Senior Design Project
Automated High Volume Bearing Bore Gage

Concept Design Review

Team 22

Eric Allgeier – Webmaster

Matthew Boler – ME Lead
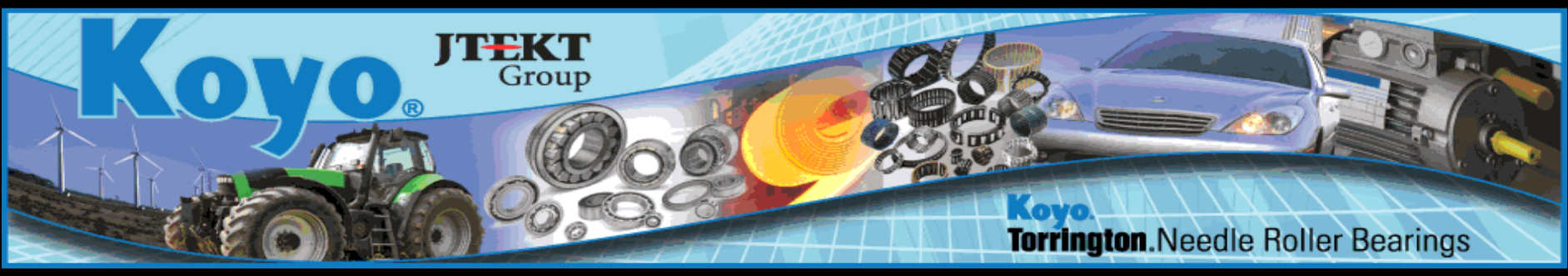
Kevin Flemming – Treasurer

Seth Norman – Project Manager / EE Lead

Christopher Proffett – Sponsor Liaison

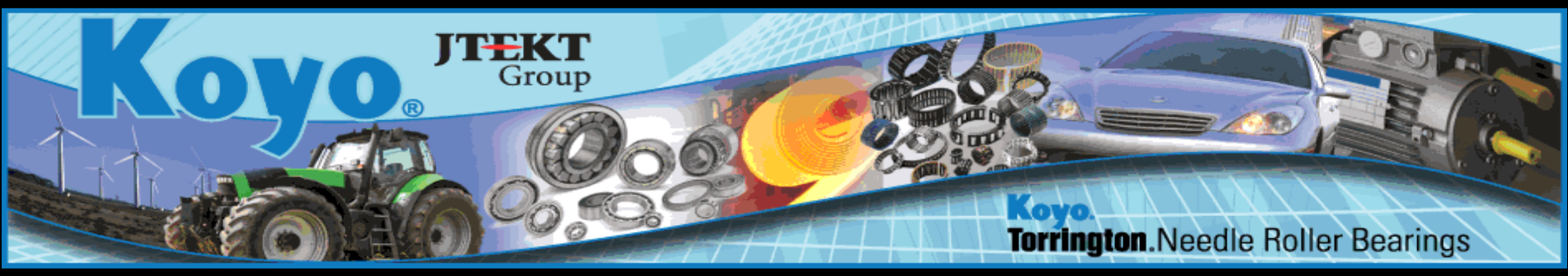**Agenda**

Intro to Koyo Bearing
Project Objectives
Fall Schedule
Component Details
Design Concepts
Possible Selections
Spring Schedule
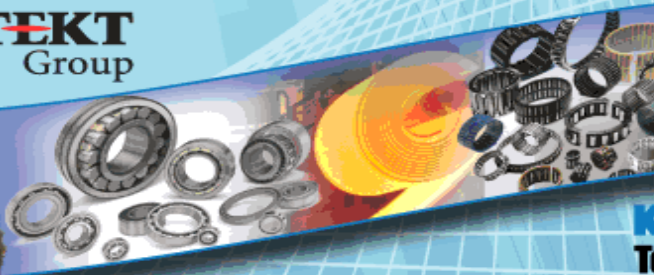Conclusion

Koyo Bearing

- HQ in Nagoya, Japan
- Produce bearings for machinery and vehicles
  - Ball, Tapered Roller, Cylindrical Roller, Spherical Roller
- Factory in Cairo, Georgia
- Contact is Robert Potts

Automated Bearing Bore Gage

- Measures bore sizes
- Determines pass or fail

Problem Statement

- Update the automated bearing bore gage
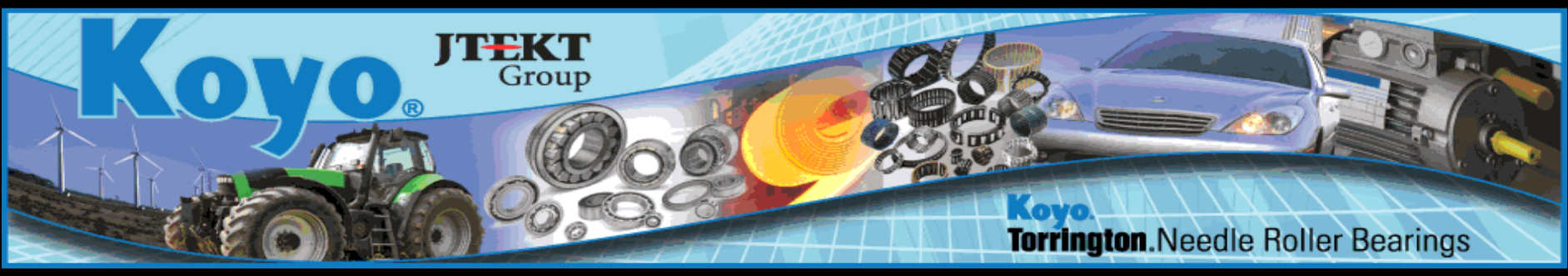- Maintain measuring quality and sampling rate
- Allow for networking with Koyo

Objectives

- New GUI
- Replace electrical components
- Keep existing pneumatic system and PLC

Fall Schedule

October

1. Research the inner workings of the machine and components.

2. Research for a heavy duty industrial rated computer and display.

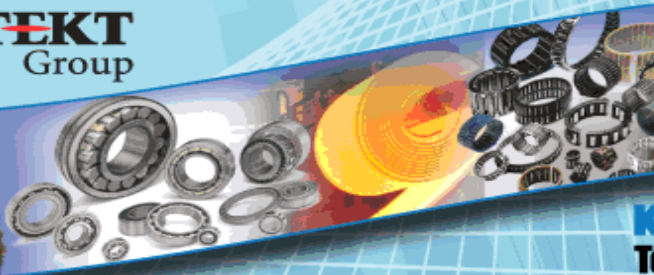3. Research interfacing options.

November / December

4. Use a Decision Matrix to choose best design.

5. Make bill of material for all the parts needed to complete this task.

6. Submit our design to Koyo Bearings.

7. Quote and order all parts needed for the design.
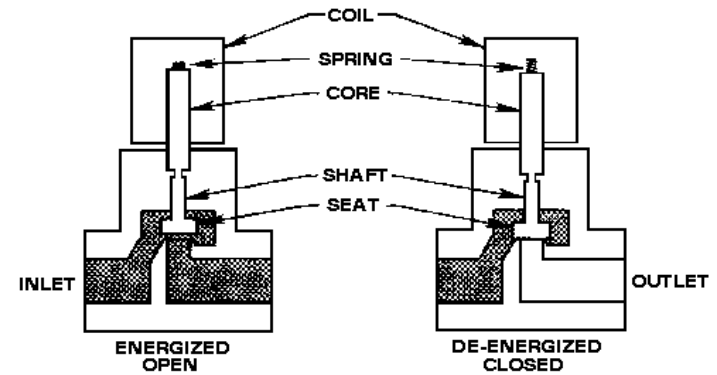
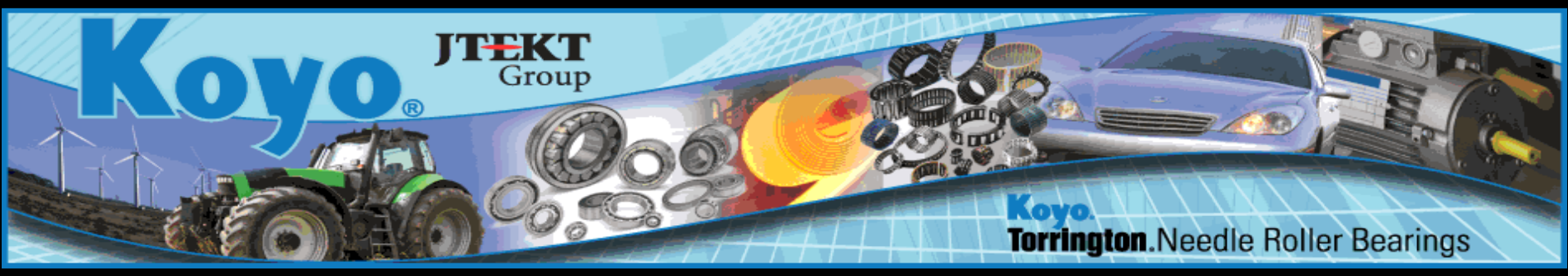8. Create Project Objectives for Spring Semester.

Pneumatic Solenoid

- Controlled by the PLC
- Solenoid produces a magnetic field
- Magnetic core moves in response to the magnetic field
- Solenoid will be used to control the pneumatic cylinders.

COIL
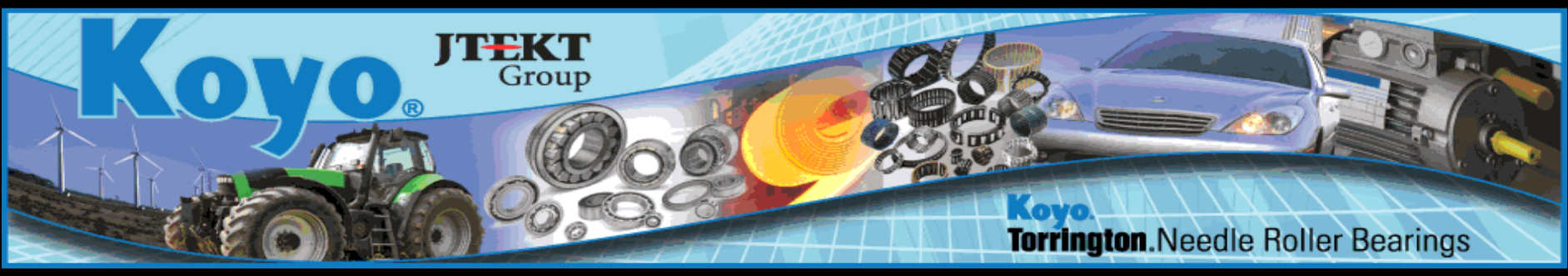SPRING
CORE
SHAFT
SEAT
INLET
OUTLET
ENERGIZED OPEN
DE-ENERGIZED CLOSED

Matthew Boler 6

Pneumatic Cylinders

- Driven by the pneumatic system
- Control all mechanical actions
- Input to a mechanism

Linear Variable Differential Transformer
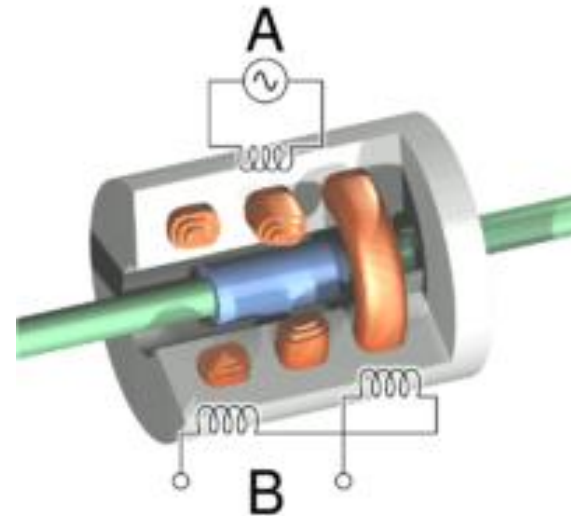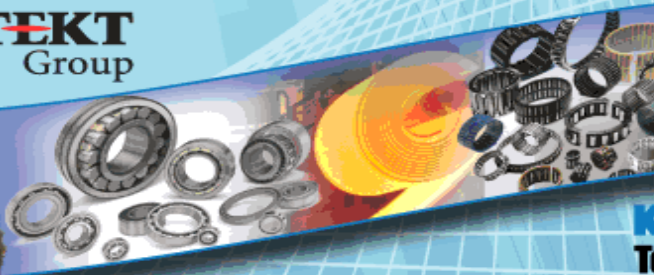## (LVDT)

- Electrical Transformer that measures position
- Primary coil is excited with an alternating current
- Sends out the differential signal between the two secondary coils
- Uses a ferromagnetic core
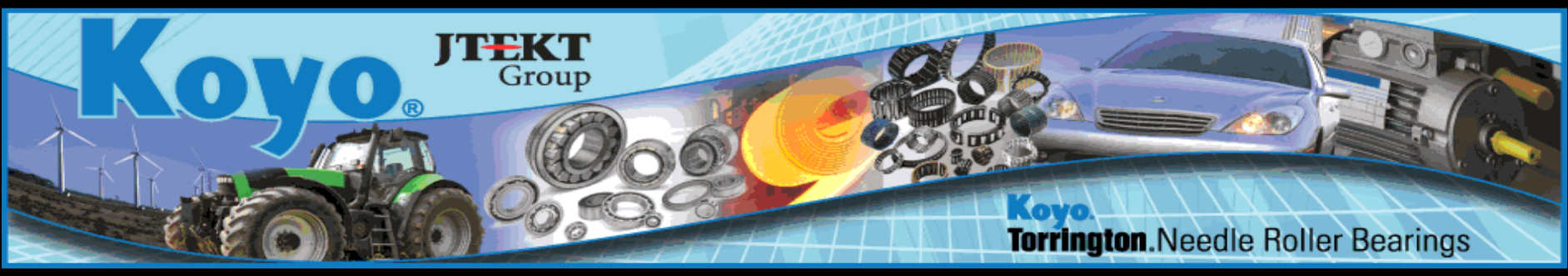- In this case, position is related to the pressure

LVDT AC Signal Conditioner (SC)

- The signal conditioner (SC) sends an excitation voltage to the LVDT.
- The SC receives two voltages back from the LVDT.
- From these voltages a calculation is performed, resulting in a position.
- When the position is within tolerances, the SC will send a logical low flag to the PLC.
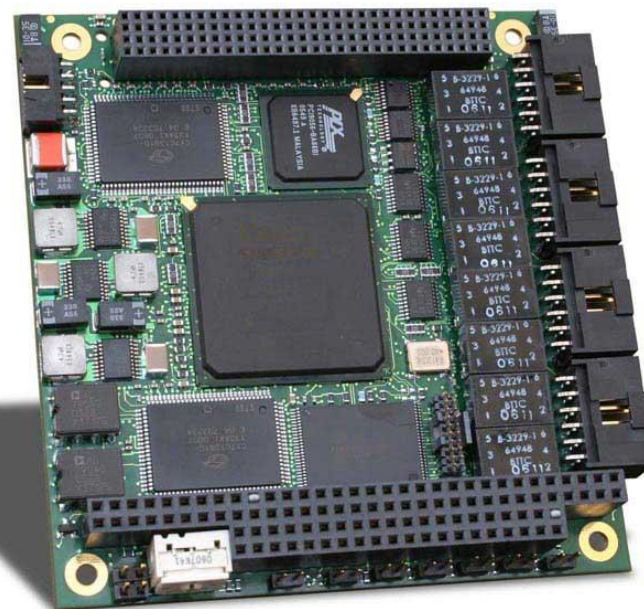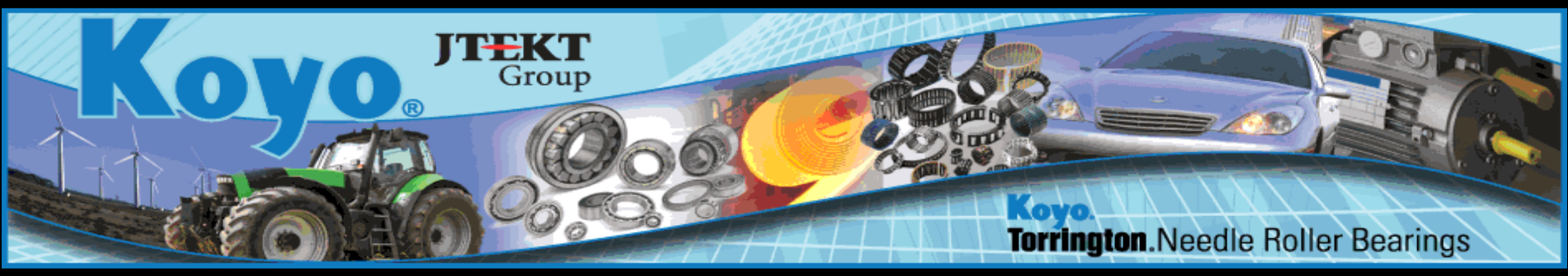- SC will send the exact position to the CPU, in the form of an digital signal (32 bit).

PC-104 Board

- PC-104 runs on Controller Area Network (CAN) bus.
- These system are very redundant.
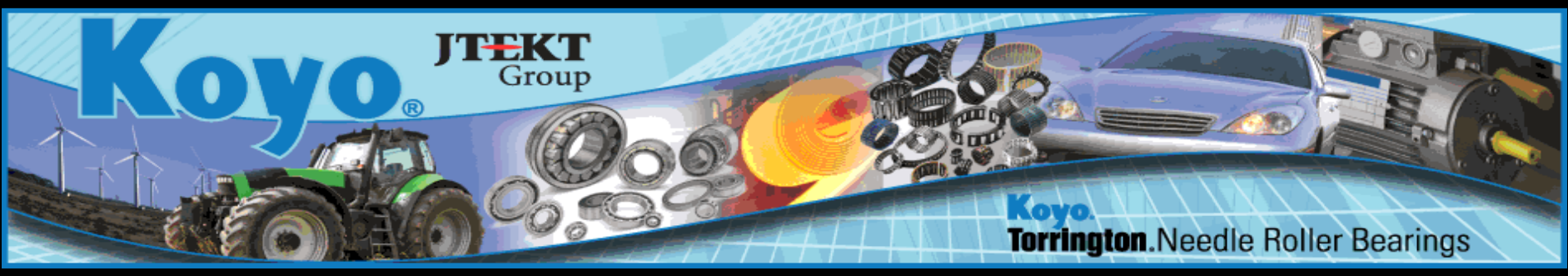- These system work on a tier level system.

Programmable Logic Control
(PLC)

- PLC is the work horse for controlling all mechanical operations.
- PLC will use a logical algorithm to make a decision if the bearing is within tolerance.
- From this decision it will command the actuators that control the pass/fail gate.
- Using existing PLC might make a monetary constraint. (Programming Software cost $2,500?)

Ethernet Switch

- The switch will network the CPU, SC, and the Koyo plant together.
- The switch will allow ease of design by the use of Ethernet cable. (RJ-45 connectors along with CAT 5e cabling).
- The switch will allow for transmission rate of 10/100/1000 Mbps.

DIN Rail

- Ease of mounting / Replacement

- All components

Central Processing Unit (CPU)

- The CPU will used to collect data from the SC.
- From this data, a histogram will be developed for the plant operator and machine operator convenience.
- CPU will be used to interface between the touch screen monitor and the SC.
- CPU will be used to calibrate the SC for the maximum and minimum bearing size.
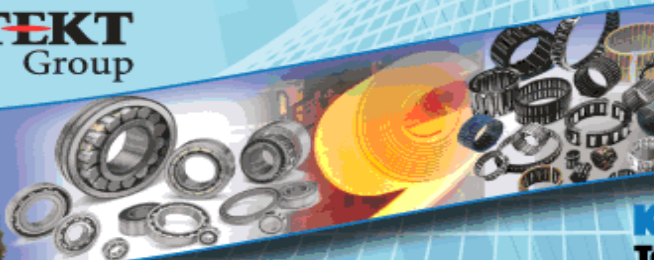
Touch Screen Display
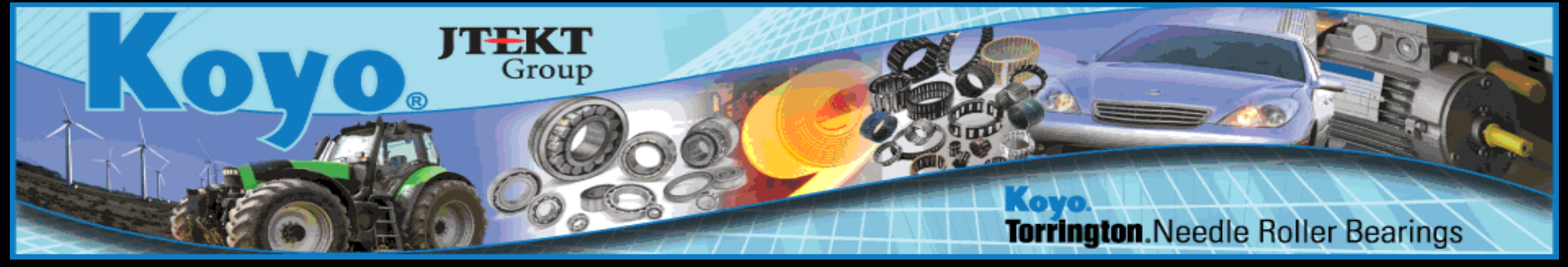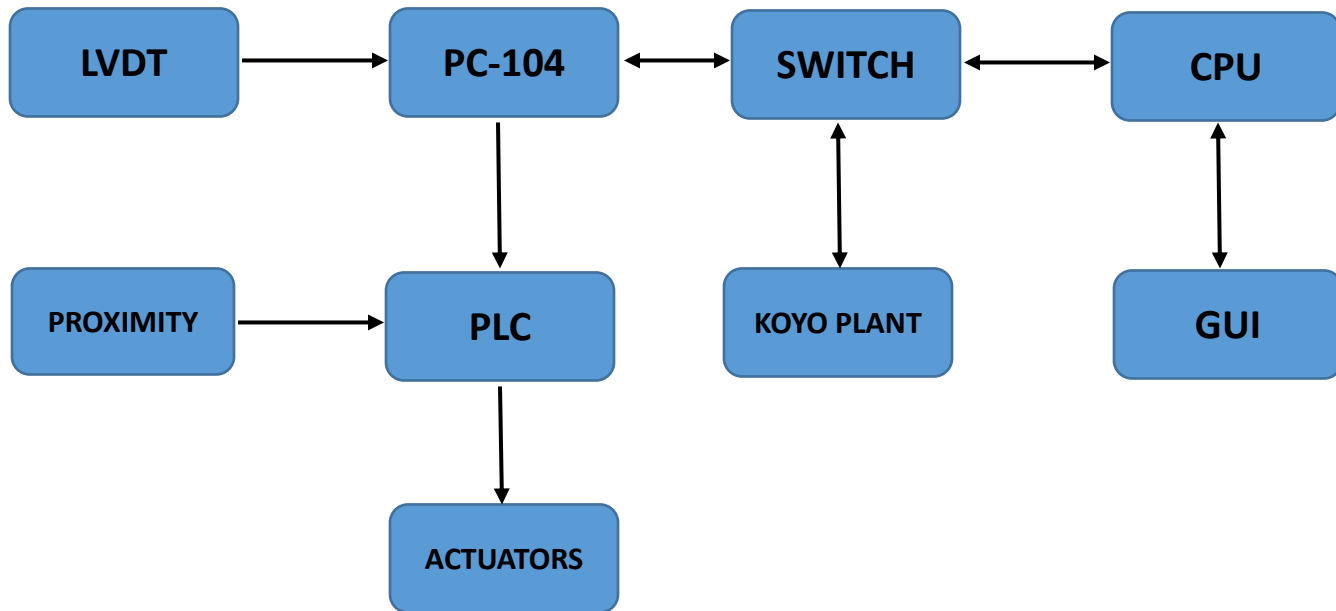
- Connects to the CPU via USB and HDMI
- Ease of operation through touch screen
- FPM-5191G-X0AE
    - 19" touchscreen HD LCD monitor
- Monetary constraints

Concept 1: PC-104

Utilizes a PC-104 board and the CPU.

```
LVDT ────────▶ PC-104 ◀────────▶ SWITCH ◀────────▶ CPU
                  │                   ▲                ▲
                  │                   │                │
                  ▼                   ▼                ▼
PROXIMITY ───▶  PLC              KOYO PLANT           GUI
                  │
                  ▼
              ACTUATORS
```
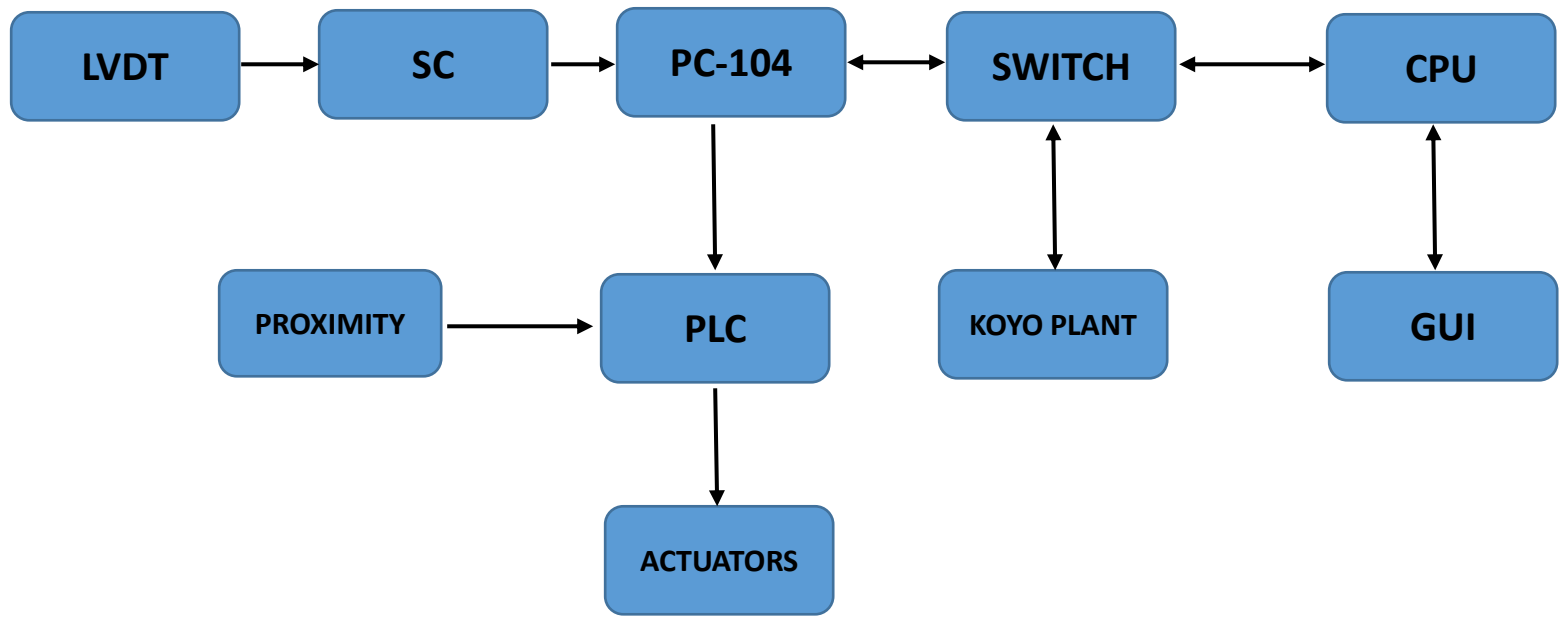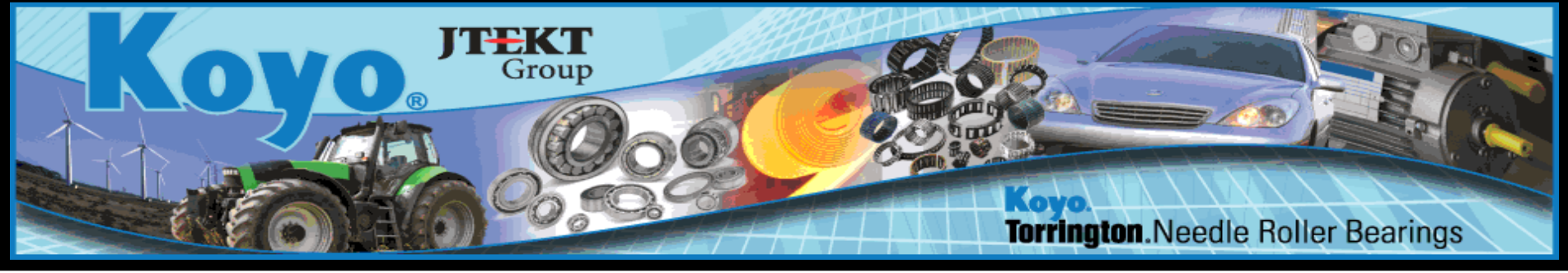
Concept 2: Signal Conditioner and PC-104

Utilizes a PC-104 board in conjunction with a signal conditioning module (SC).

LVDT → SC → PC-104 ↔ SWITCH ↔ CPU

PC-104 → PLC

PROXIMITY → PLC

SWITCH ↔ KOYO PLANT

CPU ↔ GUI

PLC → ACTUATORS

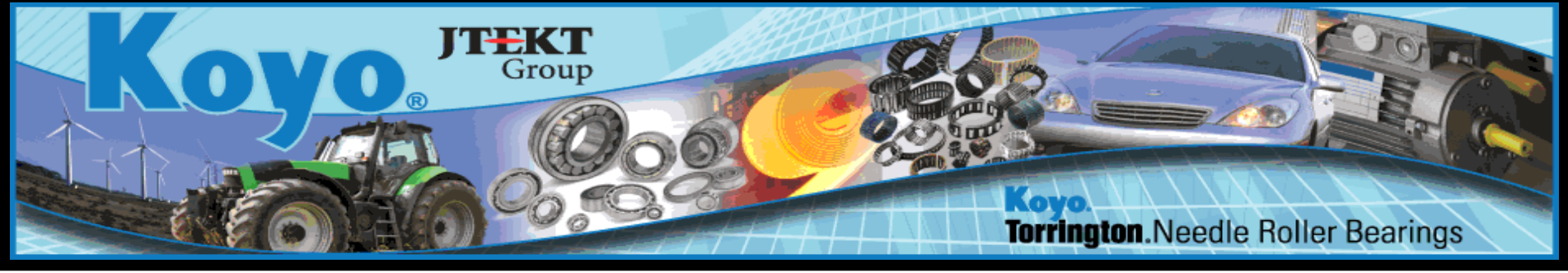## Concept 3: Signal Conditioner to PLC

Uses only a signal conditioning module in conjunction with the PLC and CPU.

LVDT → SC ↔ SWITCH ↔ CPU

SC → PLC

PROXIMITY → PLC

SWITCH ↕ KOYO PLANT

CPU ↕ GUI

PLC → ACTUATORS
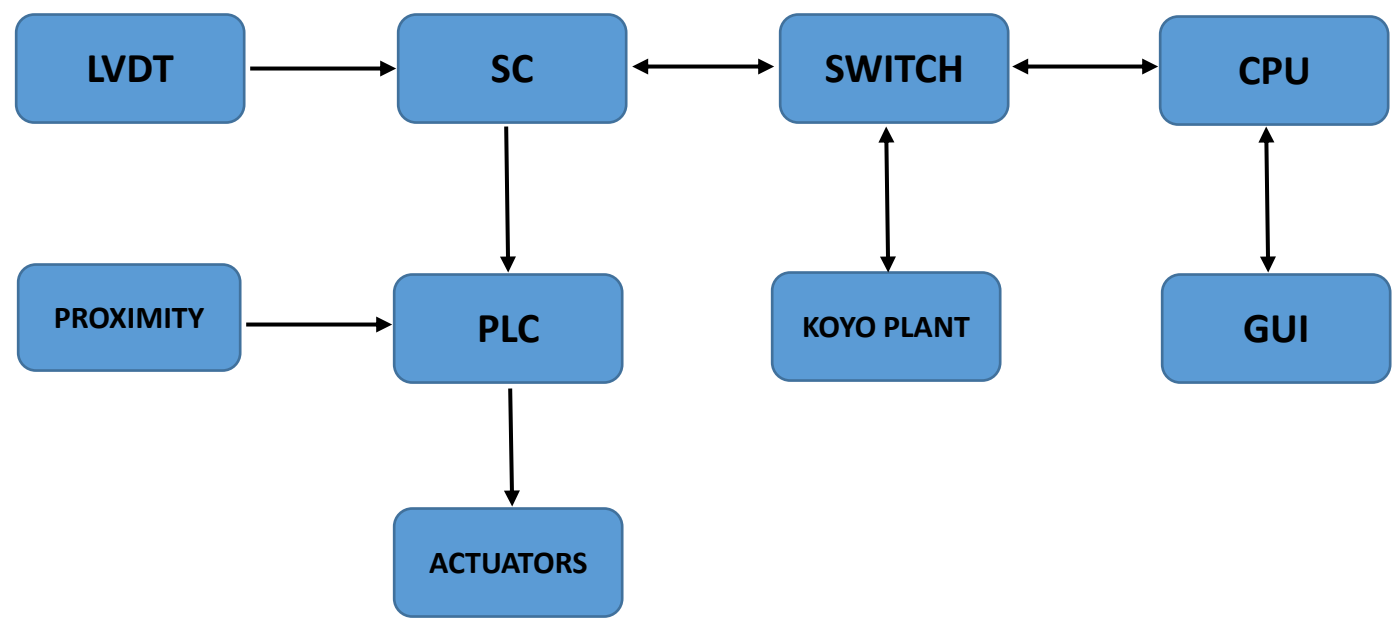
Concept 4: SC to Switch

CPU communicates with SC and Koyo simultaneously.
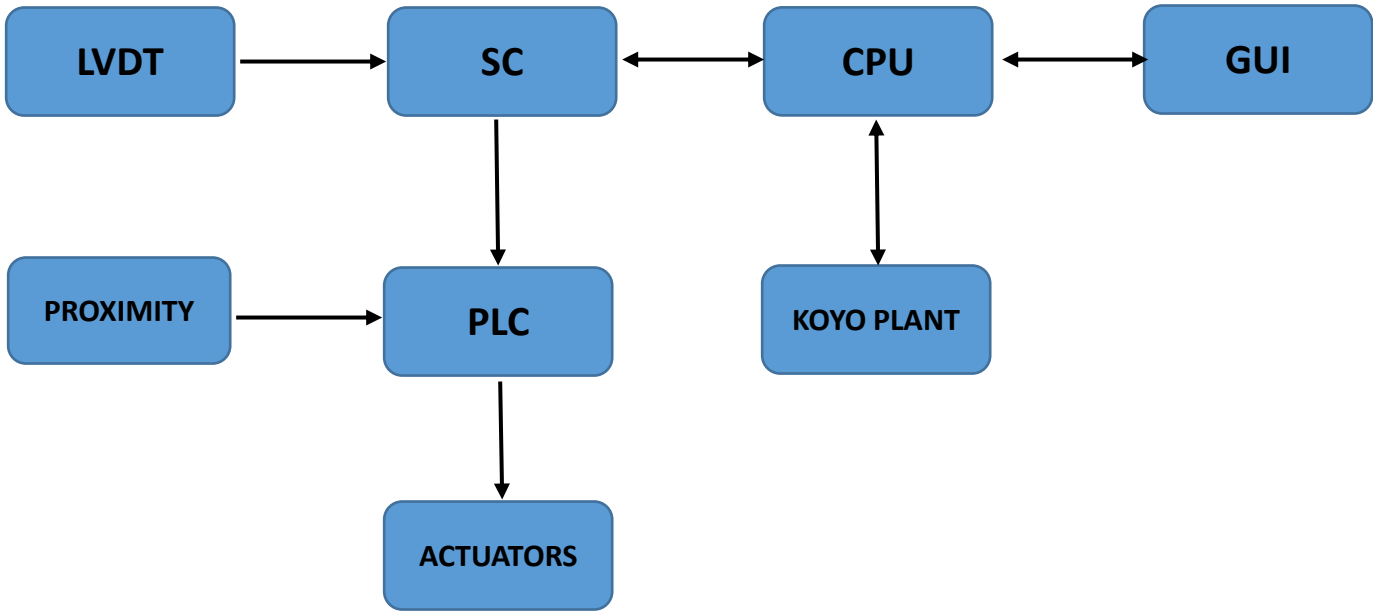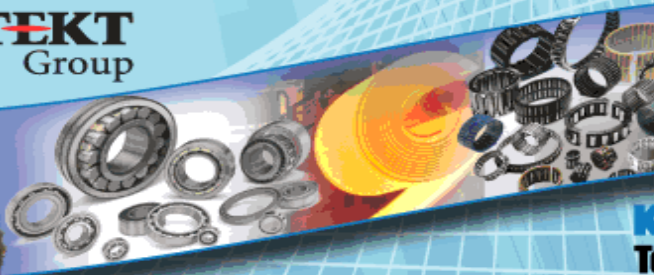
```
LVDT  ───▶  SC  ◀───▶  CPU  ◀───▶  GUI
             │          ▲
             ▼          ▼
PROXIMITY ─▶ PLC     KOYO PLANT
             │
             ▼
          ACTUATORS
```

LVDT Signal Conditioner

MODEL	COST	QTY	SIMPLICITY (MAX = 100)	TOTAL COST
AnyNET I/O ANR2	$895/$815	2	98	$1710
LVC-4000 Series AC	$521	3	70	$1563
MMx-1000 Series AC	$350	3	65	$1050
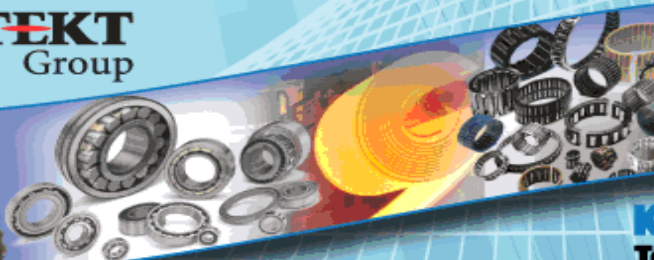
Ethernet Switch

Ethernet Switch	Cost	# of Ports	Speed [Mbps]	Power Consumption [W]	MTBF [hrs.]
N-T1005TX	$288.00	5	10/100/1000	36	2,000,000
EISK5-GT	$148.00	5	10/100/1000	3	N/A
IES5100	$77.24	5	10/100	2.4	1,677,807

Power Supply

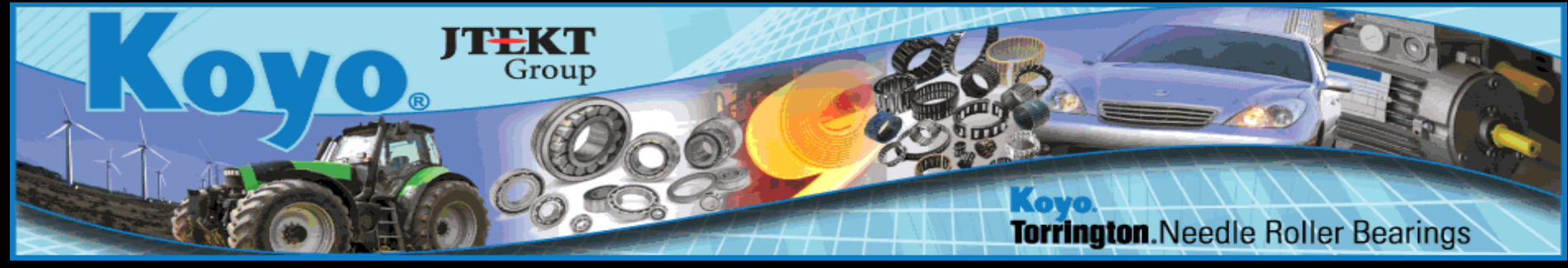| Power Supply	Cost	Output Voltage [VDC]	Output Power [W]	Housing	MTBF [hrs.]
PSB24-060-P	$28.00	24	60	Plastic	>800,000
PS24-050-D	$99.00	24	50	Metal	2,992,000
1769-PA4	N/A	24	48	Metal	N/A
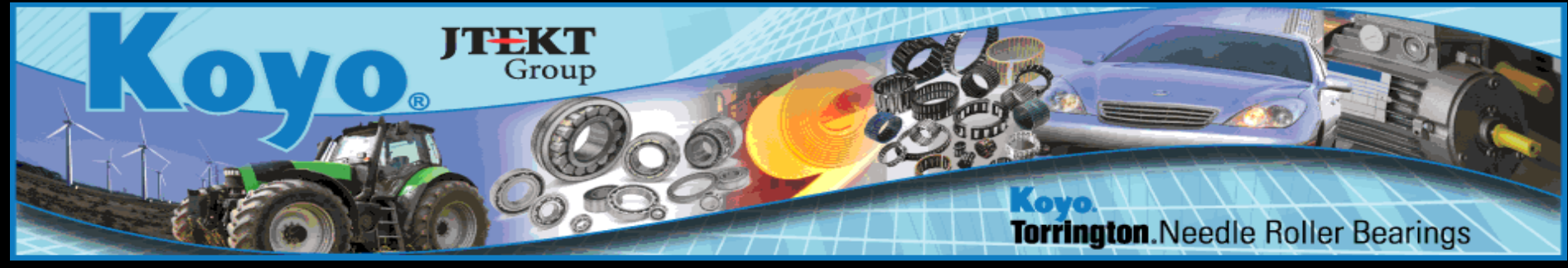
Spring Schedule

- January
  - Remove old electrical components from the machine
  - Install new components
- February / March
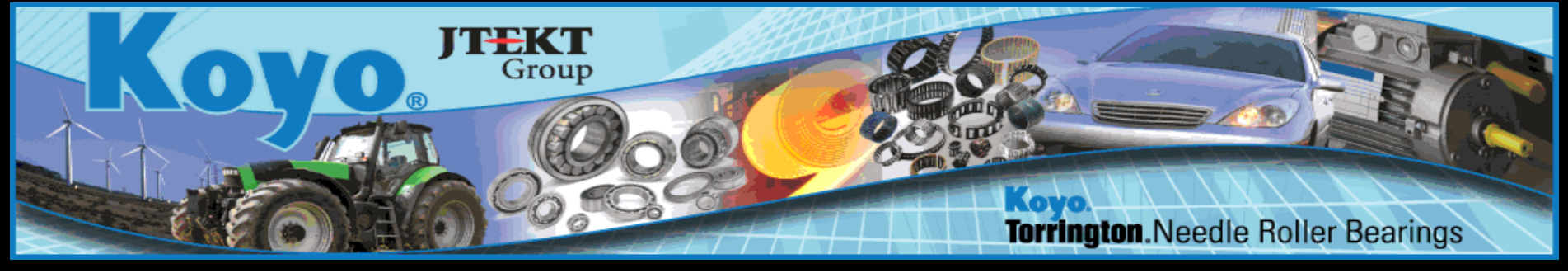 - Program and test all components.
- April
  - Debug

Conclusion

- Mechanical aspects meet Koyo Bearing's standards

- Update the electronic components of an Automated Bearing Bore Gage

- In the process of choosing an electrical layout
    - LVDT, SC, PC-104, PLC, Proximity Switch, Pneumatic Actuators, Switch, CPU, GUI

Questions and Comments

References
http://eng.fsu.edu/me/senior_design/2014/team22/