Academic Journal– Smart Packaging

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Abstract- Monocrom, a large laser device manufacturer proposed a project in which students would collaborate to design a *smart packaging*, the packaging is used for transporting expensive laser diodes and should be designed to monitor the conditions while in transit and store the information to be checked upon arrival.

Keywords— smart, package, sensors, monitor

I. Introduction

WHEN faced with the issue of diodes being damaged during shipping Monocrom then began do develop a robust packaging that could be used to protect the diodes throughout their journey. Monocrom then decided to then develop a *smart packaging* that could detect at which point the diode was being damaged and by what cause.

Monocrom approached Escuela Politécnica Superior de Ingeniería de Vilanova i la Geltrú (EPSEVG) to collaborate with a European Project Semester (EPS) team to solve the issues brought on by mishandling of diodes. The budget was set at €25 per diode and the package and was initially intended to monitor vibration, shocks, electro-static discharge (ESD), temperature and humidity. The package must also be designed with the intent of using the package for a second purpose and should take into consideration the environmental impact of manufacturing and recyclability.

II. The Issue

20.3% of laser diodes are being damaged by unknown causes and returned to Monocrom, the diodes leave Monocrom's facilities in working condition and are therefore being damaged either in transit or by the customer. By developing a smart package, we can monitor if the diodes are being damaged in transit or after being opened by the customer. We can determine by what means and at what time the diodes are being damaged.

III. Current Smart Packaging Solutions

The first steps in designing a smart packaging were to research the market for any similar existing solutions for related products. After researching the market, it was obvious that there is a gap for packaging which incorporates sensors and monitoring, this then meant that a design must be created by researching different forms of *smart packaging* out with the field of electronics.

Much time was spent researching smart packaging solutions but all current solutions use non- electronic type sensors and mostly exist in the food sector which is not suitable for our desired solution. Team members used their previous knowledge of electronics and designed a solution consisting of a microprocessor and two sensors which would be enough to monitor the package.

IV. Graphic Design

If Monocrom decides to use this smart packaging, extra information is needed to give the customer the ability to know what they must do when it arrives. The package also needs some specifications about what exactly is inside and information about the company and the customer. Therefore, we had to work on the graphics of the box, the stickers and the symbols to produce a complete design of what we had been asked to do.

Firstly, the team decided the symbols that had to be on the cardboard box to show what kind of product is inside. The symbols that were chosen are the fragile symbol, because the products are sensitive, the opening symbol, that it must be stored the right way up, and the recycling symbol.

The fact that there are sensors in the packaging makes necessary to notify Monocrom's customers about that the packaging is monitored. It is important that the customer knows that he doesn't have to act normal with this packaging; he must follow the previous instructions. Therefore, there is an extra sticker with the warning.

The customers don't have to act normal with this packaging, only opening the box; they must follow some instructions to get the aim of this project: To know the state of the products before opening the packaging and all the information about the travelling. The most important aim is to send the data to Monocrom because they want to know if their products arrive well.

V. Laser Protection

When transporting laser devices, it is imperative they are correctly packaged to minimalize any possibility of damages. Depending on the type of laser device it can be highly susceptible to either elevated or very low temperatures, shocks, vibrations, electrostatic discharge (ESD) and elevated levels of humidity.

To prevent against any water entering the package, the design of the box was made to allow it to hermetically seal with use of a gasket maker applied before closing the package. A large amount of research was made into ESD prevention as these particular diodes are very susceptible to static discharge, three categories were thoroughly researched to find the best possible solution. Anti-static, static dissipative and conductive are three types of ESD foams that can be used to cushion the laser devices and eliminate static from being a possible danger. Conductive foam was the chosen material to be used in the smart packaging, this foam is only being used as a secondary precaution as each laser from Monocrom comes with a short circuit between its positive and negative leads to eliminate ESD from being a danger.

VI. The monitoring system

In order to monitor the conditions of the package during transportation, an active electronic monitoring system is implemented to the shipping box.

An Arduino Pro Mini is used as the microcontroller to fetch data from sensors and log it on an SD card. It is also responsible for controlling the interval of which the data will be fetch. ADXL377 accelerometer is used to measure the shocks and vibrations experienced by the package, which can read up to 200g of acceleration. DHT22 sensor is used to measure temperature and humidity changes inside the box if the conditions ever varied.

A micro SD module paired with a 2GB of micro SD card are connected to the Arduino to store the data read by the sensors, aided by a sophisticated program to select only major and important values to be recorded in the SD card. To transfer the logged data to a mobile phone, a Bluetooth 4.0 LE module is used to ensure a wide compatibility with Android and iOS devices while maintaining a reliable connection between the package and the mobile phone.

A 3.7V lithium-ion battery is used to power all the electronics although a large capacity battery may be needed to avoid power shortage during long shipping period. In the future, an NFC tag may be added to the package to facilitate the pairing process to a mobile phone and to enhance the security of the recorded data.

After all, this solution will benefit not just Monocrom but also the customer as they will be able to factor out one of the reason that caused the diode to damage.

VII. Design

The packaging is made from two parts, the lid and the rest of the box which has a breakable part (a physically security system) and the costumer will have to break that part to open the box.

The final box has 3mm walls thickness, 2.25mm ribs thickness (75% of the wall thickness) and 6.75 depth (3 times wall of the rib thickness) and fillet between rib and wall has 1.13mm radius, these values are the right values which prevent against sink marks. Has 1mm hole for gasket and the rib from the lid has 0.7mm and is angled with 10° to press easily the gasket to make the box hermetically sealed. Also, the lid has ribs which will sit on the reinforcing box ribs to make the lid stiffer and protect against breaking.

A stress test with a force which simulate 6kg on the top of the box shows that the maximum displacement will be 0.29mm.

VIII. Idea Of The Mobile Application

In order to obtain the connection between a customer and the Monocrom company the special mobile application has to be developed. When the package will arrive to the customer, they will be able to get information about the shipping in the easy way. The whole process consists of scanning QR-code in order to download the application through the Internet. Straight after the application shows several steps: initiating NFC connection, processing data and checking shipping conditions. The customer has to put the phone next to NFC label on the package. The Bluetooth connection will be easily established and the application will start gathering and processing data. In the end, the application will send the results to the Monocrom via the Internet and present to the customer the status of the package. All the steps will be made before opening the package.

IX. CONCLUSION

The main objective of the project has been done. All components, sensors, electronics and labels have been designed in the proper way and they can work together in order to collect data, monitor shipping and simply protect the shipped items. Nevertheless, the project needs further development as it is stated in case of the mobile application.