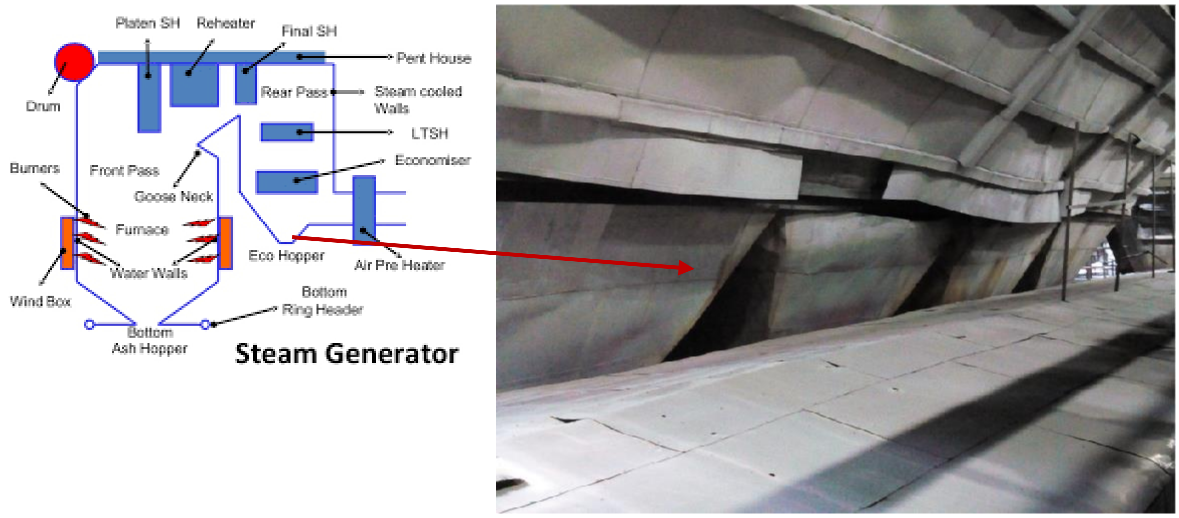
Online Monitoring to identify Economizer hopper chocking

Economizer hoppers: These are the first kind of turn hoppers where ash deposits at the first bend of a boiler. It's very hot at 330 to 400 Degree Centigrade and deposits in 4 huge hoppers. Each hopper has four faces and each of about 3 meters high.



We needed to find out a suitable monitoring system to ensure that these hoppers are empty all the time – that means the ash coming inside the hopper are going out simultaneously. When extremely hot ash flows continuously, it heats up everything that comes around its way. If we can measure the hopper skin temperature continuously then we can have an idea what's happening inside the hopper.

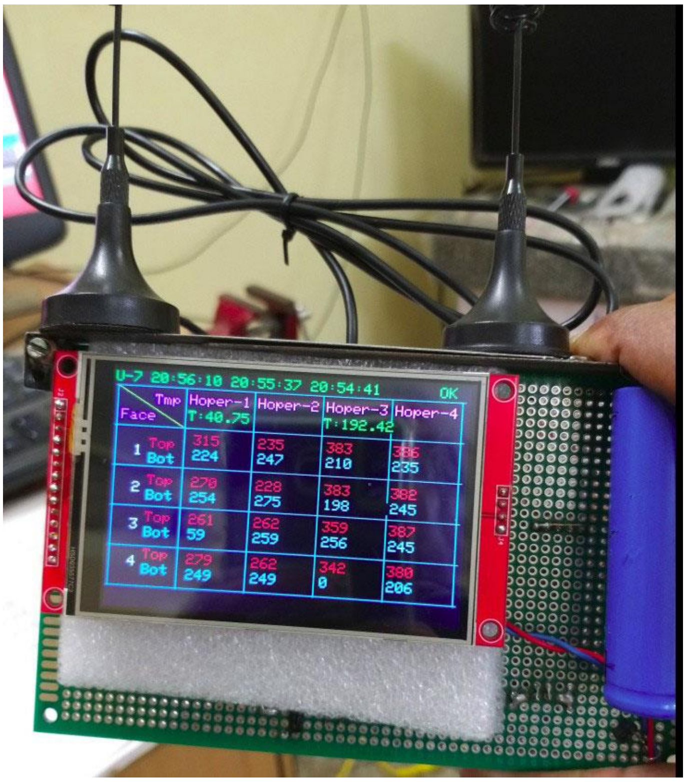
Strategy: For four faces if we can measure 8 temperatures [4 on top of the hopper where ash enters into the form of a shower and four on bottom of the hopper where it leaves the hopper], we can confirm that status inside. If all the 8 temperatures are same and above 250 Deg C for top and above 120 Deg C on bottom, then it's pretty clear that the boiler is running and ash is flowing through continuously. On the contrary if it's high on top but low on bottom, the ash is not blowing out – it's settling at the bottom! The hopper is choking otherwise.

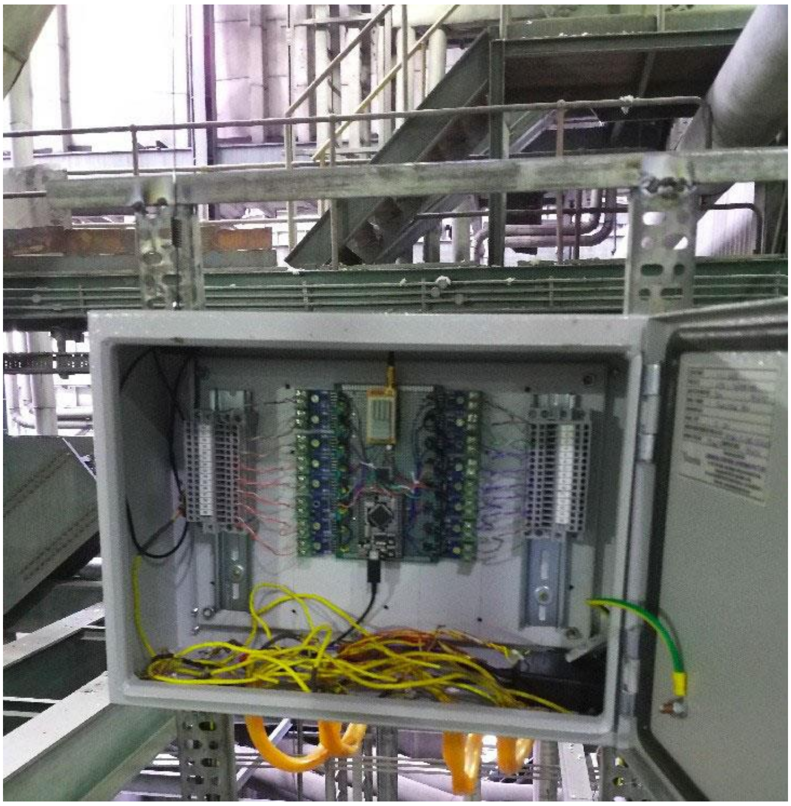
As the choking increases, the temperature differences increases further. If it is fully choked then the top temperature will be above 250 while the bottom temperature will steadily reduce to below 100 Degree C. To facilitate record of data into an attached SD Card, we have added an RTC [Real Time Clock], DS3231 on the board.

Deployment: Cabling at the vicinity of such high temperature is the real challenge. So to make things simple we decided to deploy long lead MI [Metal Impregnated] thermocouples – MAX6675 with 5meter or more cable. We cut the insulation on the body of the hopper and then fixed those long lead thermocouples on the hoppers. Eight such thermocouples are fixed on the four faces. Each hoper will have a node. Each node will consists of an ATMEGA2560 processor, a real time clock -DS3231 and a spread spectrum transceiver. Since an ATMEGA2560 has 53 GPIOs we have the future provision of putting more thermocouples at the center of each face. RTC – DS3231 is very precise and it has an on board temperature corrector to adjust the quartz frequency. It hardly varies a few milliseconds per year. With this RTC besides time, we will also be able to transfer ambient temperature of the sender unit along with time stamp on it. The data arrives once in 6 seconds.

Prototype: Small MCUs like ATMEGA has the advantage of operating at small power besides having all the intelligence it needs like UART bus, I2C, SPI or ADC etc.

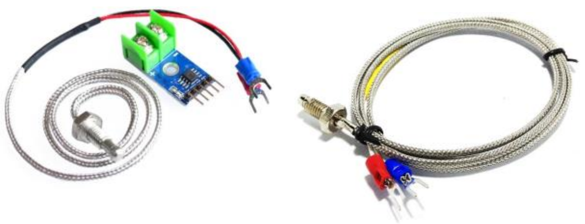
[Prototype testing at lab]





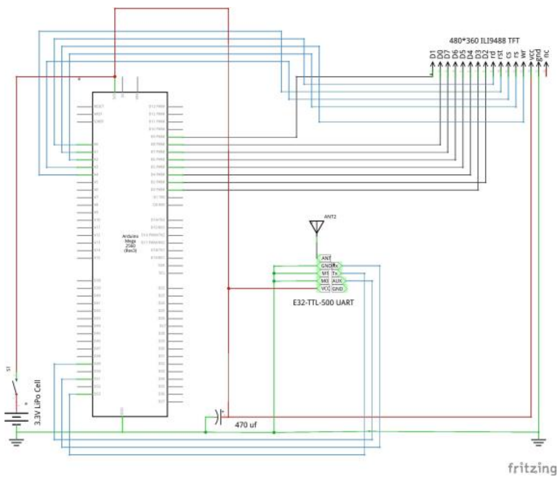
On the left is the module which will send TC [Thermocouple] data using the SS Transceiver. So far we have tested it with 32 long lead [5 meter] K-type MI thermocouples. The ATMEGA2560 processor we used has 53 GPIOs. The other 4 thermocouples will be connected on the opposite side of the board.

Insight: In case the remote transmitter stalls, there is no way to know the receiver unit about that situation. To overcome this we've added one RTC -DS3231on the receiver unit as well such that while receiving data from the remote unit, it constantly checks the lag time in seconds and if it increases beyond 30 seconds it indicates 'STALLED' on the receiver unit. For collecting the signal from as long as 5 meter lead distance was a problem.

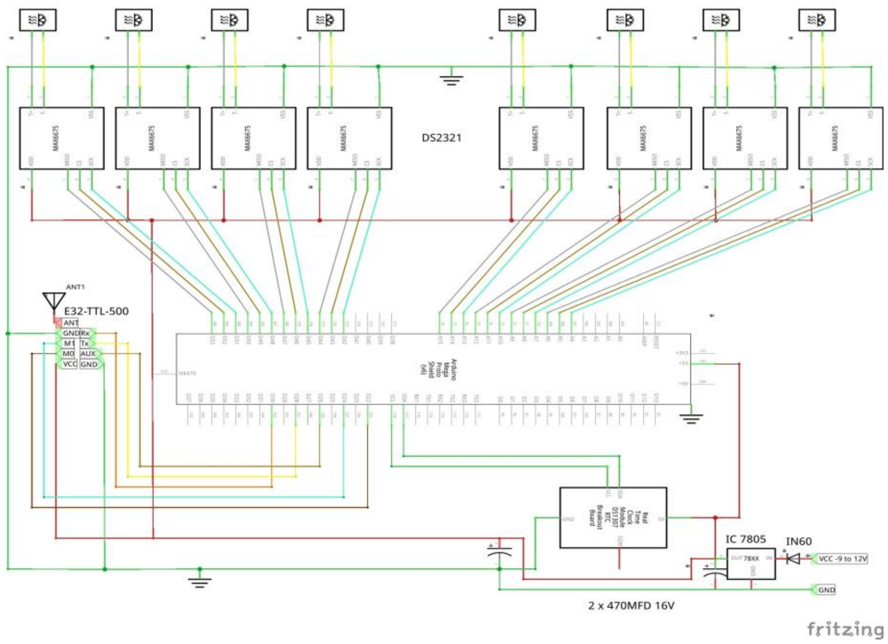


Therefore, we used long lead [5mtr or more] MAX6675. MAX6675 runs on 5 Volt and has a measuring range of 0 to 600 Deg Cent – enough for our case and costs only $8 a piece at aliexpress.com. The library max6675.h has everything to measure temperature by just using one line of code. MAX6675 has an error of +/- 1 deg cent.

Data receiver:



Data Uploader:

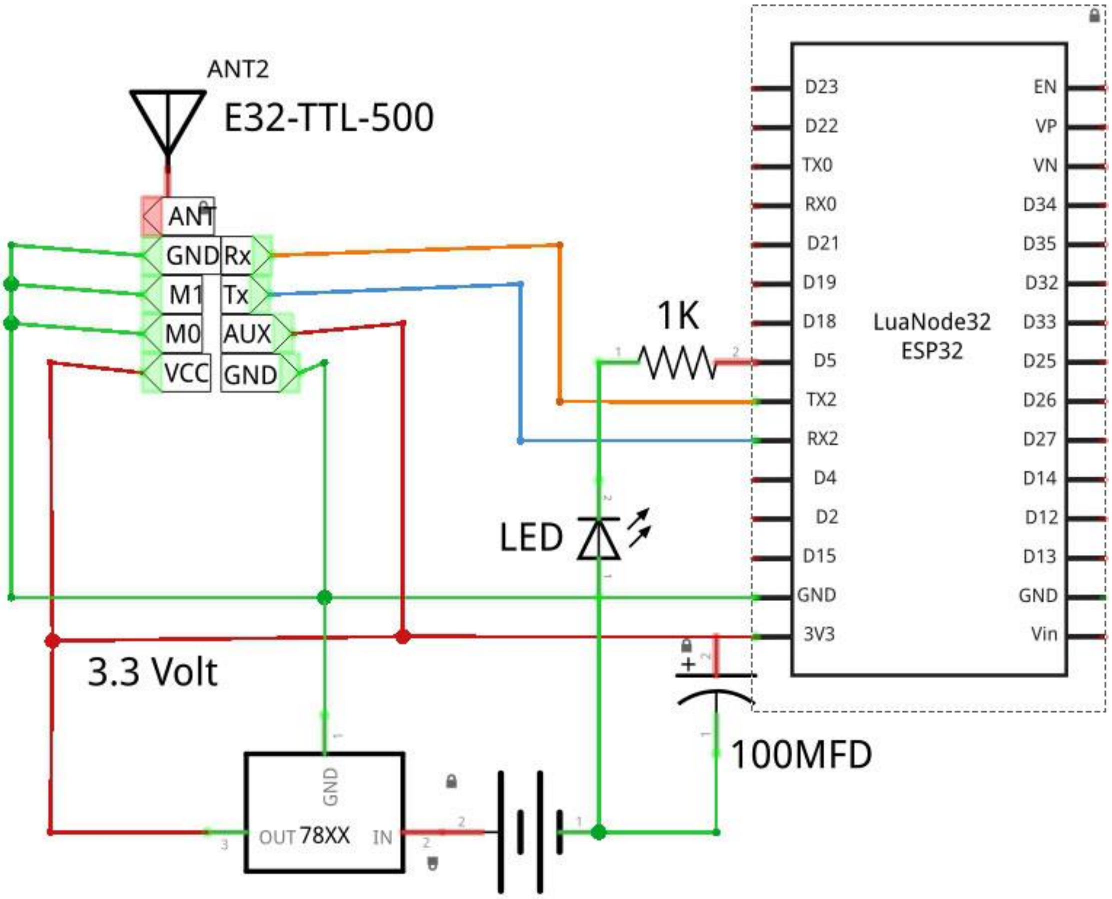


Uploader at site: [in an IP64 waterproof box]

Handheld viewer:

Softwares: Three software sketches built on ATMEGA 2560 arduino IDE are included here – Sender & Receiver unit.

Cloud uploader: Here we cleverly deployed one ESP32 with WiFi connection at one end and LoRa radio connection at the other end to upload data to NTPC cloud till we develop an way to upload data to the MODBUS system of the DCS.



Aftermath: The idea was hatched along with NETRA and is continuously evolving. This is just a beginning. Finally the data will be sent to a laptop having powerful tensorflow module installed in Python to develop a machine learning model to self-analyze and declare its own state with more than 98% confidence!

Since transfer of data on air using [865 MHz – 867 MHz] free frequency band in India with 4 byte encryption is no problem, we can use this technology to monitor for all kinds of metallic hoppers for material flow with artificial intelligence.

After covering the ECO hoppers we will take up for the ESP hoppers where ash flow and chokings are more frequent at higher ash content.

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