Design of a User Interface for Smart Mobility Cane

by

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ABSTRACT

The white cane used by the blind serves as a limited tool of navigation, and can be improved drastically. This device aims to offer mobility assistance for blind and deaf-blind people by providing obstacle and temperature feedback, thereby improving navigation. A logical user interface between the input and user is a vital part in communicating information to the user. The spatial input data gathered is processed to calculate object location and to provide an assessment of the potential hazards. Moreover, the temperature data acquired is compared to evaluate potential dangers. A vibratory stimulus user interface is used to transmit the sensed and processed hazard information. The hardware design of the user interface, the algorithm of signal processing, and the experimental data are presented.

Keywords: signal processing, obstacle detection, off-centred motor, user interface, smart white cane, assessment algorithm

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Piragath Mahalingam

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NOMENCLATURE

SMC – smart mobility cane

PAM-AID - Personal Adaptive Mobility Aid

Haptic – sense of touch

IR - infrared

Chapter 1

Introduction

1.1 Background

There is approximately 36.9 million people in the world are blind in 2002 according to World Health Organization[1]. Majority of them are using a conventional white cane to aid in navigation. The limitation in white cane is that the information's are gained by touching the objects by the tip of the cane. The traditional length of a white cane depends on the height of user and it extends from the floor to the person's sternum. But many users prefer longer canes so that they have better safe distance in front of them. Even these longer canes only detects obstacle at ground level and cannot detect at head level. Also a vast majority of blind's live in a third world nation where the smart mobility white canes are unavailable and expensive (where it is available). Aside from this, the current smart mobility canes provide limited aid information to the user. Most of them provide obstacle warning through an audio output and cannot be used by deaf-blinds.

There is a need to improve the level of detection of obstacle above ground level. And the need to reduce the amount of active scanning by the conventional white cane users is necessary. The conventional cane user actively scans the ground and can only detect ground, uneven surfaces, holes, steps, and other hazards. It also takes more than 50 hours of training to become familiar with the cane. An alternative to the white canes is guild dogs but they require extensive training. Guide dogs can cost about $20, 000 [1] and they can be useful for about 5 – 6 years.

Current technologies create the possibility for the mobility cane to provide greater aid information to the user such as hot object warning, pedestrian light status, bus route

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[1] Global estimate of visual impairment, by WHO region (millions), 2002
http://www.who.int/mediacentre/factsheets/fs282/en/

information and etc. for an affordable cost. Smart Mobility Cane (SMC) is designed to integrate temperature information with obstacle detections. SMC provide output through haptic technology to provide positional and hot object detection output though the user interface. It also is able to provide obstacle information such as glass by using ultrasonic sensors. Kajatheepan Kanagaratnam discusses the design and implementation of the obstacle detections on “Obstacle Detection for the Smart Mobility Cane”. Furthermore SMC provides information about candle, hot stove, hot pressing iron and other hot object by using infrared sensors. Alireza Akbari discusses the design of the infrared sensors and implementation on the SMC further on “Hot Object Detection for the Smart Mobility Cane”.

The user interface of this device was designed to provide more freedom to the user. Its use of vibratory output produces less noise and the device can be used while talking for just blind. This gives the blind user the freedom to still use their ear to gain the auditory information about the environment. Also the user interface guarantees output even at noisy environment and deaf-blinds can also use the device. The user interface is on the handle of the white cane and it provides three positional and one hot object output. The users will place their figures on each of the output vibrators. The obstacle warnings are communicated in three distinct ranges of close, middle and far. The hot object warning is also communicated via another vibratory output when an object is hot. The threshold temperature is set to 35 °C and an infrared (IR) sensor is placed just below the handle. The prototype of the user interface process the signal in LabVIEW and output through the hardware interface.

1.2 Objectives

The SMC address the need to improve the quality of blind and deaf-blind's life by a well-designed user interface. Improvements in technologies in the last decade allows for the integration of technology to the traditional white cane. It allows for obstacles to be detected at head level and the information can be communicated a user interface. The need for a better user interface arises due to the limitations of the current. Many current user interfaces for smart mobility canes are in the form of an external device such as headset speakers. The users are requires to carry this external device along with the cane and it is difficult to use at noisy environments. Acoustic and speech feedback device can damages the hearing and also produces disturbance to the users and others. Acoustic and speech feedback limits the cane's usability to blinds and they limit the user from using his hearing sense to possible gain extra information about the environment.

In the case of SMC, the user interface is the handle of the cane and it provides haptic vibratory output. The blind users have the freedom to use their hearing sense to gain other valuable knowledge of the environment. It can be also be used by deaf-blinds.

1.3 General Approach to the Problem

The design of user interface consists of two parts (a) signal processing using LabVIEW and (b) the design of the output user interface.

The signal is acquired by the sensors are acquired by the software through the analog to digital converter component designed by National Instrument for LabVIEW. The acquired obstacle sensor's data is then analyzed to determine the distance of obstacle. The distance is compared with the three predefined ranges and the correct output signal line is selected.

The output digital signal is then converted to analog using the same National Instrument converter. The analog signal is used as a switch to turn the output vibrator motors located on the cane. A voltage follower is used between the line output signal and the motor.

1.4 Scope of the Project

The user interface conveys the obstacle positional warning and hot object warning. The object positional warning system communicates position based on predefined ranges of near (0cm – 100cm), middle (100cm – 200cm) and far (200 – 400cm). Each predefined ranges are off-centred motors that produce haptic vibratory output. The hot object warning provide a similar vibrations as obstacle warning on the fourth motor when the object hot (greater than 35 °C). All of the motors will produce about the same intensity of vibrations (1G).

Chapter 2

Literature

2.1 Personal Adaptive Mobility Aid (PAM-AID)

PAM-AID [2] is a moving robot that acts like guide dog in navigation. Its user interface is a joystick that is mounted on the robots handrail. The feedback here is speech recorded messages. It is used to give command confirmation to the user and the direction in which the joystick is pointed at. It also provides obstacle warning through voice commands. This system is great in quite environment but at noisy environment the speech can be distorted by the noise. This is a limitation as deaf-blind are not able to use it.

The advantages of this design is that the freedom of conveying any message to the user. The users could request to use a family members voice for the messages. It provides the user friendly interface.

2.2 Computer Vision-Based Clear Path Guidance for Blind Wheelchair Users [3]

The interface works similar to how a conventional white cane is used. It scans the area in front of the wheelchair for hazard or terrain and a high-pitched audio tone is used to warn the rider. The system is set up for a predefined range of 1.8 – 3 m and the system scans three dimensionally in the direction of the cane that is attached to the wheel chair. The advantages of this are that it provides terrain features.

The disadvantage in this method of user interface is that the acoustic could be distorted by noise. It can be very hard to differentiate pattern in acoustic and required long trainings.

2.3 The Tangible Pathfinder

Tangible user interfaces [4] are physical objects that correspond to virtual world with space and structure. It uses the other senses such as hearing and whatever sense that is left from the visual impairment. It uses a game-like environment and physical actions performed are converted into audio messages summarizing the state of the interface. This is a great innovation into that could redefine the interaction with real world though a virtual environment.

Chapter 3

Statement of Problem and Methodology of Solution

3.1 Statement of Problem

The design of the user interface concerns the method of output and its effectiveness. Methods such as Acoustic or speech feedback, and haptic feedback methods were considered. The haptic feedback that concerns this user interface is vibrations and the problem arises in location of output to the user. A wristband, glove and cane handle haptic vibrations are considered. In haptic output, the anatomy of location of output is taken into consideration, the effectiveness of nerves at these locations. The discussion of each of problems discusses here is presented in the following section.

3.2 Methodology

A user interface design is carefully selected among many designs. The design methodologies of all of the designs are considered. Methodology of Acoustic or Speech Feedback and Haptic Vibrations (wrist-band, glove, and handle of the white cane) and their advantages, disadvantages and feasibilities are discussed in section 3.2.1.

3.2.1 Acoustic or Speech Feedback

The user interface using of acoustic or speech feedback provide feedback through a wireless headset speaker. Acoustic feedback produces distinct pattern of sound that corresponds to specific response. The user is required to carry the wireless headset with the white cane and the signals are acquired at cane level. Its signals are then processed by the microcontroller on the cane handle and the acoustic patterns are sent to the headset. The signal process includes the localization of the position of the obstacle in space and creations or selection of predefined acoustic/speech pattern corresponding to it. Speech feedback also works similar to the acoustic feedback system but the output produced from the microcontroller would be specific words.

The shortcomings of both acoustic and speech feedback is that the environments noise can interfere with the sound at times. It also creates discomfort to the user and may damage the user’s hearing over time. The user is also required to carry the headset, which is an additional device that could create various handling discomfort. Both cane and headset requires power, thus increases the cost of maintenance and both batteries need to be charged. There isn’t much freedom for blinds to use their hearing sense to obtain other feedback or even talking to someone while walking. Also, acoustic and speech feedback limits cannot be used by deaf-blinds. Training to differentiating the acoustic patterns with the corresponding terms take long time.

3.2.2 Haptic Vibrations Feedback

Interface technologies that communicate to user by the sense of touch by applying force, vibrations, or motions are called “haptic” technology. It is often used in telerobotic operations where the force applied on the patients’ side is conveyed to the surgeon. Sense of touch combines your response to touch, pressure, pain and temperature. Since the haptic feedback is related to the sense of touch, the anatomy of the interested regions is considered.

The nervous system is responsible for the sense of touch and it vary throughout the body. Some regions of the body require large force to feel the pressure and others requires lesser force. It is related to the density of nerve fibres in on the surface of the body. The skin and deeper tissues contain millions of sensory nerve ending for touch, mechanoreceptor sensory receptors. The mechanoreceptors sends skin surface information signals through spinal cord to the brain such as touch, pressure, motion, or stretching.

Meissner's corpuscles [5] (Figure 1) are a type of mechanoreceptors that sense light touch on skins. They have the lowest threshold in sensing vibrations meaning highest sensitivity to low frequency vibration. They are distributed throughout the body but the denser in the fingertips, palms, soles, lips, tongue, face and the male and female prepuce. The number of Meissner's corpuscles drop significantly (fourfold) between the ages of 12 and 50. This correlates with the age-related touch sensitivity loss for small probes.

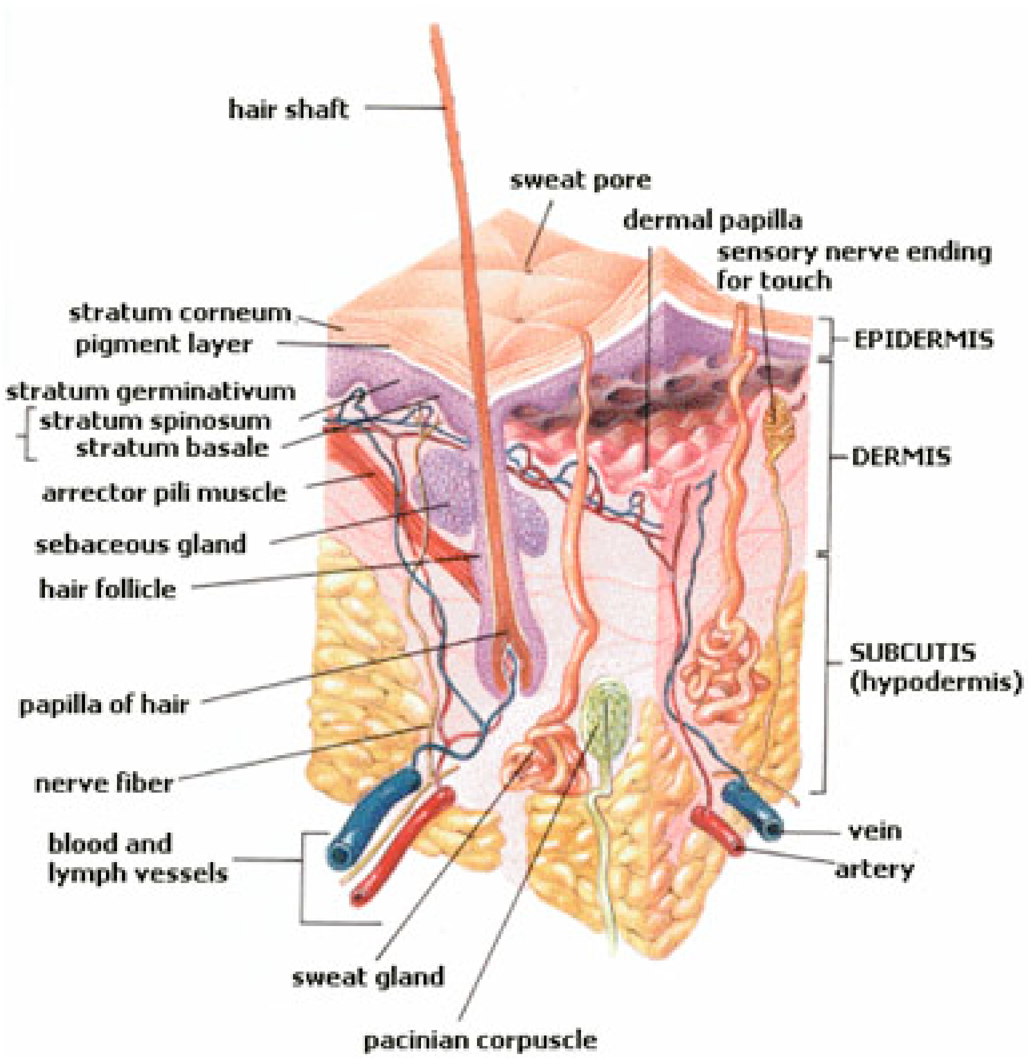

Figure 1: Skin layers showing Meissner's corpuscles – sensory nerve endings for touch (upper right) and Pacinian corpuscles (bottom)[2]

Pacinian corpuscles [6] (Figure 1) are another type of nerve ending in the skins that are responsible for skin sensitivity to deep pressure and high frequency [7] (40 Hz – 1000

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[2] http://training.seer.cancer.gov/ss_module14_melanoma/unit02_sec01_anatomy.html

Hz) vibrations. They are also distributed throughout the body similar to Meissner's corpuscles.

Now that there is a clear understanding of the anatomy and functions of the nervous system, the design methodology can be formulated.

Wrist-band

The user interface to be worn on the wrist and the obstacle positional warning outputs continuous changing vibrations on the posterior. No vibrations would correspond as there is no obstacle of further away and a maximum vibration corresponds to a very close obstacle. The hot object warning outputs on the anterior of the wrist. The acquired data is processed by the microcontroller. The signal processing includes the localization of the obstacle position and the formation of vibration corresponding to it. The output vibration signal is then wirelessly transmitted to the wristband. The hot object warning system works similar to the obstacle warning system.

The difficulty of implementing this method is that the sense of vibration by the body cannot differentiate close vibration values. Even if the body is able to distinctly identify the vibrations that are close to each other, the mind is not able to calculate a distance for every vibration on the linear or non-linear vibration curve. Lets say an obstacle is found at 100 cm and the corresponding vibration is applied to the wrist, the user cannot say that the obstacle's location if it was taught before. The complexity in the users capacity to locate the obstacle in space by the vibration makes the design insufficient.

The sensitivity of the vibration force at the wrist is low compared to the fingers. The sensitivity also creates the users ability to localize the object in space. The shortcoming of this design is that it requires an extra device. It also requires extra energy source to operate the wristband. It also creates discomfort to the user to be wearing a wristband that is vibrates. To resolve localising of the obstacle raised from the wristband, lets consider a glove system.

Glove

The glove user interface is to be worn and the output corresponds to distinct distance range. There is three distinct positional range and one hot object warning. The signal is acquired and processed by the microcontroller at the handle of the cane. The signal processing includes the localization of obstacle position and formation of three distinct outputs. The output from the microcontroller is wirelessly transmitted to the glove. The glove contains four motor vibrators, each touching the tip of the finger. The wirelessly transmitted signal activates the motor corresponding to the distance range. The hot object warning signal is transmitted similarly and activated the corresponding motor.

This method utilizes the anatomical definition of denser mechanoreceptors on the fingers. On the fingers, the vibration is understood clearly but the linear or non-linear vibration curve is insufficient. Due to this reason, four separate motors are used and the ranges of the positions are divided according to it. The distinct vibrations are understood by the user and able to learn quickly. The complaint from users in this design is that the glove creates discomfort and not ideal in summer.

Considering the complaints from the users, the design is modified. This improves the design methodology is discussed in the following.

Handle of the white cane

The handle of the white cane is considered as the user interface as it is already the user interface for the conventional cane. The handle is designed for four fingers to touch each of the vibrator motor to access the output. In this case, the user has the flexibility to obtain the output information.

The acquired signal is process by the microcontroller located at the handle of the white cane. The microcontroller localizes the obstacle position into one of the three regions. Then it selects the corresponding line and outputs a signal to activate the motor switch. The switch activates the motor when it sees a high voltage. The hot object warning is done in the similar manner. The hot object warning will only occur if the object is in the close range. In the case of a hot object being present, both the close vibrator motor and the hot object detection motor is activated.

The shortcoming of this design is that that it assumes that the user holds the handle in the correct manner. The user is responsible for placing the fingers on each of the motor and the user is expected to touch each motor with a different finger. This design only requires one energy source, which is an advantage.

Chapter 4

Experimental and Design Procedures

4.1 Experimental Procedures

The software and hardware algorithm design development of the user interface for the SMC are outlined in this section.

4.1.1 Software Algorithm

The user interface is responsible for communicating the obstacle position and temperature of nearby objects. Whether an object nearby is hot (greater than 35 °C) is determined. Concerned objects may include candles, pressing iron, heater, and others. The algorithm should provide sufficient information about both obstacle and temperatures of objects. The user interface is located on the handle of the white cane so that the users can grip on to it.

The obstacle information is conveyed as it could be somewhere with in the defined range. There are three ranges defined and the user is informed about the three ranges and the vibrator motor corresponding to it. The three predefined ranges are near (0cm – 100cm), centre (100cm – 200cm) and far (200cm – 400cm). They were chosen based on walking experiments. A user walking with SMC will know an obstacle as far as 400cm and if the obstacle continue to stay in that range as he/she is walking, the user is encouraged to walk with caution as the object in question is most likely someone else walking in front of him. If the obstacle that appeared far switched to centre, then the user is encouraged to stop and decide accordingly.

Object temperature is only provided to the user when the object is within 100cm. User knows that the object in the close range since the obstacle close will also be activated at this time. The feedback is produced every half a second and communicated to the user via the interface for 0.5s.

The obstacle detection output is assumed to be a digital and it is known in LabVIEW as a number between 0 and 400. This signal is then compared with the predefined ranges of close, centre, and far. The comparator output selects the line and creates a 5V high signal that lasts for 0.5s. The high signal switches to 0V low after 0.5s and the obstacle detection signal is acquired. This cycle repeats until the user manually turns the whole process off. Figure 2 illustrates the software algorithm for the obstacle warning system.

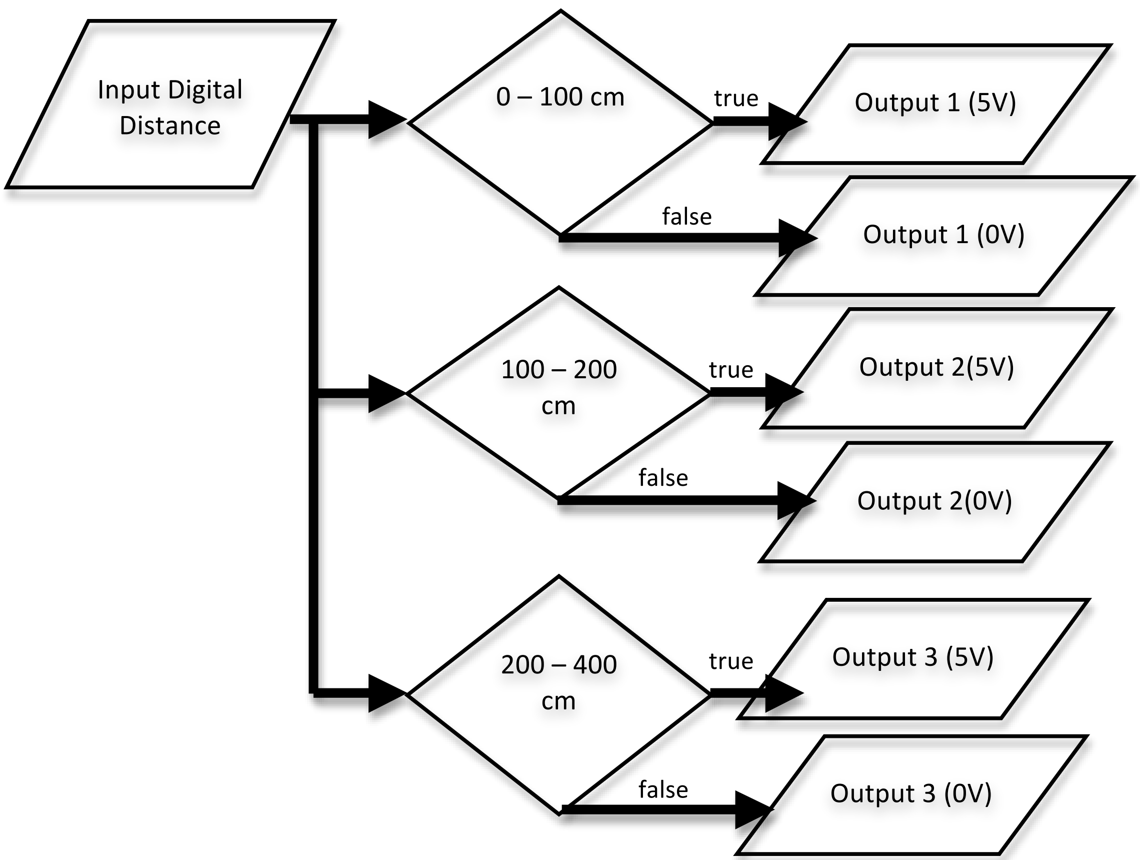


Figure 2: Signal processing algorithm of obstacle warning for the user interface.

The hot object detection output provides a digital true or false. When the status is true, a 5V high output is produced and it is fed into line 4. Figure 3 illustrates the algorithm for the hot object warning system.

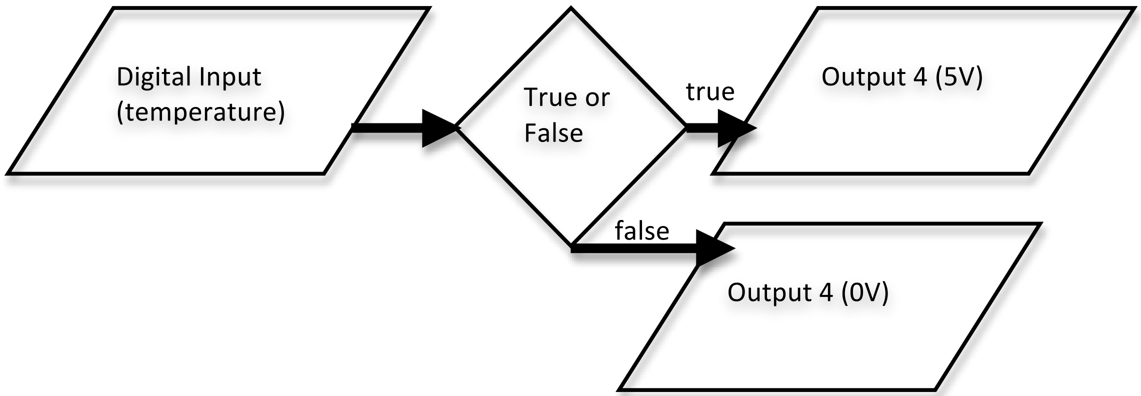


Figure 3: Signal processing algorithm of hot object warning for the user interface.

4.1.2 Hardware Algorithm

The hardware aspect of the user interface consists of four off-centred disk motors. Off-centred motors are conventional electric motor with an off-centred weight attached to it. Vibrations are produce as the motor spins and the weight on the motor changes the centre of gravity of the casing. Each motor operates at 3V and with a maximum of 80mA current. They produce about 1G vibration at 12, 000 rpm bi-directionally.

The digital signal processing produces an output of 0 or 5V DC at one of 4 lines. This output's power is not enough to drive the motor and the voltage is higher than the operating condition of the motor; a voltage follower (Figure 4) is used.

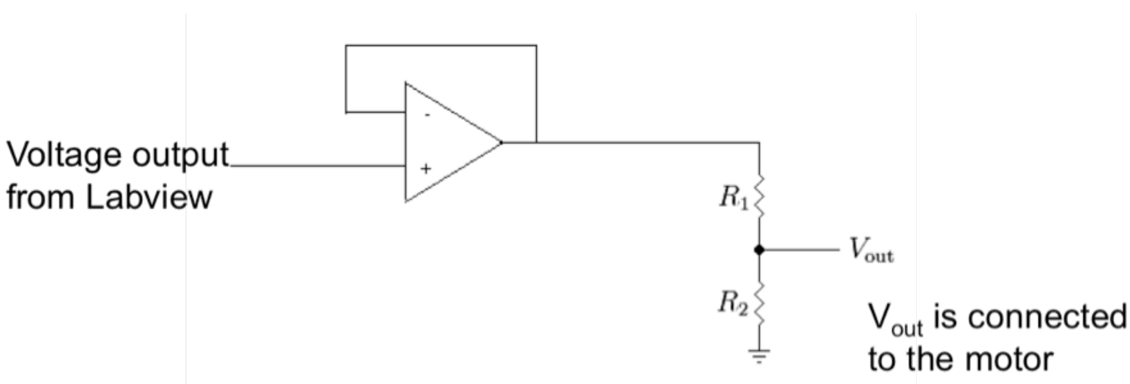


Figure 4: Voltage follower used for the user interface of SMC

The output voltage from voltage follower is calculated as follows $V_{out} = (R_2/R_1+R_2) * V_1$ and $V_{out} = 3V$. $R_1 = 80\ \Omega$ and $R_2 = 120\ \Omega$ are set to constrain the current within 80mA.

4.2 Design Procedures

The software and hardware design procedures are outlined in this section. The required apparatus for this procedure are personal computer (windows xp or higher), National Instrument BNC-2110 board, National Instrument LabVIEW software, power supply, and Multimetre. The required components are discussed in each subsection.

4.1.2 Software

The software design is done on National Instrument LabVIEW 7.0 software. The LabVIEW acquire and output data through its data acquisition board. The DAQ board used in this application is NI BNC-2110 board. It includes both analog and digital input/output. For the purpose of this design, the digital output lines are used. The software provides real time simulation of electrical circuits. It is used in this case to reduce the cost of microcontroller.

Required Components: input, DAQmx, and (∧), greater than (>), less than (<), Addition (+), division (÷), array, toggle switch, cos, build array, initiate array, for loop, wait (timer), "input" block

Procedure

First, "for loop" is created with an N of 1000 or higher. This will loop for long time and acts as the user master switch; let say the user turns off after N duration. The loop is also necessary to control the delay in acquiring signal. Everything from here on the rest of the components are placed inside the "*for-loop*".

Delay

The "*wait*" (Figure 5) block is added inside the for-loop and an "*input*" is created. The wait time is set to 500ms and is done to delay the acquisition and output duration.

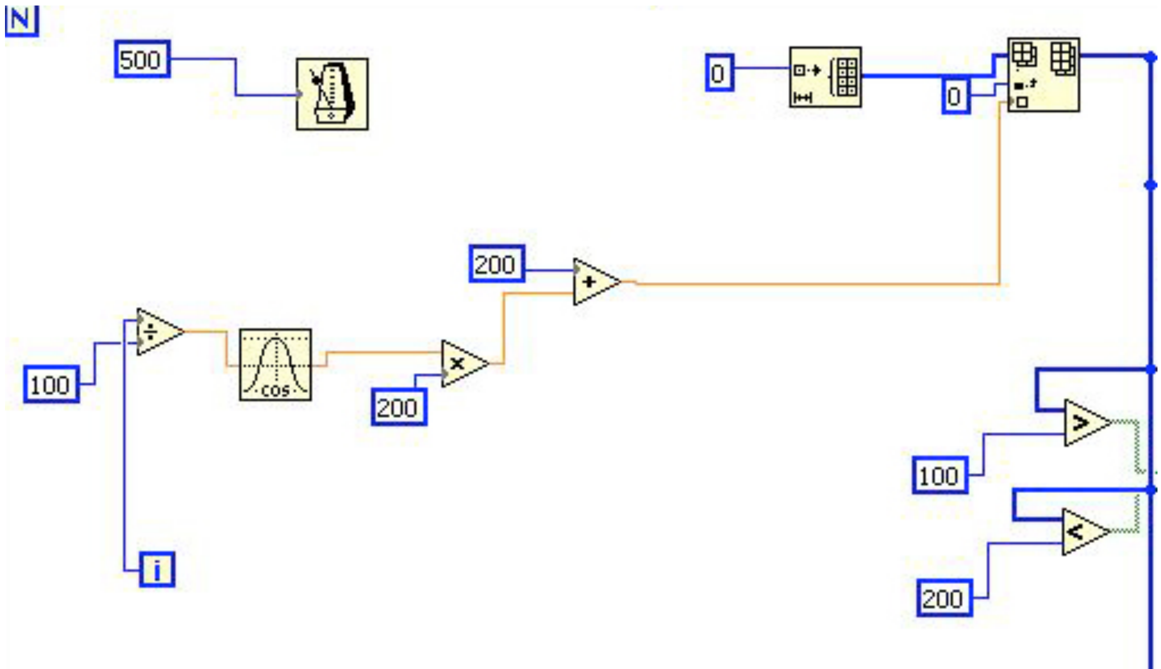


Figure 5: LabVIEW blocks showing the simulation of the signal.

Simulation of input signal (Figure 5)

Using a division block, the "*i*" of the for-loop divided with 100 by using a simple input block. The divided value is passed into the "*cos*" and it outputs a value between 1 and -1. This value then multiplied by 200 and then 200 is added to this to simulate a sine wave with and amplitude of 200 and an offset of 200.

An empty array is initiated by using the "*initiate*" block and is fed into build array block as shown in Figure 5. The sine wave is also fed into element input to the build array block. The output from the build array is a 1D Boolean.

Creation of a switch used as a hot object detector simulator (Figure 6)

An array block is created along with a toggle switch. The toggle switch is dragged into the array block. This produces 1D Boolean output of the toggle switch. The output of this component is connected directly to the output block DAQmx. DAQmx component and the implementation is discussed later.

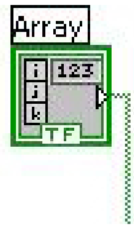


Figure 6: depiction of the toggle switch in the signal processing

Selection of motor switch (Figure 7)

Using "*greater than*", "*less than*" and "*and*" blocks, the simulated obstacle signals are compared as shown if Figure 7.

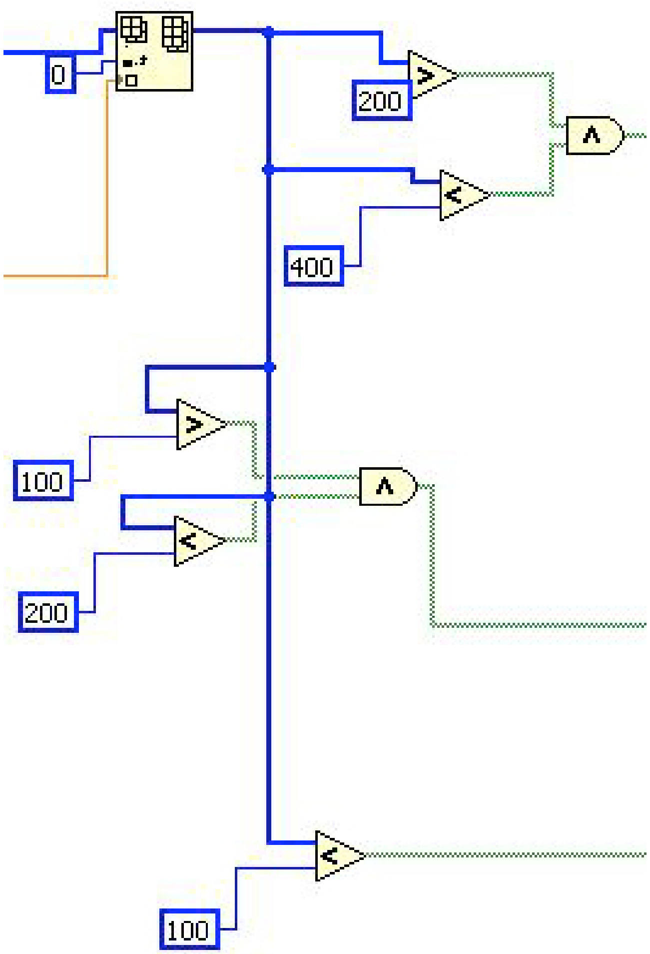


Figure 7: Shows the comparison blocks of signal processing

Output to NI BNC-2110 (Figure 8)

Each of the comparitor output are connected to the DAQmx and also the toggle switch array output is connected to the fourth DAQmx as shown in Figure 8. The DAQmx is set as "Digital 1D Boolean and NChan 1Sample" and the line output are set through the following configuration. The entire block schematic is provided in Appendix A.

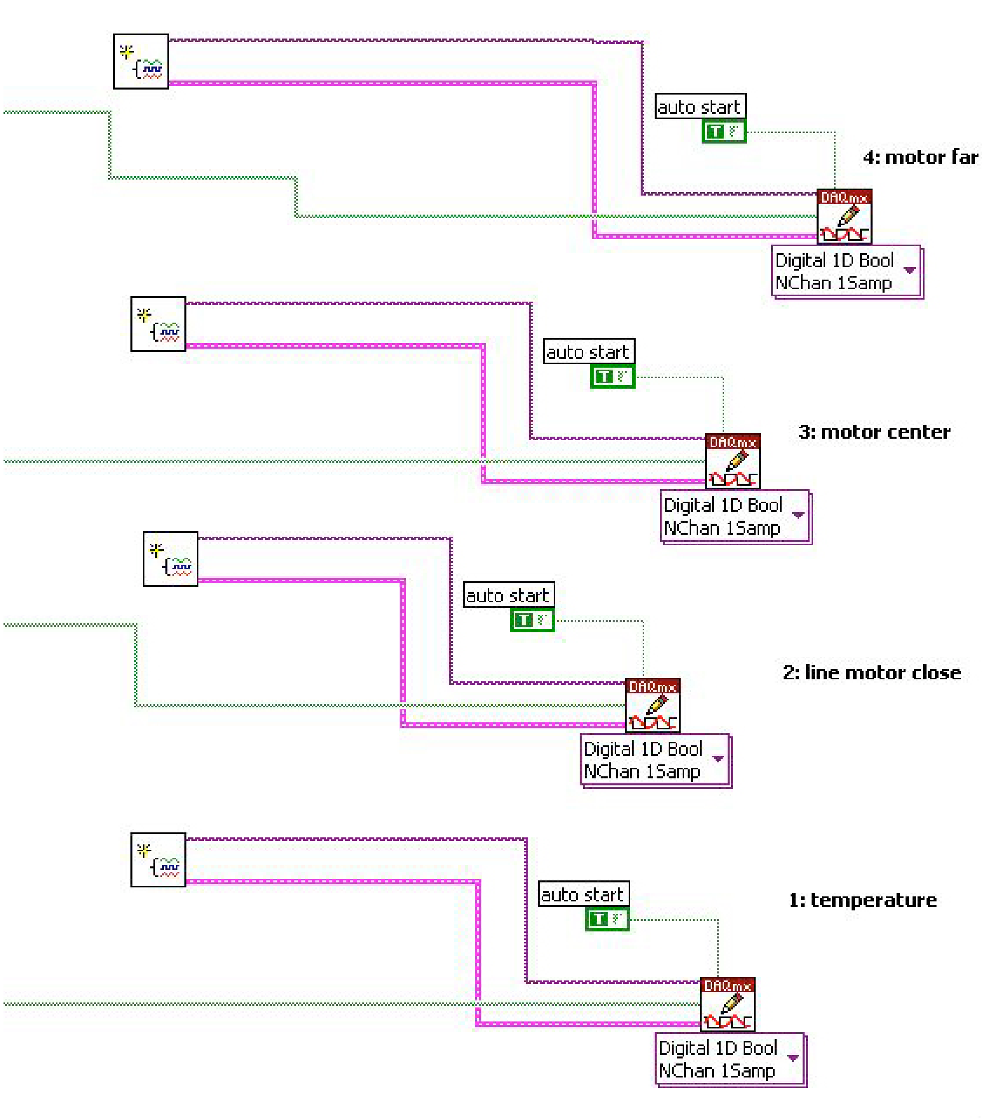


Figure 8: shows the output to DAQ hardware

4.1.3 Hardware Implementation

The LabVIEW acquire and output data through its data acquisition board. The DAQ board used in this application is NI BNC-2110 board. It includes both analog and digital input/output. For the purpose of this design, the digital output lines are used.

Required Components: four off-centred disk motors (appendix b), four LM 741 op-amps (appendix c), four 80 Ω, four 120 Ω, electrical copper wires

Procedure

The output signals are acquired at the p_0, p_1, p_2 and p_3 line of the digital section of the BNC-2110 board. The any of the ground can be chosen; g_0 is used in this procedure. p_0, p_1, p_2 and p_3 are connected to four voltage followers. The voltage followers are set up as shown in Figure 4 with R_1 = 80 Ω and R_2 = 120 Ω. Each of the op-amp V_+ are connected to +5V DC and V_- are connected to ground 0V.

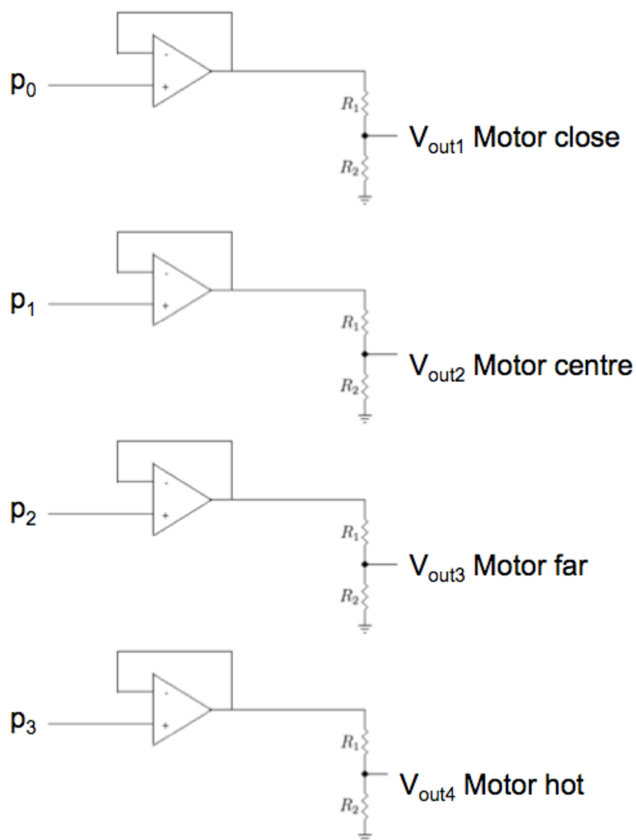


Figure 9: Complete hardware interface circuit

The V_{out} (as shown in Figure 9) of the voltage follower is connected to the off-centred disk motors. The motors are then placed on a handle-like casing (Figure 10).

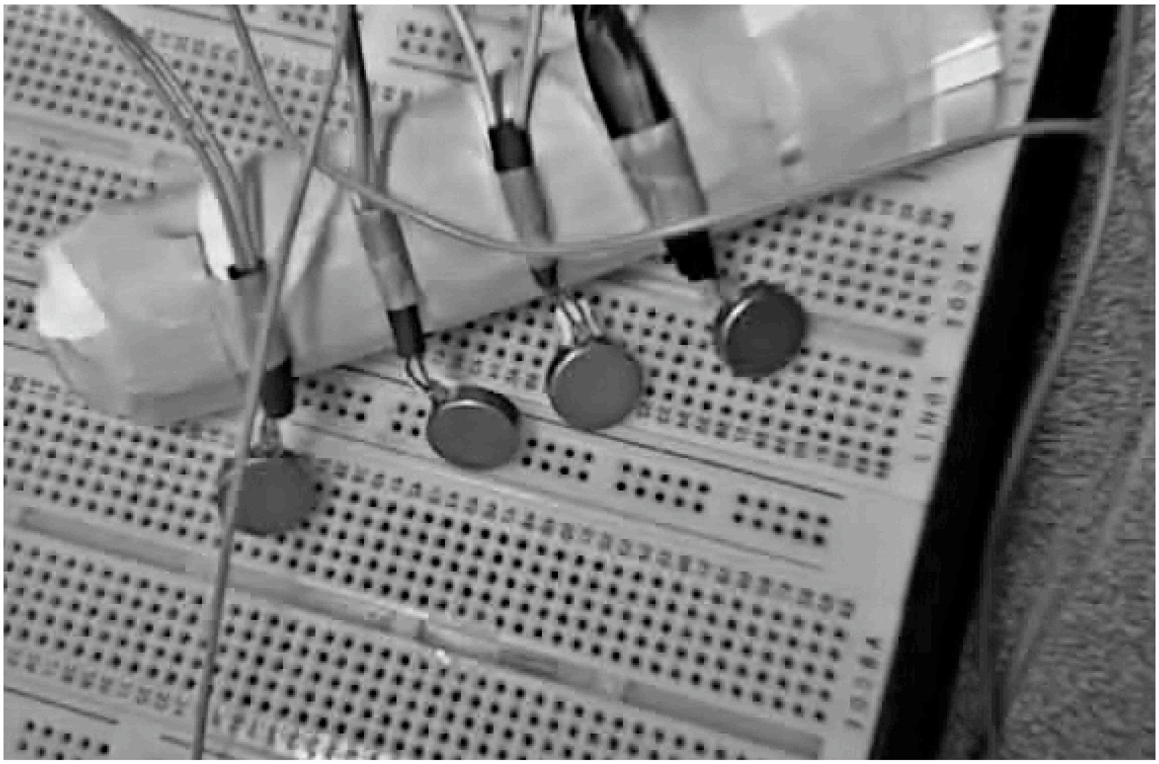


Figure 10: prototype of the user interface.

Chapter 5

Results and Discussion

5.1 Results

There is various testing performed on the user interface including obstacle warning and hot object detection based on simulated data. Low temperature object test was performed by keeping the simulated hot object warning switch turned off in LabVIEW. It yields results as expected, as the object travelled closer, each disk motor vibrated for 0.5s. As the user move closer to the object, the previous motor turns off. The results obtained can be translated to real case scenarios.

A second test was conducted on the basis that the user is travelling toward a hot object. In the case, the motors vibrated as soon as it reached the close position, both the close obstacle and hot object warning motors vibrated together for 0.5s. Also it seems that if the user decide to wait while there is an obstacle present, the same motor continue to vibrates. In conclusion, the results show that the user interface works.

The vibrations are easily understood and it takes minutes to learn. It only takes couple of hours to learn.

5.2 Discussion

The user interface cannot provide quick enough information about a fast object heading toward the user. The feedback is given to the user every half a second. The feedback can be increased to give such information but then the energy required to operate would increase. Also the feedback would be too fast that the user can be confused. Such a case is a rare occurrence and the limitations should be explained to users.

Another limitation of the user interface is that the user can hold the interface wrong. The user can place one finger over two different vibratory motors. The motors force can also be large the user may have a hard time deciphering the response. The interface cannot provide information about the number object in a region or the action that the users should take to avoid an obstacle.

The user interface only works with LabVIEW and it is not sufficient to commercially produce it. Microcontroller must be used and energy requirement should be considered.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

The user interface provides valuable information not available with other devices. It provides hot object warning that is not provided with any of the other mobility cane makers. This cane is much cheaper than other commercial product available in the market at the present time. It provides obstacles information up-to 4 meters. It cannot be commercially available since it is not wireless and it uses LabVIEW.

The simulation done on LabVIEW is not enough to conclude that it will work when a microcontroller is used. The sensors were never integrated together to fully conclude that the user interface would work as the simulation.

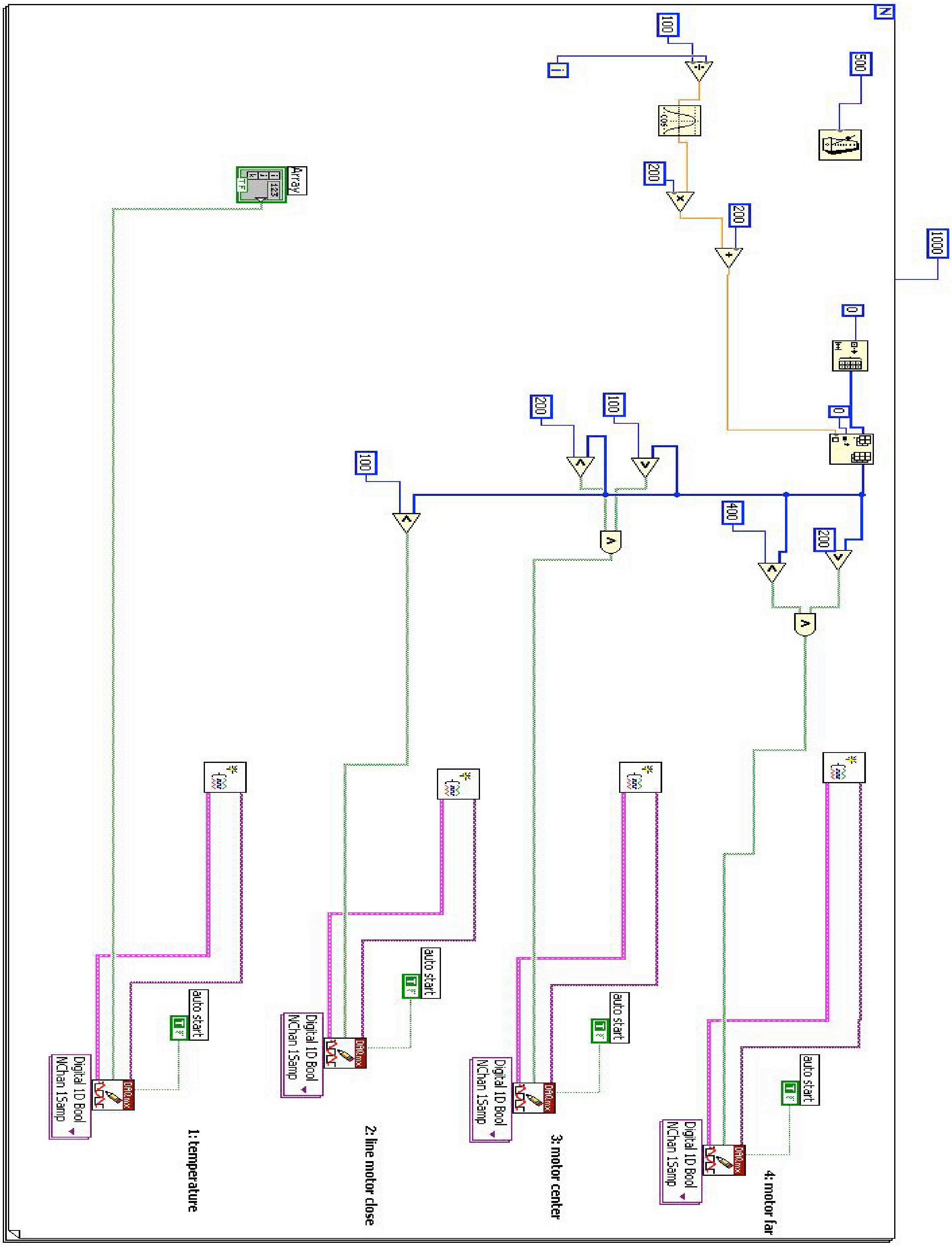
6.2 Recommendations

The user interface should become wireless by using a microcontroller. The look and feel of the interface is just as important as the theory of the electrical design. A well design casing for the motors will produce optimal result. It is recommended that user interface become wireless and is ergonomically designed.

More control of the device should be available through the user interface. Traffic signal status should be provided through the user interface. The current technology at traffic signals is insufficient and unreliable.

Finally, the interface's safety should be improved by considering the problems mentioned in 5.2.

Appendix A: LabVIEW Signal Processing



Appendix B

SOLARBOTICS Ltd

Motor Specification

Flat Type Vibration Motor VPM2

1. STANDARD OPERATING CONDITION

NO	ITEM	RATED CONDITION
2-1	STANDARD VOLTAGE	DC3.0V
2-2	OPERATING VOLTAGE GANGE	DC 2.5 ~ 3.5V
2-3	ROTATING DIRECTION	CW , CCW
2-4	OPERATING TEMPERATURE RANGR	-10℃ ~ +60℃
2-5	STORAGE TEMPERATURE RANGE	-30℃ ~+70℃

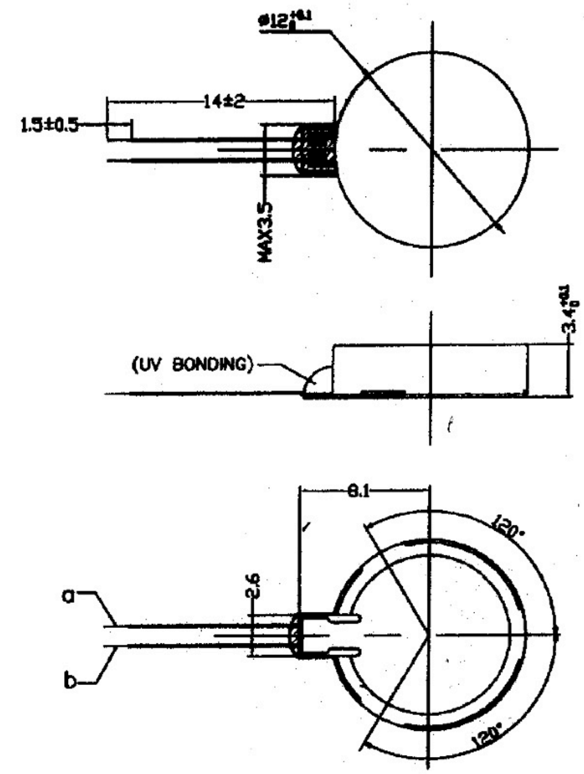
2. MEASURING CONDITION

NO	ITEM	RATED CONDITION
3-1	TEMPERATURE	5℃ ~35℃
3-2	HUMIDITY	35% ~75%RH
3-3	POWER SUPPLY,VOLTAGE SOURCE	DC POWER SUPPLY OR BATTERY3.0V
3-4	POSTURE OF MOTOR	STATE OF STANDARD MEASUREMENT

3. ELECTRICAL CHARACTERISTIC

NO	ITEM	UNIT	SPEC	CONDITION
4-1	STANDARD SPEED	rpm	12.000±3,000	STANDARD VOLTAGE : DC 3.0V
4-2	STANDARD CURRENT	mA	80 MAX	STANDARD VOLTAGE : DC 3.0V
4-3	MIN.STARTING VOLTAGE	V	2.3MAX	ON/OFF-1CYCLE,TTL5CYCLES UNDER DC3V
4-4	TERMINAL RESISTANCE	Ω	32 ± 20%	EACH BRUSH CONTACTS EACH POLE OF COMMUTATOR
4-5	STARTING CURRENT	mA	120MAX	MOTOR LOCKING
4-6	INSULATION RESISTANCE	MΩ	10MIN	MEASURING BETWEEN CASE AND TERMINAL.

TOLERANCE	



NOTE:

1. Please be careful not to drop or make over 5 kgf force.
2. Applying general tolerance grade3 for unmarked tolerance.
   (grade3 : 0~4(±0.2), 4~16(±0.3))
3. Lead wire spec: UL1571#32.
4. Weight of motor ASS'Y about 1.23g.
5. Lead-wire : a-red (+).
   Lead-wire : b-blue(-).
6. Other matters are subject to drawer's final confirmation.

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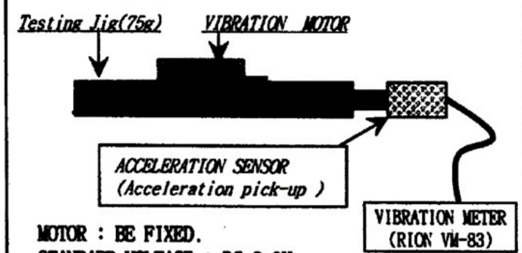
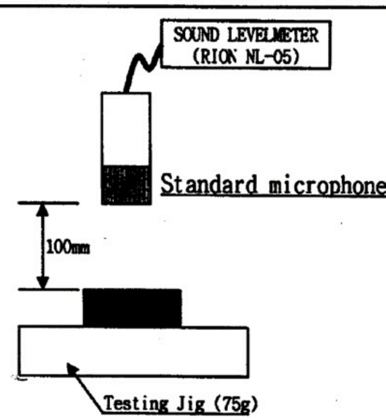
4. MECHANICAL CHARACTERISTICS

NO	ITEM	UNIT	SPEC	CONDITION
4-1	VIBRATION STRENGTH	G	(1.0)	 MOTOR : BE FIXED. STANDARD VOLTAGE : DC 3.0V . STIPULATION AT ROTATING SPEED .
4-2	MECHANICAL NOISE	dB	50 MAX	 MOTOR : BE FIXED . STANDARD VOLTAGR : DC 3.0 V BACK GROUND NOISE 25dB MAX.-A SCALE MICRO PHONE SHOULD BE VERTICAL.
4-3	SHAFT PULL STRENGTH	gf	500 MIN	DEMOLITION TEST BY PUSH-PULL GAUGE.
4-4	BRACKET DEFLECTION STRENGTH	gf	500MIN	DEMOLITION TEST BY PUSH-PULL GAUGE.

Appendix C: Data sheet op-amp LM 741

intersil

CA741, CA741C, CA1458, CA1558, LM741, LM741C, LM1458

Data Sheet | **September 1998** | **File Number 531.4**

0.9MHz Single and Dual, High Gain Operational Amplifiers for Military, Industrial and Commercial Applications

The CA1458, CA1558 (dual types); CA741C, CA741 (single types); high-gain operational amplifiers for use in military, industrial, and commercial applications.

These monolithic silicon integrated circuit devices provide output short circuit protection and latch-free operation. These types also feature wide common mode and differential mode signal ranges and have low offset voltage nulling capability when used with an appropriately valued potentiometer. A 10kΩ potentiometer is used for offset nulling types CA741C, CA741 (see Figure 1). Types CA1458, CA1558 have no specific terminals for offset nulling. Each type consists of a differential input amplifier that effectively drives a gain and level shifting stage having a complementary emitter follower output.

The manufacturing process make it possible to produce IC operational amplifiers with low burst “popcorn” noise characteristics.

Technical Data on LM Branded types is identical to the corresponding CA Branded types.

Features

- Input Bias Current . . . . 500nA (Max)
- Input Offset Current . . . . 200nA (Max)

Applications

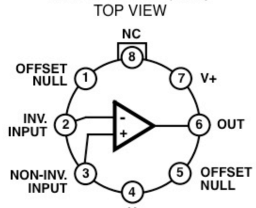
- Comparator
- Multivibrator
- DC Amplifier
- Summing Amplifier
- Integrator or Differentiator
- Narrow Band or Band Pass Filter

Ordering Information

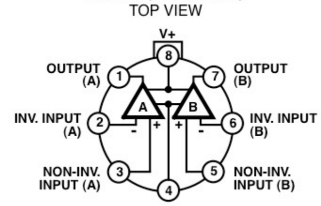
PART NUMBER	TEMP. RANGE (^oC)	PACKAGE	PKG. NO.
CA0741E	-55 to 125	8 Ld PDIP	E8.3
CA0741CE	0 to 70	8 Ld PDIP	E8.3
CA1458E	0 to 70	8 Ld PDIP	E8.3
CA1558E	-55 to 125	8 Ld PDIP	E8.3
CA0741T	-55 to 125	8 Pin Metal Can	T8.C
CA0741CT	0 to 70	8 Pin Metal Can	T8.C
CA1558T	-55 to 125	8 Pin Metal Can	T8.C
LM741N	-55 to 125	8 Ld PDIP	E8.3
LM741CN	0 to 70	8 Ld PDIP	E8.3
LM1458N	0 to 70	8 Ld PDIP	E8.3

Pinouts

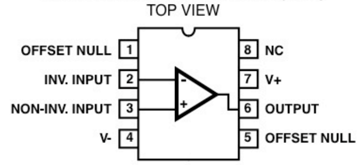
CA741, CA741C (CAN)
TOP VIEW



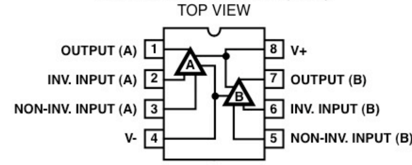
CA1558 (METAL CAN)
TOP VIEW



CA741, CA741C, LM741, LM741C (PDIP)
TOP VIEW



CA1458, CA1558, LM1458 (PDIP)
TOP VIEW



CAUTION: These devices are sensitive to electrostatic discharge; follow proper IC Handling Procedures.

Absolute Maximum Ratings

Supply Voltage
- CA741C, CA1458, LM741C, LM1458 (Note 1) 36V
- CA741, CA1558, LM741 (Note 1) 44V

Differential Input Voltage 30V
Input Voltage . . . . $\pm V_{SUPPLY}$
Offset Terminal to V- Terminal Voltage (CA741C, CA741) . . . . ±0.5V
Output Short Circuit Duration. . . . . Indefinite

Thermal Information

Thermal Resistance (Typical, Note 3)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
PDIP Package	130	N/A
Can Package	155	67

Maximum Junction Temperature (Can Package) . . . . 175°C
Maximum Junction Temperature (Plastic Package) . . . . 150°C
Maximum Storage Temperature Range . . . . -65°C to 150°C
Maximum Lead Temperature (Soldering 10s) . . . . 300°C

Operating Conditions

Temperature Range
- CA741, CA1558, LM741 . . . . -55°C to 125°C
- CA741C, CA1458, LM741C, LM1458 (Note 2) . . . . 0°C to 70°C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:
1. Values apply for each section of the dual amplifiers.
2. All types in any package style can be operated over the temperature range of -55°C to 125°C, although the published limits for certain electrical specification apply only over the temperature range of 0°C to 70°C.
3. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications
Typical Values Intended Only for Design Guidance, $V_{SUPPLY} = \pm 15V$

PARAMETER	SYMBOL	TEST CONDITIONS	TYPICAL VALUE (ALL TYPES)	UNITS
Input Capacitance	C_I		1.4	pF
Offset Voltage Adjustment Range			±15	mV
Output Resistance	R_O		75	Ω
Output Short Circuit Current			25	mA
Transient Response		Unity Gain, $V_I = 20mV$, $R_L = 2k\Omega$, $C_L \leq 100pF$		
Rise Time	t_r		0.3	μs
Overshoot	O.S.		5.0	%
Slew Rate (Closed Loop)	SR	$R_L \geq 2k\Omega$	0.5	V/μs
Gain Bandwidth Product	GBWP	$R_L = 12k\Omega$	0.9	MHz

Electrical Specifications
For Equipment Design, $V_{SUPPLY} = \pm 15V$

PARAMETER	TEST CONDITIONS	TEMP (°C)	(NOTE 4) CA741, CA1558, LM741			(NOTE 4) CA741C, CA1458, LM741C, LM1458			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Input Offset Voltage	$R_S \leq 10k\Omega$	25	-	1	5	-	2	6	mV
		Full	-	1	6	-	-	7.5	mV
Input Common Mode Voltage Range		25	-	-	-	±12	±13	-	V
		Full	±12	±13	-	-	-	-	V
Common Mode Rejection Ratio	$R_S \leq 10k\Omega$	25	-	-	-	70	90	-	dB
		Full	70	90	-	-	-	-	dB
Power Supply Rejection Ratio	$R_S \leq 10k\Omega$	25	-	-	-	-	30	150	μV/V
		Full	-	30	150	-	-	-	μV/V
Input Resistance		25	0.3	2	-	0.3	2	-	MΩ

Electrical Specifications For Equipment Design, V_{SUPPLY} = ±15V **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	(NOTE 4) CA741, CA1558, LM741 MIN	TYP	MAX	(NOTE 4) CA741C, CA1458, LM741C, LM1458 MIN	TYP	MAX	UNITS
Input Bias Current		25	-	80	500	-	80	500	nA
		Full	-	-	-	-	-	800	nA
		-55	-	300	1500	-	-	-	nA
		125	-	30	500	-	-	-	nA
Input Offset Current		25	-	20	200	-	20	200	nA
		Full	-	-	-	-	-	300	nA
		-55	-	85	500	-	-	-	nA
		125	-	7	200	-	-	-	nA
Large Signal Voltage Gain	$R_L \geq 2k\Omega$, $V_O = \pm10V$	25	50,000	200,000	-	20,000	200,000	-	V/V
		Full	25,000	-	-	15,000	-	-	V/V
Output Voltage Swing	$R_L \geq 10k\Omega$	25	-	-	-	±12	±14	-	V
		Full	±12	±14	-	-	-	-	V
	$R_L \geq 2k\Omega$	25	-	-	-	±10	±13	-	V
		Full	±10	±13	-	±10	±13	-	V
Supply Current		25	-	1.7	2.8	-	1.7	2.8	mA
		-55	-	2	3.3	-	-	-	mA
		125	-	1.5	2.5	-	-	-	mA
Device Power Dissipation		25	-	50	85	-	50	85	mW
		-55	-	60	100	-	-	-	mW
		125	-	45	75	-	-	-	mW

NOTE:

4. Values apply for each section of the dual amplifiers.

Test Circuits

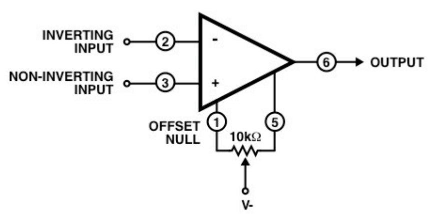


FIGURE 1. OFFSET VOLTAGE NULL CIRCUIT FOR CA741C, CA741, LM741C, AND LM741

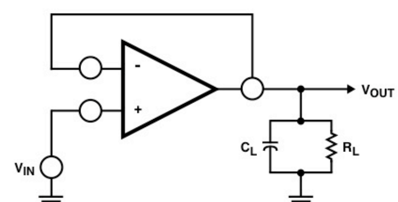
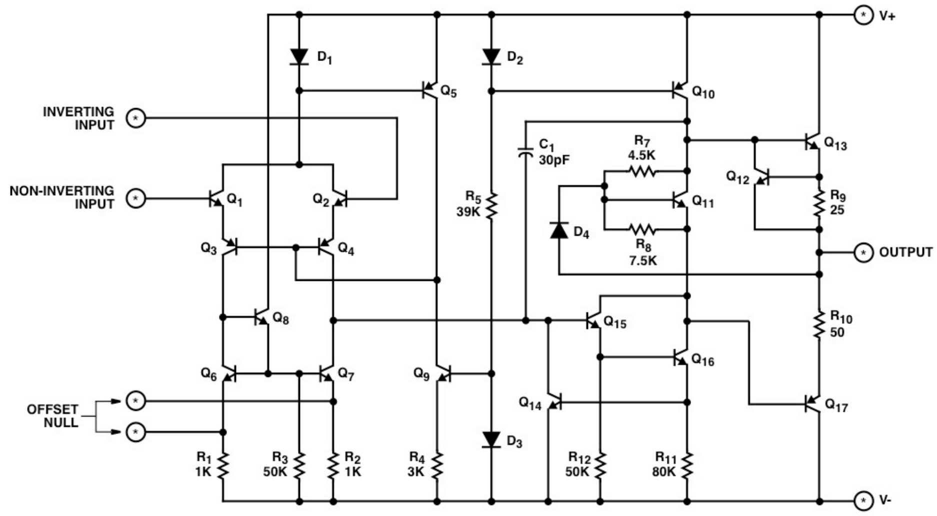


FIGURE 2. TRANSIENT RESPONSE TEST CIRCUIT FOR ALL TYPES

Schematic Diagram (Notes 5, 6)

CA741C, CA741, LM741C, LM741 AND FOR EACH AMPLIFIER OF THE CA1458, CA1558, AND LM1458



NOTES:

5. See Pinouts for Terminal Numbers of Respective Types.
6. All Resistance Values are in Ohms.

Typical Performance Curves

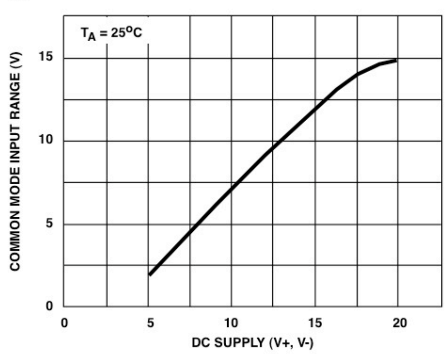


FIGURE 3. COMMON MODE INPUT VOLTAGE RANGE vs SUPPLY VOLTAGE FOR ALL TYPES

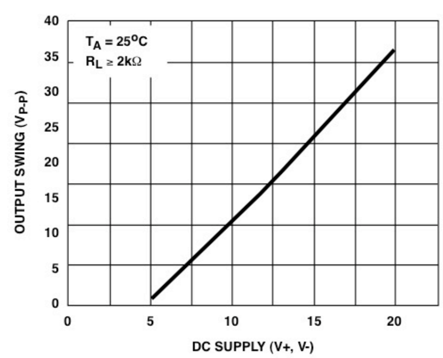


FIGURE 4. OUTPUT VOLTAGE vs SUPPLY VOLTAGE FOR ALL TYPES

Typical Performance Curves (Continued)

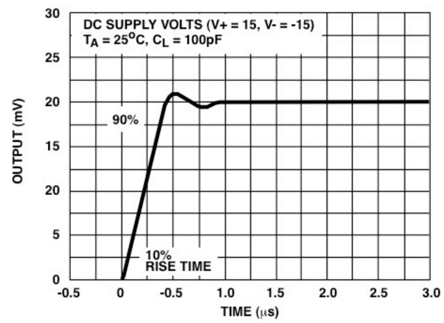
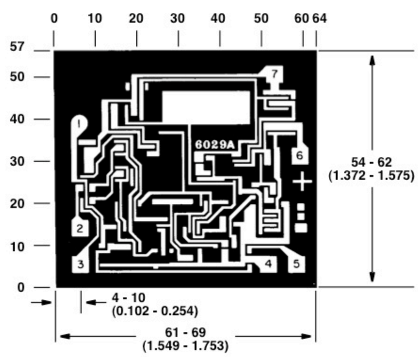


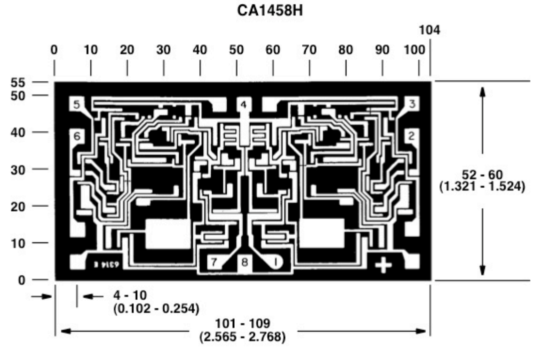
FIGURE 5. TRANSIENT RESPONSE FOR CA741C AND CA741

Metallization Mask Layout

CA741CH



CA1458H



NOTE: Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions as indicated. Grid graduations are in mils (10^{-3} inch).

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