

Condition Monitoring of Industrial Machines Using Cloud Communication

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Industry 1.0

Industry 2.0

Industry 3.0

Today: Industry 4.0

Cyber Physical systems

Internet of Things (IoT)

Automation

Smart Factories

Big Data Analytics

- Cloud Computing
- Predictive Manufacturing

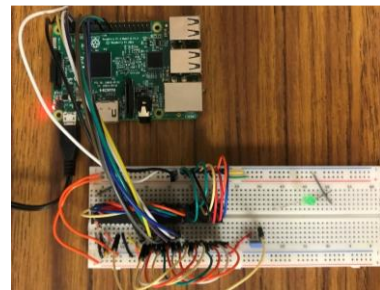
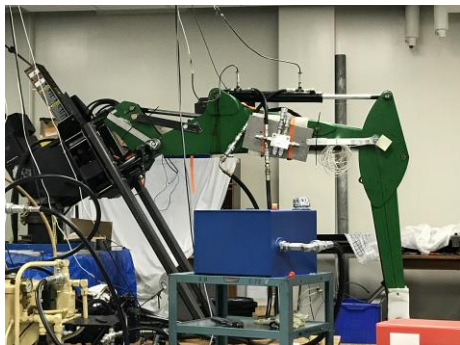




Objective and Specific Aims

Objective: Simplify the process of data acquisition for fault detection and analysis to eliminate the need for manual condition monitoring

Specific Aims: Small and Portable modular device that can be retrofitted onto various industrial machines to monitor and send data in regard to its performance to the cloud
Data can be downloaded off the cloud from anywhere in the world for analysis





Hardware Development

Raspberry Pi B Model 3

Adafruit ADC 1115 PGA Chip

Anker Power Core 20100

Basic Electrical Components





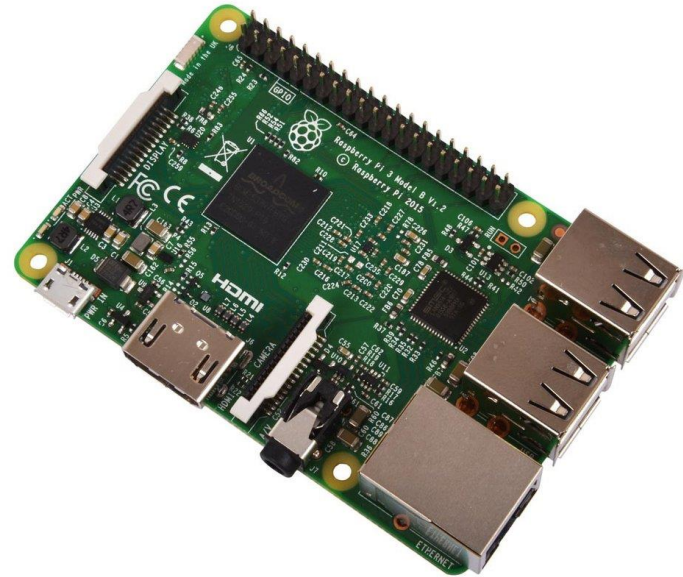
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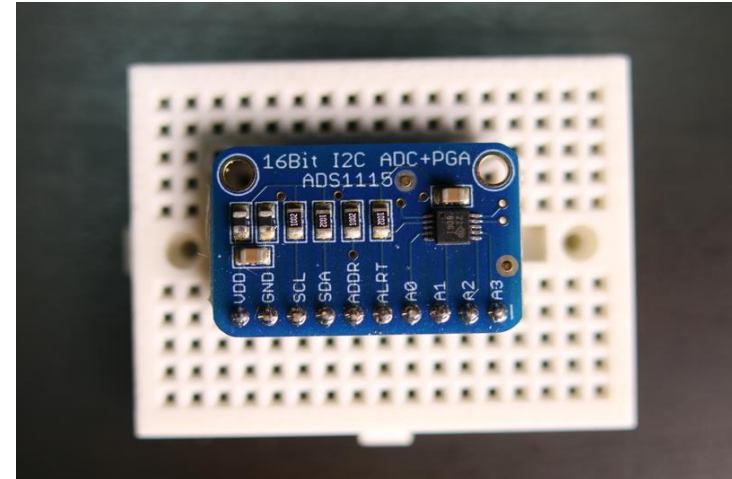
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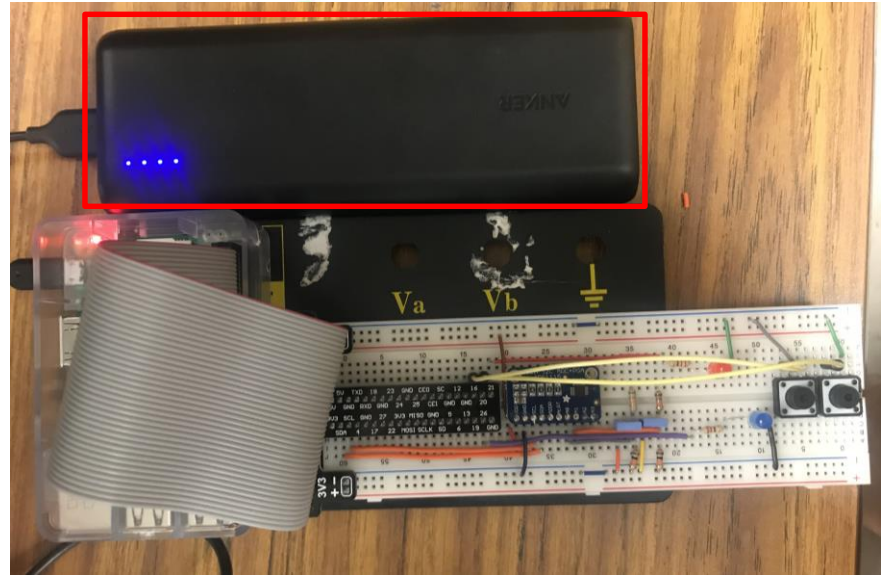
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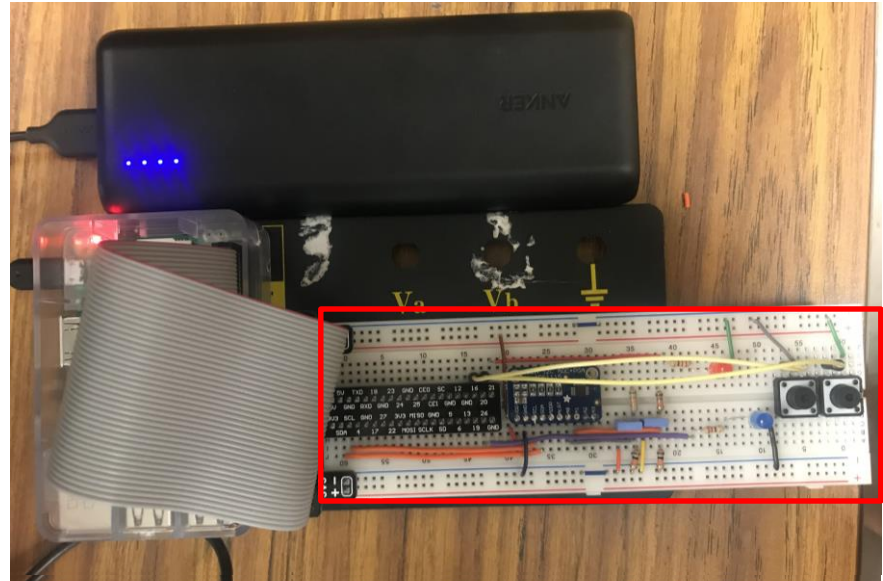
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Software Development

Python 3.6

Two different Scripts

- One ran on modular Device
- One ran on laptop/desktop



Script 1: Run on Raspberry Pi

Parameters: Total Sampling Length, Number of Signals to read

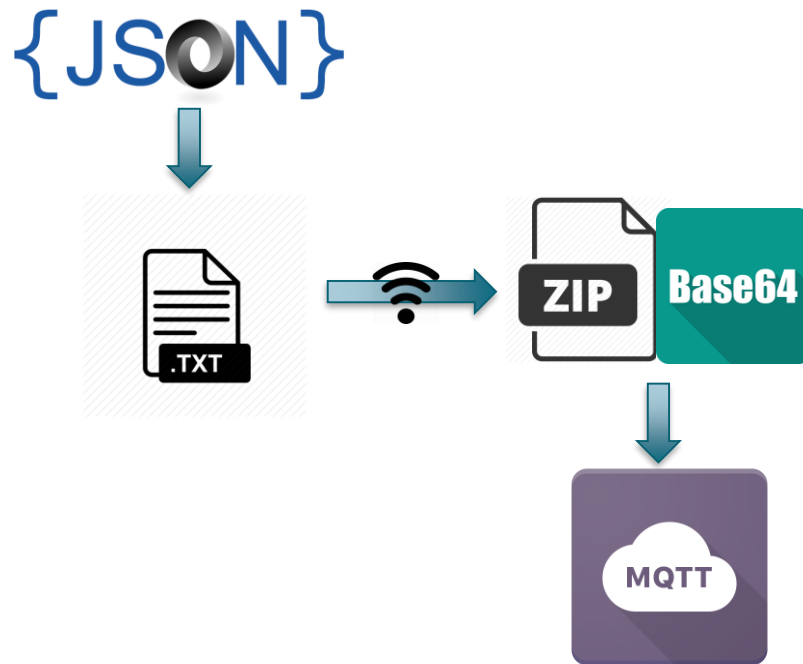
Samples data at 100 Hz for up to 5 minutes

Stores Data as JSON formatted .txt files

Compress using Gzip and encode with Base64

Send data using MQTT protocol

If no wireless connection established, data is stored until connected

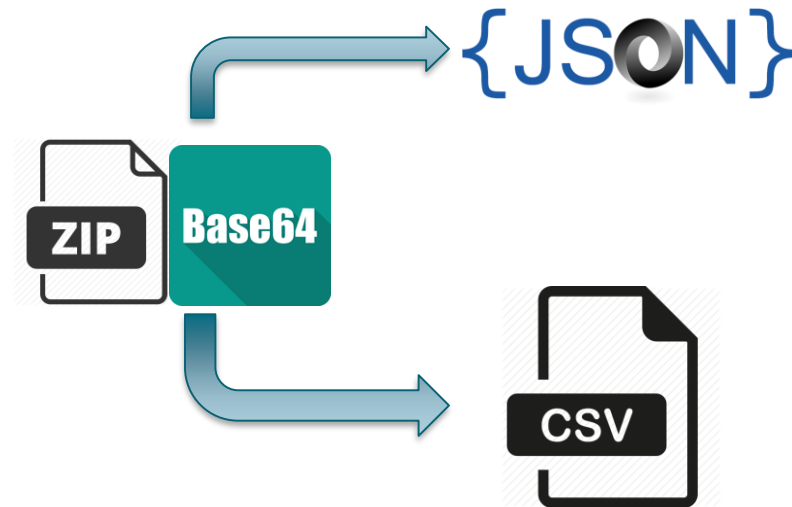


Script 2: Run on Desktop Console

After downloading compressed file off the cloud

Decompress the data and decode

Convert and output the file into JSON and CSV





Cloud Server

Amazon IoT Core for initial reception of data

Data is transferred to Amazon S3 for storage

Can be downloaded and decompressed to use in analytical programs such as Excel or Matlab

Amazon S3 > thing1data

Overview Properties Permissions Management

Search: Type a prefix and press Enter to search. Press ESC to clear.

Upload Create folder More Versions Hide Show US East (Ohio)

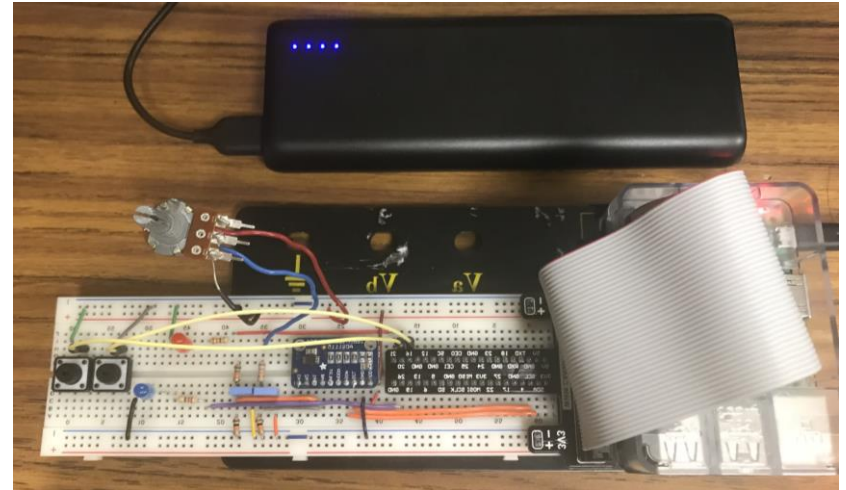
Viewing 1 to 200

Name	Version ID	Last modified	Size	Storage class
AKIAI4SKN226RB2VEVPQ				
Aug 18, 2018 6:55:31 PM (Latest version)				
	PnTE3qWid26SF21dJKWAPzgot...		45.0 B	Standard
	Aug 13, 2018 1:51:10 PM	HB5XMyaeFM43Pe7Mus7dutIMu...	37.3 KB	Standard
	Aug 13, 2018 1:48:14 PM	vavxqyijS_zD94oMidhZZAa8ENU...	56.2 KB	Standard
	Aug 13, 2018 1:48:12 PM	6E55vM3BJosN8gGalUhnvzJSW...	59.1 KB	Standard
	Aug 13, 2018 1:36:02 PM	j7dHINBpunMePWZiOQoOsbvEh...	3.0 KB	Standard
	Aug 13, 2018 1:25:39 PM	CHUEpUMRF1lemQMA9NbYLnS...	35.2 KB	Standard
	Aug 13, 2018 1:22:44 PM	jFVnpvFBOW94JW9HQDqDre5BL...	36.1 KB	Standard
	Aug 13, 2018 1:22:43 PM	Cria8tSR0zsf7BB7UibTPbuJ7PBH...	36.4 KB	Standard
	Aug 13, 2018 1:10:18 PM	5e_Ehr4a6QehDzYIG4bOhNH.zT...	39.2 KB	Standard
	Aug 13, 2018 1:05:10 PM	V004tjawdGaK1wqhPMCvUu_ali...	42.4 KB	Standard
	Aug 13, 2018 1:00:10 PM	KlUnKhnuL3xslpMxC7MchIWQ6b...	37.4 KB	Standard
	Aug 13, 2018 12:11:03 PM	NlQo435YnVvShNMAg83qy_DM8t...	33.6 KB	Standard
	Aug 13, 2018 12:06:04 PM	FBVyOos3lkwPUlwTYbn5ZgDMc...	35.4 KB	Standard
	Aug 13, 2018 12:00:55 PM	NtlUKgdyLgfdSeYbHIGKW_pQ2T...	34.6 KB	Standard
	Aug 13, 2018 11:55:56 AM	tvUhcCJ_OeeDTEIM43cNjHHzoId...	35.1 KB	Standard
	Aug 13, 2018 11:50:47 AM	OvSPRRyH14BxIU5g_Y8bXpMw...	34.8 KB	Standard
	Aug 13, 2018 11:45:47 AM	zErwExpKp_cwJH1uCWb0.HirDu...	34.5 KB	Standard
	Aug 13, 2018 11:40:37 AM	Q7CAXz32cuGDKWcMXB8H7o0...	34.5 KB	Standard

Case Study 1

Use a rotary potentiometer to create a varying signal for the modular device to read

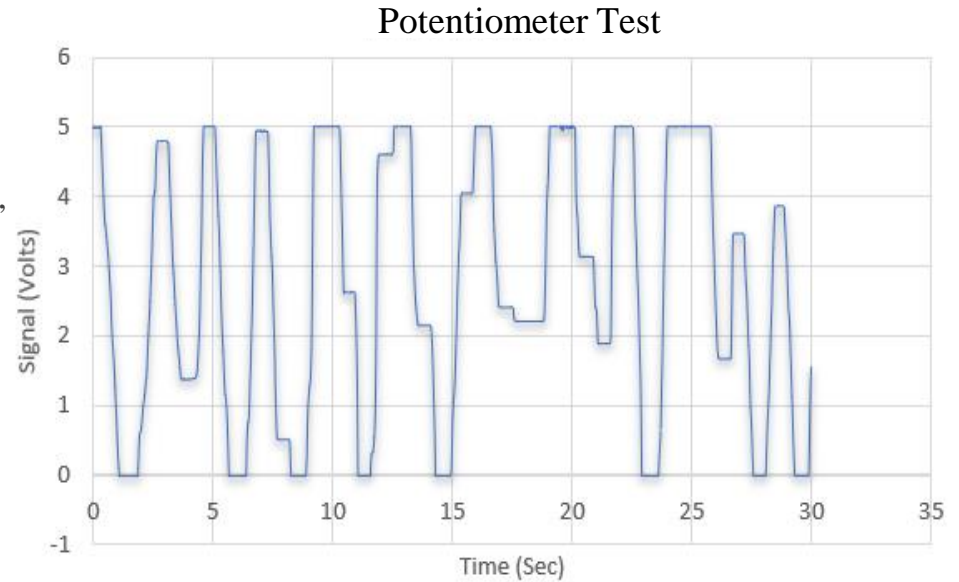
Proof of concept that the modular device can sample, store, and send accurate data to the cloud for retrieval





Data sampled at 100 Hz for 30 seconds

Data was successfully sampled, sent to the cloud,
and retrieved



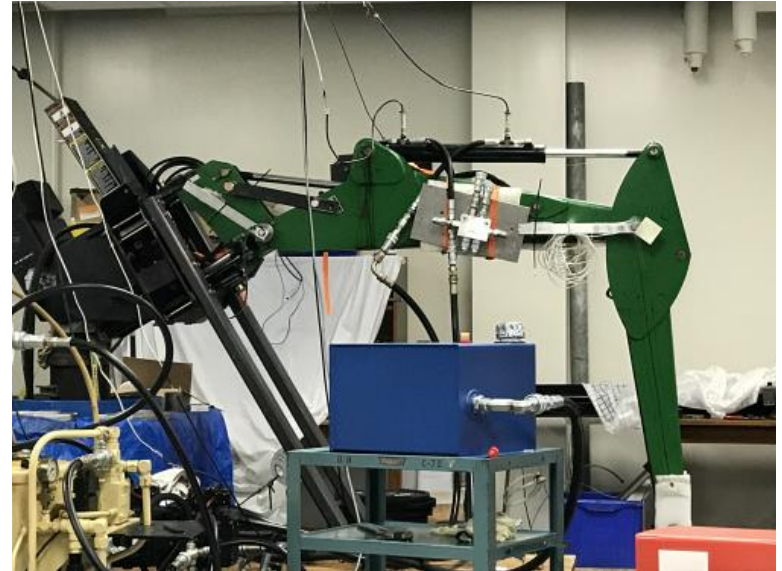
Case Study 2

Implement the modular device onto the
Laboratory Based Backhoe Machine

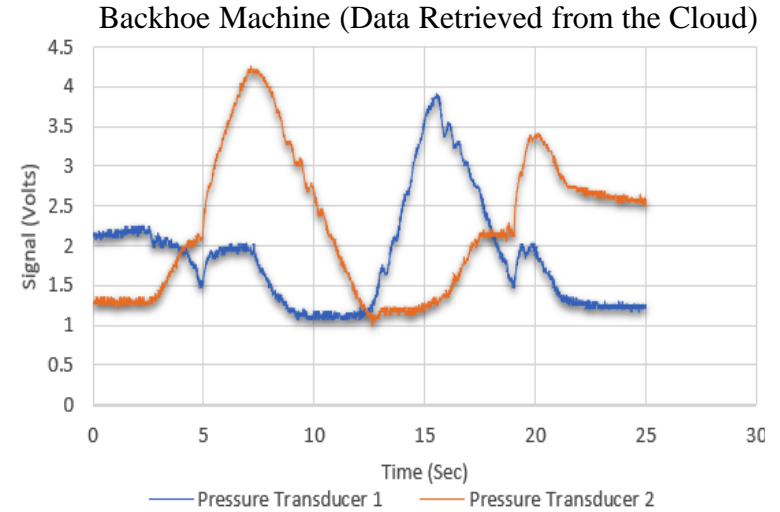
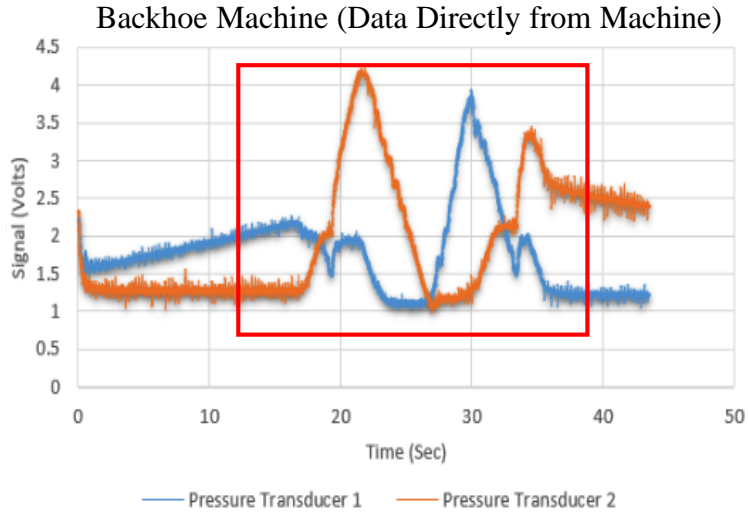
Monitoring pressure data in hydraulic cylinders
is important for internal leakage detection

Leave the modular device monitoring the
Backhoe Machine for 24 hours

Compare off the cloud data vs. Onsite data for
proof of accuracy







Internal Leakage and Fault detection Analysis can be conducted on this data

Data is of the sample level of accuracy as previous DAQ methods

Case Study 3

Implement the modular device onto an
Agricultural Farming Tractor

Monitoring Device was ran for over three hours
monitoring pressure of steering hydraulic
cylinder

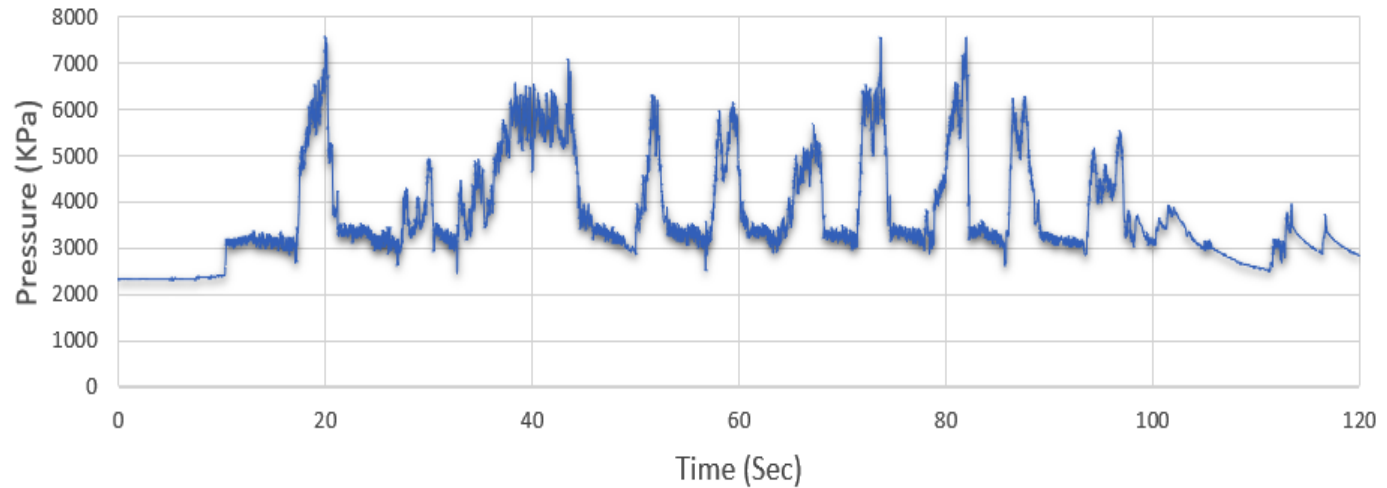
Pressure transducer attached to hydraulic
cylinder on the underside







Tractor Hydraulic Cylinder Pressure Readings: 2018/08/13 13:43:59



Internal Leakage and Fault detection Analysis can be conducted on this data

Modular Device is able to withstand robust environments is a viable option for data acquisition



Benefits

Eliminate the need for manual condition monitoring

Many machines can be retrofitted to send data to a common server

Data can be retrieved from anywhere in the world

Fault diagnosis methods can be conducted on the data

Modular Device can be used to sample and store data for long spans of time to collect large amounts of information

Future Possibilities

Modular device can sample large amounts of data over large periods of time

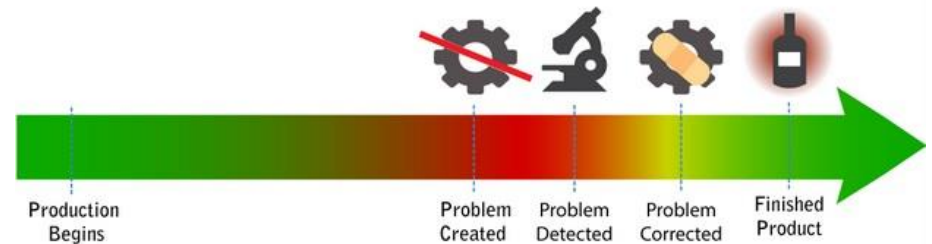
Data along with machine history and machine workload can be used to determine the state of the machine

Most optimal time to conduct maintenance can be determined prior to any breakdown

Eliminates long downtimes

Increase efficiency and reduce costs

Traditional Manufacturing





Conclusion

Based on the ideas within the Industry 4.0 framework

Modular device eliminates the need for manual condition

Three case studies were conducted to demonstrate the monitoring device

Accurate data can be acquired and sent to the cloud to be retrieved from anywhere in the world

Modular device can be a critical component to predictive manufacturing/maintenance



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Fluid Power and Telerobotics Research Laboratory