Measurement 100 (2017) 84–92

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Development of an automatic system for the measurement of force and stroke parameters of car radio keypads

Nuno Canadas [a], José Machado [a,*], José Meireles [a], Pedro Delgado [b], Aníbal Portinha [b]

[a] University of Minho, School of Engineering, MEtRICs Research Center, 4800-058 Guimarães, Portugal
[b] Bosch Car Multimedia Portugal SA, Rua Max Grundig, 35, Lomar, 4705-820 Braga, Portugal

ARTICLE INFO

Article history:
Received 24 March 2016
Received in revised form 23 December 2016
Accepted 25 December 2016
Available online 28 December 2016

Keywords:
Keypads
Mechatronic measurement system
Force-stroke curve
Quality inspection
Data acquisition system

ABSTRACT

Keypads are basic components used in Human Machine Interfaces designed for electronic devices. Different shapes and force-stroke parameters are used in the respective design covering a large range of applications. Bosch Car Multimedia is a huge manufacturer of car radio and navigation systems worldwide. Most Bosch Car Multimedia products have one or more keys and the important design parameters for these keypad elements are forces and strokes usually described as force *versus* stroke diagram with some kind of hysteresis. Keys usually have small values of force and stroke, and these low values require a measurement system with high precision and high repeatability. This paper presents a mechatronic system developed in the described context. With this system the company is better equipped to fulfil customer specifications.

1. Introduction

Robert Bosch Car Multimedia GmbH is one of the largest producers in the world of radio, entertainment, navigation, and telematics systems used in the automotive industry [1]. In order to achieve products with the best quality, a wide range of tests must be performed during different stages of development and mass production. These tests provide very important information about product performance and compliance with customer specifications [2].

Despite of recent implementation of the "touch screen" in many Bosch devices, keys and keypads will never be obsolete and they will continue to be used. Thus, it is important to have a fast and user-friendly tool capable to measure key parameters and assess their compliance with customer specifications.

The force *versus* stroke characteristic of keys in a keypad has been studied extensively in the ergonomics field, in order to understand the effects that the typing activity has on human health [3–6], but in the literature were not found many studies applied to the industry.

In order to achieve the proposed goals, this paper is organized as follows: Section 2 describes keys and keypad parameters; Section 3 presents the developed mechatronic system and the main issues taken into account during system design; Section 4 presents the obtained results when using the developed system in a specific case study, with extrapolation of results to similar ones; and, finally, Section 5 presents the final conclusions.

2. Keys and keypads

A key is a basic component present in nearly all mechanical and electronic devices, allowing the user to interact with their functionalities. Acting like system inputs, keys are pressed (actuated) with the purpose of running an action in order to obtain one or more outputs, such as to switch on/off lights, to change the volume and frequency of a radio, and others. According to their application, keys have different shapes and sizes, making them suitable for the functions they will perform.

2.1. Constructive aspects

For a long time, keys were only mechanical. However, with the need of application of keypads in common devices (cell phones, calculators, keyboards, etc.), silicone rubber membrane keys started to be used [7]. Due to technological developments, rubber silicone keys became the first choice in most applications mainly because when compared with the mechanical ones, silicone keys are cheaper, they resist more effectively to aggressive environments (humidity, dust, etc.) and they allow building more simple and user-friendly keypads [8,9].

* Corresponding author.
E-mail address: jmachado@dem.uminho.pt (J. Machado).

http://dx.doi.org/10.1016/j.measurement.2016.12.044
0263-2241/

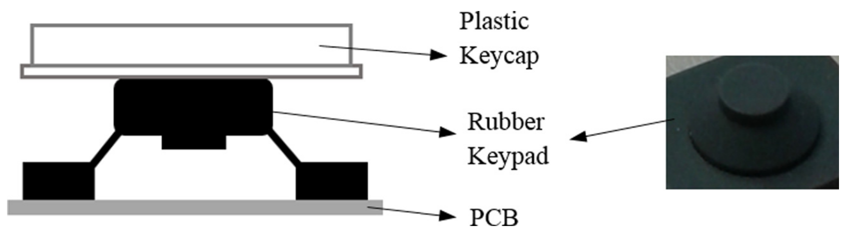

Fig. 1. Schematic of a membrane key mechanism and example of rubber/silicone dome.

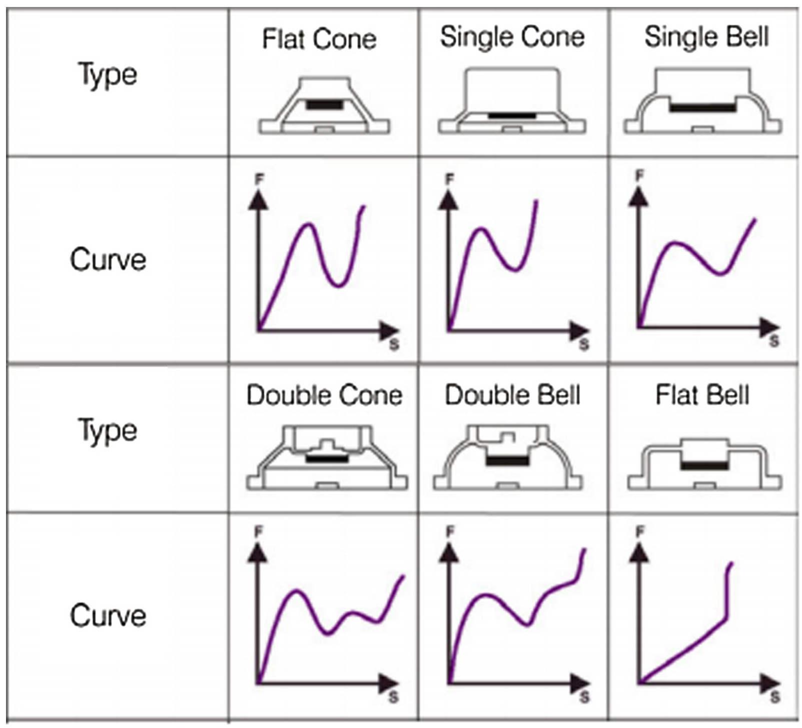

Fig. 2. Characteristic curve shapes obtained from different types of membranes used in the keys [12].

Fig. 1 shows the structure of a membrane keypad and an example of a rubber silicone dome.

2.2. Force-displacement characteristic of keys

Several works have been dedicated to studying force-stroke curves [10]. When performing a mechanical test, the key's behaviour is described as a force-stroke curve. The characteristic curve can have different shapes depending on the type and the physical characteristics of the membrane (geometry, shape, and others), and this will affect the performance of the key [11]. Fig. 2 shows how the membrane design affects the force-stroke curve.

Fig. 3 shows an example of a typical force-stroke curve of a car radio keypad key. The solid line corresponds to the actuation phase made in the forward direction, when the key is pressed until its abutment. The dashed line represents the release phase in the backward direction, when the key is released after getting pressed.

The points represented in Fig. 3 are the characteristic points which are fundamental to define the characteristics of a key (especially for manufacturers, other points of interest can be identified as illustrated in [12]). The overall curve indicates the keypad behaviour and through quantitative understanding of these points and resulting combinations of their relationship, it is possible to evaluate the key's performance [13]. Each point has a specific meaning, described in [14]:

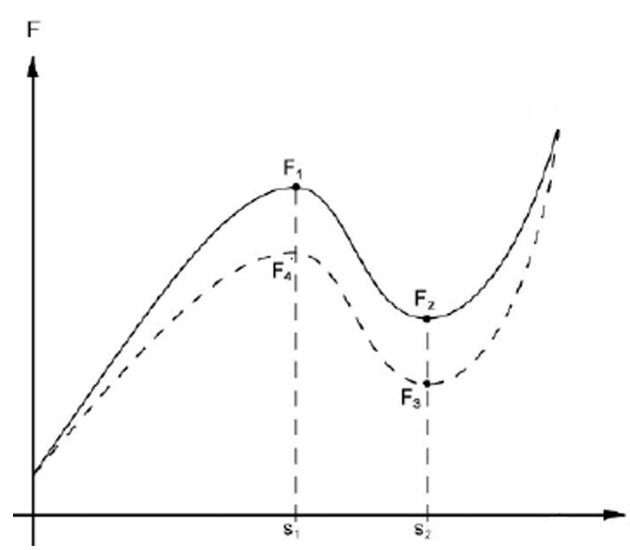

Fig. 3. Characteristic curves expected from a car radio keypad key.