
Windows CE[®] Evaluation Report

Test Plan and Preliminary Results

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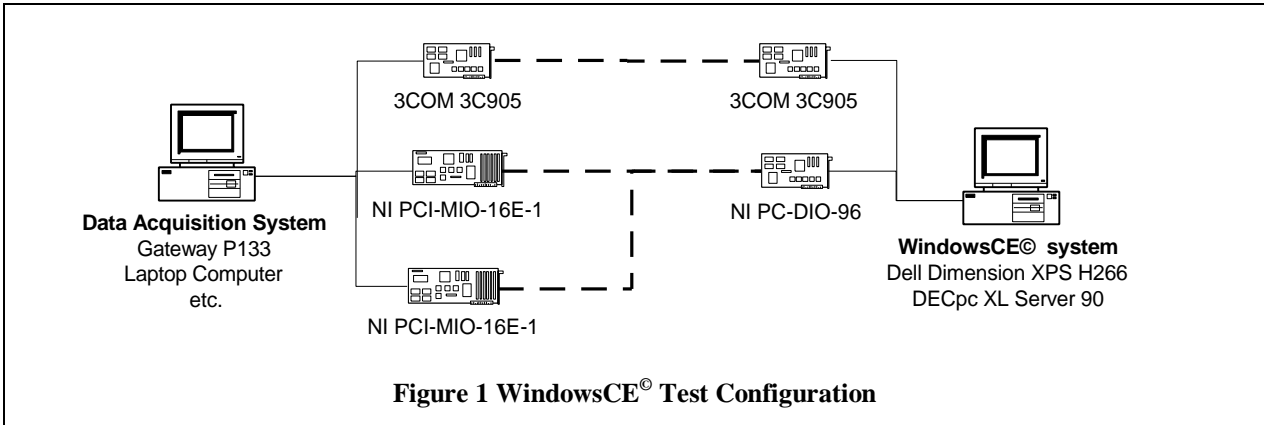
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Introduction

As General Motors Powertrain (GMPT) moves towards open, modular architecture control (OMAC) systems, the need for a real-time operating system (RTOS) is clear. There are currently several commercial real-time operating systems available. However, GMPT would like to use an industry standard OS that provides seamless support for all commercial software packages. For this reason, GMPT and many others are investigating commercially available real-time extensions for the Microsoft WindowsNT® Operating System. In addition, with the emergence of WindowsCE®, it is important to include WindowsCE® in this evaluation process. This report details the testing of WindowsCE®.

This report details the test plan and some preliminary test results. The test methodology was the same as our previous testing of the Hard Real-time Extensions for WindowsNT®. The diagram below shows the hardware configuration used for the Phase 1 testing. In our preliminary tests, a DEC computer ran the WindowsCE® while the Gateway computer was used to record the timing results. Future tests of WindowsCE® performance will utilize the same Dell computer utilized in the testing of the real-time extensions for WindowsNT®.



Test Plan

System Configuration

This section describes the system configuration that will be used to test and evaluate WindowsCE[®] and any CE extensions that become available on the market. The primary hardware configuration shall consist of a Dell Dimension XPS H266 utilizing a National Instruments PC-DIO-96 card. A small application shall be written using the tools available for each OS. The application shall update I/O, etc. at a periodic rate while test software is also run on WindowsCE[®] to utilize varying degrees of systems resources.

A data acquisition system with two National Instruments PCI-MIO-16E-1 data acquisition cards or two DAQCard-AI-16E-4 PCMCIA data acquisition cards will measure WindowsCE[®] performance. This system will measure jitter, scan time and interrupt latency. LabView applications will program the data acquisition cards to acquire and store data. LabView will also perform Statistical measurement and analysis of each WindowsCE[®] performance.

Phase I Tests

The first phase of testing will involve a real-time application running with and without other CE s/w running. The primary objective of these tests is to determine the unloaded and loaded jitter and response times of CE.

Test 1. Square Wave Generation Test

A real-time application utilizing the real-time services of the OS shall toggle digital outputs on and off.

- The output shall be the second output bit for the PC-DIO-96 card.
- The output shall toggle between +5V and 0V at 500 μ s intervals (or as fast as possible with the current version of CE being tested). The output should remain at the toggled level for 500 μ s (see Figure 2).
- A time trace will record a fixed number of transitions. The acquisition system will measure the time between state changes and statistically plot the results.

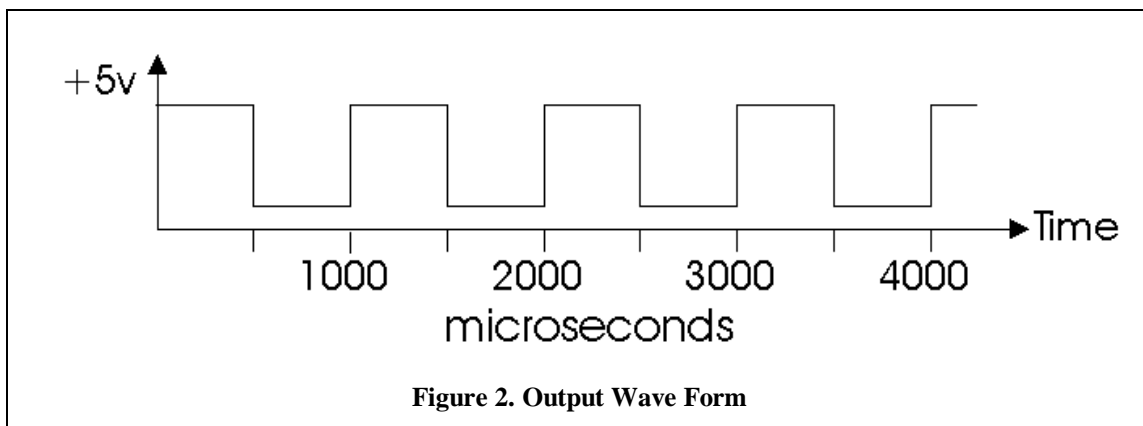
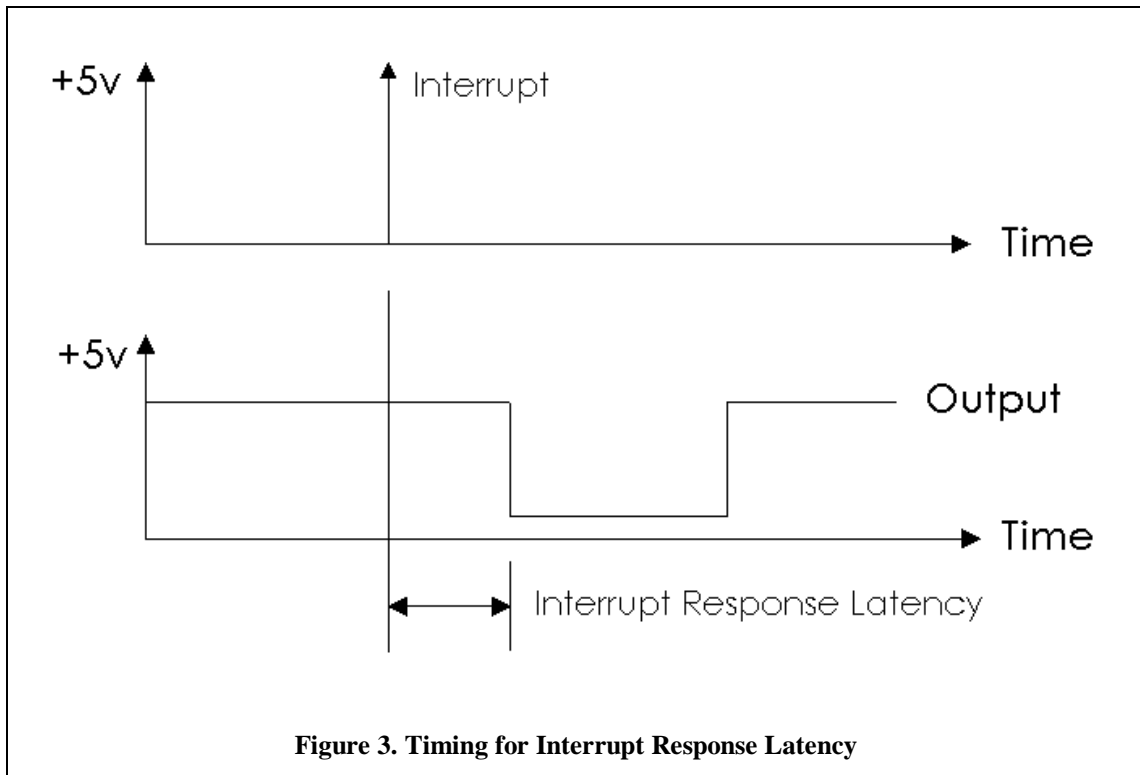


Figure 2. Output Wave Form

Test 2. Interrupt Latency Response Test

The application shall respond by turning on a digital output when an interrupt occurs. The output (initially high) shall toggle low for at least 1 millisecond and then return high. Any interrupts occurring while the output is low should be ignored. Interrupts that occur when the output is high shall cause the output to be set low.

- The output shall be the third output bit for the PC-DIO-96 card.



Tests 1 and 2 will be executed under several combinations of the following factors (not all will be documented in this report):

- Execution of real-time applications with no additional WindowsCE[®] software running
- Execution of real-time applications with POLY, a CE graphics demo program, running on CE
- Network communications

Phase II Tests

The second phase of testing will validate the communications from the real-time (high priority) application to normal priority and back to the real-time application. The phase II tests cannot be performed until Microsoft implements enhanced functionality in CE.

Test 1. CE Normal Priority Thread and Real-time Thread Communication Test

The main objective of this test is to measure the WIN32 communication interface timing between real-time tasks and non-real-time tasks. Goals of Phase II Test 1 are as follows:

- verifying shared memory communications;
- verifying semaphored or mutexed access to the shared memory;
- verifying Win32 application access to shared memory areas.

Phase II Test 1 shall be based on a modification to the Interrupt Latency Response test of Phase I. An external source shall create an interrupt on the PCI DIO96 card and monitor the response of an output port that is to be held high for 5 ms after 1000 semaphored or mutexed communications have happened. A simple diagram with Pseudo code follows:

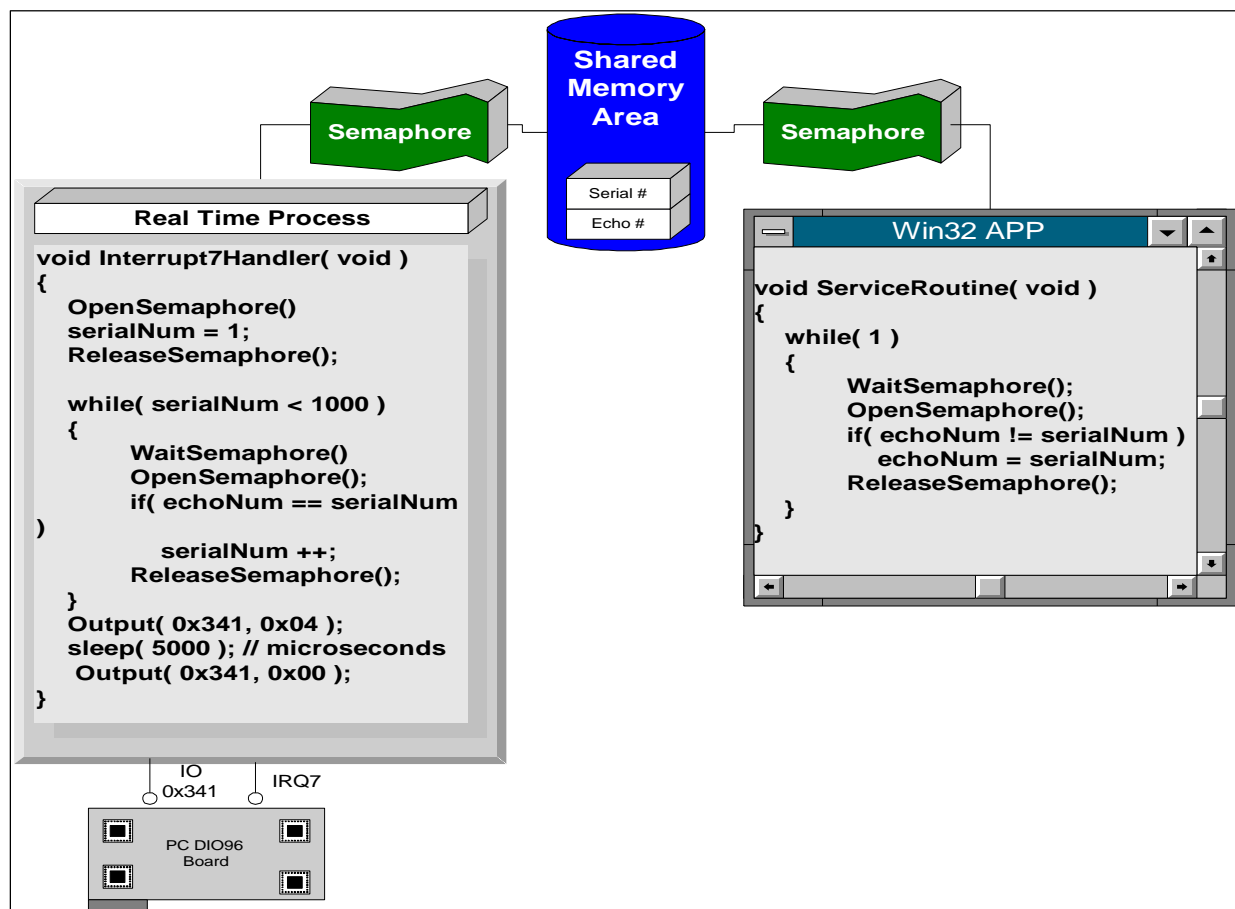


Figure 4. Phase II Test 1 Block Diagram

The Win32 application is allowed to spin in a loop to maximize its response.

Test 2. Real-time Thread to Real-time Thread Communication Test

The main objective of this test is to measure the communication interface timing between two real-time threads. Goals of Phase II Test 2 are as follows:

- verifying shared memory communications;
- verifying semaphored or mutexed access to the shared memory;

Phase II Test 2 shall be based on a modification to the Interrupt Latency Response test of Phase I. An external source shall create an interrupt on the PCI DIO96 card and monitor the response of an output port that is to be held high for 5 ms after 1000 semaphored or mutexed communications have happened. Pseudo code follows:

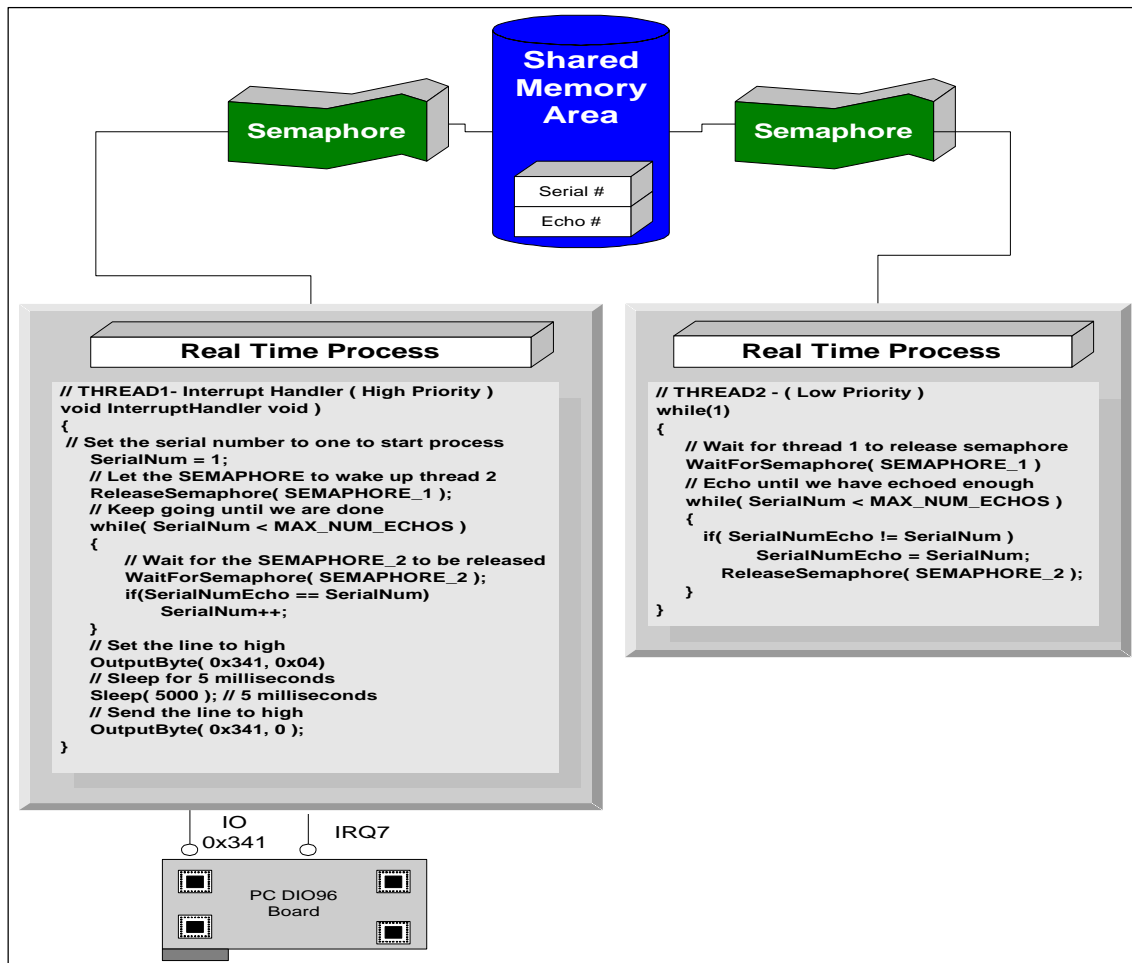


Figure 5. Phase II Test 2 Block Diagram

Preliminary Phase I Test Results

The Preliminary test results presented were run on the following hardware configuration:

- DECpc XL Server 590 (90MHz Pentium)
- 32 MB RAM
- Diamond Stealth 64 Video Card

The software configuration and test results for each test are described in the following sections. For each of the tests, a pre-determined number of timing samples were collected (e.g. 1,000 for the interrupt latency test in our preliminary tests). The mean, standard deviation, maximum and minimum for each set of data was determined and the data was also plotted on a histogram to show the distribution of the data about the desired value. The LabView front panel displaying the data has been included in the Appendices and the data has been saved in excel format.

Only the interrupt latency response test was run and is documented in this report. A real-time application generates an interrupt when an input transitions high. The interrupt causes a normally high output to transition low for a specified period.

How to Read the Test Results

The test results are presented in tables following each test configuration and condition. Software configuration is presented first to describe test conditions and particular hardware settings. Appropriate test results are then listed. For example the following table shows the results of an Interrupt Response test for CE. The results show that interrupt response time, generated using the high priority thread in CE, had a mean of 15.29 microseconds. The maximum, minimum, and standard deviation values are also given. The sample size for this test was 1,000.

	CE Version 2.0
mean	15.29
max	40.00
min	10.00
Standard Deviation	6.09
Sample Size	1,000

Preliminary CE Version 2.0 Results

The following preliminary tests characterize the interrupt service thread latency for WindowsCE®.

CE Interrupt Latency Response Test: Condition 1

S/W configuration:

- Quiet CE system
- Interrupt Service Thread at Real-time priority (Priority 0)

Test Results:

	CE Version 2.0
mean	15.29
max	40
min	10
Standard Deviation	6.09
Sample Size	1,000

CE Interrupt Latency Response Test: Condition 2

S/W configuration:

- Graphics running on CE (POLY, etc.)
- Interrupt Service Thread at Real-time priority (Priority 0)

Test Results:

	CE Version 2.0
mean	90.05
max	230
min	10
Standard Deviation	41.582
Sample Size	1,000

CE Interrupt Latency Response Test: Condition 3

S/W configuration:

- Quiet CE system
- Interrupt Service Thread at Normal priority

Test Results:

	CE Version 2.0
mean	15.7
max	190
min	10
Standard Deviation	14.104
Sample Size	1,000

CE Interrupt Latency Response Test: Condition 4

S/W configuration:

- Graphics running on CE (POLY, etc.)
- Interrupt Service Thread at Normal priority

Test Results:

	CE Version 2.0
mean	6845.66
max	80,000*
min	10
Standard Deviation	9,285.66
Sample Size	1,000

Note: the max value we could record was 80,000 us, the actual max was probably higher but it is clear that it was too high and obtaining the actual value was not necessary.