# XPAC/WinPAC Interrupt Performance Test

## Overview

For high-performance embedded applications (PAC, P**rogrammable Automation Controller),** the need for time-critical response and real-time performance is indispensable. A **Real-time Operating System** (RTOS) which is a computing environment that reacts to input within a specific time period, is needed for these applications on a PAC.

Applications where specific timings are requested include:

- Hard real time:
  Applications where system fails if timings are not met
- Soft real time:
  Applications where the system tolerates large timing latencies
- Actual timing requirements are system-specific

The following items are used to assess the Windows CE design in terms of the most common hard real-time requirements:

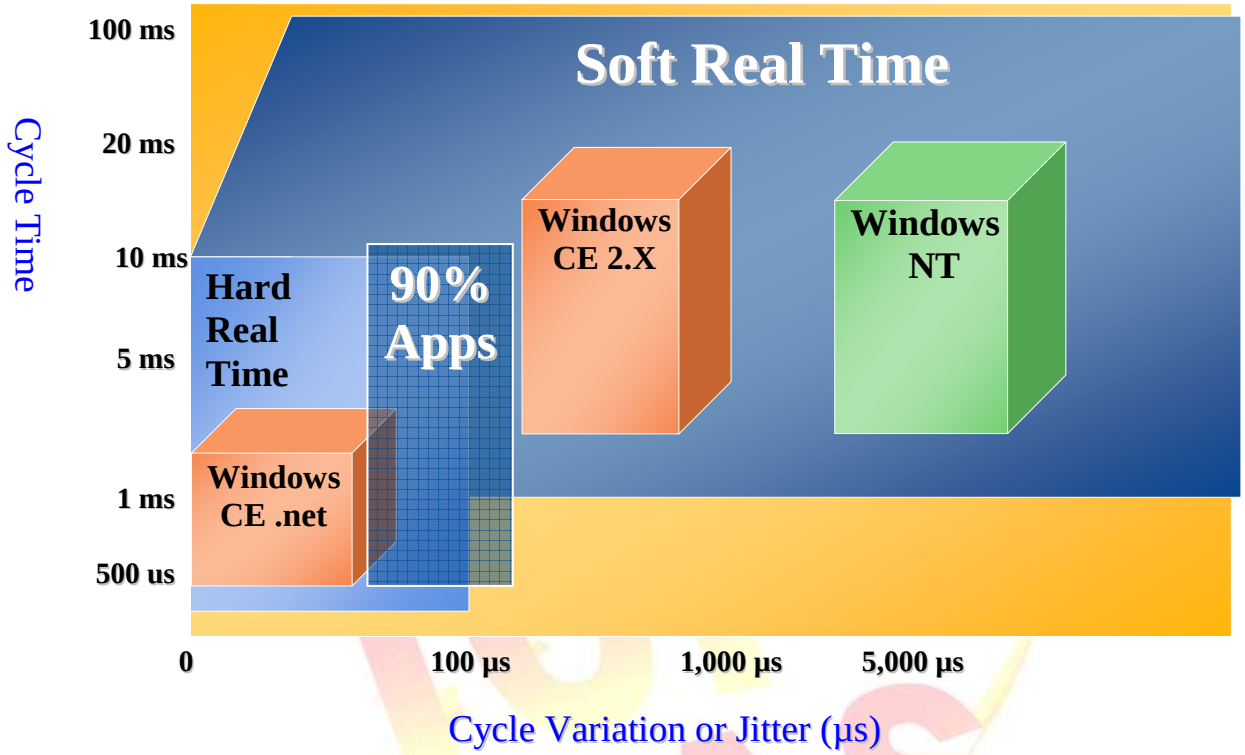
- Interrupt latency prediction and reduction
- Control of interrupt handling by the OEM
- Predictable system response
- Thread access to system interval timer
- Thread context and synchronization
- Thread priority support
- Thread switching
- Time slicing

Microsoft Windows CE.NET is an operating system that incorporates **hard real-time capabilities** and is embedded in the WinPAC/XPAC series.

**Reference:**

- **http://www.scribd.com/doc/18269801/Wince-Realtime**
- **http://msdn.microsoft.com/en-us/library/ms836770.aspx**

## OMAC represents Industrial Automation Community




**Note:**

The Open Modular Architecture Control Users' Group (**OMAC**, Research Triangle Park, NC) has changed its name to the Organization for Manufacturing Automation and Control (OMAC) to reflect an evolution of the group's mission.

http://findarticles.com/p/articles/mi_qa3618/is_200810/ai_n30992784/?tag=rel.res3

http://www.omac.org/

### Basic Terminology

**Interrupt**

An interrupt is a Hardware signal indicates that a real-world event has occurred

The corresponding hardware device needs to be serviced by the computer system in some way.

**Latency**

Latency describes the time from when the interrupt occurred to when the hardware begins to be serviced.

**Jitter**

Jitter defines the range of allowable variations in service times, and is usually defined by the “tolerance” of a mechanical system for variability in the response.

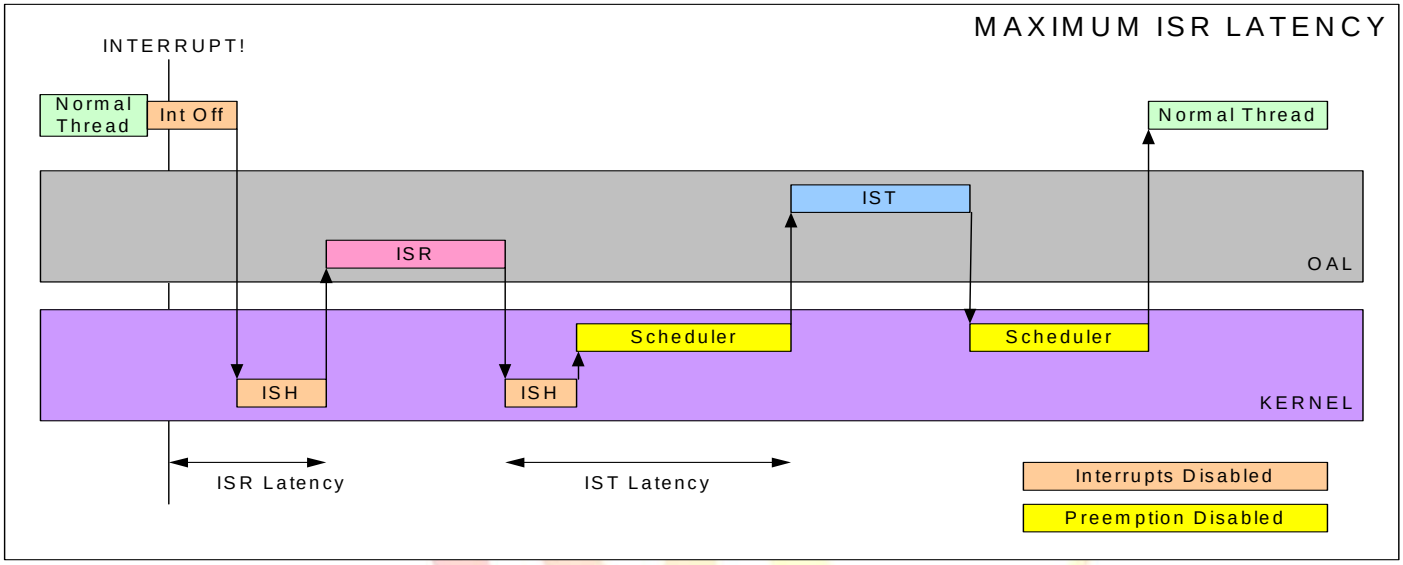
**Bounded**

Bounded indicates the extreme limits that are known precisely.

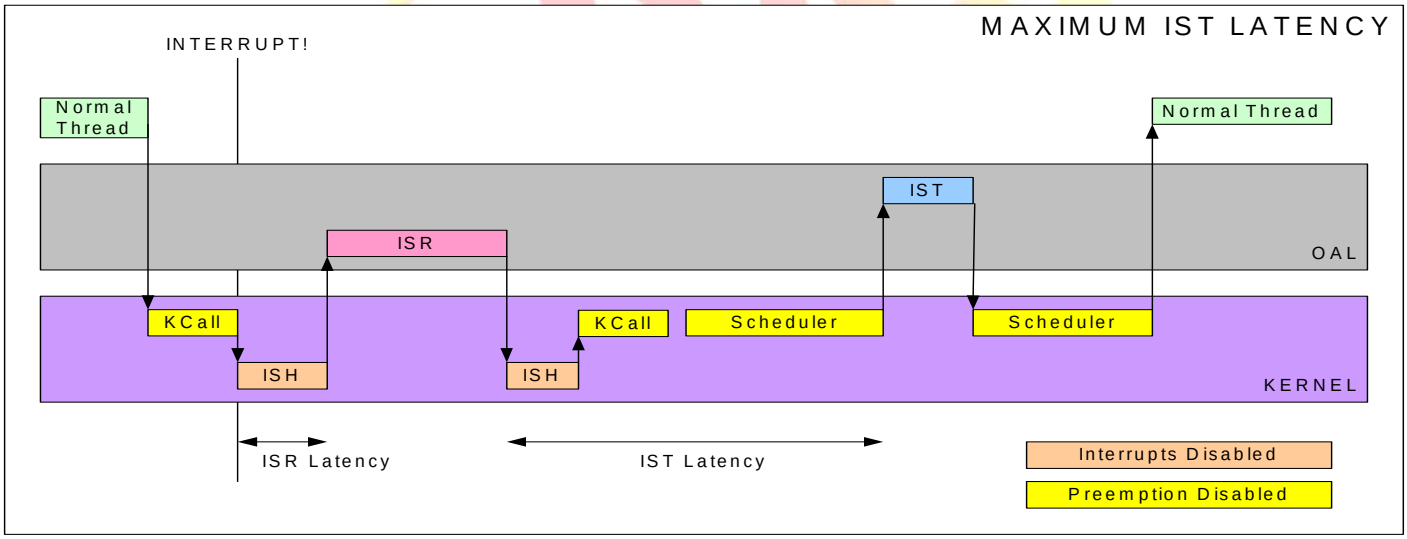
The combination of bounded low latency and jitter = “hard” real time

**ISR/IST Latency definition**

**Maximum ISR Latency Path**




**Maximum IST Latency Path**



# Interrupt Measurement Tools

ILTiming.exe is a testing tool that allows an OEM to measure an interrupt service routine (ISR) and the interrupt service thread (IST) latency

## Iltiming.exe Test for ICPDAS's PAC

Comparison (Units: microseconds µs)

| | Min. | | Avg. | | Max. | |
|---|---|---|---|---|---|---|
| ISR/IST | ISR Latency | IST Latency | ISR Latency | IST Latency | ISR Latency | IST Latency |
| XPAC8000_CE6_Atom | 5.0 | 13.4 | 5.0 | 14.0 | 5.0 | 14.2 |
| XPAC8000_CE6_LX800 | 5.8 | 12.5 | 6.7 | 14.1 | 7.5 | 15.0 |
| WP8000/ViewPAC (PXA270) | 4.9 | 24.3 | 5.1 | 25.5 | 6.4 | 31.3 |

**Reference:**

*http://msdn.microsoft.com/en-us/library/ee483144%28WinEmbedded.60%29.aspx*

# Benchmarking Real-time Determinism in PAC

## IST/ISR Latency and Jitter Test

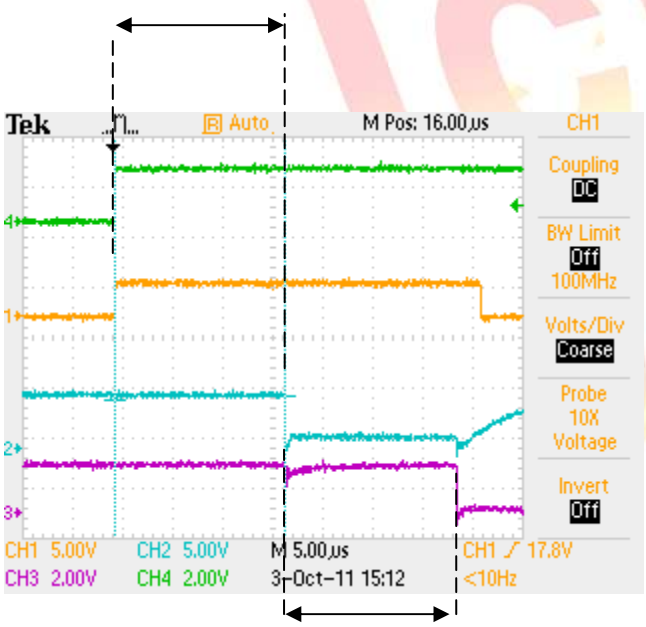
### Test Equipment:

XP-8341-CE6 XP-8341-Atom-CE6 WP-8441
i-8048W * 1 (Digital Input with Interrupt Module)
i-8055W * 1 (Non-isolated Open-collector DO module)
Signal Generator: Agilent 33210A
Oscilloscope: Tektronix TDS2014B

### Test method and procedure:

1. Install i-8048W DI module and i-8055W DO module on a PAC (XPAC/ WinPAC).
2. Use a signal generator to create a signal to channel 0 of i-8048W. This interrupt pulse signal was also connected to CH 1 (yellow line) of the oscilloscope for monitoring purposes.
3. The ISR[Note1] signal was connected to CH 2 (Blue line) and the IST[Note2] single was connected to CH3 (Pink line) of the oscilloscope.

ISR Latency




IST Latency

CH1 (Yellow Line): Interrupt trigger from i-8048W
CH2 (Blue Line): ISR time for i-8048W
CH3 (Pink Line): IST time for i-8048W

4. Send a signal to a controller and measure how long it takes to respond. The "latency time" and the "jitter time" for this response are the quantified measures of determinism.

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Note1 The ISR signal is generated by DO0 channel of i-8055W, and is generated from the ISR code of the OS kernel when i-8044W channel receives the external trigger signal.

Note2 The IST signal is generated by DO1 channel of i-8055W, and is generated by the thread code of this application when the kernel (ISR) passes the signal to the interrupt thread (IST).

5. Continually send a square wave input to channel 0 of i-8048W at a frequency of 5KHz (a 200 microsecond pulses period) using a pulse generator set at a duty cycle of 50 percent.
6. Set the system loading to 100% and use the persistence feature of the oscilloscope. This feature records and overwrites ALL traces for a total of many hundreds of thousands of traces for 24 hours.
7. The results of the ISR/IST latency and the Jitter time can be measured from the oscilloscope.

**Results:**

Comparison (Units: microsecond μs)

| | **Avg. (Min. /Max.)** | | |
|---|---|---|---|
| **ISR/IST** | **ISR Latency** | **IST Latency** | **Jitter** |
| XPAC8000_CE6_Atom | 22 (21/28) | 15 (13.8/24.4) | 10 |
| XPAC8000_CE6_LX800 | 17 (16/23.2) | 17.2 (18/24) | 10 |
| WP8000 (PXA270) | 19.6 (14 / 21) | 51.6 (44/ 122) | 100 |

Note:

Thread Priority set to 100

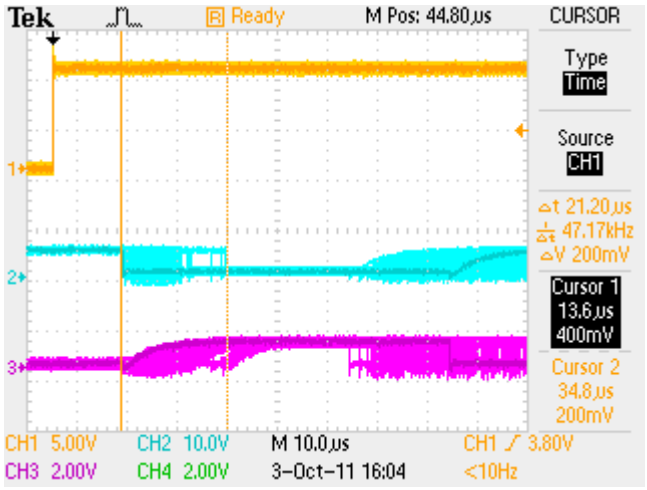
**References:**

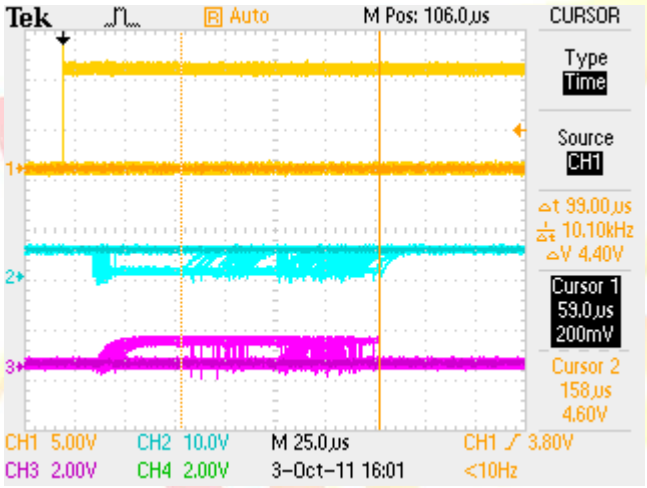
http://msdn.microsoft.com/en-us/library/ms836535.aspx for Benchmarking Real-time Determinism in Microsoft Windows CE

http://www.icpdas.com/products/Remote_IO/i-8ke/i-8048w.htm for more details regarding to i-8048W

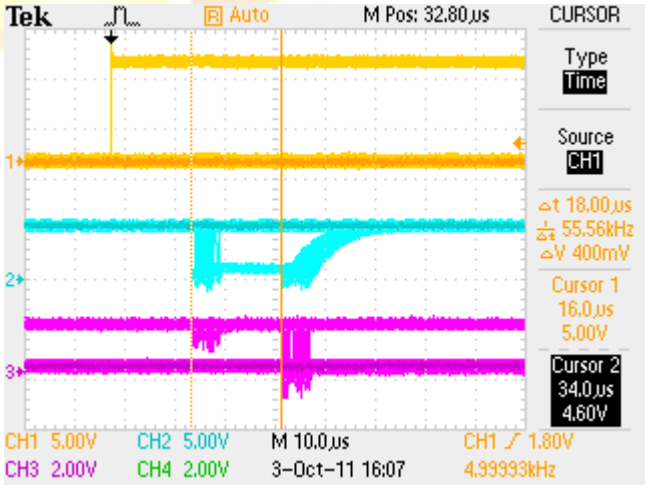
http://www.icpdas.com/products/Remote_IO/i-8ke/i-8055w.htm for i-8055W

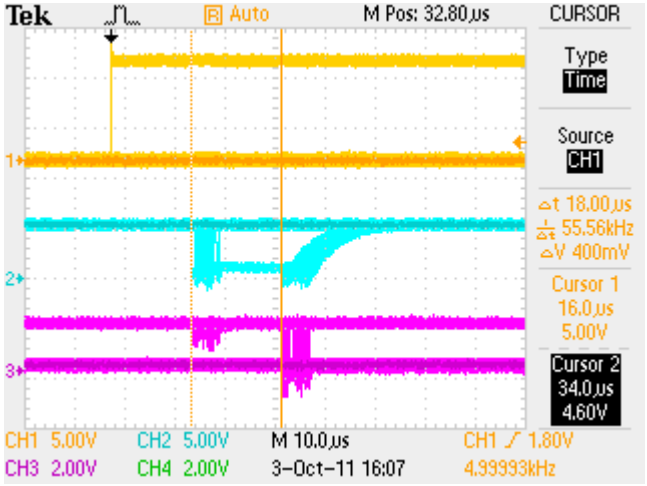
PXA270



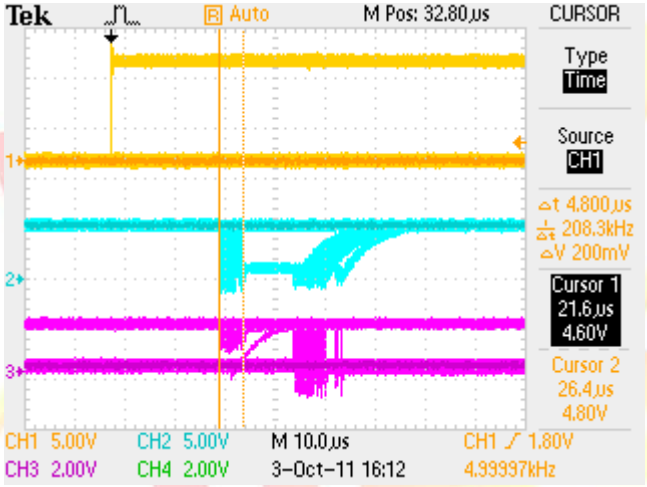



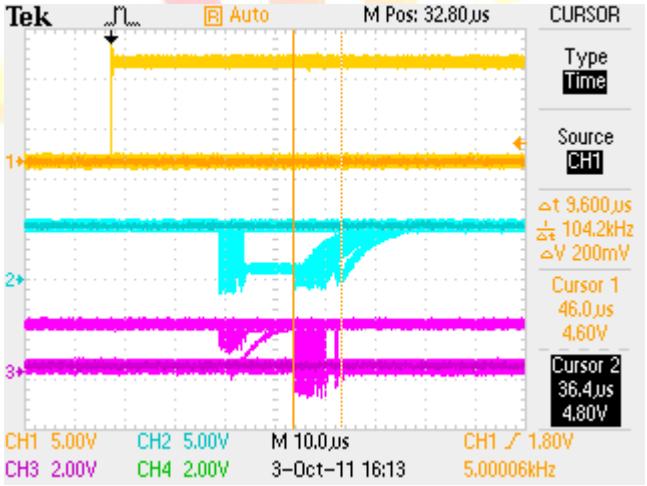

LX800




Tek
Auto
M Pos: 32.80µs
CURSOR
Type
Time
Source
CH1
Δt 18.00µs
1/Δt 55.56kHz
ΔV 400mV
Cursor 1
16.0µs
5.00V
Cursor 2
34.0µs
4.60V
CH1 5.00V
CH2 5.00V
M 10.0µs
CH1 ∕ 1.80V
CH3 2.00V
CH4 2.00V
3-Oct-11 16:07
4.99993kHz

Atom


Tek
Auto
M Pos: 32.80µs
CURSOR
Type
Time
Source
CH1
Δt 4.800µs
1/Δt 208.3kHz
ΔV 200mV
Cursor 1
21.6µs
4.60V
Cursor 2
26.4µs
4.80V
CH1 5.00V
CH2 5.00V
M 10.0µs
CH1 ∕ 1.80V
CH3 2.00V
CH4 2.00V
3-Oct-11 16:12
4.99997kHz


Tek
Auto
M Pos: 32.80µs
CURSOR
Type
Time
Source
CH1
Δt 9.600µs
1/Δt 104.2kHz
ΔV 200mV
Cursor 1
46.0µs
4.60V
Cursor 2
36.4µs
4.80V
CH1 5.00V
CH2 5.00V
M 10.0µs
CH1 ∕ 1.80V
CH3 2.00V
CH4 2.00V
3-Oct-11 16:13
5.00006kHz