Introduction to PG & LA

Digital Circuit Lab

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Outline

- Programmable Data Generator
- Logic Analyzer
- Complete the RSA System

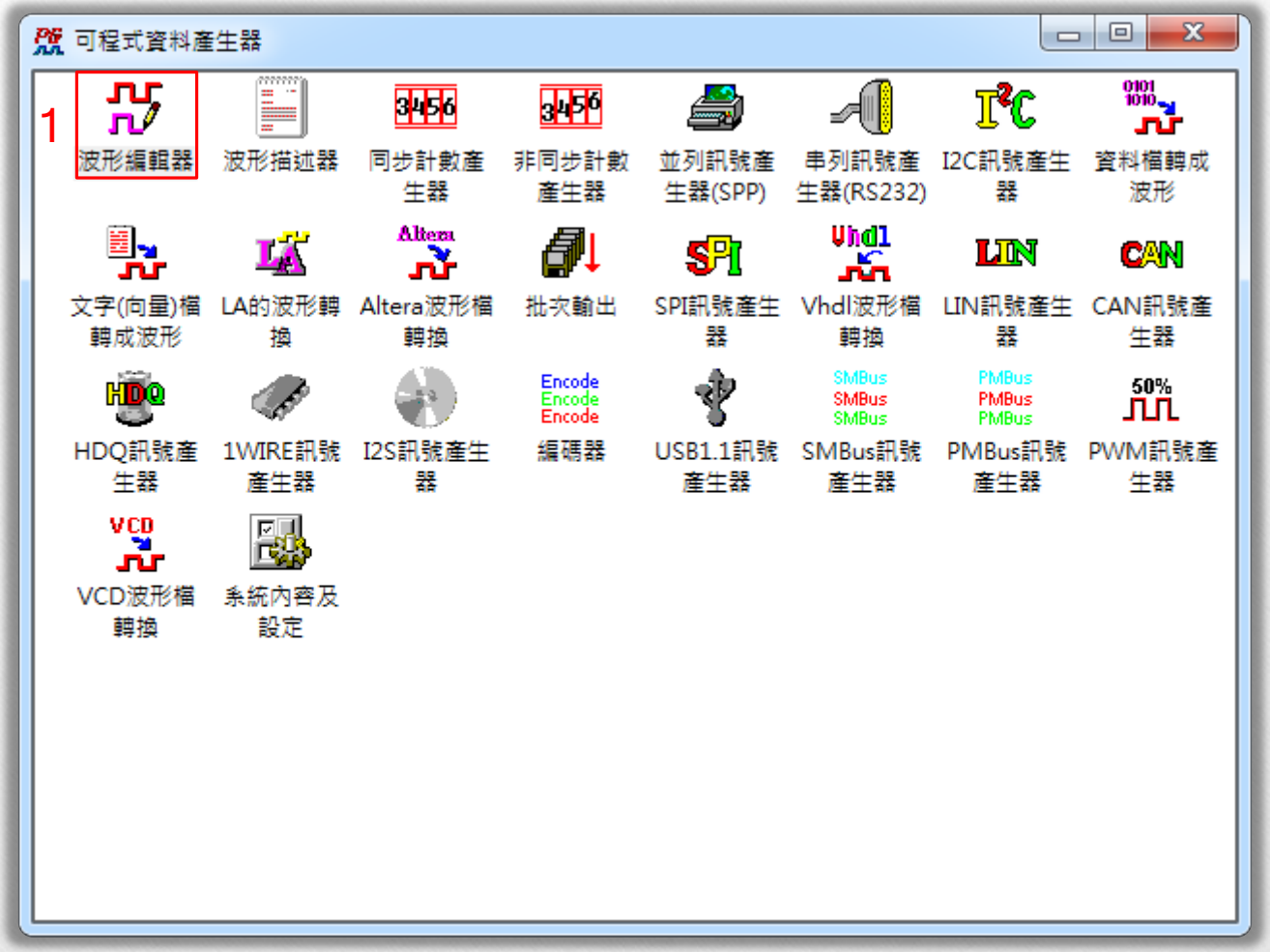
Programmable Data Generator

Introduction to PG

- Programmable data generator (PG in brief) is powerful of generating several kinds of digital waveforms.
- Combining logic analyzer (LA) and PG will make an auto testing system or auto verification system.

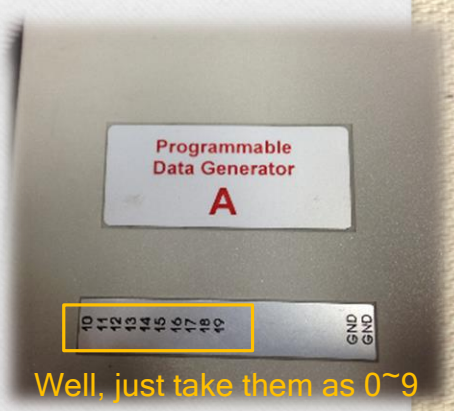
System Properties Setup

Wave Editor


可程式資料產生器
1
波形編輯器
波形描述器
同步計數產生器
非同步計數產生器
並列訊號產生器(SPP)
串列訊號產生器(RS232)
I2C訊號產生器
資料檔轉成波形
文字(向量)檔轉成波形
LA的波形轉換
Altera波形檔轉換
批次輸出
SPI訊號產生器
Vhdl波形檔轉換
LIN訊號產生器
CAN訊號產生器
HDQ訊號產生器
1WIRE訊號產生器
I2S訊號產生器
編碼器
USB1.1訊號產生器
SMBus訊號產生器
PMBus訊號產生器
PWM訊號產生器
VCD波形檔轉換
系統內容及設定

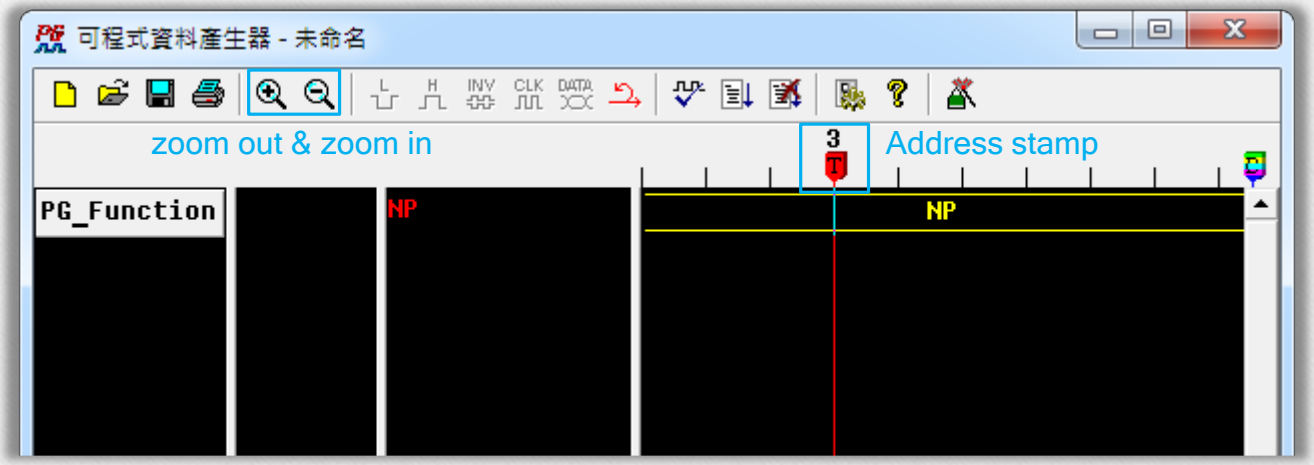
Definitions

- Label (signal name)
  - Labels can be defined as numeric, alphabetic, underscore _, [, or], yet their length **cannot** be over 31 characteristics (bytes).
- Channel (POD order from left to right)
  - Pod A = CH-00 ~ CH-09
  - Pod B = CH-10 ~ CH-19
  - Extended Pod = Event_1, …, Clock_Out

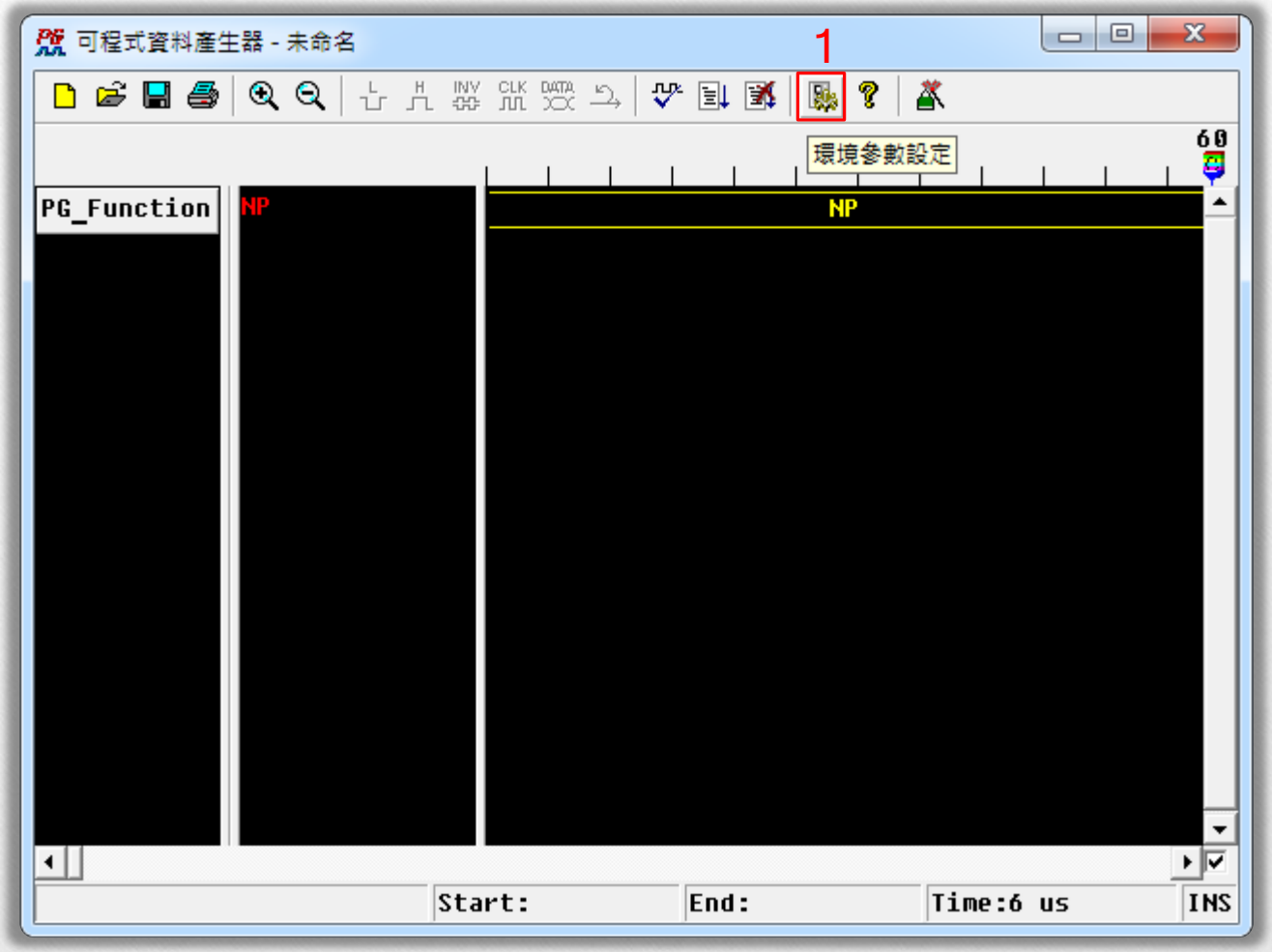


Zoom in & Zoom out

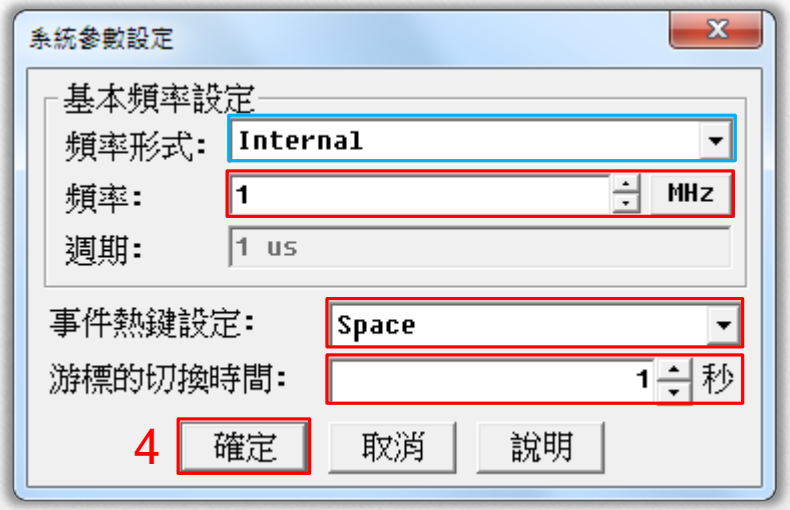
- Note! The base point is the Address Stamp of the waveform field whenever the waveform is either zoomed in or zoomed out.



Set Parameter



PG is positive-edge-triggered.



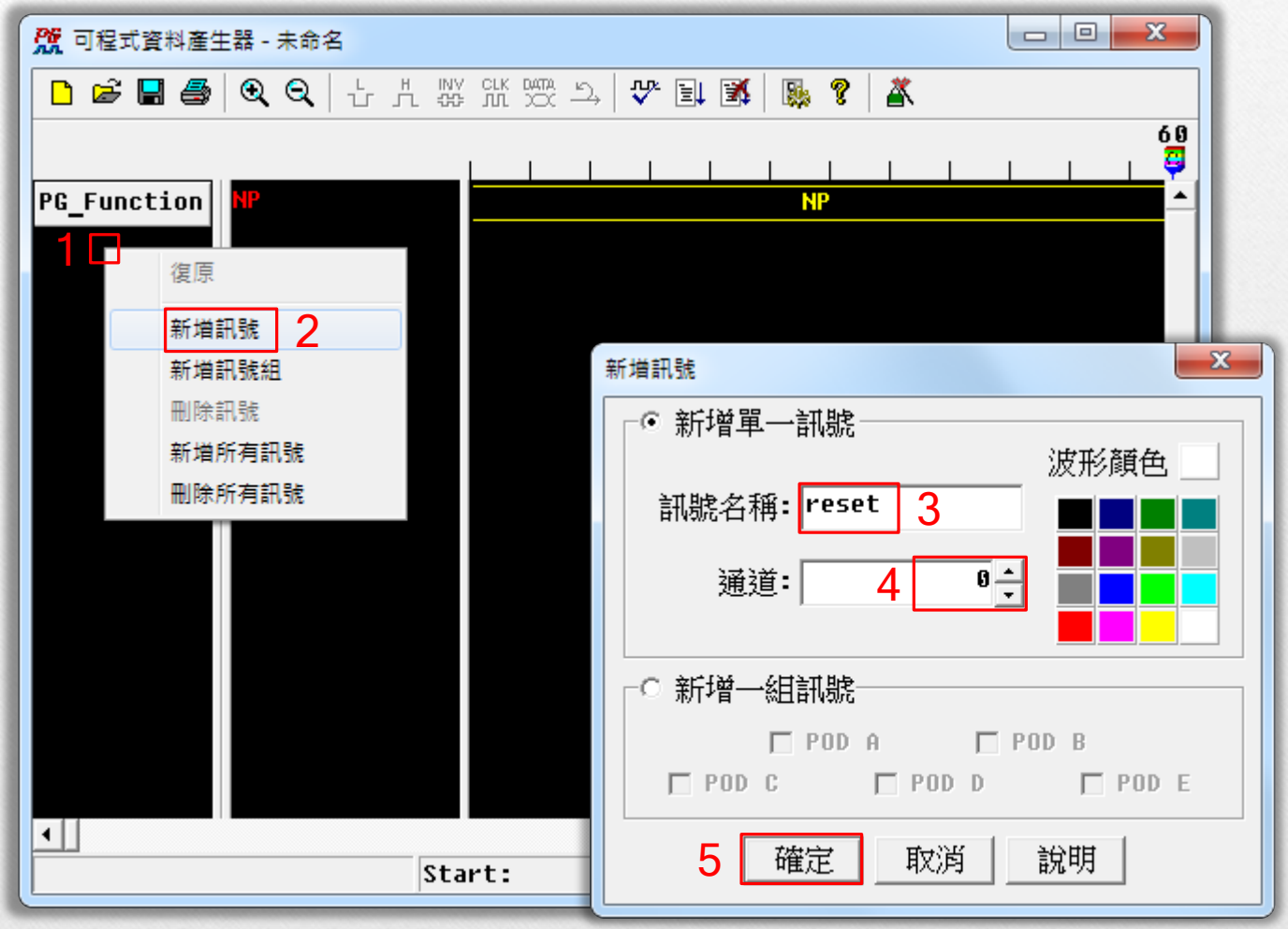
1 (internal clock frequency)

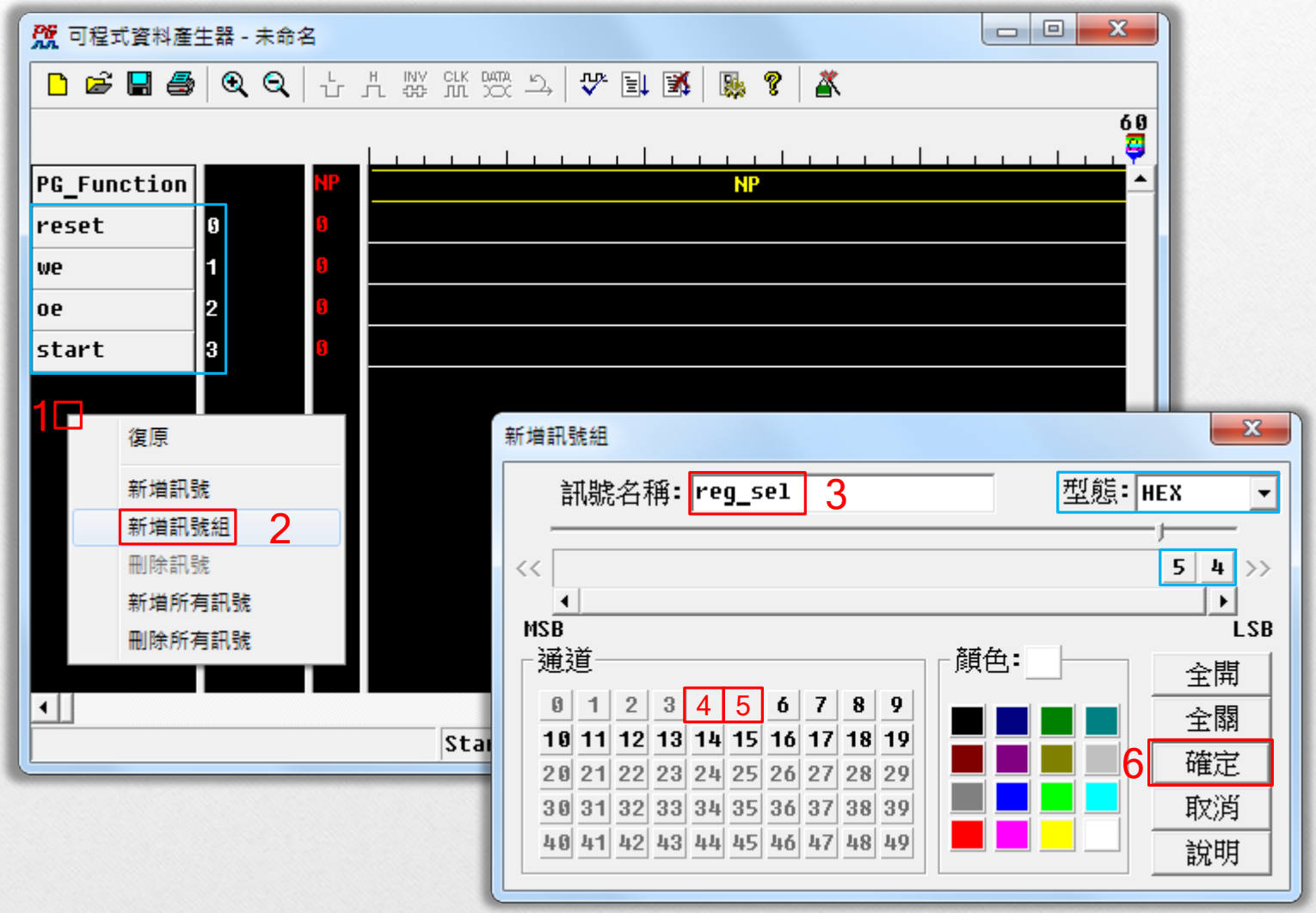
2 (keyboard event)

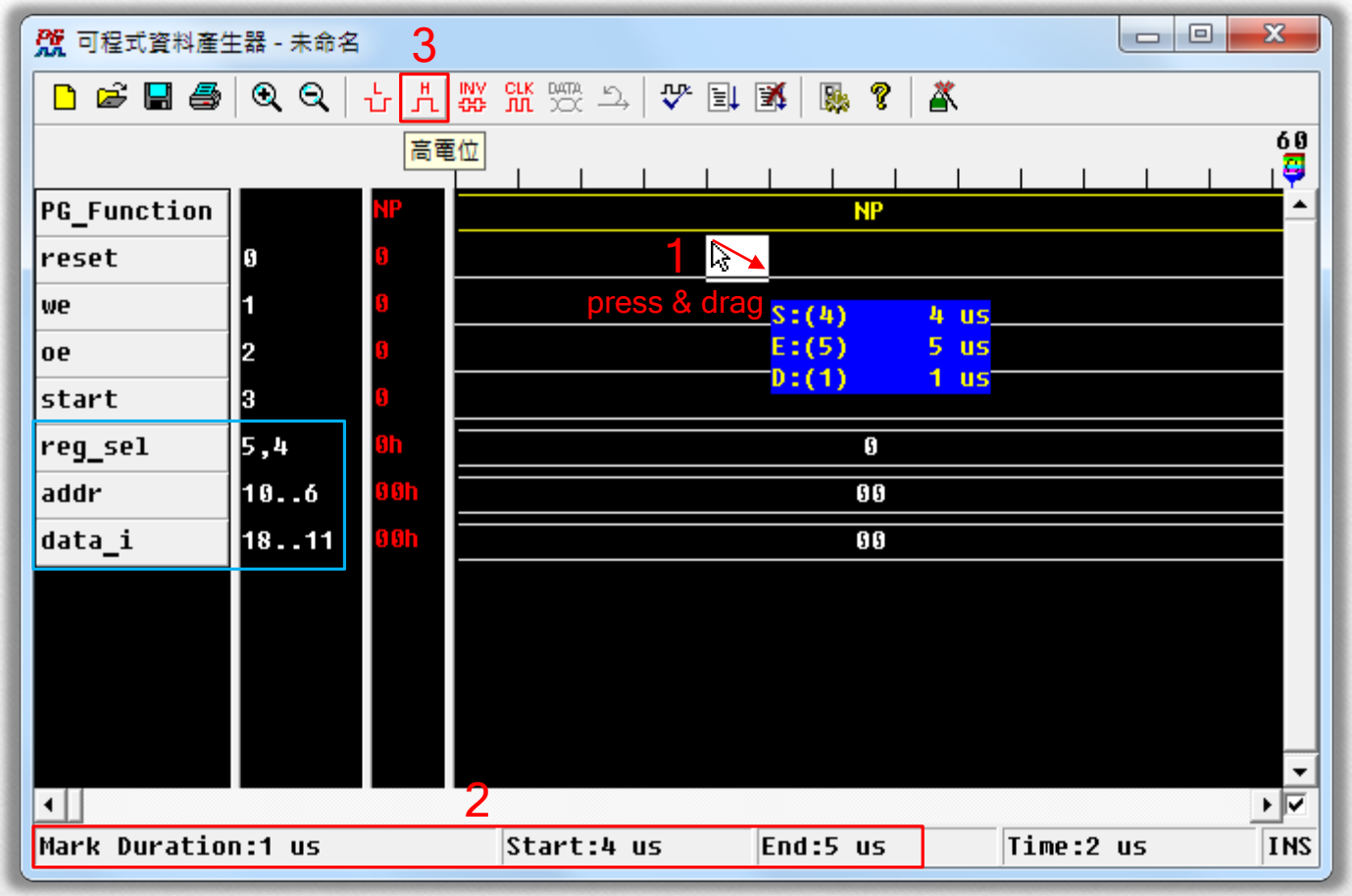
3 (cursor change time gap,
the cursor transformation depends on it)

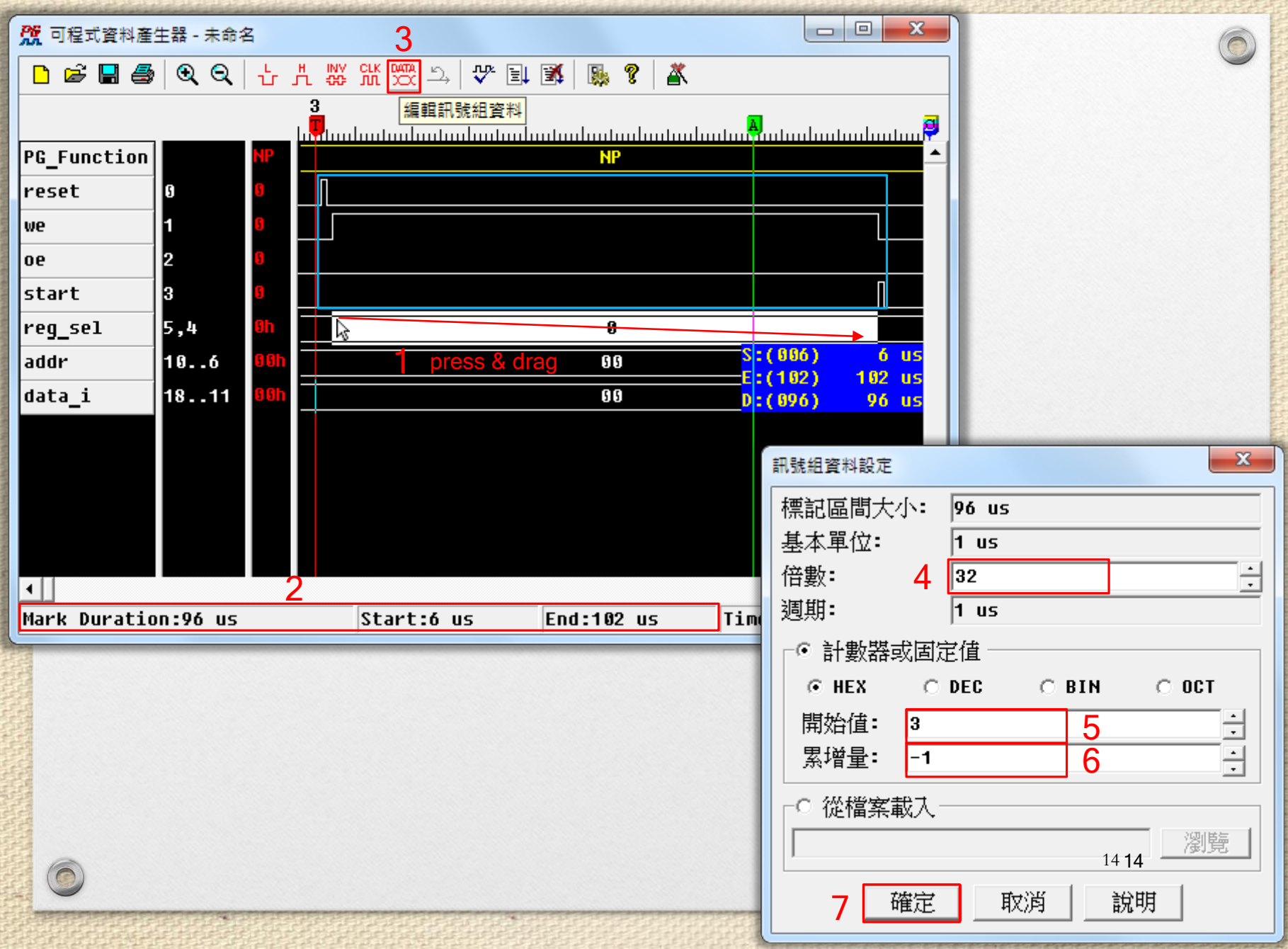
Cursor	Drag mode	When you stop the Drag cursor for a while, it will restore to Point cursor.
	Point mode	You just move Point cursor quickly then the Point Cursor will change to be Drag cursor automatically.

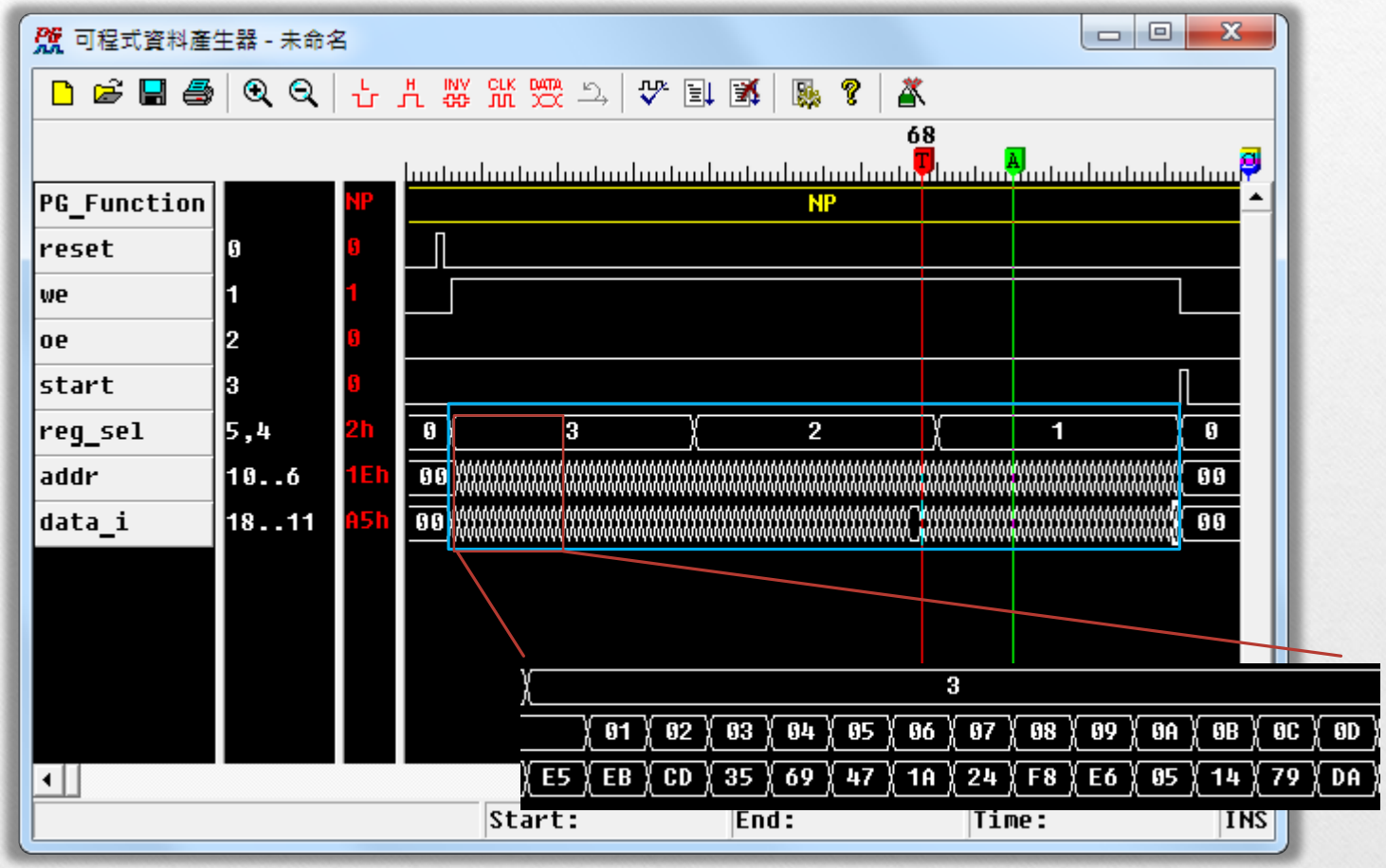
Add Label


可程式資料產生器 - 未命名
PG_Function
NP
NP
60
1
復原
新增訊號
2
新增訊號組
刪除訊號
新增所有訊號
刪除所有訊號
Start:
新增訊號
新增單一訊號
波形顏色
訊號名稱:
reset
3
通道:
4
0
新增一組訊號
POD A
POD B
POD C
POD D
POD E
5
確定
取消
說明


可程式資料產生器 - 未命名
PG_Function
reset
we
oe
start
NP
復原
新增訊號
新增訊號組
刪除訊號
新增所有訊號
刪除所有訊號
1
2
新增訊號組
訊號名稱: reg_sel
3
型態: HEX
MSB
LSB
通道
顏色:
全開
全關
確定
取消
說明
6


可程式資料產生器 - 未命名
3
高電位
60
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
5,4
10..6
18..11
NP
0h
00h
00h
1
press & drag
S:(4) 4 us
E:(5) 5 us
D:(1) 1 us
2
Mark Duration:1 us
Start:4 us
End:5 us
Time:2 us
INS

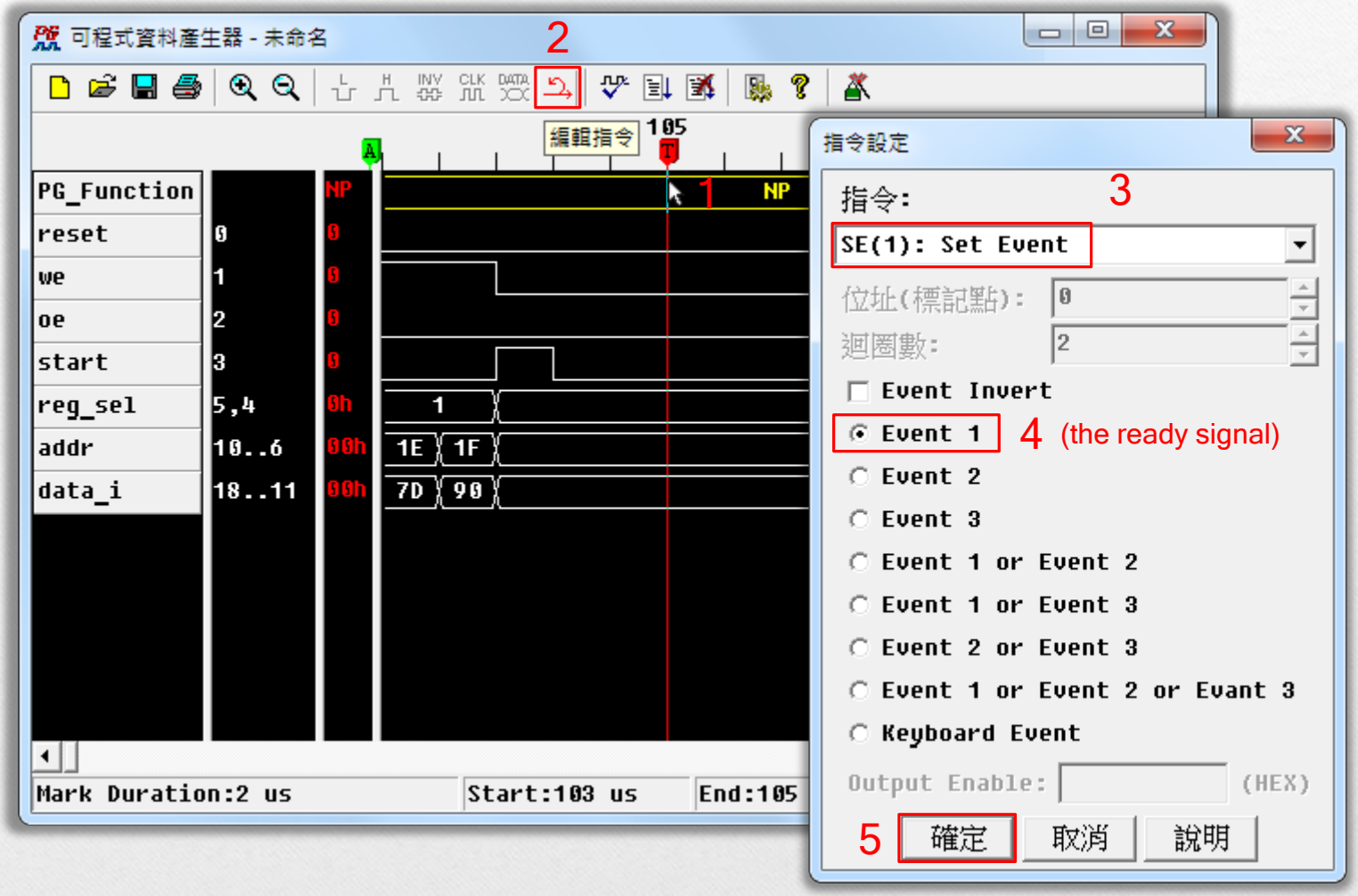

可程式資料產生器 - 未命名
3
編輯訊號組資料
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
NP
press & drag
S:(006) 6 us
E:(102) 102 us
D:(096) 96 us
2
Mark Duration:96 us
Start:6 us
End:102 us
訊號組資料設定
標記區間大小: 96 us
基本單位: 1 us
倍數: 4 32
週期: 1 us
計數器或固定值
HEX DEC BIN OCT
開始值: 3 5
累增量: -1 6
從檔案載入
瀏覽
14 14
7 確定 取消 說明

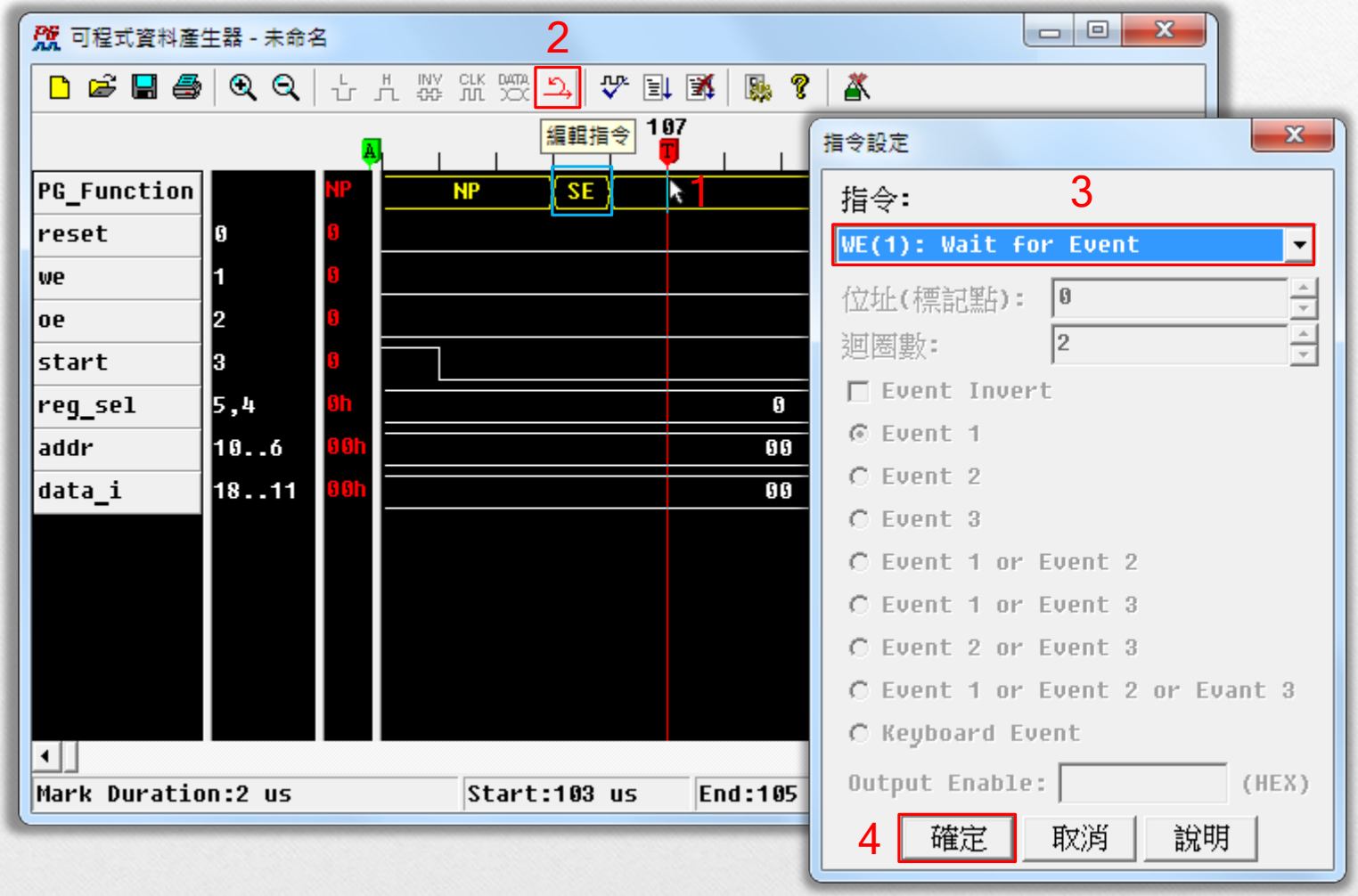

可程式資料產生器 - 未命名
68
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
NP
0
1
2
3
5,4
10..6
18..11
NP
0
1
0
0
2h
1Eh
A5h
0 3 2 1 0
00 00
00 00
3
01 02 03 04 05 06 07 08 09 0A 0B 0C 0D
E5 EB CD 35 69 47 1A 24 F8 E6 05 14 79 DA
Start:
End:
Time:
INS

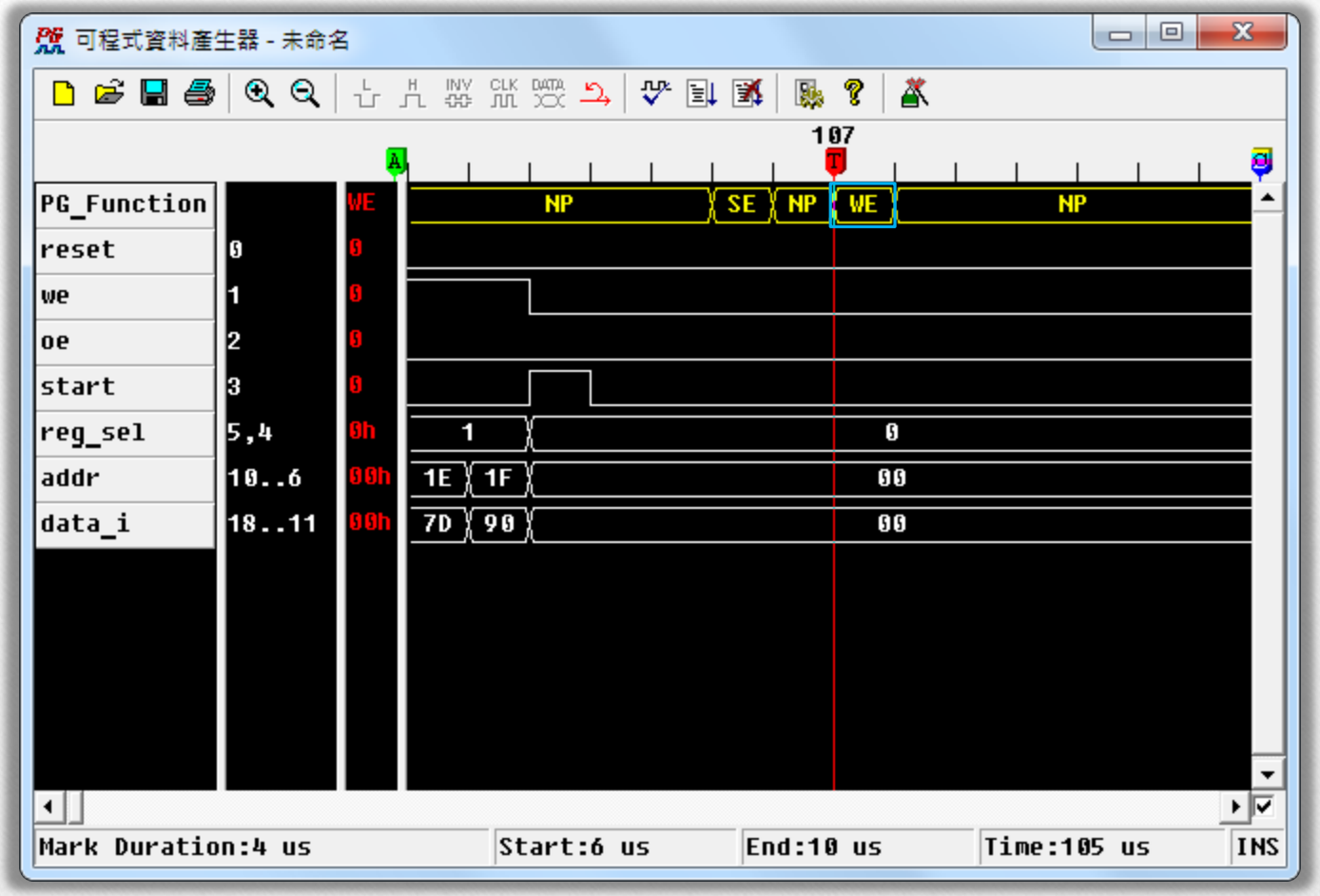
Command Setting

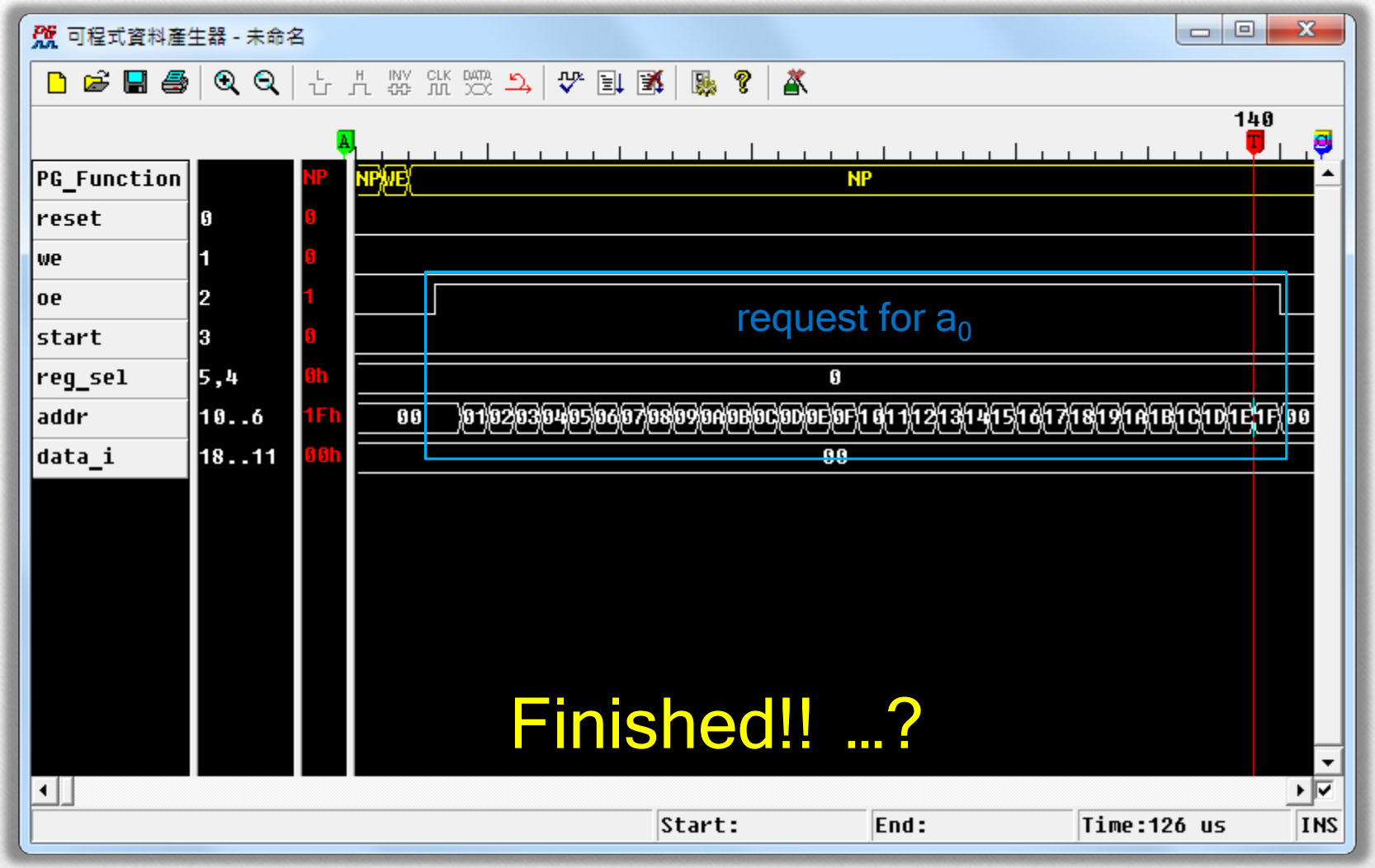
- There is one label named PG_Function in waveform field cannot be deleted. You may set PG_Function command to control the waveform output flow.

Name	Intruction	Description
NP	No Operation	No action
SE	Set Event	Set Event to be a trigger
WE	Wait Event	Stop for waiting Event received
…	…	…


可程式資料產生器 - 未命名
2
編輯指令
105
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
NP
1
1E
1F
7D
90
Mark Duration:2 us
Start:103 us
End:105
指令設定
指令:
3
SE(1): Set Event
位址(標記點):
迴圈數:
Event Invert
Event 1
4
(the ready signal)
Event 2
Event 3
Event 1 or Event 2
Event 1 or Event 3
Event 2 or Event 3
Event 1 or Event 2 or Evant 3
Keyboard Event
Output Enable:
(HEX)
5
確定
取消
說明

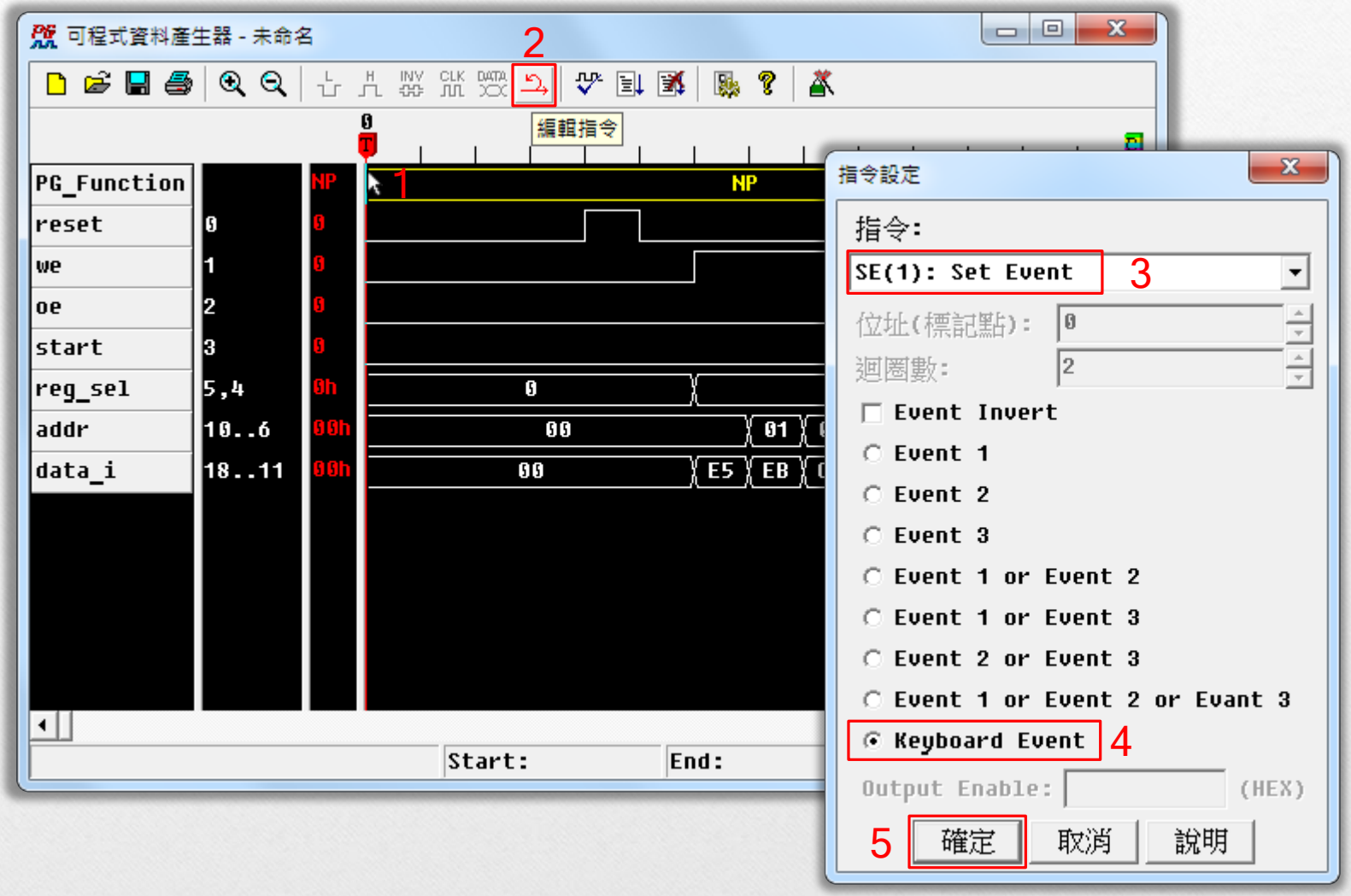

可程式資料產生器 - 未命名
2
編輯指令
107
A
T
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
NP
SE
1
Mark Duration:2 us
Start:103 us
End:105
指令設定
指令:
3
WE(1): Wait For Event
位址(標記點):
迴圈數:
Event Invert
Event 1
Event 2
Event 3
Event 1 or Event 2
Event 1 or Event 3
Event 2 or Event 3
Event 1 or Event 2 or Evant 3
Keyboard Event
Output Enable:
(HEX)
4
確定
取消
說明

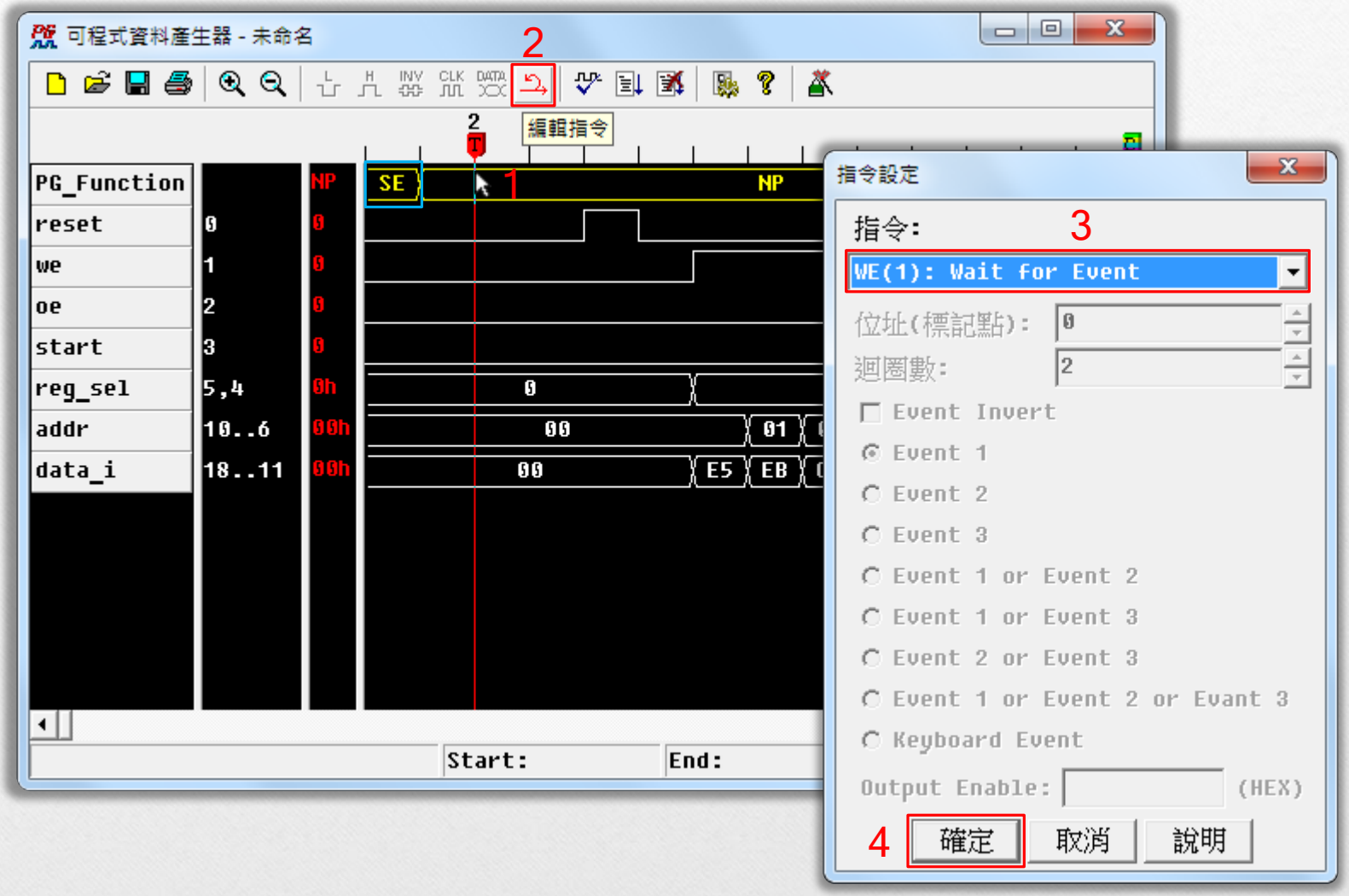

可程式資料產生器 - 未命名
107
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
5,4
10..6
18..11
WE
0h
00h
NP
SE
NP
WE
NP
1
0
1E
1F
00
7D
90
00
Mark Duration:4 us
Start:6 us
End:10 us
Time:105 us
INS

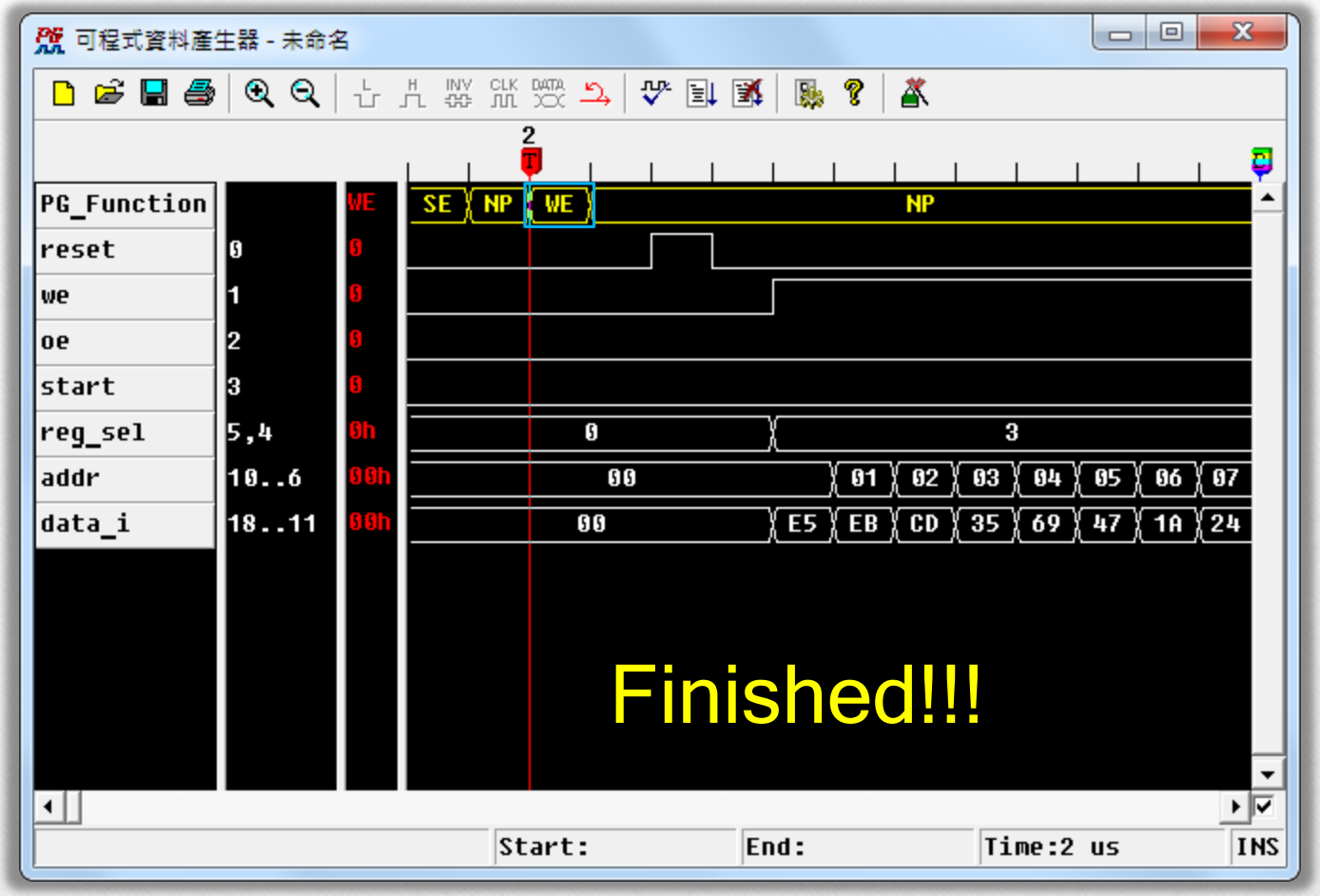

可程式資料產生器 - 未命名
140
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
5,4
10..6
18..11
NP
0h
1Fh
00h
request for a_0
Finished!! ...?
Start:
End:
Time:126 us
INS

Before Running

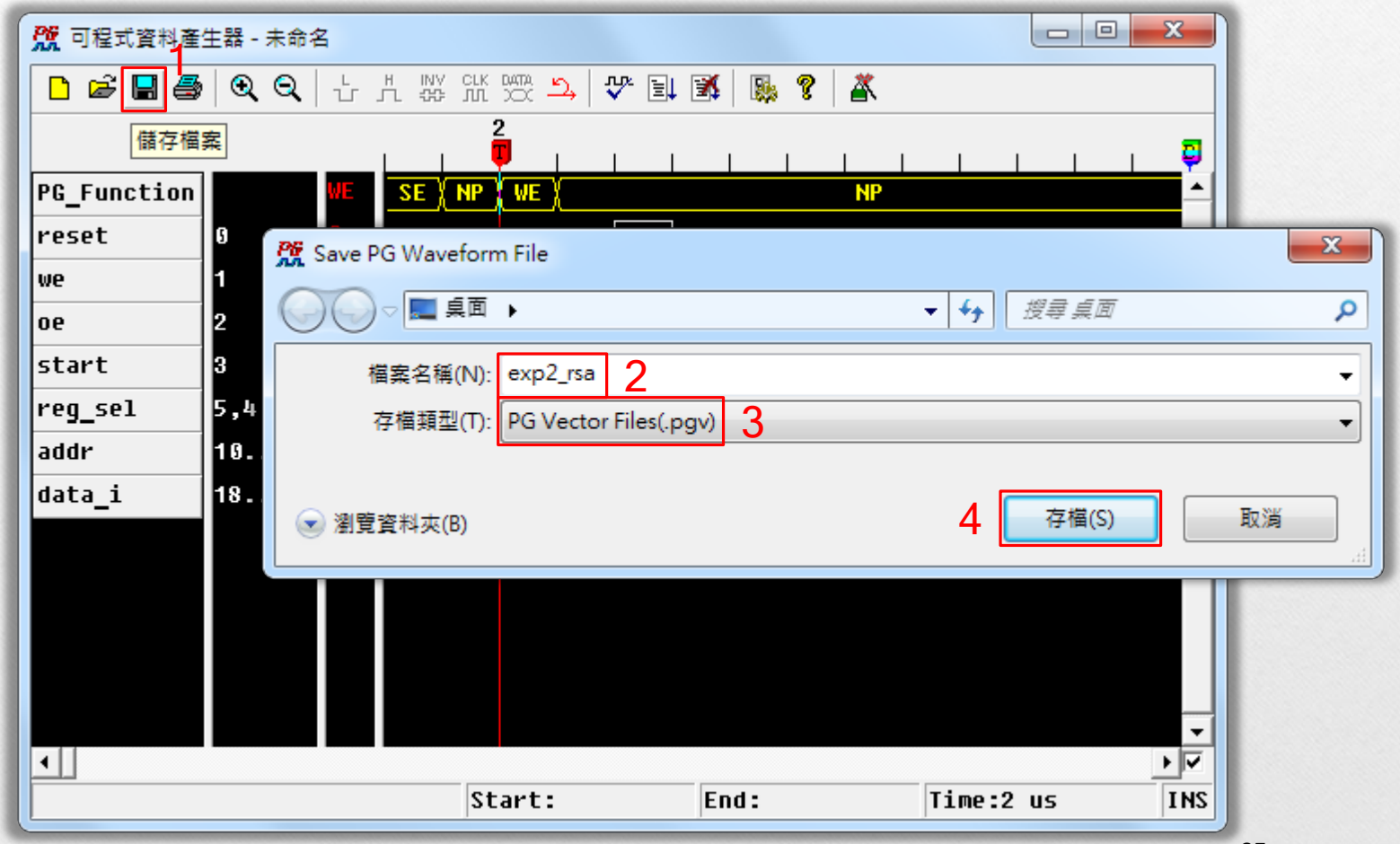
- After finished waveform check and reported no errors, you may click Run button to output these data.
  - PC will take 0.5~1 second to transform these data into PG through USB port.
  - The tip of running PG is to insert Set Keyboard Event and Wait Event command in the empty front area of waveform field.


可程式資料產生器 - 未命名
2
編輯指令
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
NP
1
0
1
2
3
5,4
10..6
18..11
0h
00h
00h
00
01
00
E5
EB
Start:
End:
指令設定
指令:
SE(1): Set Event
3
位址(標記點):
迴圈數:
Event Invert
Event 1
Event 2
Event 3
Event 1 or Event 2
Event 1 or Event 3
Event 2 or Event 3
Event 1 or Event 2 or Evant 3
Keyboard Event
4
Output Enable:
(HEX)
5
確定
取消
說明

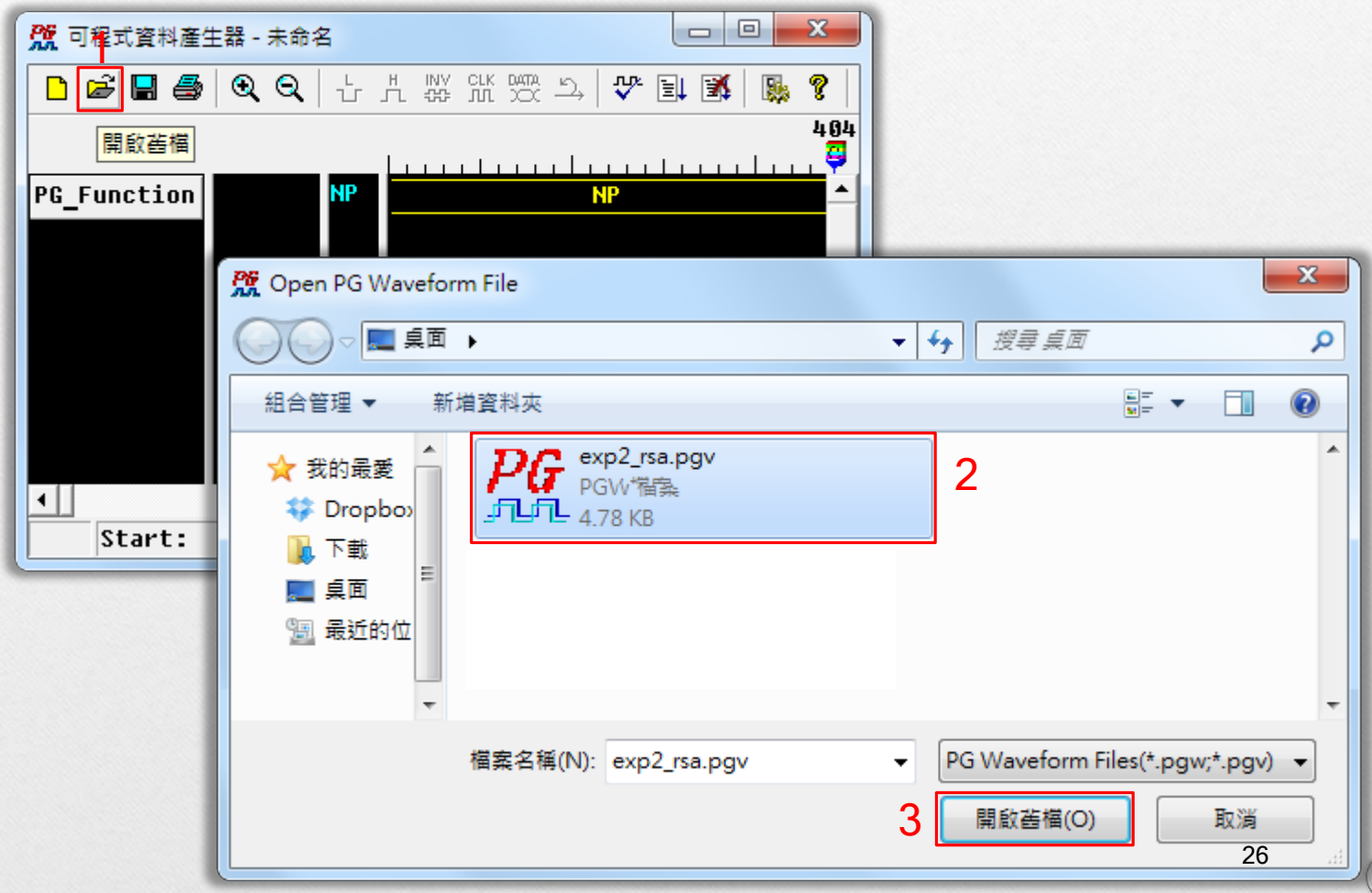

可程式資料產生器 - 未命名
2
編輯指令
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
SE
NP
1
Start:
End:
指令設定
指令:
3
WE(1): Wait for Event
位址(標記點):
迴圈數:
Event Invert
Event 1
Event 2
Event 3
Event 1 or Event 2
Event 1 or Event 3
Event 2 or Event 3
Event 1 or Event 2 or Evant 3
Keyboard Event
Output Enable:
(HEX)
4
確定
取消
說明

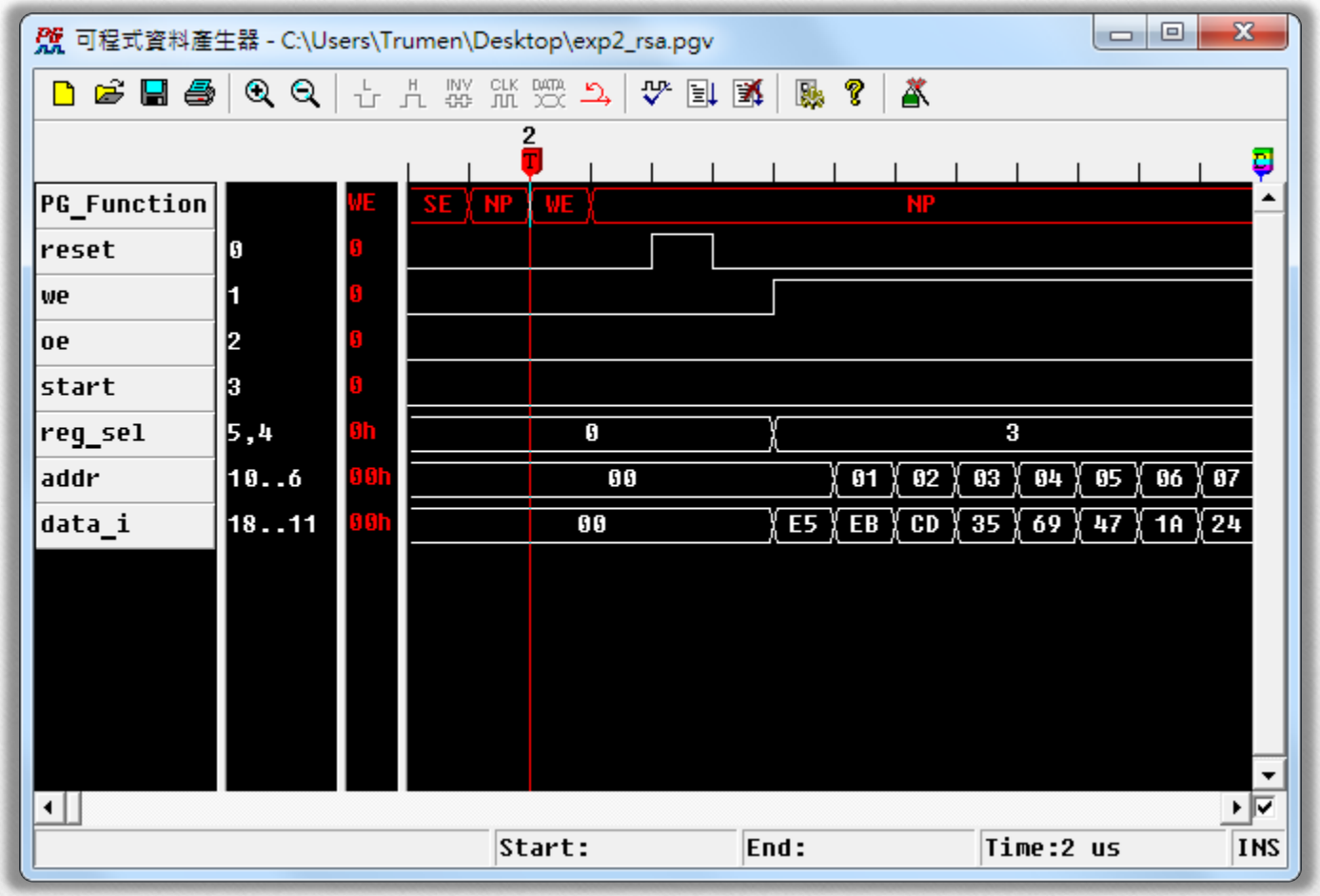

可程式資料產生器 - 未命名
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
5,4
10..6
18..11
WE
0h
00h
SE
NP
WE
NP
00
01
02
03
04
05
06
07
E5
EB
CD
35
69
47
1A
24
Finished!!!
Start:
End:
Time:2 us
INS

Save PG File


可程式資料產生器 - 未命名
1
儲存檔案
2
PG_Function
reset
we
oe
start
reg_sel
addr
data_i
WE
SE
NP
WE
NP
Save PG Waveform File
桌面
搜尋 桌面
檔案名稱(N): exp2_rsa
2
存檔類型(T): PG Vector Files(.pgv)
3
瀏覽資料夾(B)
4
存檔(S)
取消
Start:
End:
Time:2 us
INS

Load PG File


可程式資料產生器 - 未命名
開啟舊檔
PG_Function
NP
NP
Start:
Open PG Waveform File
桌面
搜尋 桌面
組合管理
新增資料夾
我的最愛
Dropbox
下載
桌面
最近的位
exp2_rsa.pgv
PGW 檔案
4.78 KB
2
檔案名稱(N): exp2_rsa.pgv
PG Waveform Files(*.pgw;*.pgv)
3
開啟舊檔(O)
取消



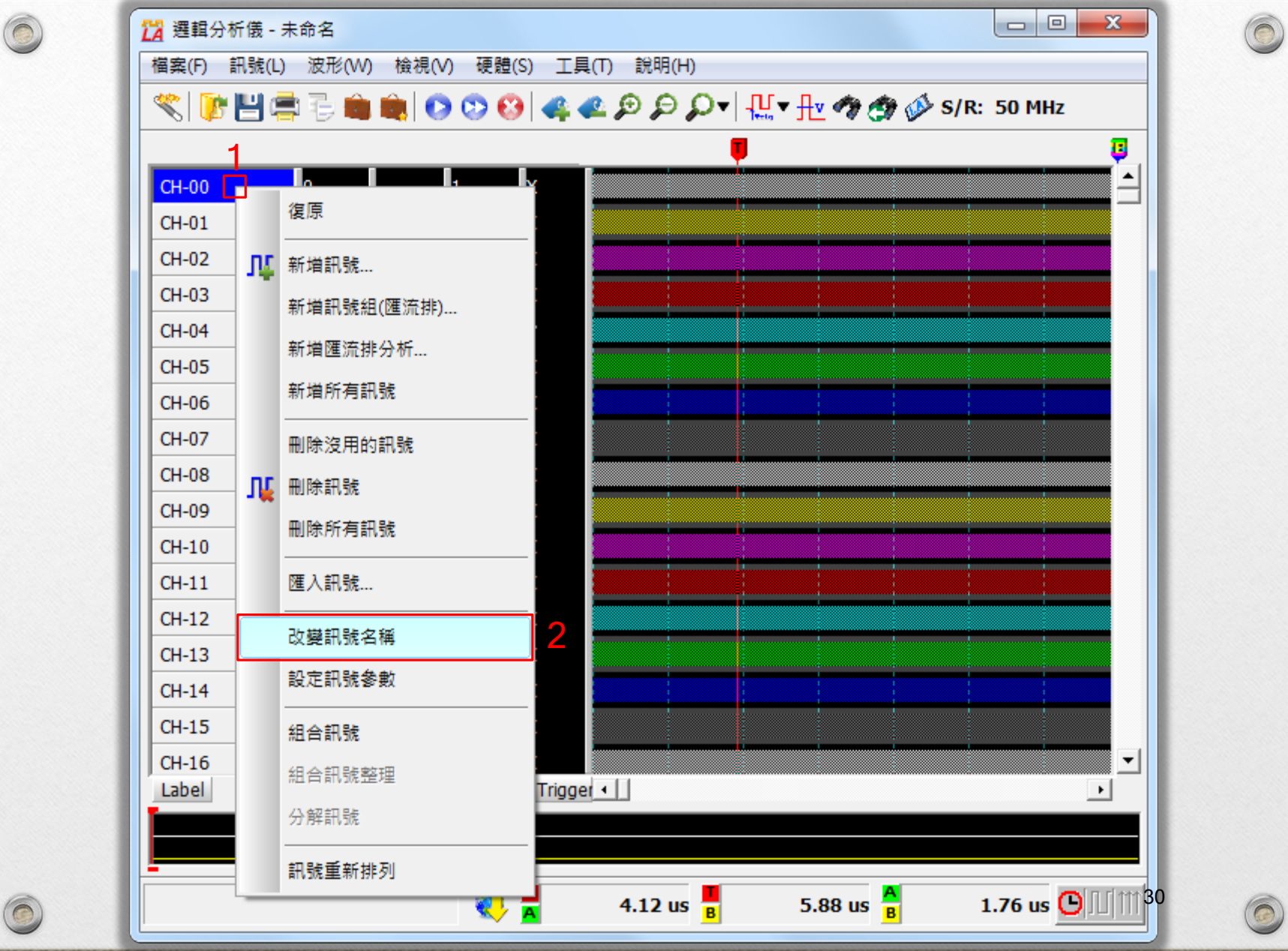
Double click ⇒ Doesn't work!

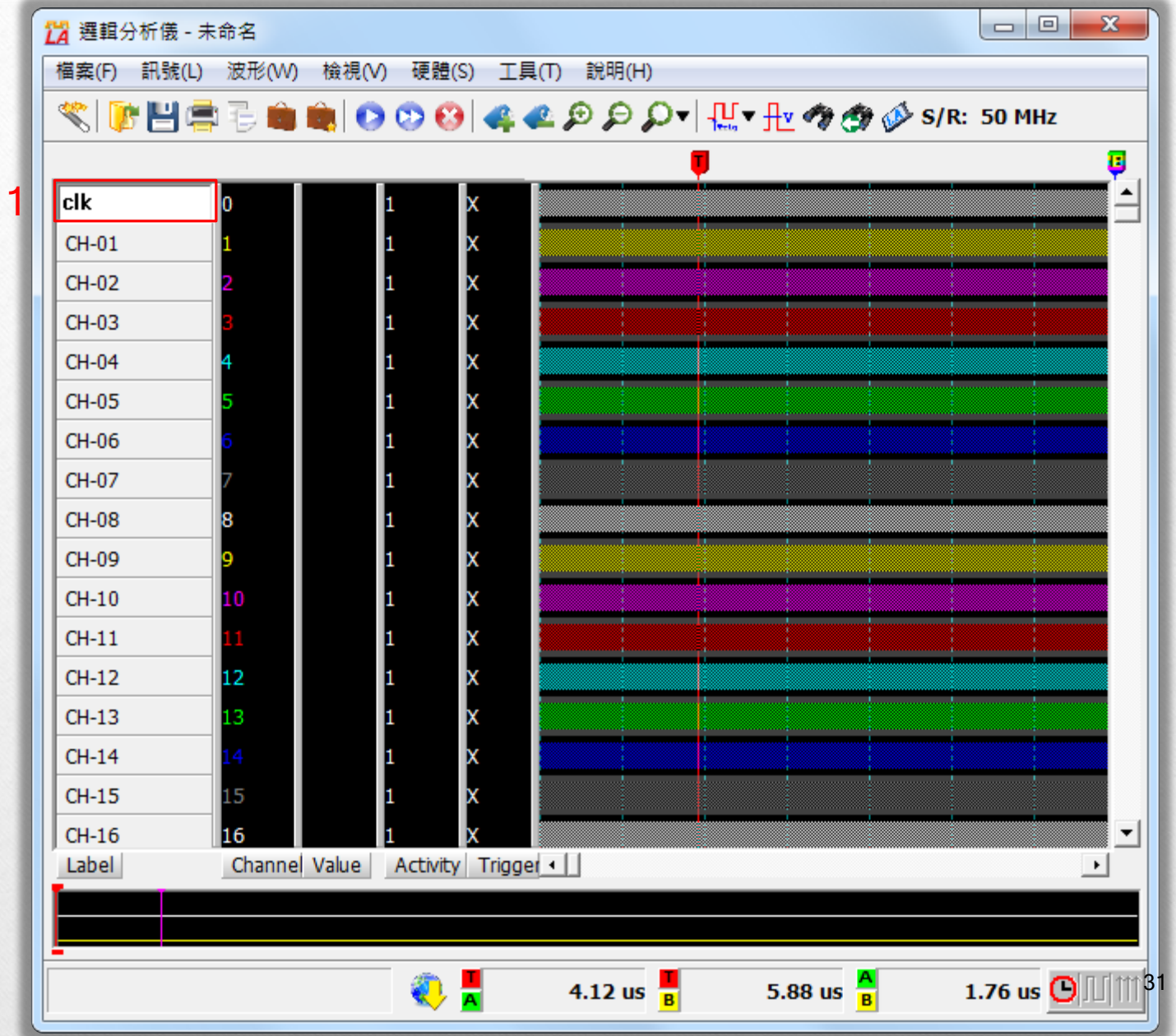
(It only open the PG software but does not load the waveform file. So you have to load it again.)

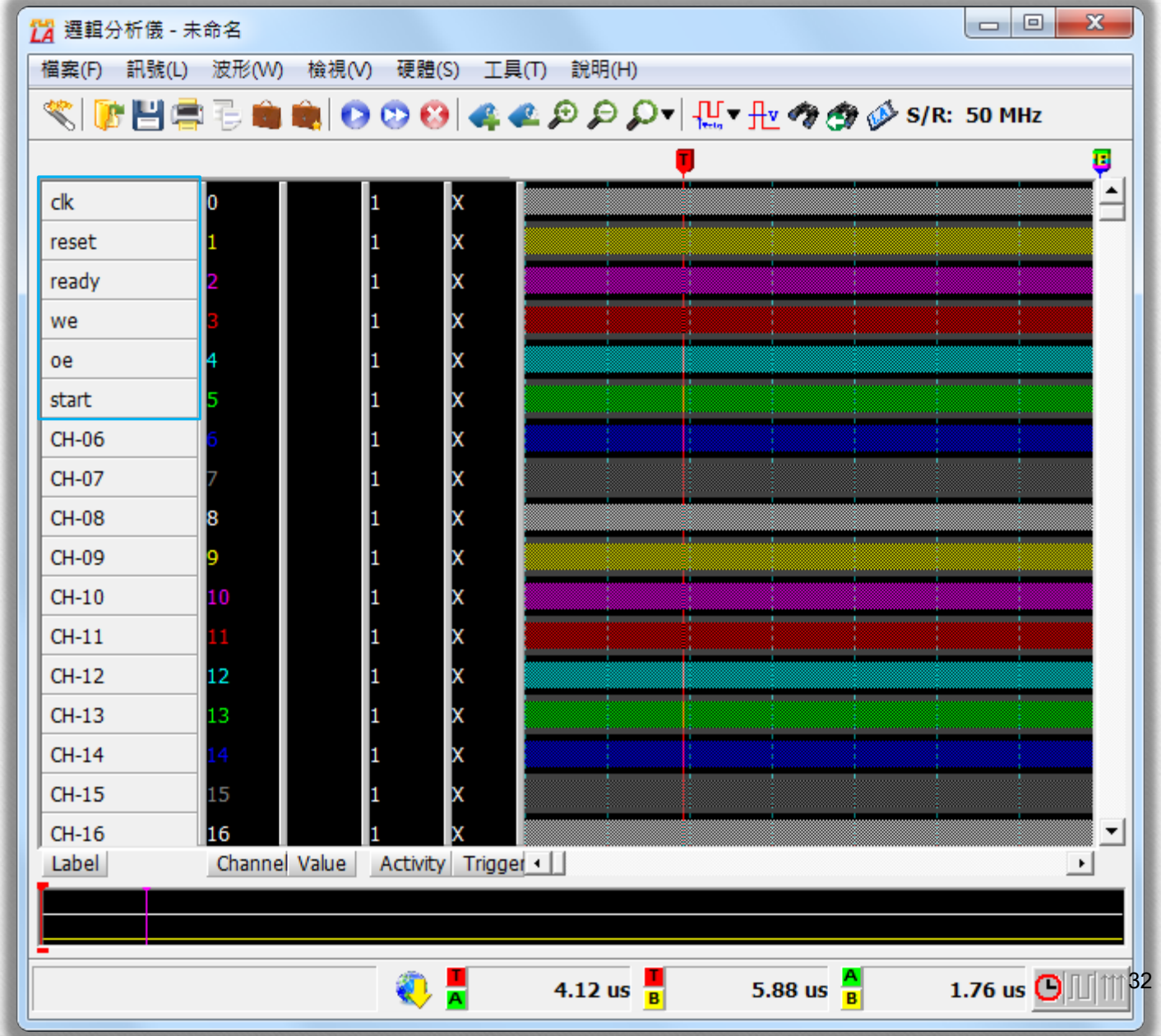
Logic Analyzer

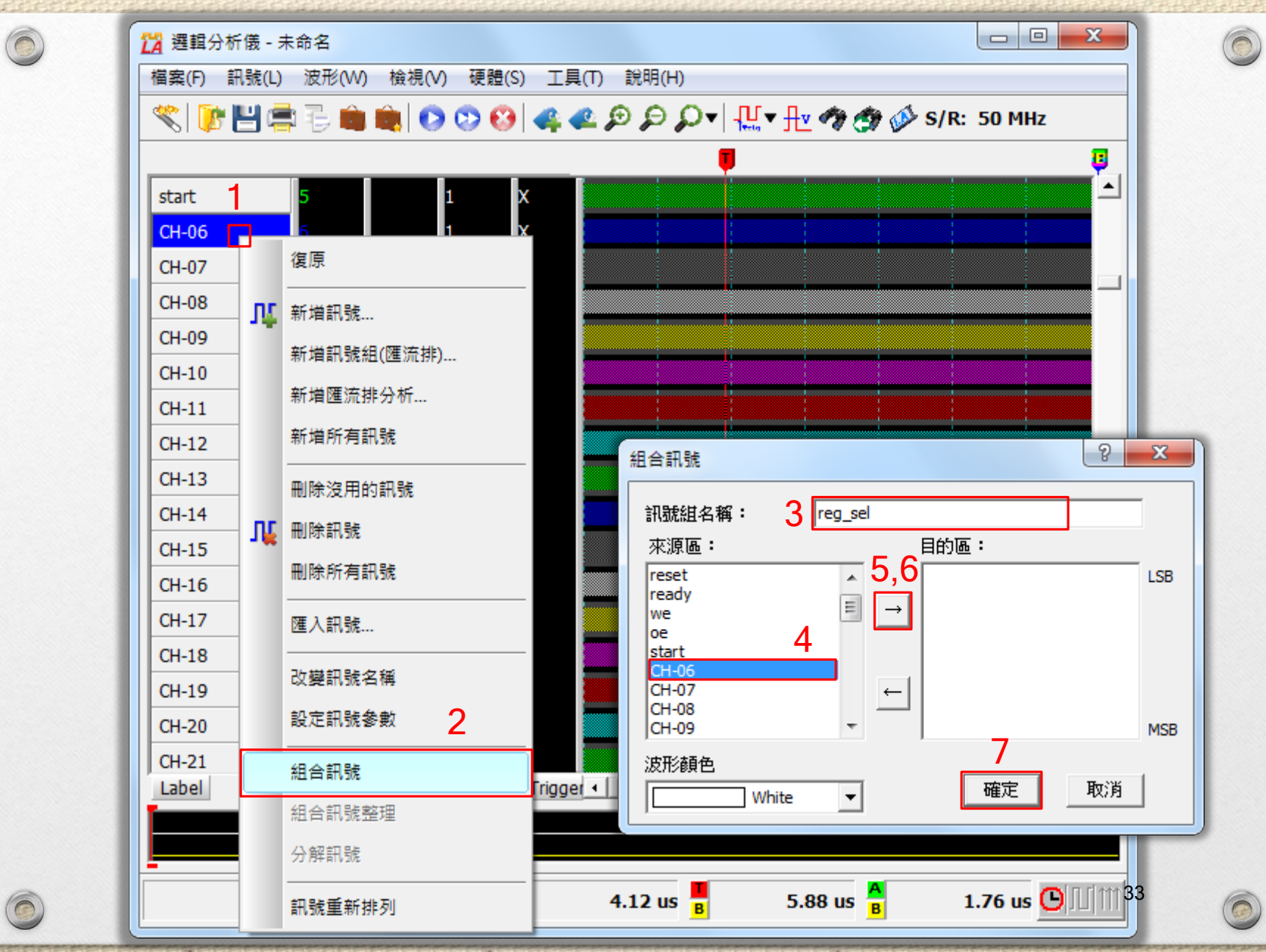
Introduction to LA

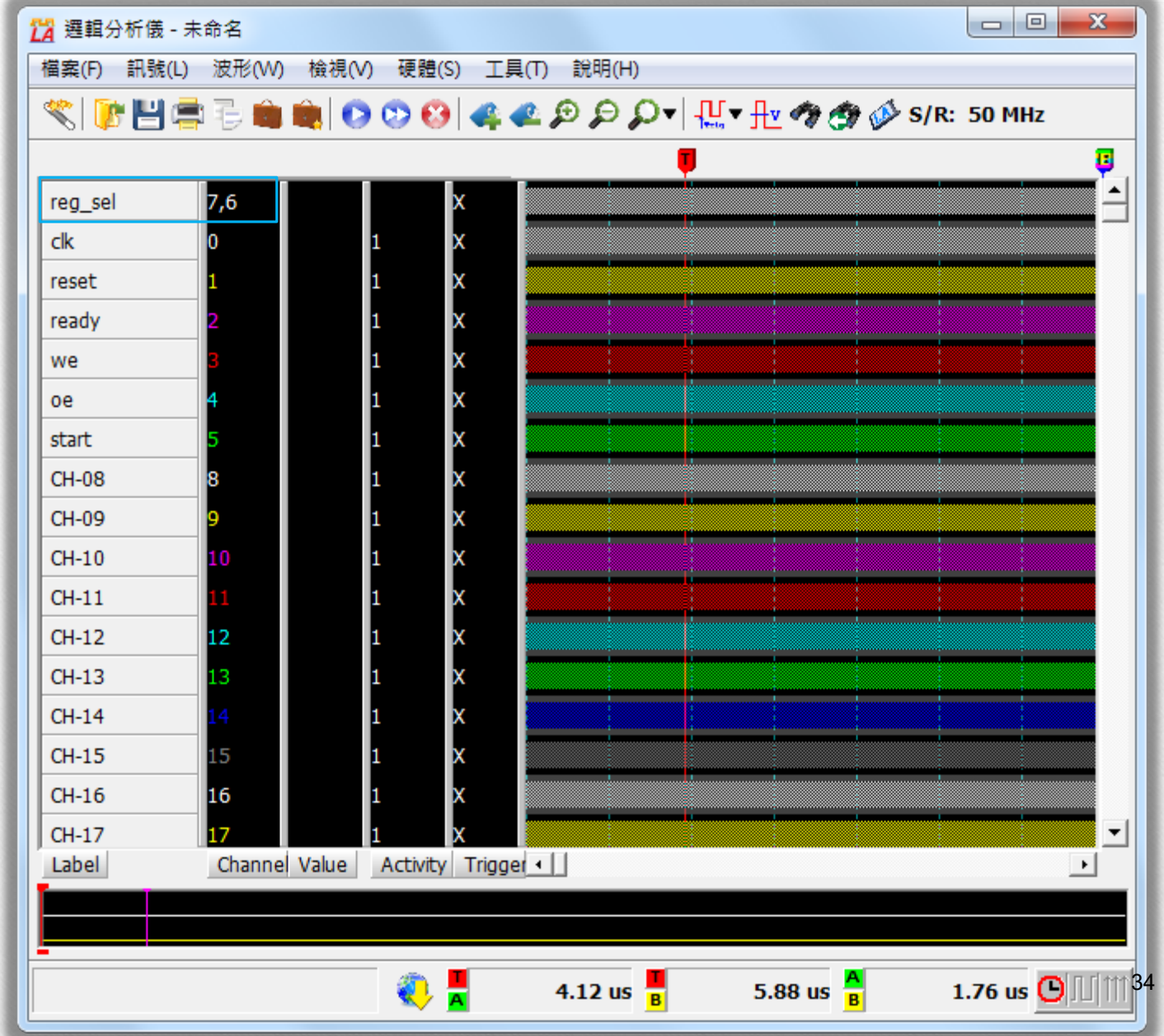
- Logic Analyzer (LA in brief) is used to observe the output signals from other devices.
- TravelLogic series (which are used in our experiments) has 36 channels.

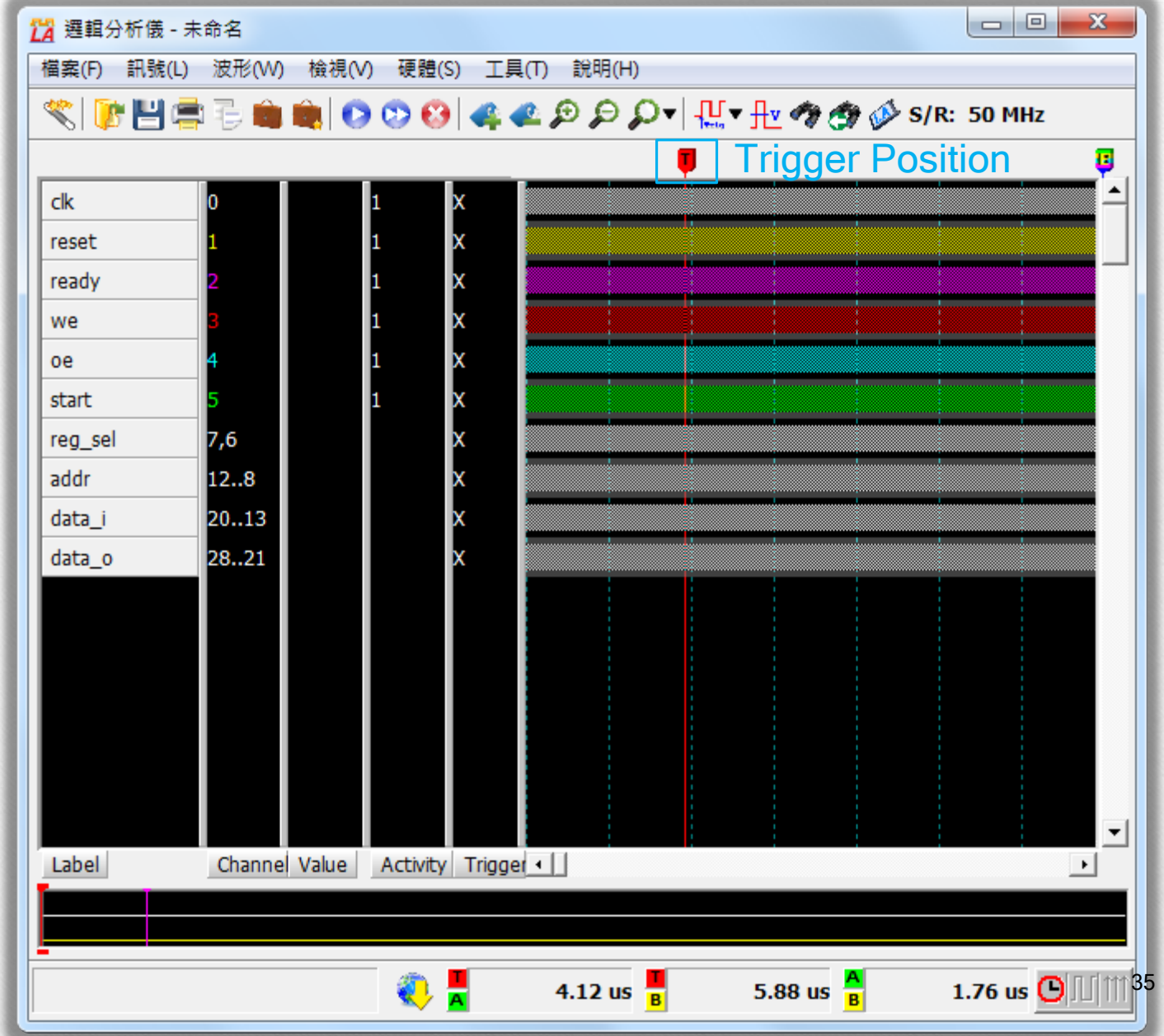

邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
1
CH-00
CH-01
CH-02
CH-03
CH-04
CH-05
CH-06
CH-07
CH-08
CH-09
CH-10
CH-11
CH-12
CH-13
CH-14
CH-15
CH-16
Label
復原
新增訊號...
新增訊號組(匯流排)...
新增匯流排分析...
新增所有訊號
刪除沒用的訊號
刪除訊號
刪除所有訊號
匯入訊號...
改變訊號名稱
2
設定訊號參數
組合訊號
組合訊號整理
分解訊號
訊號重新排列
Trigge
4.12 us
5.88 us
1.76 us

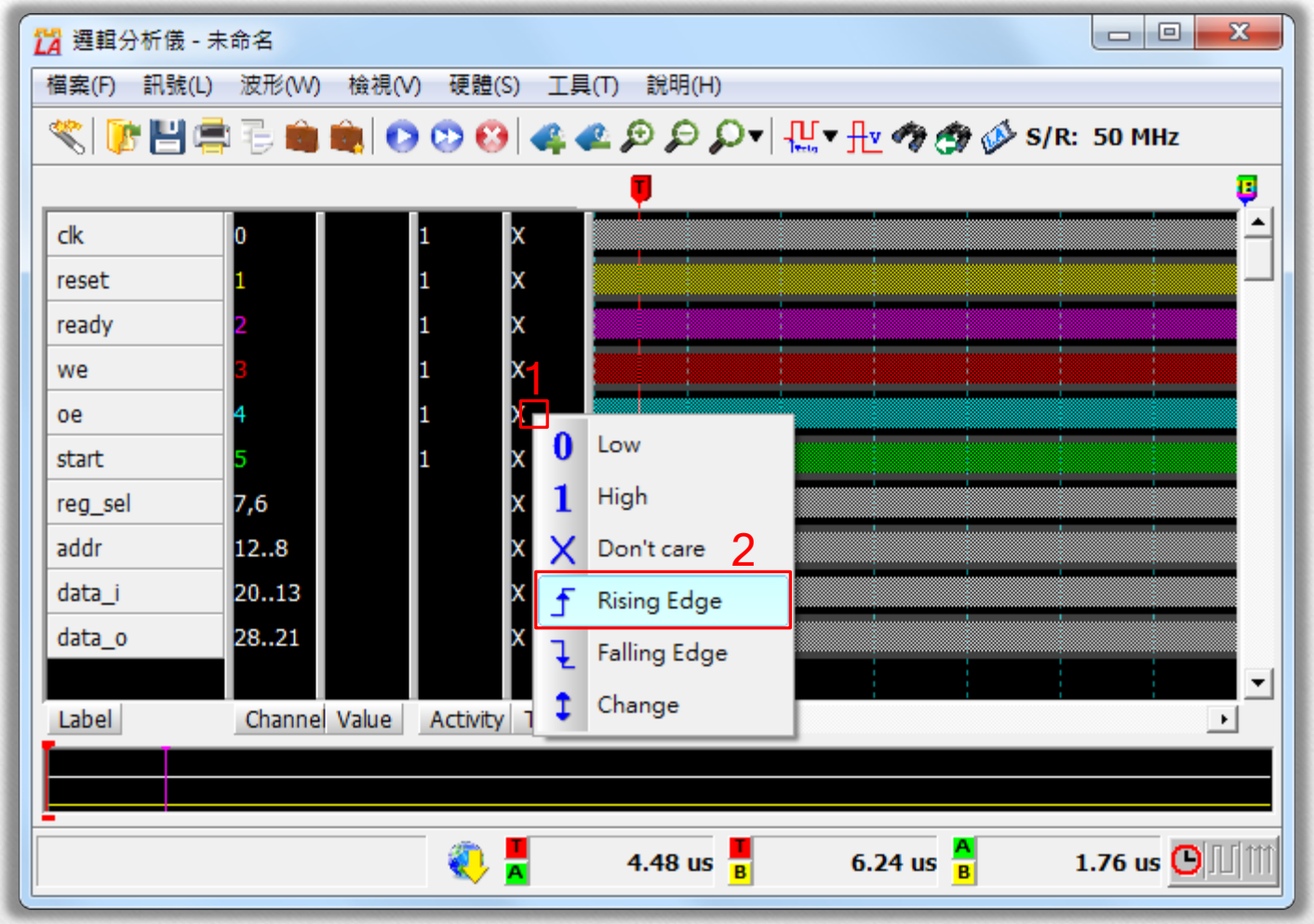

邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
1
clk
CH-01
CH-02
CH-03
CH-04
CH-05
CH-06
CH-07
CH-08
CH-09
CH-10
CH-11
CH-12
CH-13
CH-14
CH-15
CH-16
Label
Channe
Value
Activity
Trigge
4.12 us
5.88 us
1.76 us


邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
clk
reset
ready
we
oe
start
CH-06
CH-07
CH-08
CH-09
CH-10
CH-11
CH-12
CH-13
CH-14
CH-15
CH-16
Label
Channe
Value
Activity
Trigge
4.12 us
5.88 us
1.76 us

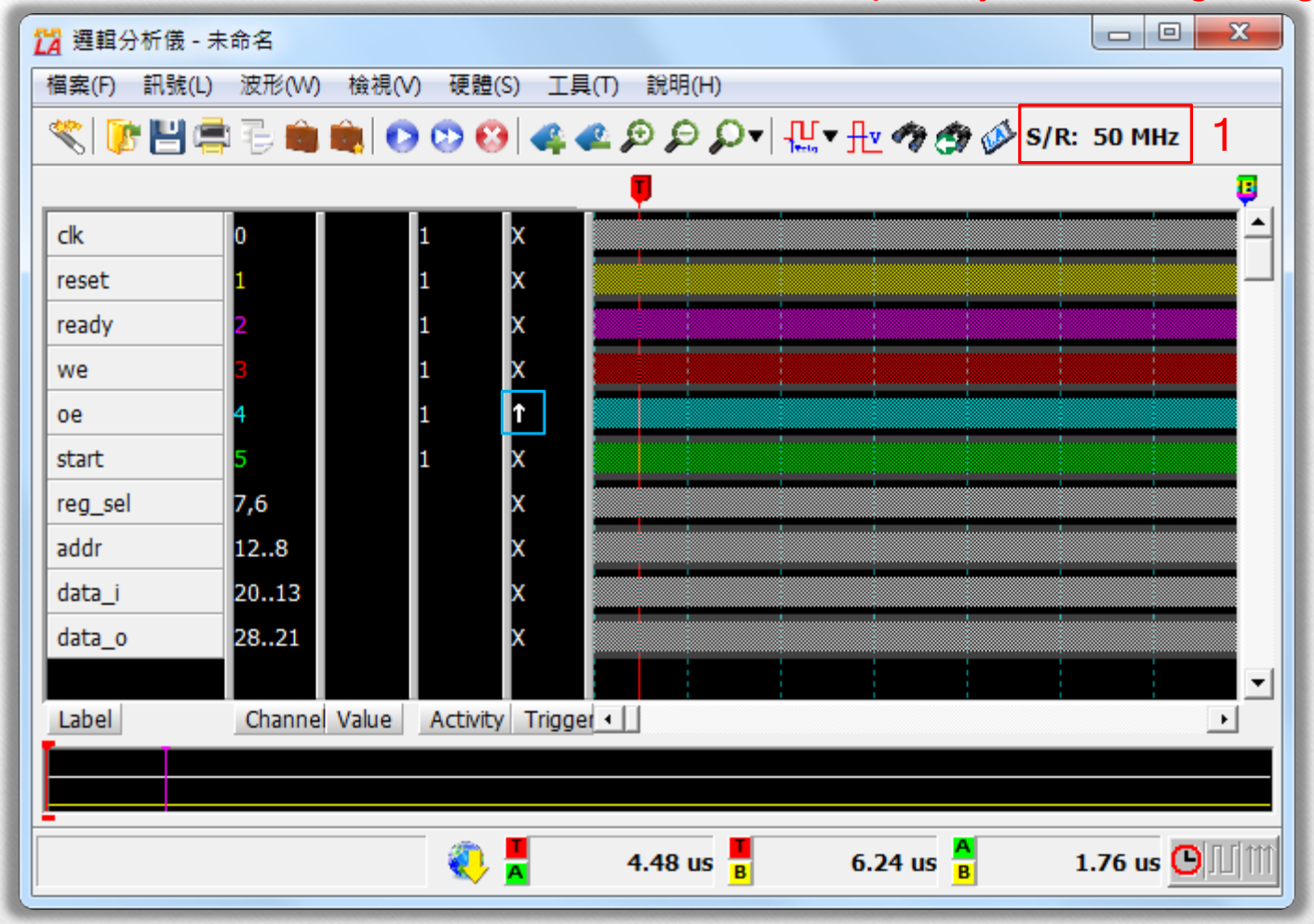

邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
start
CH-06
CH-07
CH-08
CH-09
CH-10
CH-11
CH-12
CH-13
CH-14
CH-15
CH-16
CH-17
CH-18
CH-19
CH-20
CH-21
Label
1
復原
新增訊號...
新增訊號組(匯流排)...
新增匯流排分析...
新增所有訊號
刪除沒用的訊號
刪除訊號
刪除所有訊號
匯入訊號...
改變訊號名稱
設定訊號參數
2
組合訊號
組合訊號整理
分解訊號
訊號重新排列
組合訊號
訊號組名稱：
3
reg_sel
來源區：
目的區：
reset
ready
we
oe
start
4
CH-06
CH-07
CH-08
CH-09
5,6
LSB
MSB
波形顏色
White
7
確定
取消
4.12 us
5.88 us
1.76 us

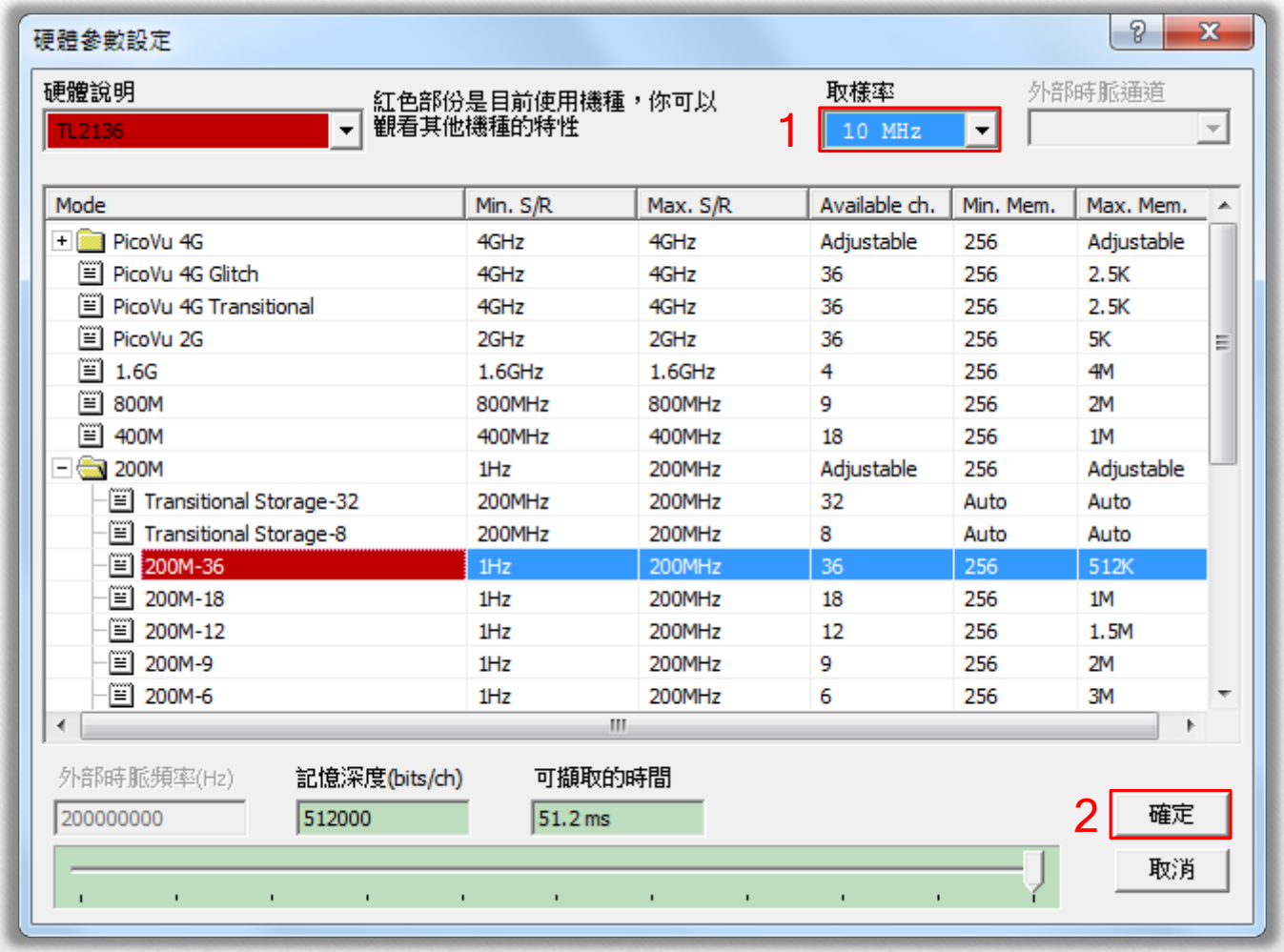

邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
reg_sel 7,6 X
clk 0 1 X
reset 1 1 X
ready 2 1 X
we 3 1 X
oe 4 1 X
start 5 1 X
CH-08 8 1 X
CH-09 9 1 X
CH-10 10 1 X
CH-11 11 1 X
CH-12 12 1 X
CH-13 13 1 X
CH-14 14 1 X
CH-15 15 1 X
CH-16 16 1 X
CH-17 17 1 X
Label
Channe
Value
Activity
Trigge
T A
4.12 us
T B
5.88 us
A B
1.76 us

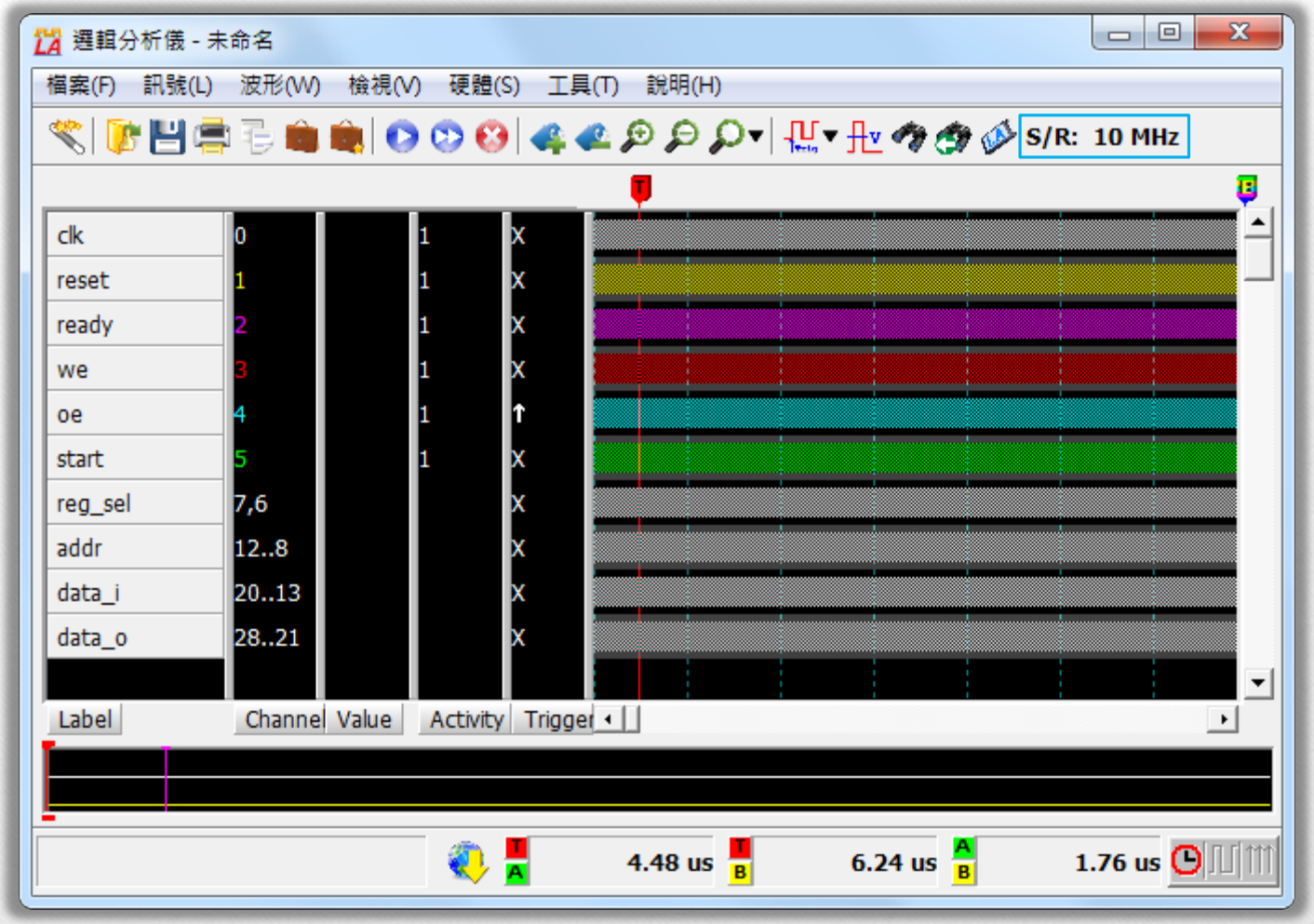

邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
Trigger Position
clk
reset
ready
we
oe
start
reg_sel
addr
data_i
data_o
0
1
2
3
4
5
7,6
12..8
20..13
28..21
Label
Channe
Value
Activity
Trigge
4.12 us
5.88 us
1.76 us


邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 50 MHz
clk
reset
ready
we
oe
start
reg_sel
addr
data_i
data_o
7,6
12..8
20..13
28..21
1
2
Low
High
Don't care
Rising Edge
Falling Edge
Change
Label
Channel
Value
Activity
4.48 us
6.24 us
1.76 us

The sampling rate ideally should be 5-10 times of the frequency of the target signal.




硬體參數設定
硬體說明
TL2136
紅色部份是目前使用機種，你可以觀看其他機種的特性
1
取樣率
10 MHz
外部時脈通道
Mode
Min. S/R
Max. S/R
Available ch.
Min. Mem.
Max. Mem.
PicoVu 4G 4GHz 4GHz Adjustable 256 Adjustable
PicoVu 4G Glitch 4GHz 4GHz 36 256 2.5K
PicoVu 4G Transitional 4GHz 4GHz 36 256 2.5K
PicoVu 2G 2GHz 2GHz 36 256 5K
1.6G 1.6GHz 1.6GHz 4 256 4M
800M 800MHz 800MHz 9 256 2M
400M 400MHz 400MHz 18 256 1M
200M 1Hz 200MHz Adjustable 256 Adjustable
Transitional Storage-32 200MHz 200MHz 32 Auto Auto
Transitional Storage-8 200MHz 200MHz 8 Auto Auto
200M-36 1Hz 200MHz 36 256 512K
200M-18 1Hz 200MHz 18 256 1M
200M-12 1Hz 200MHz 12 256 1.5M
200M-9 1Hz 200MHz 9 256 2M
200M-6 1Hz 200MHz 6 256 3M
外部時脈頻率(Hz)
200000000
記憶深度(bits/ch)
512000
可擷取的時間
51.2 ms
2
確定
取消


邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 10 MHz
clk
reset
ready
we
oe
start
reg_sel
addr
data_i
data_o
Label
Channel
Value
Activity
Trigger
4.48 us
6.24 us
1.76 us

Save LA File


邏輯分析儀 - 未命名
專案管理
檔案(F)
訊號(L)
硬體(S)
工具(T)
說明(H)
1
10 MHz
clk
reset
ready
we
oe
start
reg_sel
addr
data_i
data_o
Label
Channel
Value
Activity
專案管理
專案列表
專案會儲存所有訊號名稱、觸發參數及觸發準位。可用滑鼠右鍵來載入、刪除、更名或是觀看內容。
Default
新增專案
用目前的設定，新增一個專案
專案名稱
exp2_rsa
2
3
新增
4
離開
3.8 us

Load LA File


邏輯分析儀 - 未命名
專案管理
檔案(F)
訊號(L)
硬體(S)
工具(T)
說明(H)
1
10 MHz
CH-00
CH-01
CH-02
CH-03
CH-04
CH-05
CH-06
CH-07
CH-08
CH-09
CH-10
Label
Channel
Value
Activity
專案管理
專案列表
專案會儲存所有訊號名稱、觸發參數及觸發準位。可用滑鼠右鍵來載入、刪除、更名或是觀看內容。
Default
exp2_rsa
2 (double click)
新增專案
專案名稱
離開
Open Project
請進新的專案後，原來的訊號都將會被刪除。
3
確定
取消
76 us

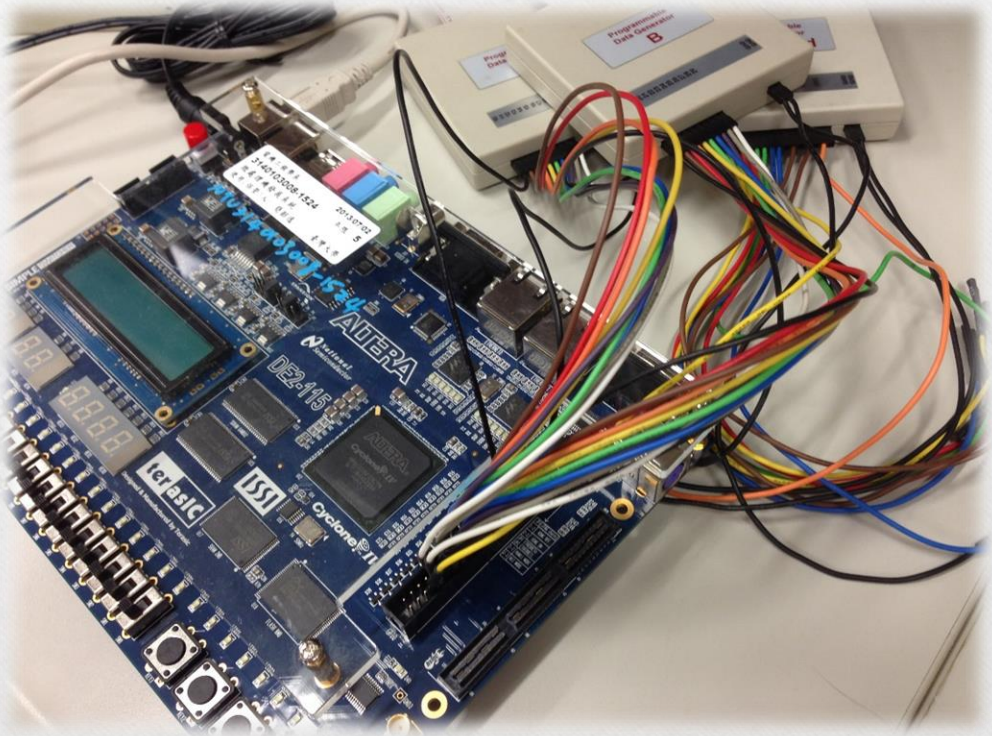
Complete the RSA System

System Overview

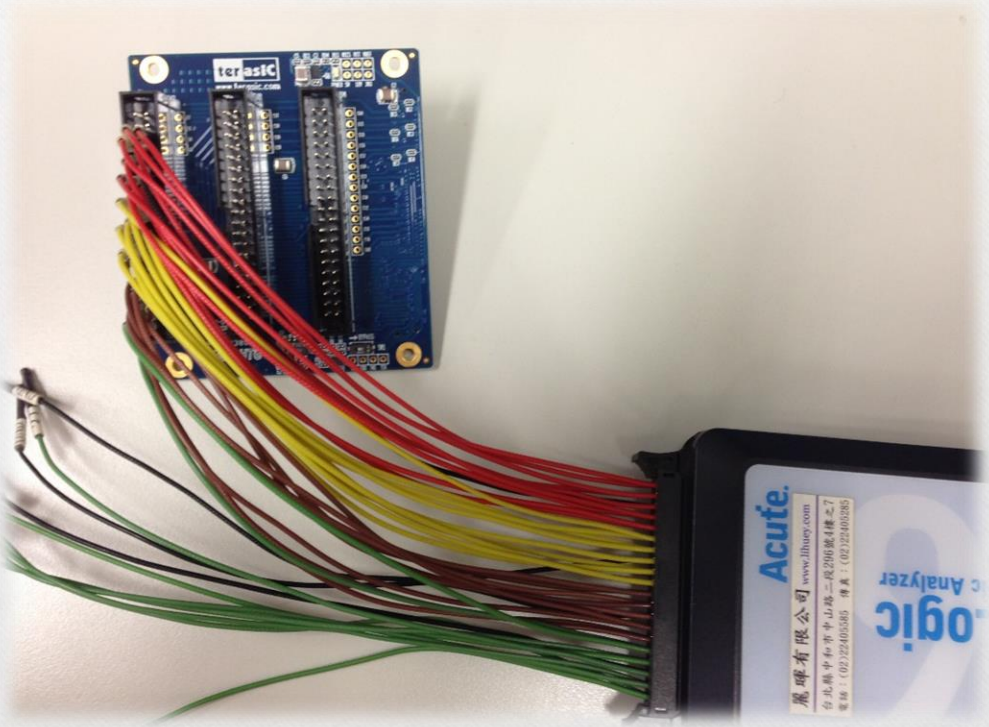
Connect PG Components (1/3)

Connect PG Components (2/3)

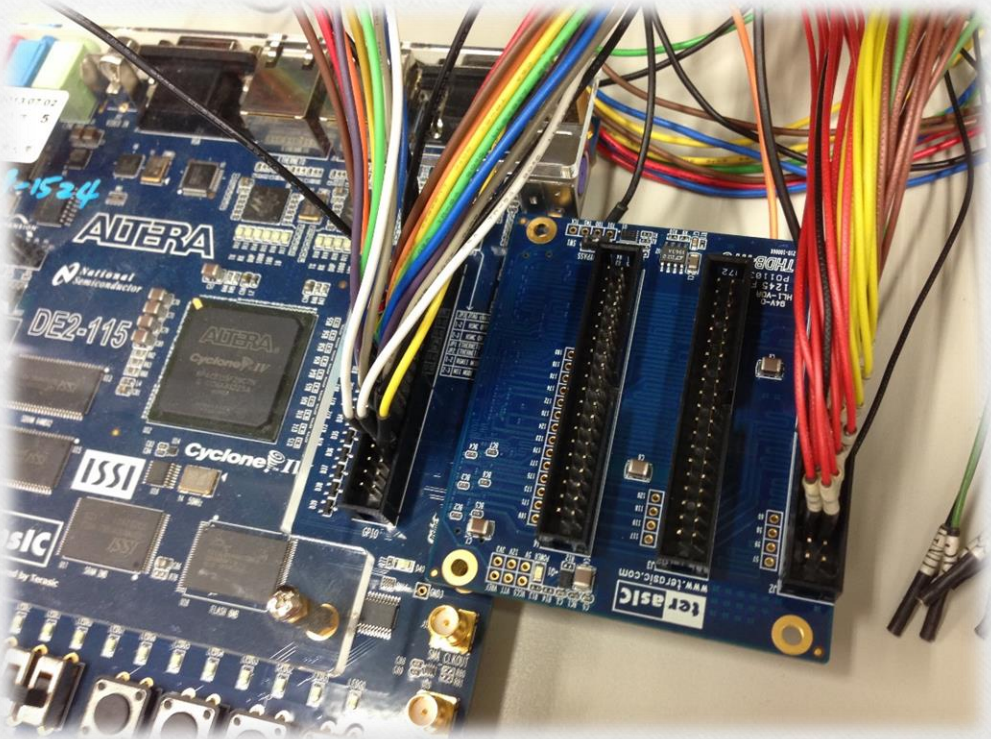
Connect PG Components (3/3)

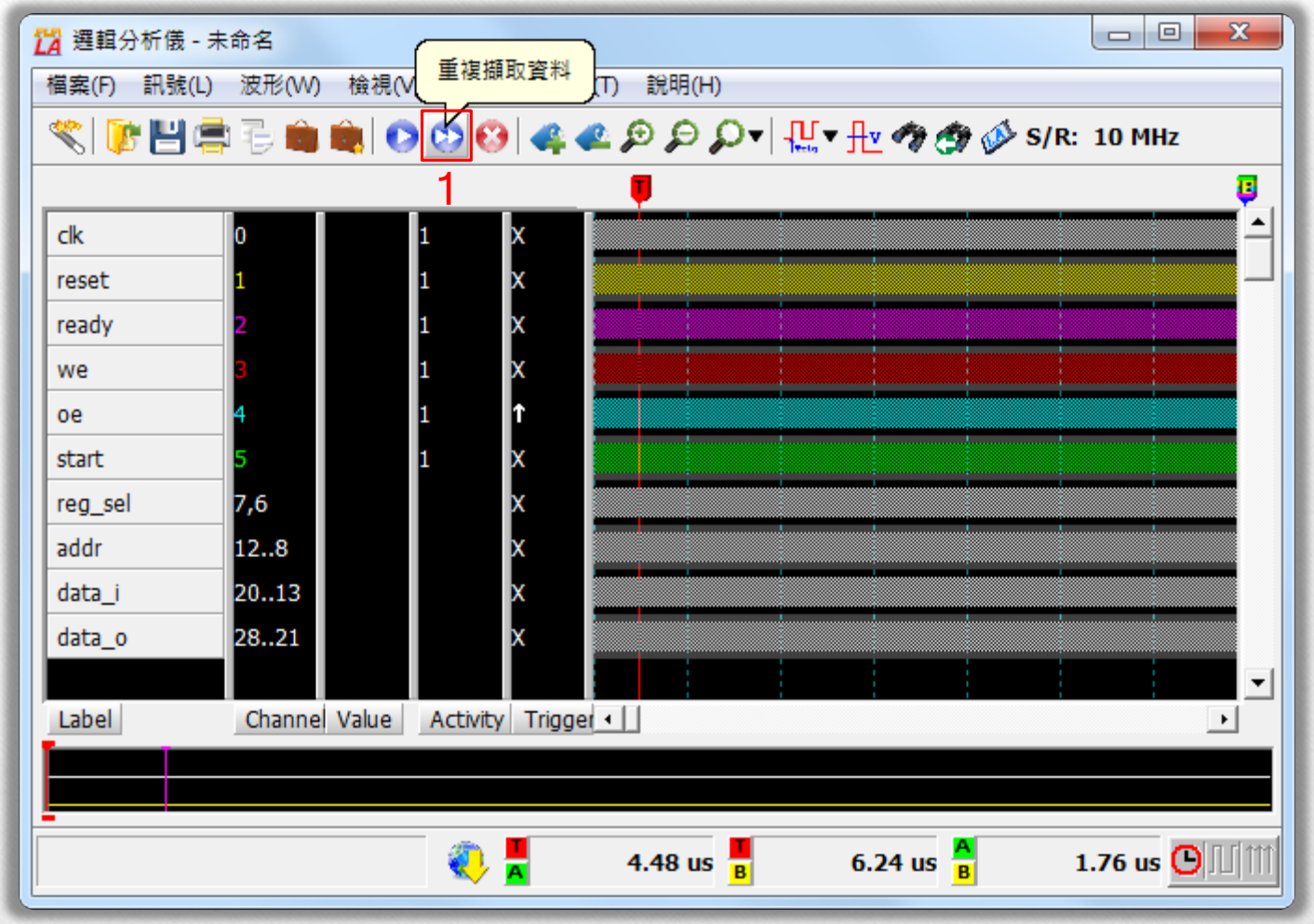


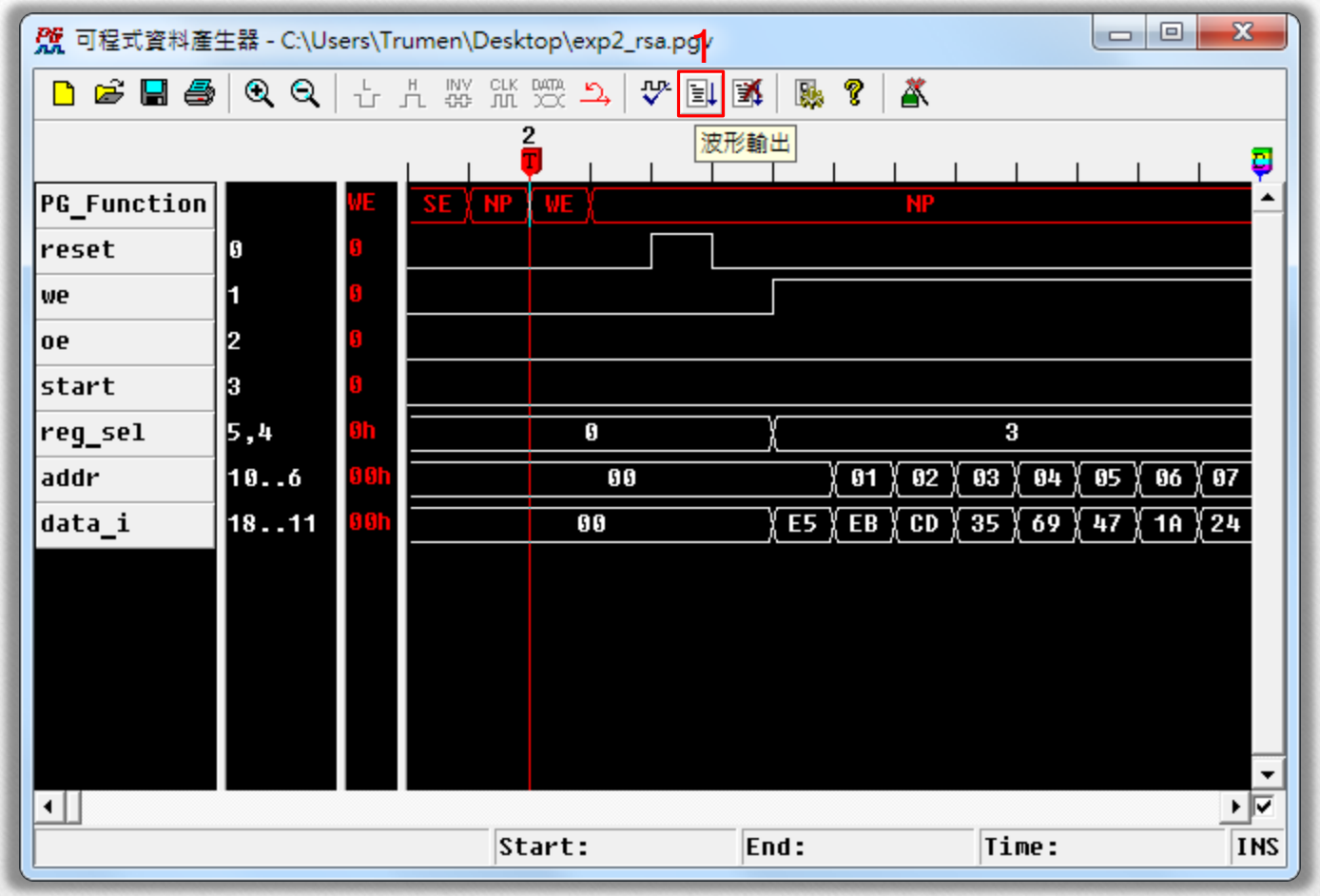
Connect LA Components (1/2)



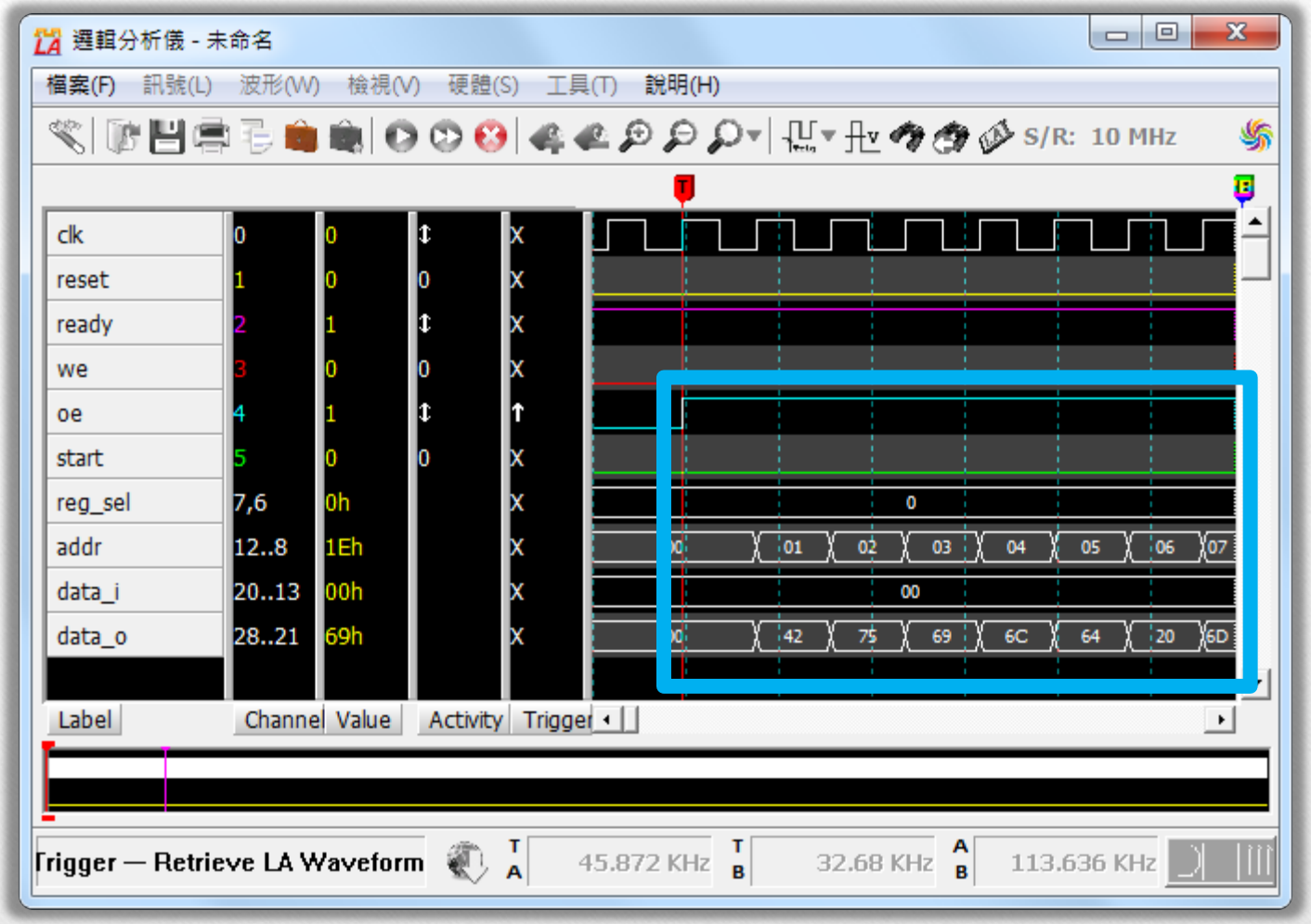
Connect LA Components (2/2)




邏輯分析儀 - 未命名
重複擷取資料
檔案(F)
訊號(L)
波形(W)
檢視(V
(T)
說明(H)
S/R: 10 MHz
1
clk
reset
ready
we
oe
start
reg_sel
addr
data_i
data_o
0
1
2
3
4
5
7,6
12..8
20..13
28..21
Label
Channel
Value
Activity
Trigger
4.48 us
6.24 us
1.76 us



2 Push Space Key


邏輯分析儀 - 未命名
檔案(F) 訊號(L) 波形(W) 檢視(V) 硬體(S) 工具(T) 說明(H)
S/R: 10 MHz
clk
reset
ready
we
oe
start
reg_sel
addr
data_i
data_o
7,6
12..8
20..13
28..21
0h
1Eh
00h
69h
Label
Channe
Value
Activity
Trigger
Trigger — Retrieve LA Waveform
45.872 KHz
32.68 KHz
113.636 KHz

How to Optimize? (1/2)

- Modify the constraint file exp2_rsa.sdc and then compile again.
  - Ex:

```
create_clock -period 500 [get_ports clk]
derive_clock_uncertainty
set_input_delay 0 -clock clk [all_inputs]
set_output_delay 0 -clock clk [all_outputs]
```

- Change the signal frequency of PG and check if the result is still correct.
  - Don’t forget to change the sampling rate of LA.
- Record the min. clock period (max freq.).

How to Optimize? (2/2)

- Modify the testbench
  - clock period to min. clock period
  - TEST_DATA to 6

```
`timescale 1ns/1ps
`define CYCLE       500.0
`define End_CYCLE   1000000000
`define TOTAL_DATA 38
`define TEST_DATA   6
```

- Run the Verilog simulation to get the finish time.

```
# ------------------------------------------------------
#
# Congratulations! All data have been generated successfully!
#
# -------------------------PASS-------------------------
#
# ** Note: $finish    : C:/Users/Trumen/Desktop/exp2_rsa/testbench.v(175)
#    Time: 99269 ms  Iteration: 1  Instance: /testbench
```

The End.

Any question?

Reference

1. "DE2-115 User Manual" by Terasic Technologies Inc.
2. "enPG.pdf" by Acute Technology Inc.
3. "enLA.pdf" by Acute Technology Inc.