Testing Real-Time Applications on Windows 10 IOT Using the Nyquist Theory

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Abstract. Raspberry Pi is a mini-computer that is provided to carry out activities quickly and precisely, but Raspberry Pi was created to not be able to do the real-time system with the support of Windows 10 IoT operating system, so the real-time system can be done on Raspberry Pi. The real-time applied in the application needs to be tested with the Nyquist theory. The purpose of this study was to get real-time system measurements available on Windows 10 IoT. This test is done using the Nyquist theory by calculating the results of measurements on mp3 streaming performed on Windows 10 IoT.

1. Introduction
Most devices that are included in the Internet of Things (IoT) utilize Raspberry Pi as their device. Raspberry Pi is a mini computer the size of a credit card. The Raspberry Pi has a Broadcom BCM2835 chip (SoC) system, which includes the ARM1176JZF-S 700 MHz processor, VideoCore IV GPU, and originally shipped with 256 MB RAM, then upgraded to 512 MB. Includes a built-in hard disk or solid-state drive, but uses an SD card for long-term boot and storage (Horan, 2013).

One operating system that supports Raspberry Pi devices is Windows 10 IoT. Windows 10 IoT aims to be used in real-time with the real-time capabilities of Windows 10 IoT, the devices that use it will be very helpful where real-time performance is very important to ensure fast, deterministic response times. Based on the background described, the problem that must be solved is to do a real-time online radio application test, measured by an oscilloscope and tested using the Nyquist theory. Thus the results of these measurements will appear that Windows 10 IoT can be used in real-time systems with the help of Raspberry Pi devices.

2. Methodology
This research was conducted on streaming online radio applications to get measurements of the results of the sound frequency then use an oscilloscope.

Figure 1. Oscilloscope
Besides measuring oscilloscope to ensure that this measurement is accurate, it is necessary to calculate using the Nyquist theory so that the results obtained in the oscilloscope can be calculated using the Nyquist theory, the Nyquist theory is a fundamental result in the field of information theory, certain telecommunications and signal processing, the Nyquist theory reads that analog signals must be sampled with a sampling frequency of at least twice the highest frequency of the sampled signal to be completely reconstructed (Shannon 1949), so that the more sampling process will approach the original signal.

![Diagram of sampling](image)

**Figure 2. Sampling**

The formula of theory *Nyquist*:

\[
fs > 2f_{\text{in max}}
\]  

Information:
Minimum sampling frequency (Fs) is 2 times the frequency of the analog signal to be converted (Fin max).

3. **Results and Discussion**

In this test, the test is carried out with an oscilloscope and the calculation with the Nyquist theory is by way of sampling an analog signal into a district signal. With the Nyquist criterion, when the results of the sampled signal can be converted back to the analog signal without any change in frequency. Analog signals will be converted into digital signals so that they can be processed by DSP (Digital Signal Processor). ADC converts analog to digital and DAC converts digital to analog.

3.1. **Raspberry Pi**

Raspberry Pi is a mini kit that can be made into a mini-computer the size of a credit card weighing about 45 grams. The computer, named Raspberry Pi, originally ran with the Linux operating system. This computer was developed for 6 years by the non-profit Raspberry Pi Foundation, which consists of volunteers and British technology academics.

3.2. **Windows 10 IoT Operating System**

Windows 10 IoT is a Windows 10 derivative operating system, but the Windows 10 IoT operating system is designed specifically for single board computers such as Raspberry Pi and can work with screens or without screens, the release of Windows 10 IoT is new to Microsoft because unlike previous generations Windows 10 IoT can be downloaded freely without having to buy because of open source so that users are free to download it. Windows 10 IoT is designed without using a desktop like other computers so there is no user interface like the previous operating system.
The above display is the initial display of the Windows 10 IoT operating system using a browser and entering a network IP that is connected with 170.20.10.9 and the port is 8080 so that it can enter into the basic display of Windows 10 IoT. Windows 10 IoT has an online radio application that will be tested as a real-time system, following an online radio display.

![Figure 3. Windows 10 IoT Display](image)

3.3. Measurement with oscilloscope and calculation with the Nyquist theory

The measurements obtained using an oscilloscope are:

![Figure 5. Oscilloscope Measurement Results](image)

That way the results of the oscilloscope are converted into Nyquist theory with a frequency of 2 Hz, a frequency of 1000 Hz cuplike or a period of 0.001 seconds and then sampling until the results are close to results, to calculate the Nyquist theory using Matlab.
Results you want to search:

```matlab
>>t=0:0.001:1;
>>f=2;
>>y=sin(2*pi*f*t);
```

Next set up the time variable t1 with the sampling frequency = signal frequency (or period 1 / f second) with the command:

```matlab
>>figure;
>>t1=0:1/f:1;
>>y1=sin(2*pi*f*t1);
>>plot(t,y,t1,y1,’-o’);
>>title(sprintf(’frekuensi sampling = frekuensi sinyal, jumlah data %d’,length(y1)));
```

At the first sampling the results are still far from the original signal, namely:

![Figure 6. Sampling results with period 1](image)

In sampling both signal frequencies (or 2.5 / f second period) with the command:

```matlab
>>figure;
>>t1=0:1/(2.5*f):1;
>>y1=sin(2*pi*f*t1);
>>plot(t,y,t1,y1,’-o’);
>>title(sprintf(’frekuensi sampling = 2,5 x frekuensi sinyal, jumlah data %d’,length(y1)));
```

And the second sampling results are close to the results but not exactly the same as the original signal.

![Figure 7. Sampling results with period 2.5](image)
Sampling the three signal frequencies (or the 10 / second period) with the command:

```matlab
>>figure;
>>t1=0:1/(10*f):1;
>>y1=sin(2*pi*f*t1);
>>plot(t,y,t1,y1,'-o');
>>title(sprintf('frekuensi sampling = 10 x frekuensi sinyal, jumlah data %d',length(y1)))
```

And the third sampling results are close to the original signal.

![Figure 8. Sampling results with period 10](image)

Sampling all four signal frequencies (or periods 20 / f seconds) with the command:

```matlab
>>figure;
>>t1=0:1/(20*f):1;
>>y1=sin(2*pi*f*t1);
>>plot(t,y,t1,y1,'-o');
>>title(sprintf('frekuensi sampling = 20 x frekuensi sinyal, jumlah data %d',length(y1)))
```

The result of the fourth sampling is the same as the original signal so that the result of the calculation of the Nyquist theory by doing 20 times sampling.

![Figure 9. Sampling results with period 20](image)
4. Conclusion
From the results of measurements and testing of real-time online radio applications that it takes up to several sampling tests so that the results are in accordance with measurements using an oscilloscope.

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