1,T:1,F:0] Seq[P:1,T:1,F:0]
RESULT LIST
  R1   Test status                                = Test OK
  R114 Rel: just released             [244/245]   =    0.995  V
  R115 Rel: just operated             [246/247]   =    1.015  V
  R116 Rel: unstable region           [   /248]   =    0.020  V
DATALOG True [Always]
PRINT   True [Always]
HANDLER BIN Fail:1, Pass:0
JUMP    False [Never] to <End> ELSE <Continue>
--------------------------------------------------------------------------------
5 [P] Measure CRNC                     MaxCRNC:  0.0254  R
CONDITION LIST
  C121 Device coil format                       = VI Changes only
  C101 Device contact format                    = 2PCO   (Sets 1,2)
  C102 Contacts to test                         = C,C,X,X,X,X,X,X
  C201  # Voltage default                       =    0.000  V
  C301  # Current default                       =    0.000 mA
  C402  # RContact default                      =   0.0000  R
  C401  # RCoil default                        =    0.000 kR
  C501  # TStable default                      =    0.000  s
  C124 Device coil suppression                  = Network #0
  C103 Contact side to measure                  = Normally closed
  C212 VClamp                                   =   50 mV
  C104 Contact load                             = CA0 (as gen and clamp)
  C210 Voltage to apply          =    1.791  V [MeasureVRelease.R114 * 1.2]
```

```
  C310 Current to apply                          =  100.000 mA
  C510 Settling time                             =   15.000 ms
  C410 CR Measurement range                      = 1R
  C411 CR measurement precision                  = 1 (best stability)
  C412 Min RContact pass limit        [   /413]  =   0.0000  R
  C413 Max RContact pass limit        [412/   ]  =   0.1000  R
RESULT SUMMARY MaxCRNC:  0.0254  R
TOTALS THIS STEP 100%% Batch[P:1,T:1,F:0] Seq[P:1,T:1,F:0]
RESULT LIST
  R1   Test status                               = Test OK
  R499 CR: Max this test              [412/413]  =   0.0254  R
  R491 CR: Contact #1                 [412/413]  =   0.0254  R
  R492 CR: Contact #2                 [412/413]  =   0.0248  R
DATALOG True [Always]
PRINT   True [Always]
HANDLER BIN Fail:1, Pass:0
JUMP    False [Never] to <End> ELSE <Continue>
```