EEE163 Systems Design Analysis – Mechanical Boiler Timer Tear Down

1 Task A

Product Name: MT10 Mechanical Timer (**Figure 1**)

Part Number: 8 716 106 663

Manufacturer: Worcester (Now Worcester Bosch)

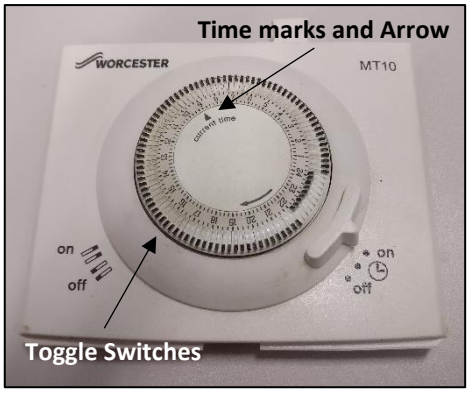

Figure 1: Worcester MT10 Mechanical Timer

2 Task B

To switch the central heating of a house on and off at user set times over a 24-hour period in 15-minute intervals.

3 Task C

The front dial of the Mechanical Timer shown in **Figure 1** contains a set of 96 mechanical toggle switches, allowing the user to program their central heating cycle over a 24-hour period in 15-minute intervals. The time the switch corresponds to is shown via markings in the centre of the dial; the current time is shown by an arrow pointing to one of the markings on the dial. A switch pushed towards the centre of the dial turns the central heating on for the corresponding 15-minute interval.

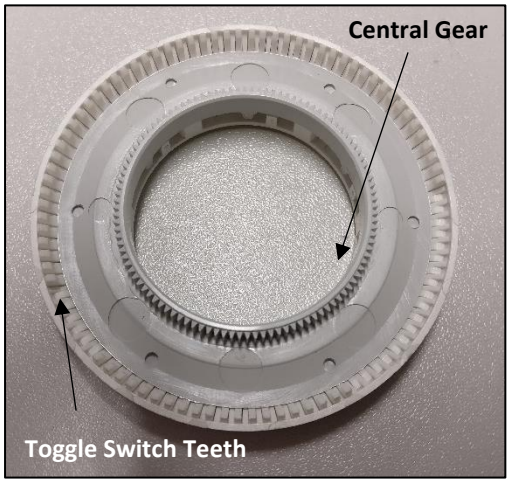

Figure 2: Backside of Front Dial

Figure 2 shows the back side of the front dial. When the toggle switches are pushed towards the centre of the dial (central heating on) small teeth protrude from the outer circumference of the dial. These teeth actuate a switch via a lever mechanism that electronically signals whether the central heating system should be on or off.

Figure 2 also shows the gear incorporated into the wall of the central cut out of the front dial. This gear mates with an internal gearing system that is driven by a shaded pole electric motor [1], allowing the system to maintain the current time by rotating the front dial.

4 Task D

The product is entirely assembled from press fit or snap fit injection moulded parts. Press fit parts are held together due to their high dimensional tolerance producing large amounts of friction between the parts when they are mated together, making them difficult to separate. Snap fit parts uses small latches to lock parts together once they have been pushed in place. Parts such as the Printed Circuit Board (PCB) and Nylon Gears are sandwiched between the top and bottom sections of the case, holding them in place.

Signs of injection moulding are shown in **Figure 3** via the sprue markings left on the part as well as the material specifications moulded into the case design. Due to the simplicity of the products assembly and the lower required scale of manufacture it is likely this product was hand assembled.

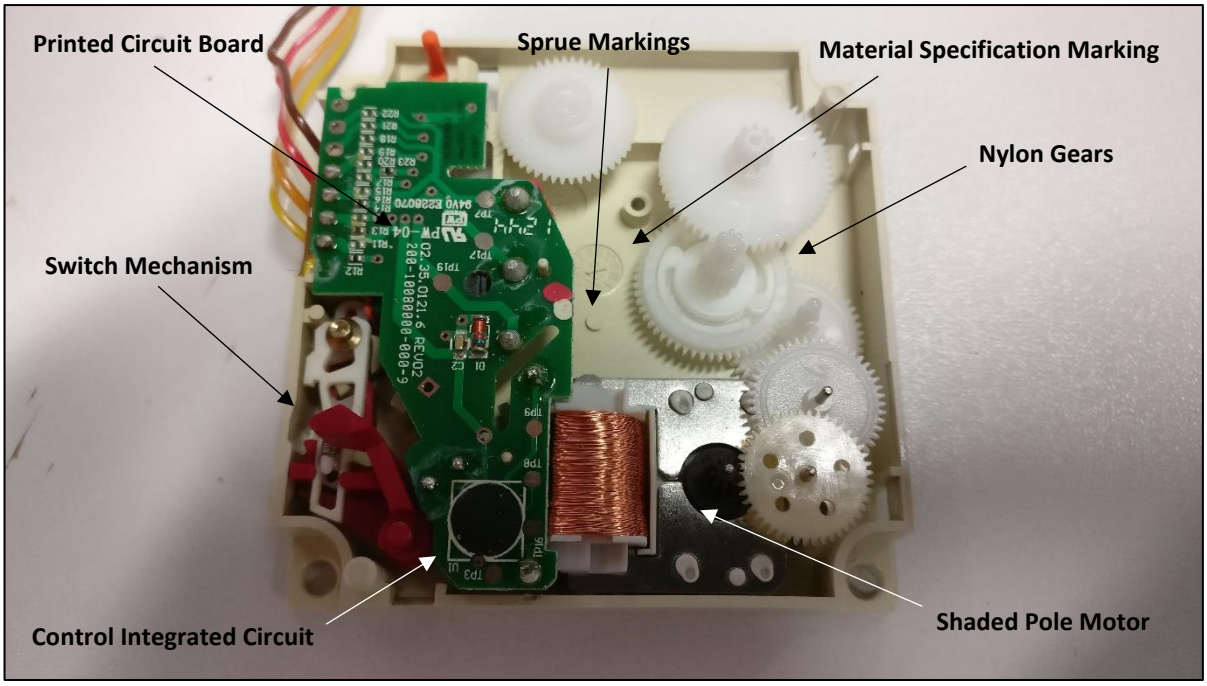

Figure 3: Inside of main system casing

5 Task E

Input:

- A rotary dial with a set of 96 mechanical toggle switches that engage and disengage an electrical switch as the front dial spins.

Output:

- An electric motor for rotating the gearing system to maintain the current system time.
- An external wire to board connector incorporating system power wires and a signal wire that connects to the rest of the boiler system.

6 Task F

- Custom Injection Moulded Casing Parts (6) (Polyphenylene Ether, Polystyrene, Glass Fibre)
- Flat Profile Shaded Pole Inductor (1) (Steel, Copper Wire, Plastic Parts)
- Custom Printed Circuit Board (FR4)
    - SMD Capacitors (3) (Ceramic)
    - 32.768kHz Crystal Oscillator (1) (Quartz)
    - Integrated Circuit (1) (Silicon, Potting Compound)
    - Diode (2)
    - Cherry DB Series Sub Miniature Switch (1)
    - SMD Resistors (6)
    - Wire to Board Connector (1)
- Custom Injection Moulded Gears (6) (Nylon)

7 Task G

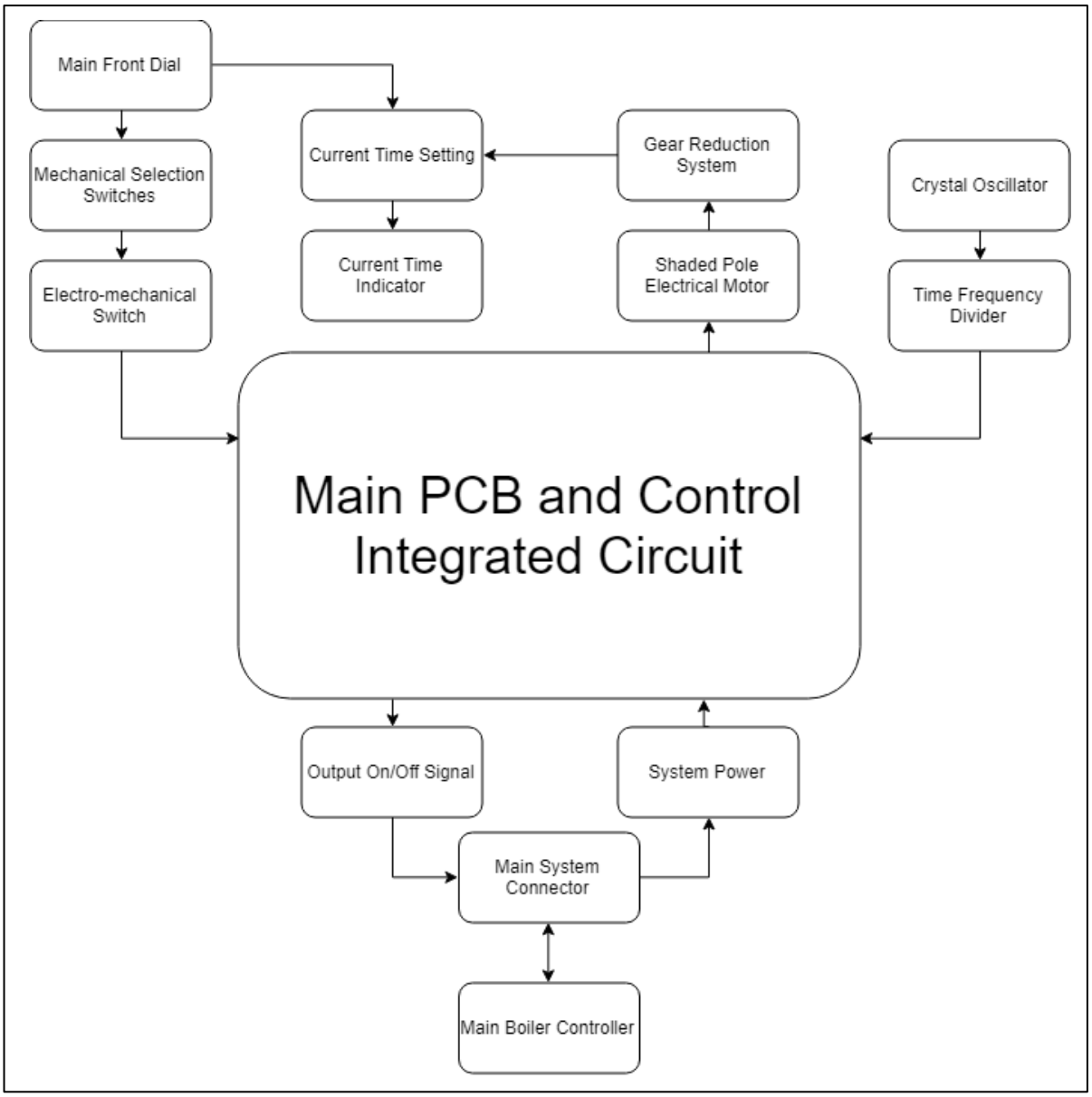

Figure 4: Systems Diagram of the Mechanical Boiler Timer

8 Task H

The likely failure mechanisms for the product are as follows:

- Snapping of small nylon gears with delicate teeth profiles.
- Wearing out of nylon gear teeth.
- Electromechanical Switch Failure.
- Small mechanical toggle switches breaking or snapping.
- Fraying or breaking of wires/connector to main boiler controller.
- Corrosion of circuit board due to temperature and humidity inside boiler.
- Failure of circuit board components due to high temperatures inside boiler.

9 Task I

The main electromechanical switch inside the timer used to send the on or off signal to the main boiler controller is a Cherry DB Series Sub Miniature Switch [2, pp. 12-15]. This switch uses a sprung actuator connected to a contact. This contact is moved between the other two contacts via the actuation of the button on the top of the switch casing, this gives the switch the ability to act as a normally closed or normally open actuator, allowing two input signals to be generated within the system from one device and giving the system the ability to fail safe (boiler switched off). A diagram of the switch mechanism can be seen in **Figure 5**.

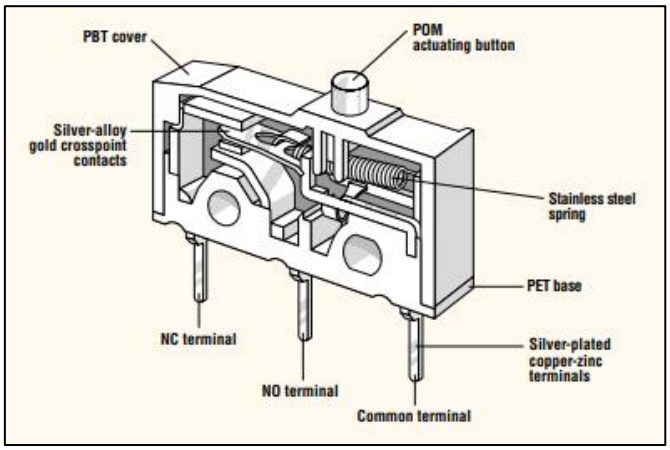

Figure 5: Cherry DB Series Switch Mechanism Diagram [2, p. 12]

The mechanism is rated for 15 Million actuations and can operate in environmental temperatures up to 120°C. The switch used in the mechanical timer is a DB6 variant and thus can carry 6A at 250VAC. Materials such as Silver and Gold are used to improve the conductivity and lifetime (resistance to oxidisation and corrosion) of the internal contacts; plastics such as PET and PBT are used to protect the internal mechanism and to provide electrical insulation.

10 Task J

Modern systems that perform the same function are now completely electronic and vary in performance and functionality. All systems comprise of small wireless modules (approximately 200 x 100 x 10mm) that incorporate thermostat and timing functionality; the wireless capability allows the device to be placed anywhere in the house, providing a better temperature reading. Device functionality ranges from simple temperature and timing settings on a small liquid crystal display to smart phone connectivity that allows remote control of the houses temperature and gives graphs of energy usage and cost in real time. All devices are battery powered to support their wireless functionality and usually incorporate a wall mounting system. Due to the wide range in performance and functionality the price of these modern systems varies from approximately £40 to £240.

11 References

[1] P. H. Trickey, “An Analysis of the shaded pole motor",” September 1936. [Online]. Available: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6540295&isnumber=6540283. [Accessed 15 03 2018].

[2] Cherry Electrical Products, “Cherry Switches Master Catalog,” 2004. [Online]. Available: https://www.mouser.com/catalog/supplier/library/pdf/Cherryswitches.pdf. [Accessed 15 03 2018].