# The Environmental Electronic Nose

Allan M. Sitar

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# ABSTRACT

**The Environmental Electronic Nose**

**Allan M. Sitar**

New and exciting methods of detecting chemical gases electronically and classifying them intelligently have emerged in the last few of years. The so-called electronic nose has been constructed and introduced to four closely related combustible gases for analysis The basis of *smelling* consists of an array of broadly tuned Taguchi gas sensors connected to an analogue-to-digital conversion system A database or knowledge of information of those signal-patterns is then compiled for a training input of a neural network system that can successfully discriminate (100%) among known individual samples of methane, propane, ethylene and ethane.

# ACKNOWLEDGEMENTS

I would like to sincerely thank those professors who helped me achieve the distance needed to further my academic knowledge during this two year applied thesis project. From the Concordia Physics Sensors Group: **Dr. David Cheeke**, with his support in both guiding the proposed project and assisting financially; **Dr. Nelson Eddy**, who helped supervise and encourage my progress; and **Professor Joe Shin**, who also helped co-supervise the project

Appreciation is given to other professors and fellow students who indirectly helped me get through those *tougher* times Special thanks is given to my parents, **Vlado** and **Katica**, for both their encouragement and moral support in beginning and completing this part of my life during that time of great difficulty

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I'd like to wish my fellow grad students luck in their endeavors and without them there would have been emptiness throughout my graduate experience of the past two years. Good luck to: **Steve Armstrong**, **Steve Beaudin**, **Manas Dan**, **Ping Ji**, **Xing Li**, **Veselin Petkov**, and **Nehad Tashtoush**

I would like to express my deep gratitude to **Mr. Wray Downes** who, at some time during my seven years of study at Concordia University, *really* taught me how to open my ears, eyes and thoughts. Thank you Sir Wray.

Appreciation is given to **Erica Bird** who helped me crack the TASM nightmare Now leave them soaps and go practice your clarinet! Also, credit goes to my sister **Rebecca** who sat at my desk daily and helped make it look busy!

So what did I learn from the whole process? What could one really achieve by bringing an unopened coconut to a thesis defense entitled *The Environmental Electronic Nose*?

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## 1.0 INTRODUCTION

Up to the present, various attempts to detect combustible gases have been adopted by employing one of the following methods:

1. *Color indication of chemical reaction in a detecting tube.*
2. *Optical interference.*
3. *Infrared absorption* (spectrum)
4. *Heat generation from catalytic reaction on a hot wire* (e.g. platinum)

However, they all suffer from the drawbacks of difficulty in handling, maintenance, high cost and limited life expectancy A very simple detector which holds a major part of the market is:

5. *Semiconductor sensor employing metal oxide.*

This two year project relates to a system comprising an array of highly discriminating metal oxide gas sensors (Taguchi Gas Sensors in particular) linked to a microcomputer for information processing and display, mimicking a mammalian olfactory system and hence meriting the description ELECTRONIC NOSE. This Master's thesis explores the feasibility of this new system of *smart* gas sensing

To date there are a number of different test systems which have been previously implemented to accompany the electronic nose. As a result of this, the Concordia Sensors

Group project had decided, because of its limited funds and lab equipment, to create an intermediate device which could monitor environmental gas efficiently, quickly and effectively, while keeping the costs to a minimum. The ideal gas injector for use with a static chamber would combine the accuracy advantages of manual methods with the convenience of computer control, whilst maintaining simplicity, versatility, ease of maintenance and low gas-consumption levels, coupled with acceptable error margins. The present gas-injection system has been designed and built for a static chamber and is based on the concept of establishing a constant gas flow through a circuit and then diverting this flow for a known period of time to the chamber, so injecting a specified value of this gas. In the meantime, as this latest system evaluator was in the process of being both built and waiting for purchased equipment to arrive, preliminary testing was carried out with the simple static rig and micropipette method

A description of both systems is presented, with weighted emphasis on the gas flow method, along with its experimental data, observations and results. An introductory section on the concept of neural networks and its implementation of the experimental data is also presented Data sheets and computer source code files are found in the appendices An overall conclusive remark , including an assessment on the Taguchi gas sensors, on the project is given at the end of this thesis.

# 2.0 FUNDAMENTAL CONCEPTS AND THEORY

## 2.1 Various Sensing Devices and Sensor Array Configurations

Many types of gas sensors are available and several have already received attention for electronic nose applications. Included among these are an assortment of varistor devices, use metal oxides, conducting polymers, Langmuir-Blodgett films, phthalocyanines, as well as MOS devices. Other forms using Schottky barrier structures, surface acoustic wave effects and piezoelectric phenomena are also applicable. Table 2-1 shows some of these sensor types as well as their target gases The requirement for the sensors in an electronic nose, however, is that they have a general sensitivity (i e they can respond broadly to a range or class of gases rather than to a specific one) Of course, this is the opposite of the ideal gas sensor, which should respond to only one gas (e g ethane), and provide a unique output. However, with an electronic nose, like the human nose, it would be desired to identify many odours that may contain hundreds of individual chemical components Thus, the need for a sensor which can generalize at the molecular level is required.

TABLE 2-1. *Common sensors for detecting gases and vapours.*

| **Active material** | **Sensor type** | **Typical target gases** |
|---|---|---|
| Sintered metal oxide | chemoresistor | combustible gases |
| Catalytic metal | thermal, e.g pellistor | combustible gases |
| Lipid layers | acoustic, e.g piezoelectric/SAW | organics |
| Phthalocyanines | chemoresistor | $NO_x$, $H_2$, $NH_3$ |
| Conducting polymer | chemoresistor | $NH_3$, alcohols |
| Electrochemical | potentiometric/amperometric | $NH_3$, CO, $CH_3CH_2OH$ |
| Catalytic gate | potentiometric, e.g. Pd-MOSFET | combustible gases |
| Organic semiconductors | optical, e.g IR absorption | $CH_4$, $CO_2$, $NO_x$ |

These devices can be used in a variety of array configurations for this kind of study. The active material employed in this study is the commercially available sintered metal oxide, popularly known as the Taguchi Gas Sensor (TGS) and is manufactured by Figaro Engineering Inc. These sensors are tailored to have a broad tuned response that is off-set from each individual sensor's elements. Table 2-2 lists three sensor array sampling systems along with some of their typical uses.

TABLE 2-2. *Sensor array sampling systems and their applications.*

| **Sensor array sampling system** | **Applications** |
|---|---|
| Static rig<br>- automated or manual sampling | - off-line process control<br>- odour description<br>- odour classification<br>- authentication |
| Mass flow system<br>- automated sampling<br>- mixed with carrier gas | - on-line process control<br>- environmental monitoring<br>- gas mixture analysis<br>- odour mixture analysis |
| Open system | - threshold detection<br>- environmental monitoring |

The first system, the static test rig, consists of a large glass flask enclosed with an array of sensors. The sensors are linked via a multiplexer to an A/D converter and then to a microcomputer. The method of measurand delivery involves the use of a micropipette which injects volatile liquids through an injection port that passes through the glass, permitting minute quantities of test substances to be introduced. These static test rigs have proven successful to some degree by discriminating a wide range of chemical substances, as well as beverages, including beers, lagers, wines and spirits [1]. In this case, the quantity injected is controllable to 5%. One disadvantage is the relatively slow response which can mean diffusion times exceeding 1 minute

A second test configuration involves a mass-flow control system and can be used as an unattended automatic operation This method has been described by researchers at the Tokyo Institute of Technology [2]. Essentially, a carrier gas is used (e g air) which may be fed, together with test gases, into a mixing chamber, each line containing a controller linked to a solenoid-operated valve. The output of the mixing chamber is fed into the sensor enclosure prior to a gas exhaust, while the sensor output feeding directly into a computer via the interface unit, as the static test rig In this case, control of the gas concentration may be achieved with an accuracy better than 1%.

A third configuration, although not common in study, may consist of a sensor array placed in an open environment with no induced sampling This system would rely on diffusion and convection of the odourous species to the sensor array for sample detection and classification.

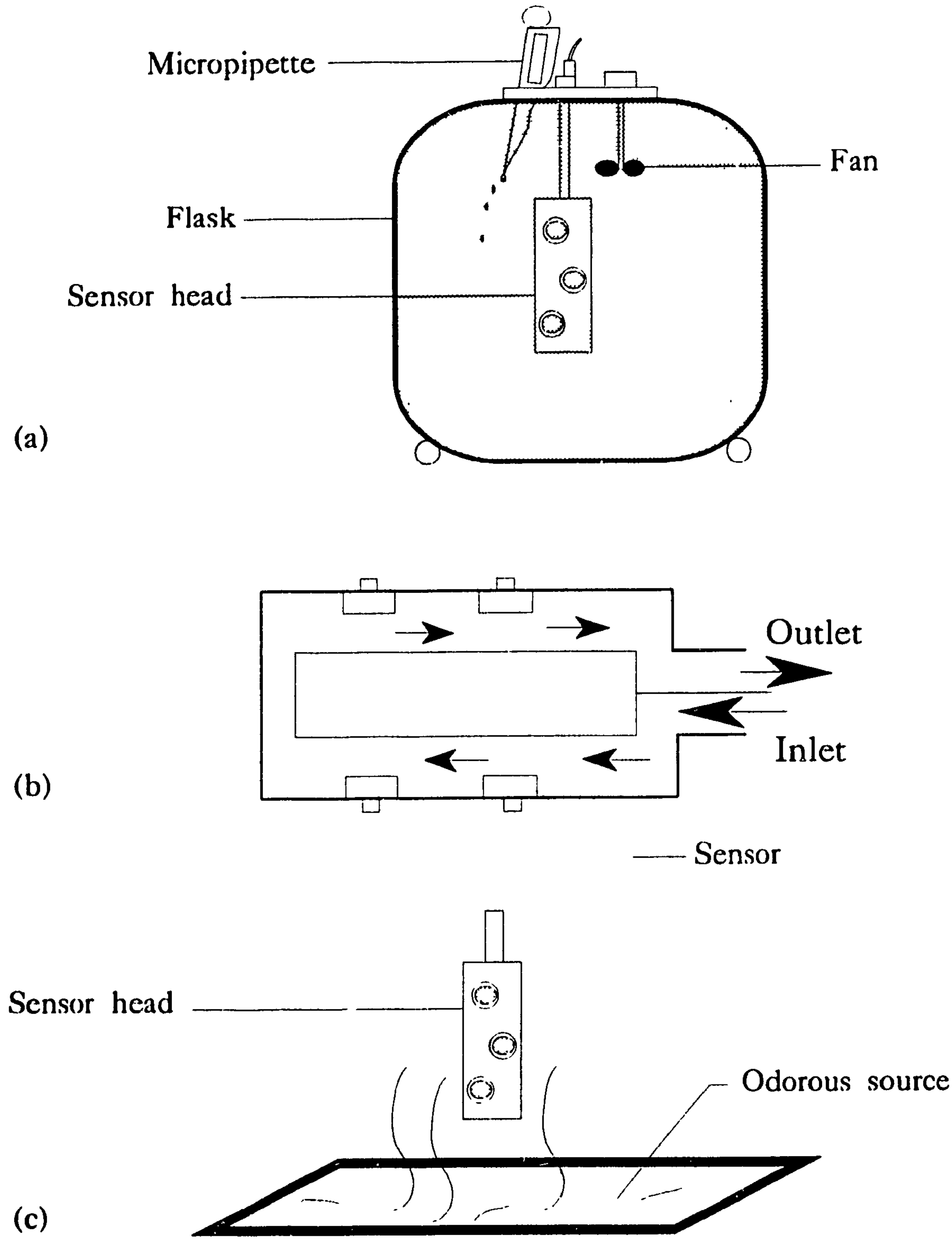



**Figure 2-1.** *Sensor array sampling system: (a) static rig; (b) mass flow system; (c) open environment.*

## 2.2 The Electronic Nose: an Intelligent System

Figure 2-2 shows the schematic representation of a biological nose and an electronic analogue that has been investigated at Coventry [3]. The human nose contains approximately 50 million cells (i.e. olfactory neurons) in the olfactory epithelium that act as primary receptors to odourous molecules. There are about 10 000 primary neurons (i.e. glomeruli nodes) associated with these primary receptors that synaptically link into a single secondary neuron (composed of about 100 000 mitral cells) which in turn feeds the olfactory cortex of the brain [4]. This parallel architecture suggests an arrangement that could lead to an analogous instrument capable of mimicking the biological system

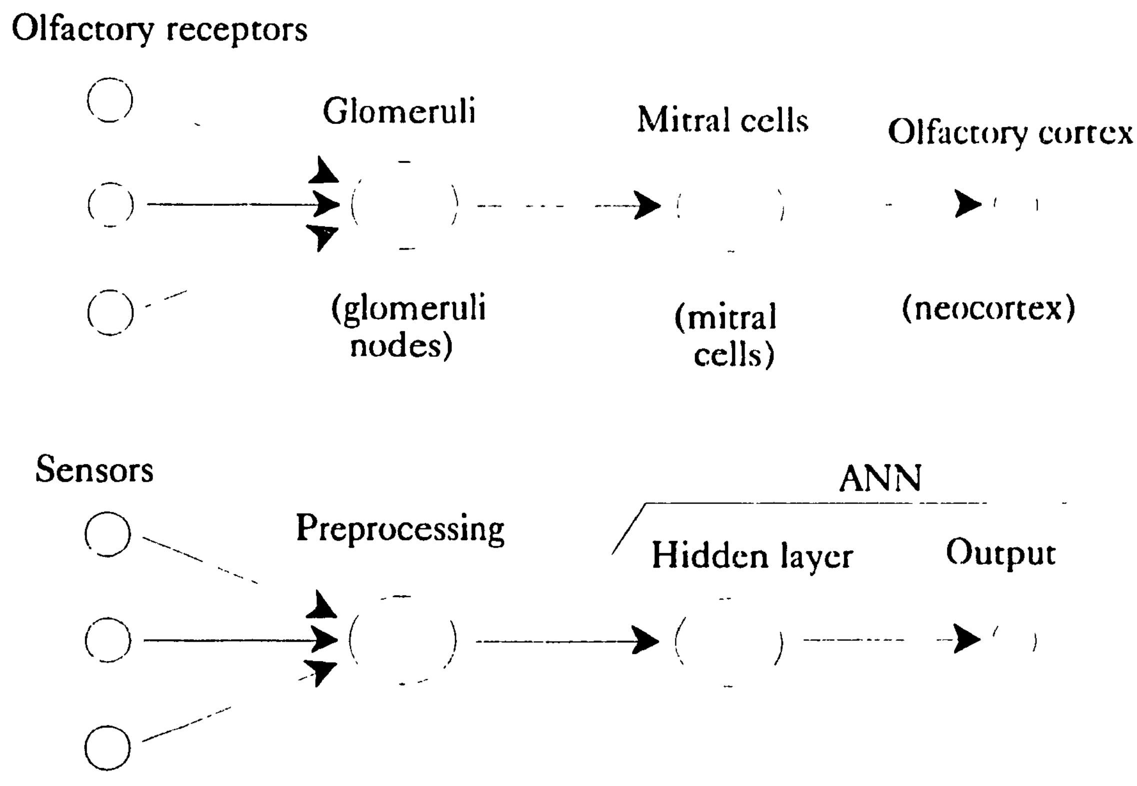



**Figure 2-2.** *Schematic representation of a biological nose and an electronic analogue.*

The primary receptors in the biological system are replaced by an array of detectors (e.g. metal oxide films) that respond to a broad range of chemical vapours or odours. The response, characterized by a change in electrical resistance, is processed at the secondary level by an analog-to-digital converter and is finally fed into a microcomputer for processing/analysis. This was also shown by the Coventry group [5].

In this study, the application of artificial neural networks (ANN) software was the employed method to process a multi-sensor chemical hardware array.

Figure 2-3 demonstrates a schematic diagram of the present Concordia Sensors Group electronic nose. First, a four-element MOS array response to a narrow range of chemically similar combustible gases producing a set of analogue signals (conductance change). Second, voltage divider circuits modify the signals followed by an A/D converter. Finally, the signals from the sensor array are processed in order to identify the target odourant.

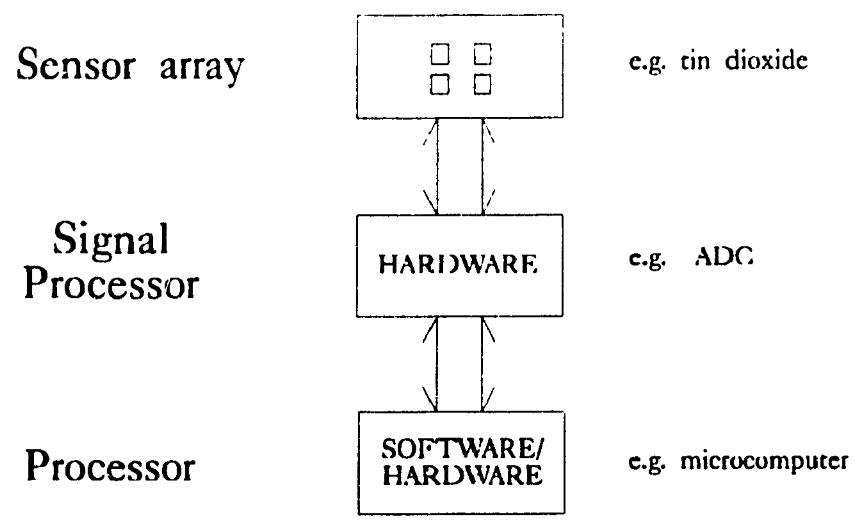



**Figure 2-3.** *Schematic diagram of the Concordia electronic nose*

The human nose is still the primary *instrument* used in many industries to evaluate the smell, or flavour of products such as perfumes (cosmetics, soaps, etc ..), foodstuffs (fish, meat, cheese, etc...) and beverages (beer, whiskey, coffee, etc...). This is a costly process because trained panels of experts are required who can only work for relatively short periods of time. On the other hand, artificial methods such as gas chromatography are used to characterize odours; unfortunately this determines the chemical composition of the odour rather than subjective terms such as *pungent*, *minty* or *fishy*. It is found in practise that an array of semiconducting sensors in which each element provides a broad-band response, offset from that of the other elements, can provide selectivity (Persaud and Dodd, for only 3 sensors) [4] Consequently, there is an enormous demand for an electronic instrument that can mimic the human sense of smell and provide low-cost and rapid sensory information [6].

The realization of an artificial nose consists both in the designing of hardware comprising gas sensors with associated electronics and in developing suitable software for processing the responses of the sensors to detect and interpret the different odours Figure 2-4 shows how a typical expert or *smart* system would operate

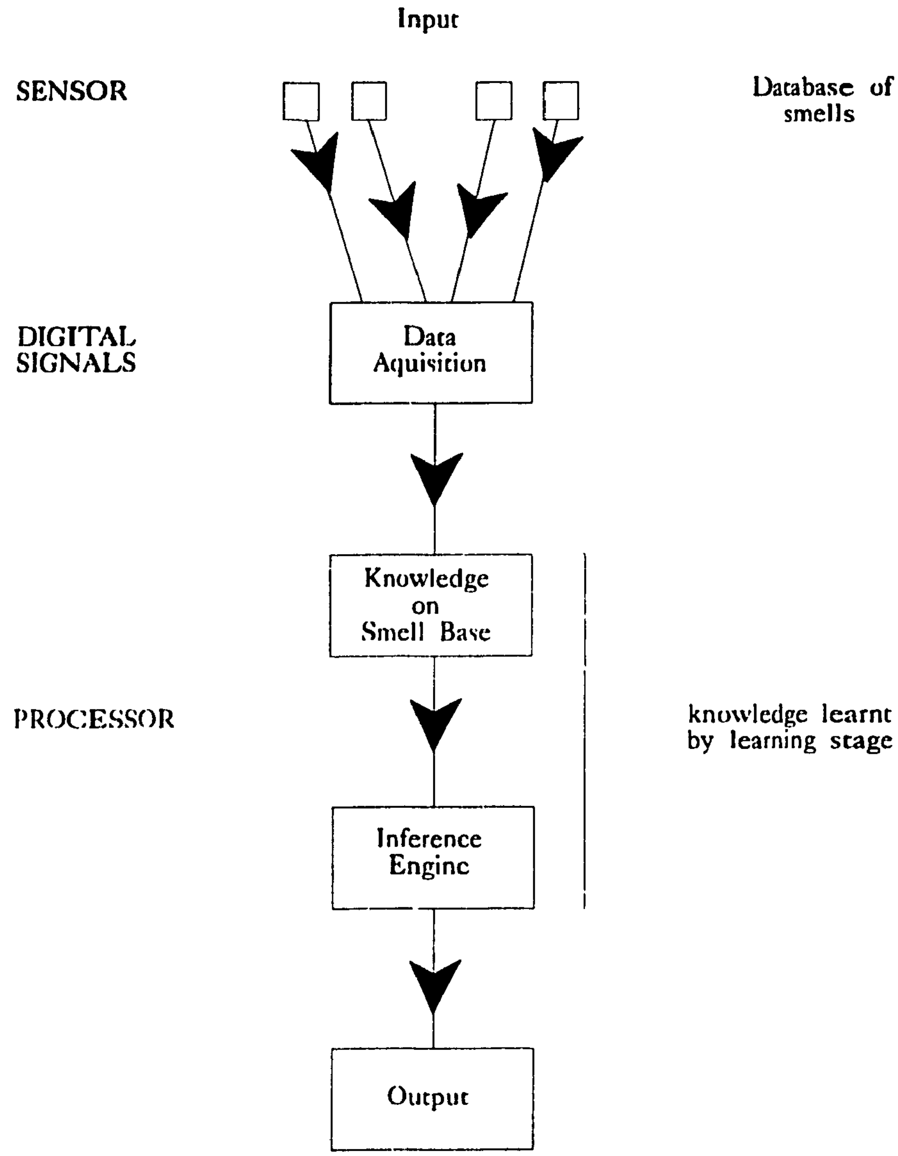



**Figure 2-4.** *Schematic diagram of an expert system.*

### 2.2.1 Historical overview of the term *Electronic Nose*

There have been previous developments, back in the 1960's, of a mechanical instrument built specifically to detect odours. However the concept of an electronic nose as an intelligent chemical array sensor system for odour classification did not really emerge until a publication by Persaud and Dodd (1982) at Warwick University in the UK [4] and Ikegami *et al.* (1985, 1987) at Hitachi in Japan [7,8]. The term *Electronic Nose* appeared around the late 1980's especially after a session in a NATO Advanced Workshop on Chemosensory Information Processing (1989). The topic of electronic noses was first dedicated at a conference held in 1990 [9]. The following definition could be accepted to describe the electronic nose:

*An* **electronic nose** *is an instrument, which comprises an array of electronic chemical sensors with partial specificity and an appropriate pattern-recognition system, capable of recognizing simple or complex odours* [6]

## 2.3 Gas Detecting Mechanism - Principles of the TGS Sensor

When the Taguchi Gas Sensor (TGS) is heated to a high temperature (e.g. 400 °C) without the presence of oxygen, free electrons flow easily through the grain boundaries of the tin dioxide ($SnO_2$) particles

But when the TGS sensor is heated at a certain high temperature in **air**, oxygen which can accept electrons, is dissociatively adsorbed on the surface which has negative charge. This charge results from an electron transfer from the donor levels in the surface region. As a result, the electron depletion layer develops from the surface to the bulk and is positively charged so as to balance the surface negative charge which oxygen maintains. Then, potential barriers against bulk conduction electrons are formed at the grain boundaries of the sintered body. The barrier prevents the electrons from moving at the grain boundaries so that the sensor obtains a very high electrical resistance. This model can be seen in figure 2-5.

When the sensor is exposed to an environment containing **reducing gases** (e.g. combustible gases, CO, etc .) the tin dioxide surface adsorbs these gas molecules which in turn reacts with the adsorbed oxygen causing oxidation. This lowers the potential barrier, allowing free electrons to flow more easily, thereby reducing the electrical resistance (taken from Figaro Technical Notes ) [10]. This diminishing resistivity is proportional to the reducing gas concentration.

The reaction for various gases is altered by the sensor element's temperature and minute components added to $SnO_2$ semiconducting materials. In other words, different types of TGS sensors with their own relative sensitivities have been produced by controlling the temperature and added materials. A scanned image of various Taguchi gas sensors can be seen in Figure 2-6.

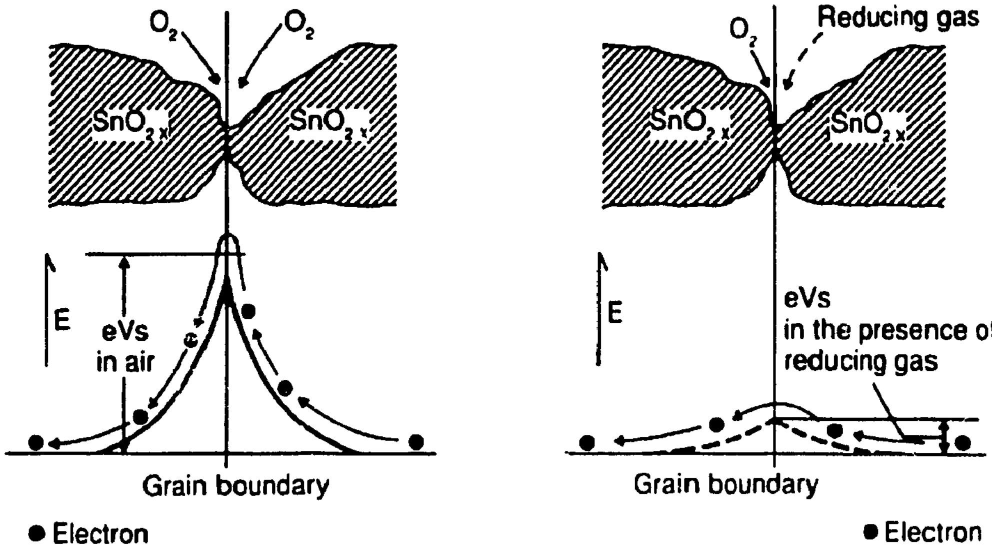



**Figure 2-5.** *Model of inter-grain potential barrier.*

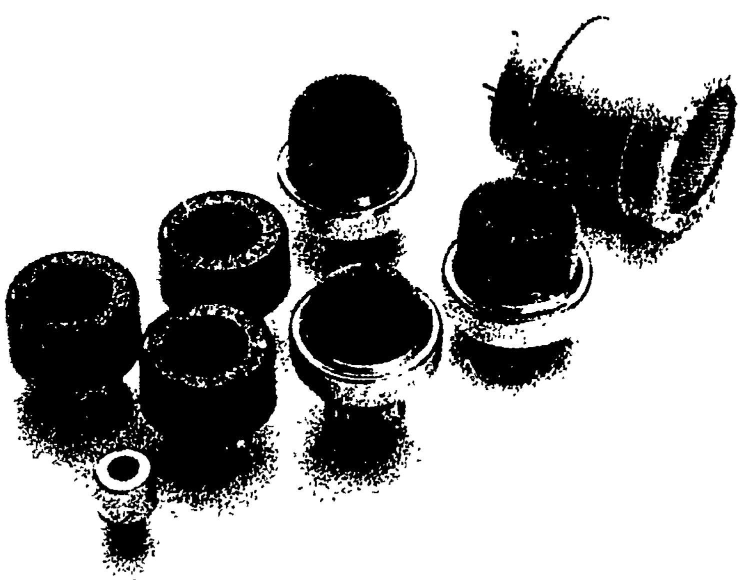


**Figure 2-6.** *Scanned image of various TGS sensors.*

## 2.4 Experimental System Description

A system description of the signal processing can be seen in the figure below. There are four discrete Taguchi Gas Sensors (TGS) mounted on the inside surface of a plexiglass casing lid. The electrical connections to and from the sensors pass through an insulated hose to a control unit which supplies power to the sensor heaters, drives the sensor with the appropriate circuit voltage and processes the sensor's output signal. The analog-to-digital converter (ADC) digitizes this output signal and the data is read by an assembly-language procedure interfaced with a C++ program which writes the data into a DOS file. The volume of the test chamber is 6174 milliliters (i.e. 29.4 x 15 x 14 $cm^3$) and attached to it inside is a small 5 V dc fan to ensure uniform dispersion of the test gas. The lid rests flat and is firmly screwed against the perimeter of the chamber walls with foaming fastened and sealed at all sides. Also, the lid serves to hold a temperature/hygrometer probe as well as a 12 V dc, 3-way valve solenoid The system opens the gas input port via the solenoid valve for a specified amount of time (the valve has a switching response of 30ms). Another port (1/2 inch hole) located near the bottom of one side of the testing rig is connected to a manual ball-valve which, when opened, allows a vacuum pump to withdraw gas samples after every experiment.

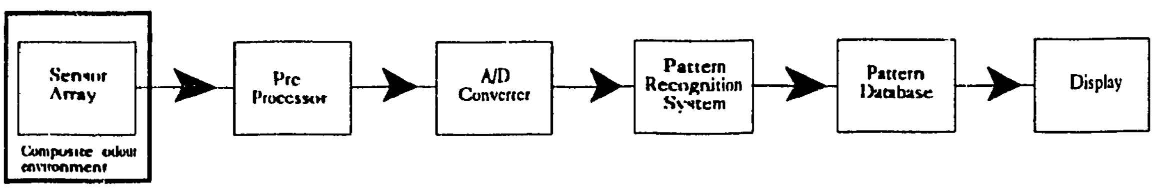



**Figure 2-7.** *Signal processing for the Concordia artificial nose.*

The four Taguchi sensors used for study in this project are listed below. All four TGS models were individually driven by the same circuit and heater voltages at 10 and 5 V dc respectively. In particular, the TGS816 is especially designed to withstand severe environments up to 200 °C.

TABLE 2-3. *The four employed TGS sensor types used in this study.*

| **Sensor No.** | **Model** | **Objective Gases** | **Structural Remarks** |
|---|---|---|---|
| Sensor #1 | TGS822 | Organic solvents | Standard type; resin base and housing |
| Sensor #2 | TGS816 | General combustible | Heat resistant ceramic base, mesh cover |
| Sensor #3 | TGS812 | Combustible, toxic | Standard type; resin base and housing |
| Sensor #4 | TGS813 | General combustible | Standard type; resin base and housing |

## 2.5 Introduction to Neural Networks

A neural network is an information processing system that is non-algorithmic, non-digital (i e input and output variables are real numbers), and intensely parallel. It consists of a number of very simple and highly interconnected processors called neurodes, which are the analogues of the biological neural cells, or neurons, in the brain (see section 2 2 and figure 2-2) The neurodes are connected by a large number of weighted links over which signals can pass Each neurode typically receives many signals over its incoming connections, some of the incoming signals may arise from other neurodes, and others may come from the outside world - a photon striking a photoreceptor, for example, or an input signal pattern presented to the network by the designer The neurode usually has many of these incoming signal connections, however, it never produces more than a single outgoing signal This output signal transmits over the neurode's outgoing connection (corresponding to the biological axon of a neuron), which usually splits into a very large number of smaller connections, each of which terminates at a different destination Each of these branches of the single outgoing connection transmits the same signal, the signal is not split or divided among them in any way. Most of these outgoing branches terminate at the incoming connection of some other neurode in the network and generate control or response patterns

Figure 2-8 illustrates the physical connections of a typical neural network As noted earlier, the reason these connection rules are used in artificial neural networks is that they are directly inspired by the architecture of the human brain Thus, most successful network architectures mimic the brain's construction. In other areas, the neural network's neurodes are less true to their biological roots In particular, the artificial neural network's neurode is, in nearly all cases, only a crude approximation of a biological neuron. As a result, current neural network's cannot be assumed to operate exactly the way a biological neural network does

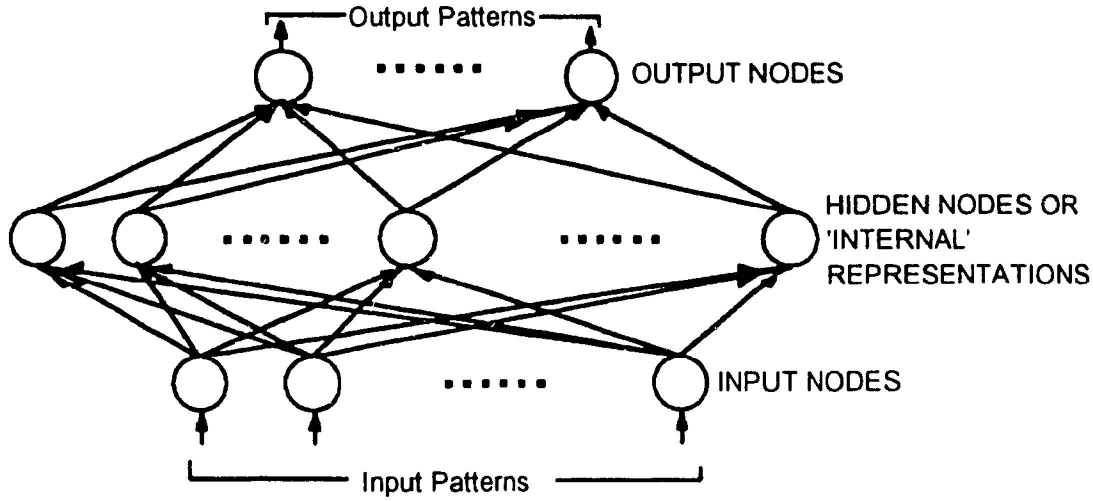



**Figure 2-8.** *Physical Connections of a typical neural network.*

### 2.5.1 Learning and Training in a Neural Network

Neural networks *learn* to solve a problem; they are *not programmed* to do so Learning and training are thus fundamental to nearly all neural networks Learning is achieved not by modifying the neurodes in the network but by modifying the weights on the interconnections in the network. Consider how an individual neurode determines its output. If it is assumed that the transfer function is fixed (i e the mathematical expression that describes the translation of input stimulus pattern to output response signal), then each neurode's output is determined by two things only The incoming signal and the weights on the input connections to the neurode. Clearly, if the neurode is to learn to respond correctly to a given incoming signal pattern, the only possible element that can be used to improve the neurode's performance is the weight on the connection. Learning in neural networks consist of making systematic changes to these weights in order to improve the network's performance to acceptable levels.

Training and learning are not the same. Training is the procedure by which the network learns: learning is the end result of that procedure. Training is done by example and the most common one is the supervised training method. In this technique, the network is provided with an input stimulus pattern along with the corresponding desired output pattern. The learning law for such networks typically computes an error, that is, how far from the desired output the network's actual output really is. This error is then used to modify the weights on the interconnections between the neurodes.

The three-layer network which was used to model Concordia's 4-element artificial nose is shown in figure 2-9. The input layer consists of 4 processing elements, corresponding to the olfactory receptors in the artificial nose, set to the value of the normalized conductance change. The hidden layer, so called because it is not readily accessible, processes a number of processing elements (or primary neurons) which can be determined experimentally The outer layer has a number of output elements (or secondary neurons), N, that depend on the number of odours or vapors analyzed. The number of output elements of Concordia's artificial nose is four.

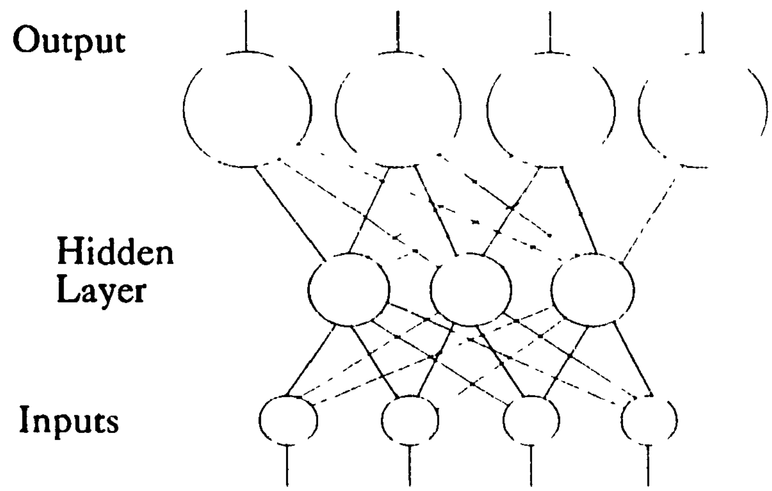



**Figure 2-9.** *Symbolic representation of the Concordia three-layer network with 4 inputs and 4 outputs.*

An existing artificial neural network source code (called GENERALIZED DELTA RULE NET PROGRAM FOR SUPERVISED LEARNING) was already available [11] and provides support in the following tasks:

1. *Specify net architecture.*
2. *Learn weights and thresholds with use of training set patterns.*
3. *Use network to obtain output values for new patterns, either for classification purposes or an estimation of values of associated attributes.*

The source code was a C language program and was entered and compiled within the UNIX operating system.

### 2.5.2 Sensors and Signal Preparation

Figure 2-9 shows the generic architecture of an electronic nose. An odour *j* is presented to the active material of a sensor *i*, which converts a chemical input into an electrical signal. The individual sensor *i* within the electronic nose produce a time-dependent electrical signal $V_{ij}$ (t) in response to an odour *j*. The rise and decay time in the sensor signal will depend upon one or more of the following parameters:

- *The flow delivery system that carries the odour from the source to the sensor array.*
- *The nature of the odour* (eg. type, concentration).
- *The reaction kinetics of the odour and the active material.*
- *The diffusion of the odour within the active material.*
- *Ambient conditions* (eg. temperature of active material, carrier gas, humidity, pressure).

To date, no use has been made of the transient information in the sensor signal by appropriate processing while a variety of steady-state models have been summarized and used to process odour and gas sensor signals [6].

The response from an array made up of **n** sensors is a vector $\mathbf{X}_j$, which can be written as

$$\mathbf{X}_j = \{ x_{1j}, x_{2j}, \ldots , x_{nj} \} \qquad (2.5.1)$$

in which this set could then become normalized and prepared as input data for pattern recognition techniques.

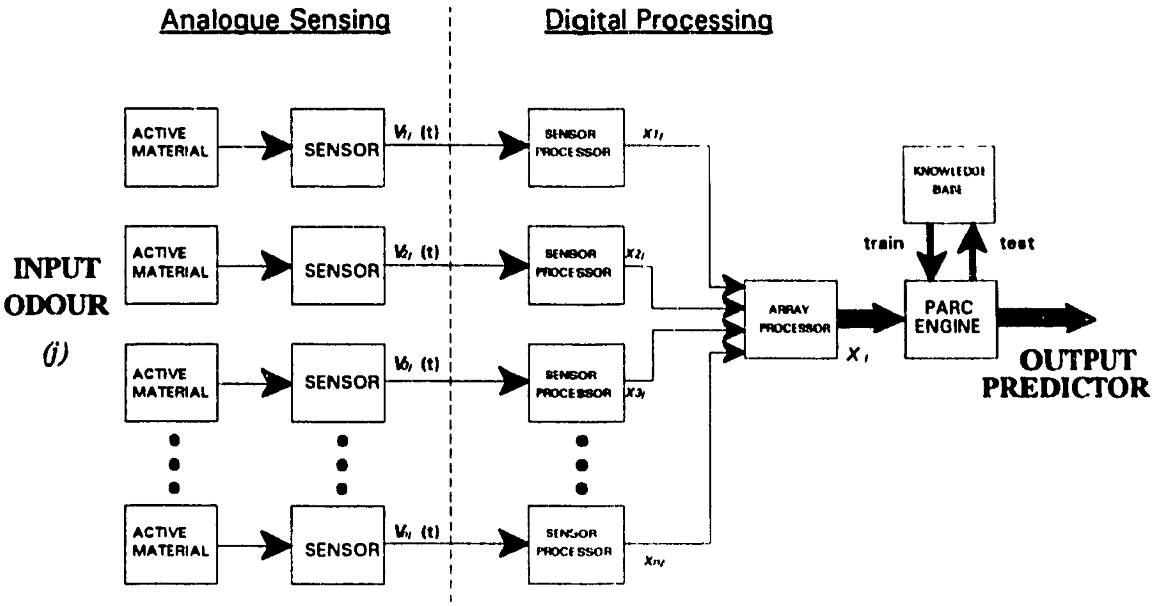



**Figure 2-10.** *Generic Architecture of an Electronic Nose.*

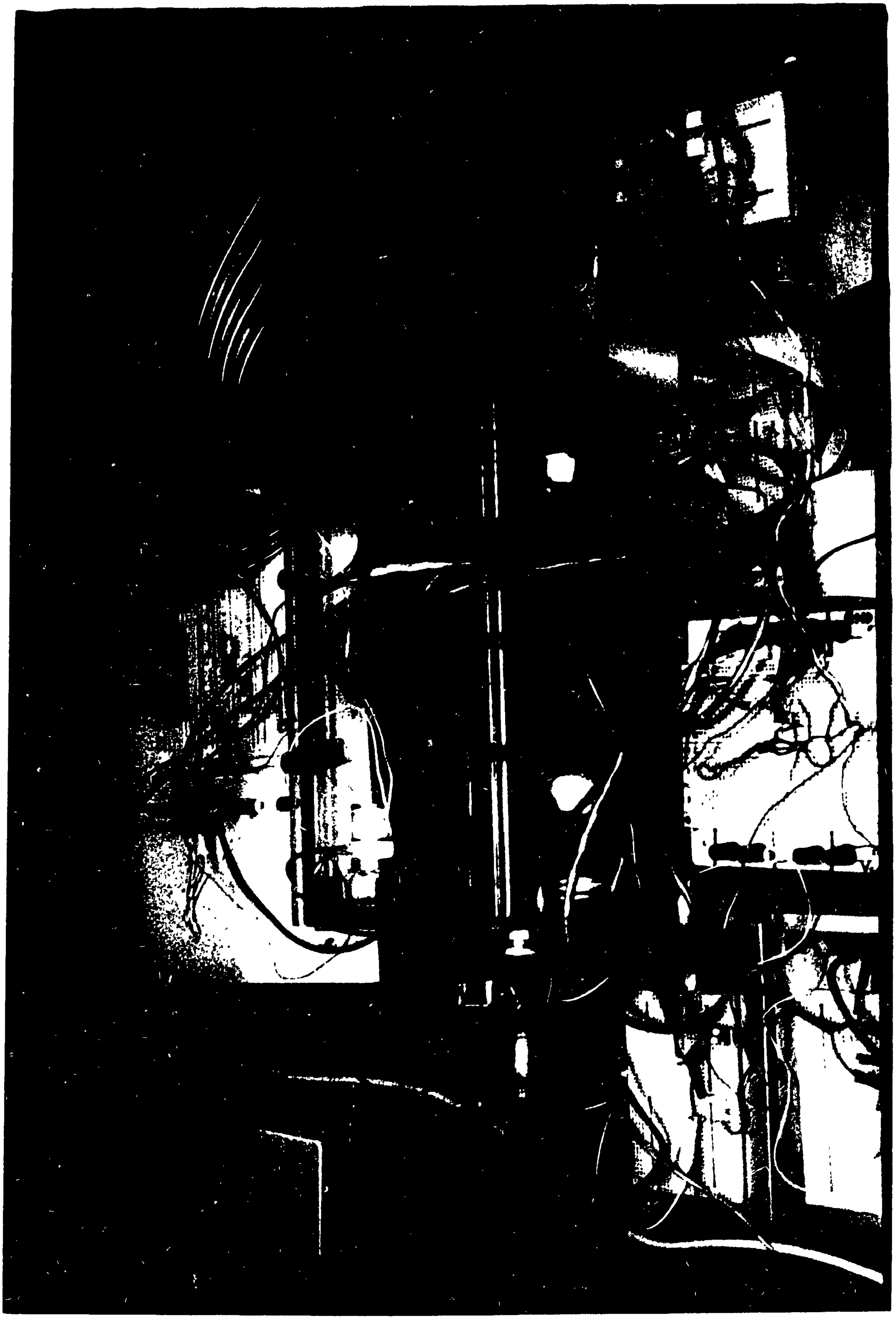
The response vectors generated by the sensor array are then analyzed using a pattern-recognition (PARC) engine. In most cases there are two stages used in the pattern-recognition processes. First, the output of the sensor array is trained by the PARC method using mathematical rules that relate the output from a known odour to a set of descriptors held in a knowledge base. This process is known as supervised learning. Then, the response from an unknown odour is tested against the knowledge base and the predicted class membership is then given.

## 3.0 EXPERIMENT

### 3.1 Experimental System Set-up

Four chemically pure (CP) combustible gases: methane; propane, ethylene and ethane, were selected to simulate a volatile gaseous environment. Each cylinder is composed of 99% CP combustible gas in 1% air.

A photograph of the Concordia Electronic Nose is shown on the following page (not shown in the picture is the flowmeter, gas cylinders and vacuum pump). The actual delivery from the 2-stage gas regulator was set to 50 psi which accommodates a Matheson high-accuracy valve flowmeter Calibrated look-up tables were supplied to convert the tube's scale readings into standard cubic centimeters per minute (SCCM) After a constant flow rate is selected, the gas can be switched via a three-way 12 VDC solenoid valve, entering the test chamber only when activated by the computer The 3 Watt solenoid was purchased through Cole Palmer products and has a responsive switching time of 30 milliseconds The 6174 ml plexiglass fabricated transparent chamber firmly encloses the four discrete Taguchi Gas Sensors (TGS) inside while a small 5 VDC fan is mounted to ensure uniform gas circulation throughout the enclosed volume After one trial of an experiment has taken place, a pump extracts the combustible gas which sets the chamber free from leftover measurand In fact, because of the tiny porous openings around the fan's shaft penetrating through the bored plexiglass and the pin holes for the four sensors, it can be assumed that shortly after the cessation of pumping the vacuum is lost. This can be verified by the fact that when the flow rate is set and the free-floating glass ball remains fixed, there is no movement whatsoever by the floating ball at the moment the solenoid is activated. An altered pressure difference would have upset the flowmeters equilibrium. A period of 30 second delay after evacuation was observed to restore chamber pressure to near atmospheric. All experiments were carried out in this way to



minimize errors due to pressure variations. In this way, a partial simulation of a true-life environment was conceived.

The injected gas concentration is calculated as follows:

$$C_{gas} = \frac{F \cdot t \cdot U}{V} \times 10^6 \quad \text{ppm} \tag{1}$$

where, F = *the flow rate in milliliters per second*

t = *injection time in seconds*

V = *volume of test chamber in milliliters*

U = *dilution ratio*

## 3.2 Procedure

Presented here is a detailed procedure for a typical experiment:

[1] The system was turned on and allowed to warm up for 15 minutes prior to a series of experiments.

[2] While the test gas was continuously running in the background at some selected constant flow rate, the experiment was initialized by invoking the working executable file called: E-NOSE.EXE. The user is then prompted by the terminal display to select a filename in which the data is to be stored, as well as the number of seconds for the gas to be injected into the test chamber.

[3] Once the actual experiment is activated, the screen displays the sampled data in succession for 1000 iterations (i.e. approximately 1 minute) Because of the sensor's quick response time (i.e. in the order of seconds) a stable voltage value is achieved. In this way, the last 500 iterations were averaged out to become the value in relation to the applied gas concentration The temperature and relative humidity were also recorded automatically at the end of the 1000 iterations.

[4] From the chamber's output port, the ball-valve was then opened for exactly 2 minutes so that a vacuum pump could withdraw all the test gas away. After the 2 minutes, the ball-valve was shut and the chamber pressure was allowed to equalize for 30 seconds before commencing another experiment.

[5] All subsequent experiments were carried out in this fashion. Each individual gas was explored on different days although all followed the above-mentioned procedure.

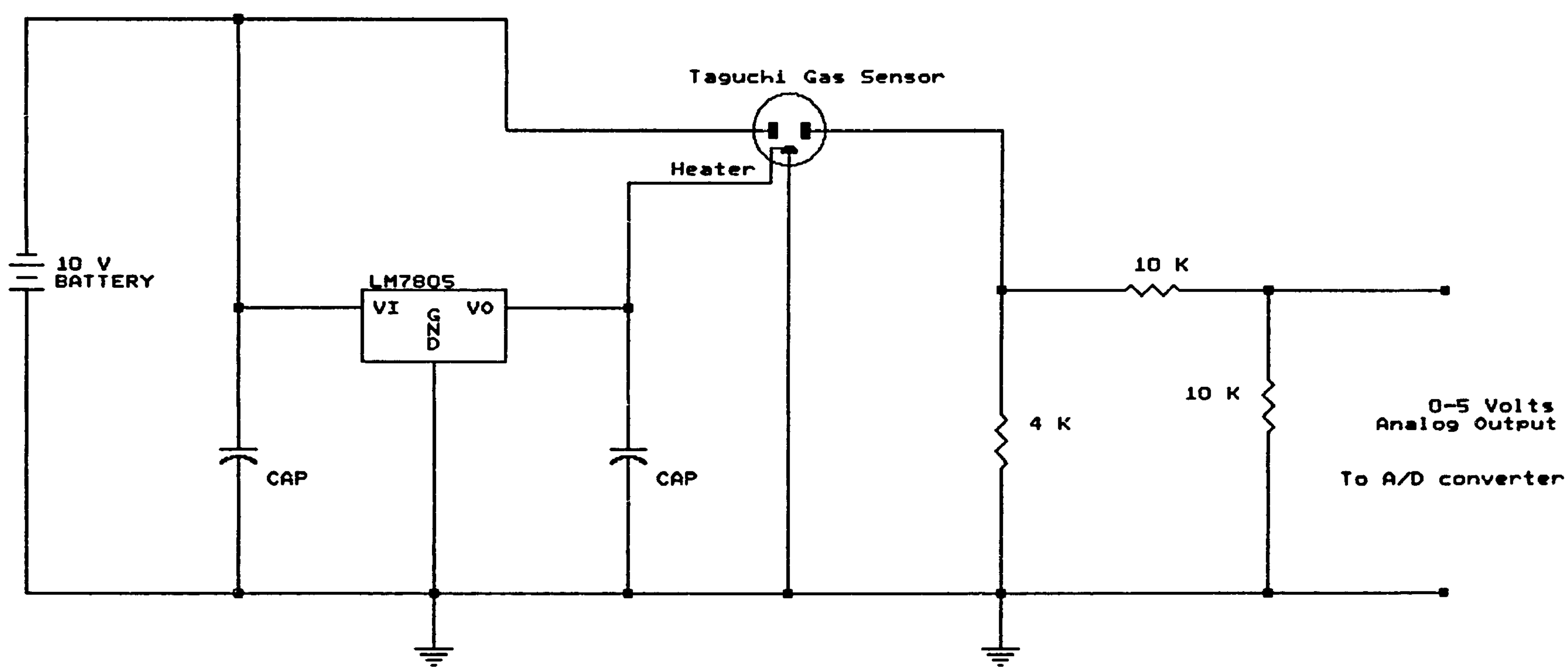
## 3.3 Hardware

The following circuit diagram on the next page is an electrical description for one Taguchi gas sensor.

The circuit is driven by a 10 V dc voltage supply fed to the sensor and a 7805 voltage regulator chip which supplies 5 volt to a heater element enclosed within the sensor. At the sensor's output there is a 2:1 voltage divider circuit used to bring the voltage maximum from 10 volts down to 5 volts. The resulting analogue voltage follows to the analogue-to-digital converter which translates the signal into an 8-bit digital value.

Diagrams of the structural sensor (e.g. TGS812) and associated electrical circuits are displayed in Appendix I and II respectively.

# Signal Processing for a Single Taguchi Gas Sensor




NOTE:

1. Capacitor values are 10 uF.

2. Output must be no more than 5 Volts max.

| SENSORS GROUP CONCORDIA | | |
|---|---|---|
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| Title<br>Signal Processing for a Single TGS | | |
| Size<br>A | Document Number<br>TGS-NOSE-01-AS | REV<br>AS |
| Date: | March 5, 1995 | Sheet 1 of 1 |

# 4.0 DATA AND RESULTS

## 4.1 Typical Sensor Responses

The array of curves shown in figure 4-1 demonstrates the four different but simultaneous sensor responses resulting from the use of the present gas-flow injector system This group of curves is displayed as a typical example and is taken from a set of 15 different responsive concentrations of methane gas. The introduction of 400 ppm of methane gas at 25 °C and 2% relative humidity produced the voltage levels listed in table 4-1 and plotted in figure 4-1. The 4 average voltages make up a 4-component pattern vector unique to $CH_4$ under these physical conditions. This fingerprint-like pattern-vector could then become the basis to any pattern recognition system. Table 4-1 lists the final 13 sample readings of the 4 sensors along with the time of sampling in seconds after initiation of the experiment. A complete list of this data is displayed line by line on the computer screen and also saved to a DOS file over the course of an experiment (see Appendix IV). As mentioned earlier, the final average voltage was calculated by averaging the last 500 samples. In effect, this averaging scheme focuses only on the linear regime and is safe from the initial non-linear rise-time at the beginning In fact, of the 1000 samples, which amounts to nearly 60 seconds, the steady state region normally begins only in and around the 10 second mark Due to the computer's limitation of performing one task at a time, recording of the data only begins after the event of the injection period. That is, in this case the injection period was 5 seconds and only after this time could the sampling then be recorded. However, this detail has no effect in the sensor's performance and is completely independent of its rise time. Hence, it is the steady state region that is of interest here since this voltage level defines the characteristic of the gas in question. The values from this region (as averages) are then used as training inputs for pattern recognition.

TABLE 4-1. Sensor Responses Employing a Flow-Injection Method

| SAMPLE | Sensor #1 | Sensor #2 | Sensor #3 | Sensor#4 | Time [s] |
|---|---|---|---|---|---|
| ... | ... | ... | ... | ... | ... |
| 988 | 2.69 | 3.24 | 1.69 | 4.12 | 57 64 |
| 989 | 2.69 | 3.24 | 1.67 | 4.12 | 57 69 |
| 990 | 2.71 | 3 24 | 1.69 | 4.10 | 57.75 |
| 991 | 2.69 | 3.24 | 1.67 | 4 10 | 57 80 |
| 992 | 2.69 | 3.24 | 1.67 | 4.12 | 57 86 |
| 993 | 2.71 | 3.24 | 1.69 | 4 10 | 57.91 |
| 994 | 2.69 | 3.24 | 1.67 | 4.10 | 57 97 |
| 995 | 2.71 | 3.24 | 1.67 | 4 10 | 58 02 |
| 996 | 2.69 | 3.24 | 1.69 | 4.10 | 58.08 |
| 997 | 2.69 | 3.24 | 1.67 | 4.10 | 58 13 |
| 998 | 2.71 | 3.24 | 1.69 | 4.12 | 58.19 |
| 999 | 2.69 | 3.24 | 1.67 | 4.12 | 58.24 |
| 1000 | 2.71 | 3.24 | 1.67 | 4.12 | 58.30 |
| AVERAGE VOLTAGE: | 2.69 | 3.23 | 1.68 | 4.11 | 58 30 seconds |
| TEMP: | 25 Celsius | | | | |
| REL.HUM: | 2 % | | | | |

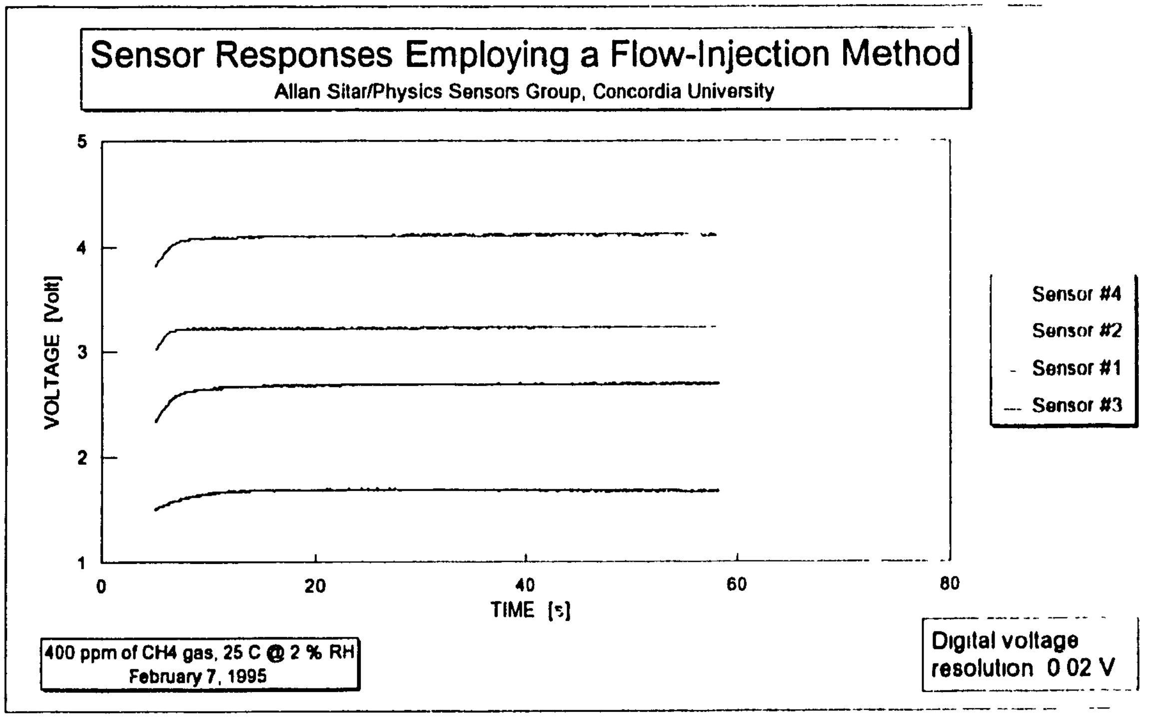



FIGURE 4-1. Sensor Responses Employing a Flow-Injection Method

## 4.2 Sensor Responses for 4 Individual Gases

Shown in the following pages are 4 tables of averages and 4 graphs of experiments conducted on 4 different gases These combustible gases each generate the same number of selected concentration points All 4 experiments were conducted on different days (i e 4 sets of 15 data points per day) In all cases, both the ambient temperature and relative humidity varied somewhat with a maximum difference of about 4 °C for temperature and an 8% for the relative humidity For each gas, the set of 15 selected concentration points lie within the domain of about 55 to 750 ppm This amounts to a total set of 60 data points which later make up the training inputs for the pattern recognition software

By inspection, the response captured on these graphs does indeed show a unique pattern for each For example, methane, throughout the domain spectrum, shows all 4 sensor responses behaving in the same way except that they are separated by nearly equal average voltage responses with the inner 2 sensors (TGS822 and TGS816) slightly closer together Methane's pattern is similar to ethane although for ethane the individual sensor responses are grouped closer together and are located in the higher average voltage response range Also the inner sensors tend to cross-over at the lower concentration end Another gas, propane, begins to look like a cross between both methane and ethane but only in the upper concentration region As the concentration descends, a series of cross-overs occur again by the 2 inner sensors Ethylene on the other hand, has quite a different appearance in that two groups of two response patterns occur quite closely to each other at the upper concentration end then separate while descending at lower concentrations There is a cross-over near the lower end by both sets It is particularly noted that for propane, sensor #3 (i e TGS812) does not yield a well defined smooth relation as all 3 others do This phenomenon is difficult to explain since all 4 data points are always accumulated simultaneously

TABLE 4-5. Sensor Responses for Methane Gas.

| TRIAL # | SENSOR 1 | SENSOR 2 | SENSOR 3 | SENSOR 4 | Conc [ppm] |
|---|---|---|---|---|---|
| 1 | 3.09 | 3.70 | 1.98 | 4.47 | 749 |
| 2 | 3.02 | 3.63 | 1.91 | 4.43 | 694 |
| 3 | 3.00 | 3.59 | 1.89 | 4.39 | 636 |
| 4 | 2.93 | 3.51 | 1.82 | 4.34 | 577 |
| 5 | 2.85 | 3.43 | 1.77 | 4.27 | 518 |
| 6 | 2.78 | 3.34 | 1.73 | 4.20 | 458 |
| 7 | 2.69 | 3.23 | 1.68 | 4.11 | 399 |
| 8 | 2.61 | 3.14 | 1.61 | 4.03 | 342 |
| 9 | 2.49 | 3.00 | 1.55 | 3.90 | 288 |
| 10 | 2.39 | 2.83 | 1.48 | 3.78 | 237 |
| 11 | 2.29 | 2.71 | 1.45 | 3.64 | 190 |
| 12 | 2.15 | 2.53 | 1.40 | 3.44 | 147 |
| 13 | 1.98 | 2.30 | 1.30 | 3.20 | 111 |
| 14 | 1.78 | 1.98 | 1.30 | 2.85 | 80 |
| 15 | 1.70 | 1.80 | 1.26 | 2.64 | 56 |

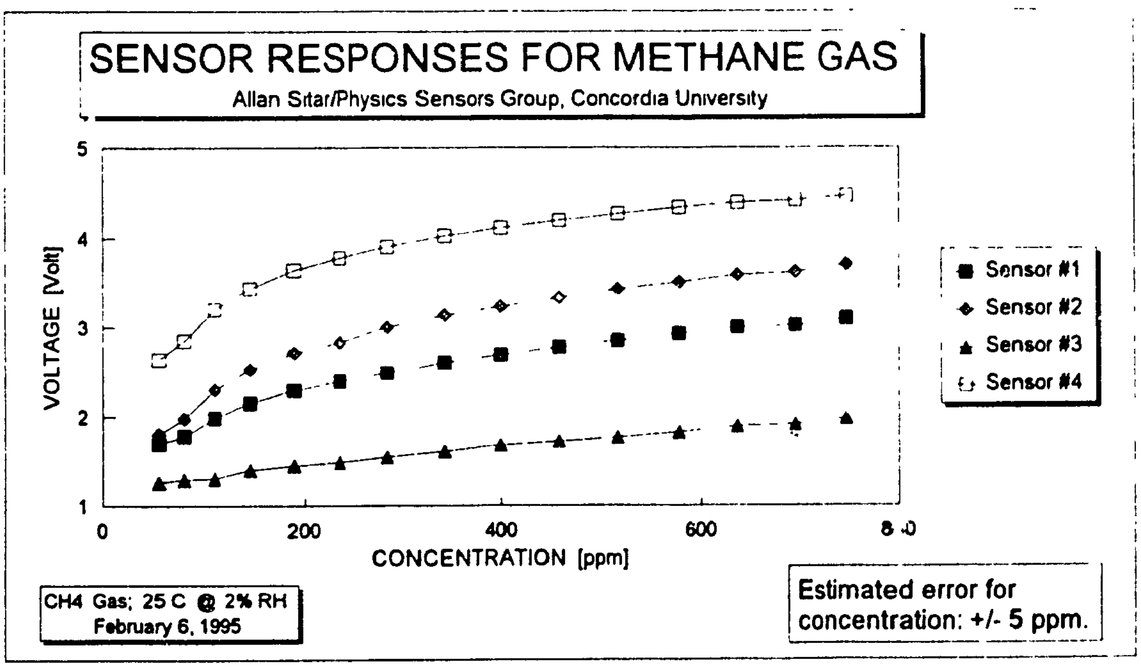



FIGURE 4-5. Sensor Responses for Methane Gas.

TABLE 4-5. Sensor Responses for Propane Gas.

| TRIAL # | SENSOR 1 | SENSOR 2 | SENSOR 3 | SENSOR 4 | Conc [ppm] |
|---|---|---|---|---|---|
| 1 | 4.14 | 4.37 | 3.61 | 4.47 | 749 |
| 2 | 4.12 | 4.33 | 3.59 | 4.42 | 694 |
| 3 | 4.08 | 4.29 | 3.49 | 4.36 | 636 |
| 4 | 4.05 | 4.24 | 3.52 | 4.29 | 577 |
| 5 | 4.01 | 4.18 | 3.46 | 4.22 | 518 |
| 6 | 3.95 | 4.10 | 3.38 | 4.12 | 458 |
| 7 | 3.90 | 4.02 | 3.35 | 4.03 | 399 |
| 8 | 3.79 | 3.92 | 3.24 | 3.90 | 342 |
| 9 | 3.74 | 3.81 | 3.18 | 3.78 | 288 |
| 10 | 3.69 | 3.68 | 3.15 | 3.64 | 237 |
| 11 | 3.57 | 3.51 | 2.91 | 3.45 | 190 |
| 12 | 3.45 | 3.29 | 2.83 | 3.23 | 147 |
| 13 | 3.22 | 2.95 | 2.63 | 2.89 | 111 |
| 14 | 3.02 | 2.64 | 2.47 | 2.63 | 80 |
| 15 | 2.69 | 2.24 | 2.22 | 2.29 | 56 |

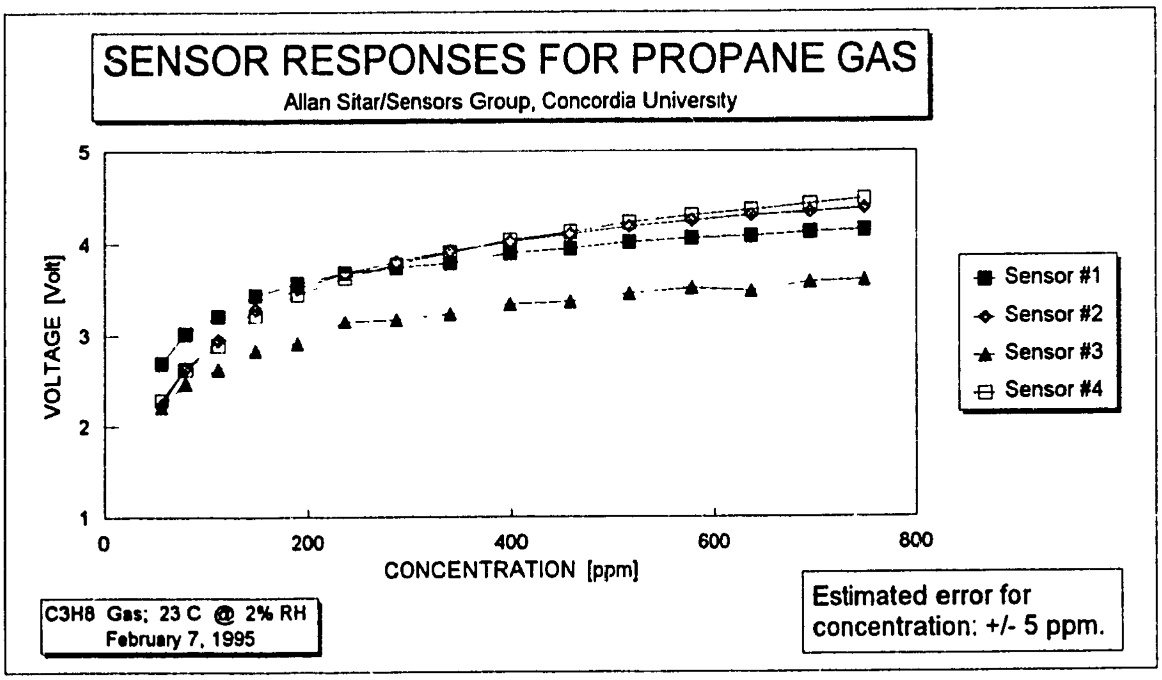



FIGURE 4-5. Sensor Responses for Propane Gas.

TABLE 4-5. Sensor Responses for Ethylene Gas.

| TRIAL # | SENSOR 1 | SENSOR 2 | SENSOR 3 | SENSOR 4 | Conc [ppm] |
|---|---|---|---|---|---|
| 1 | 4.98 | 4.41 | 4.86 | 4.27 | 749 |
| 2 | 4.96 | 4.30 | 4.85 | 4.17 | 694 |
| 3 | 4.94 | 4.22 | 4.84 | 4.09 | 636 |
| 4 | 4.92 | 4.14 | 4.82 | 3.99 | 577 |
| 5 | 4.89 | 4.04 | 4.80 | 3.89 | 518 |
| 6 | 4.86 | 3.92 | 4.78 | 3.76 | 458 |
| 7 | 4.82 | 3.77 | 4.73 | 3.62 | 399 |
| 8 | 4.77 | 3.65 | 4.69 | 3.48 | 342 |
| 9 | 4.71 | 3.46 | 4.64 | 3.30 | 288 |
| 10 | 4.63 | 3.25 | 4.57 | 3.10 | 237 |
| 11 | 4.55 | 3.02 | 4.49 | 2.89 | 190 |
| 12 | 4.44 | 2.79 | 4.39 | 2.70 | 147 |
| 13 | 4.25 | 2.43 | 4.25 | 2.42 | 111 |
| 14 | 4.06 | 2.19 | 4.05 | 2.21 | 80 |
| 15 | 3.79 | 1.86 | 3.80 | 1.98 | 56 |

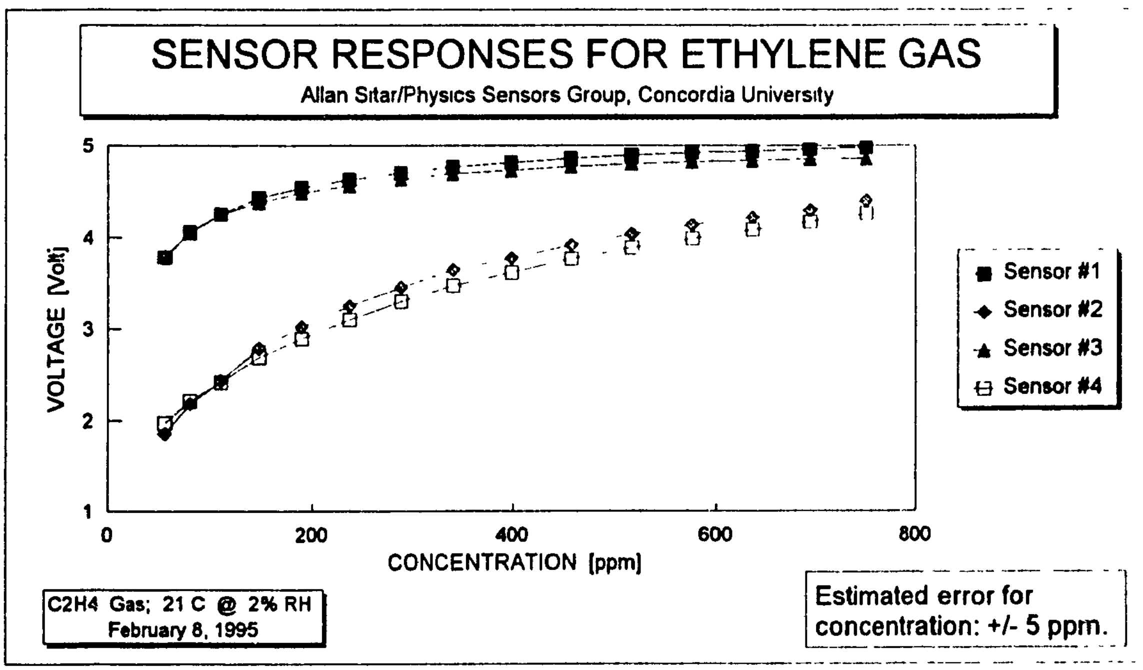



FIGURE 4-5. Sensor Responses for Ethylene Gas.

TABLE 4-5. Sensor Responses for Ethane Gas.

| TRIAL # | SENSOR 1 | SENSOR 2 | SENSOR 3 | SENSOR 4 | Conc [ppm] |
|---|---|---|---|---|---|
| 1 | 4.16 | 4.35 | 3.66 | 4.75 | 749 |
| 2 | 4.13 | 4.32 | 3.64 | 4.71 | 694 |
| 3 | 4.08 | 4.28 | 3.56 | 4.66 | 636 |
| 4 | 4.04 | 4.24 | 3.50 | 4.61 | 577 |
| 5 | 3.99 | 4.20 | 3.43 | 4.56 | 518 |
| 6 | 3.92 | 4.14 | 3.38 | 4.50 | 458 |
| 7 | 3.86 | 4.06 | 3.31 | 4.42 | 399 |
| 8 | 3.79 | 3.96 | 3.25 | 4.33 | 342 |
| 9 | 3.69 | 3.85 | 3.16 | 4.23 | 288 |
| 10 | 3.59 | 3.73 | 3.03 | 4.10 | 237 |
| 11 | 3.45 | 3.55 | 2.91 | 3.94 | 190 |
| 12 | 3.29 | 3.35 | 2.73 | 3.75 | 147 |
| 13 | 3.04 | 3.04 | 2.55 | 3.47 | 111 |
| 14 | 2.75 | 2.68 | 2.27 | 3.16 | 80 |
| 15 | 2.50 | 2.39 | 2.08 | 2.89 | 56 |

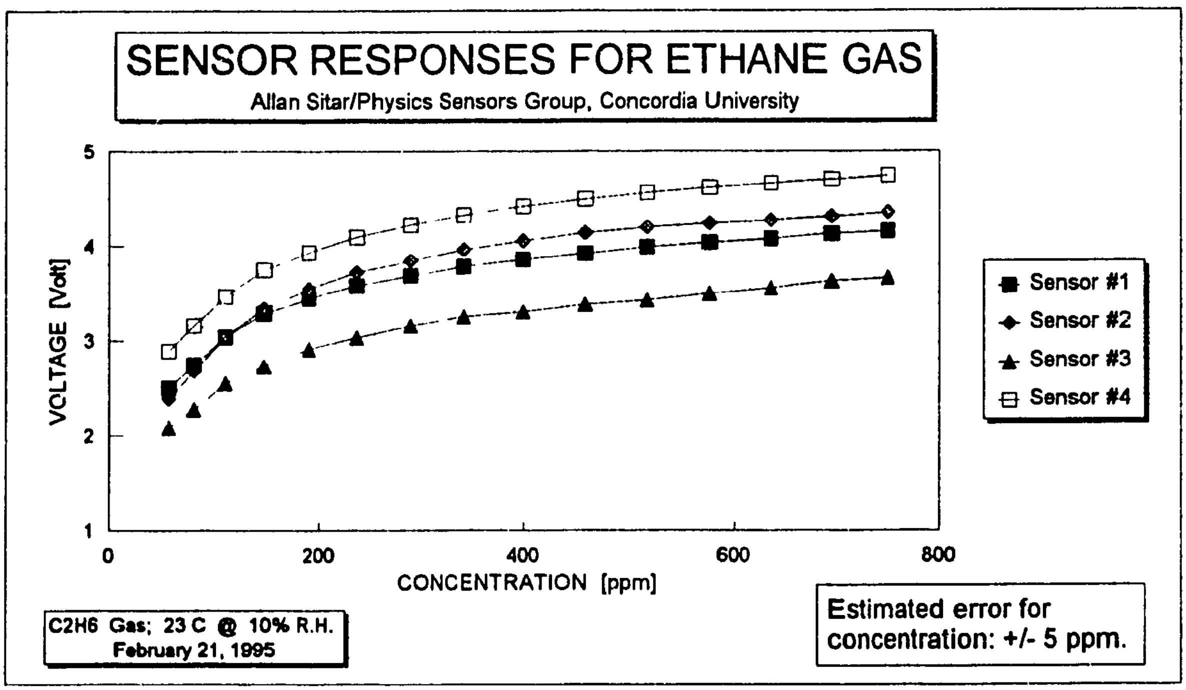



FIGURE 4-5. Sensor Responses for Ethane Gas.

## 4.3 Observations and Experimental Significance

### 4.3.1 The Effect of a Mixing Fan

In the first of a series of graphical figures (figure 4-6), four experiments were conducted in which two employed the use of a mixing fan and two did not. Only the TGS822 was used here and 100 μL of liquid methanol was micropipetted into the chamber (static experiment). It can be clearly seen that two curves superimpose each other in relation to proper gas mixing while the other two curves (i.e. without fan) seem to respond irregularly. It is this fact that supports the idea of simulating a uniform gaseous environment, thereby allowing for unambiguous sensor response

### 4.3.2 Sensor's Warm-up Characteristics

Before conducting the first experiment of the day, when the electronic nose system is first turned on after some lengthy non-operating period, an initialized warm-up time span of at least 15 minutes is required. This can be seen in figure 4-7 in which a stabilized region occurs around the 15 minute mark. Before that region, repeating tests show the non-linear drifting responses with time while afterwards a stable linear regime prevails Ideally it would be necessary to obtain this constant linear regime throughout the day however this is not the case in practice as independent results will later show slight drifting effects. Because of the TGS's discrete characteristics, the heating element temperature within the sensor needs some time to become constant The detector with the slowest response is sensor #3 (i.e. TGS812) with its change of 1.9 volts. On the other hand, a

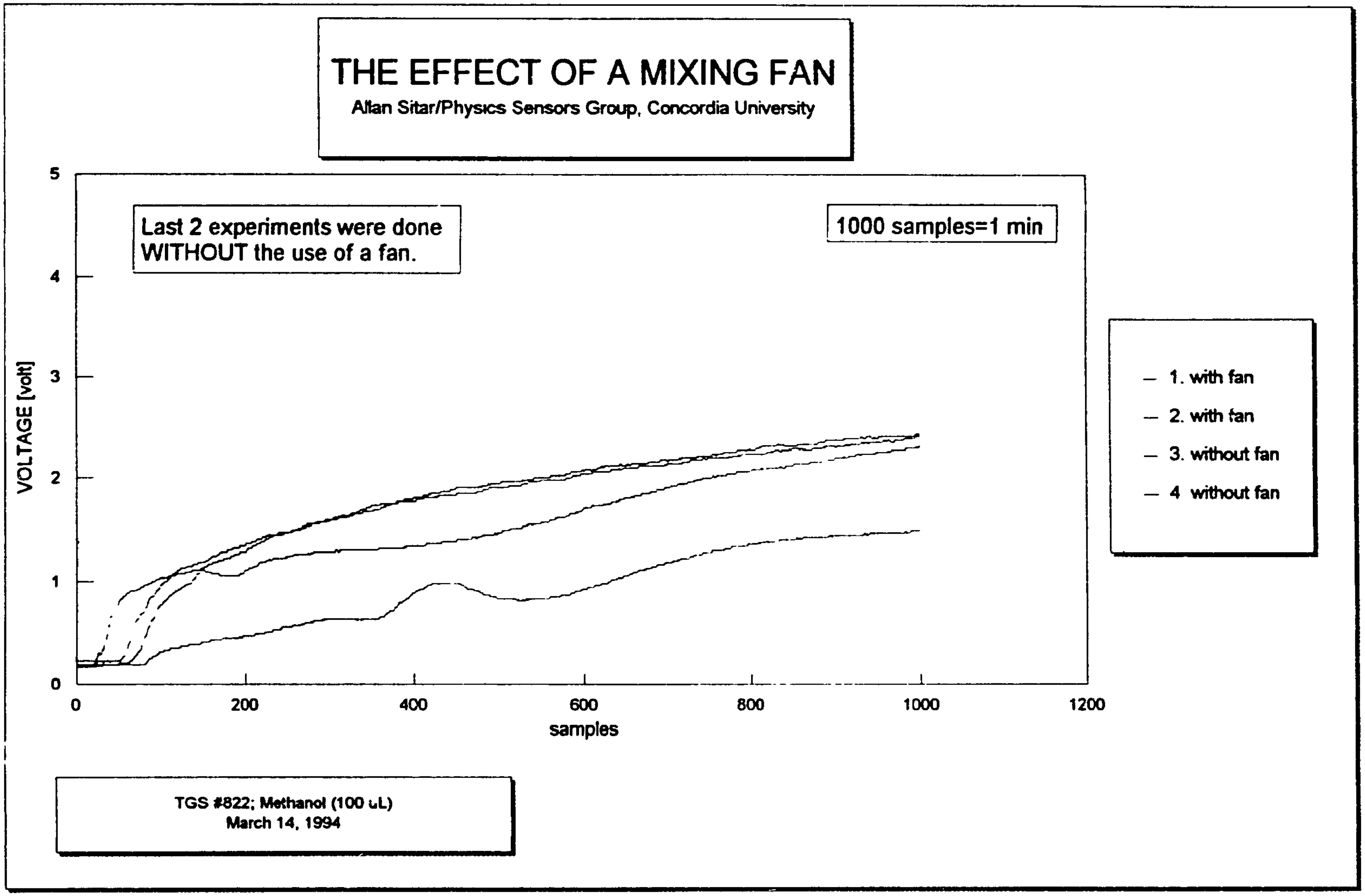



FIGURE 4-6. The Effect of a Mixing Fan.

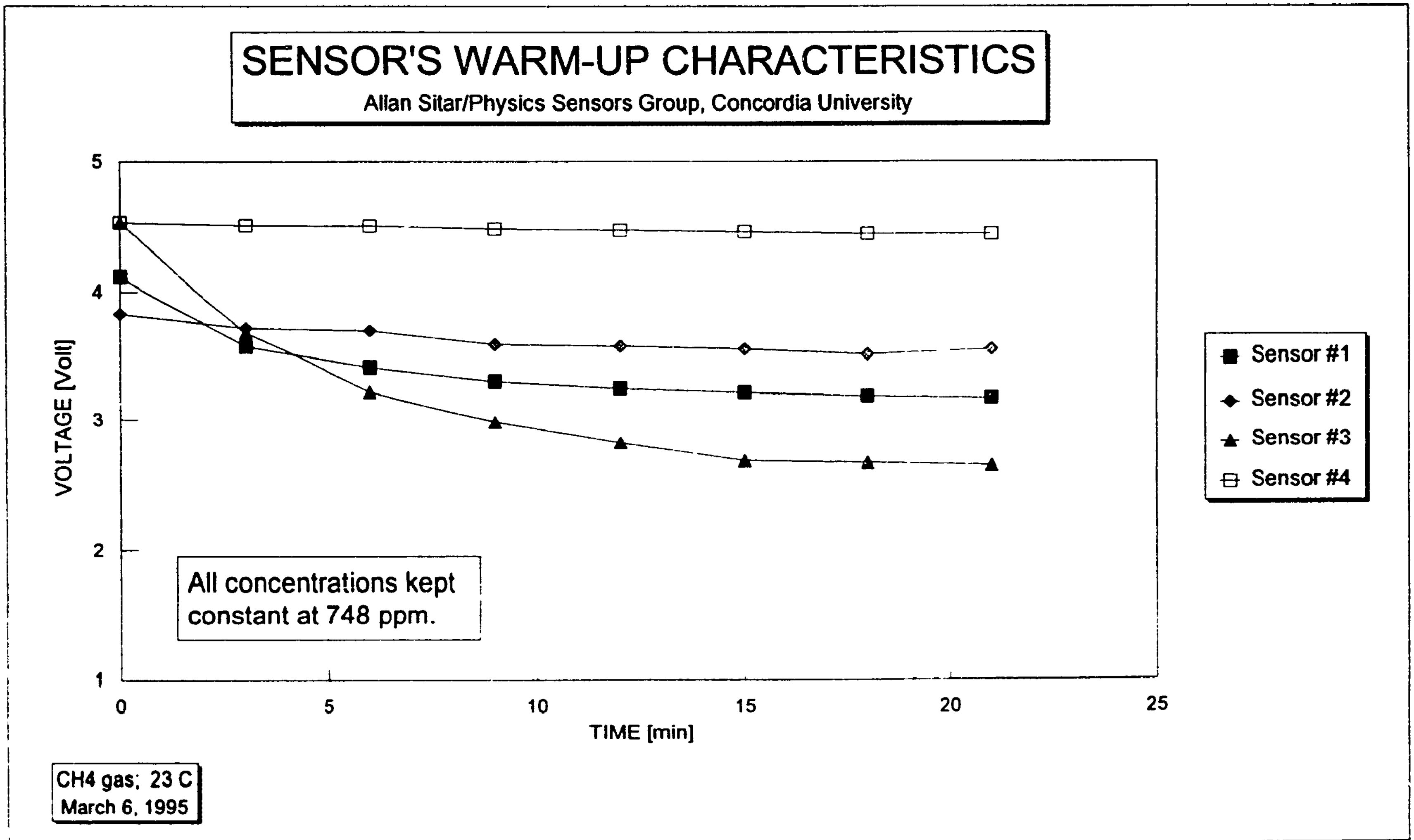



FIGURE 4-7. Sensors Warm-up Characteristics.

negligible warm-up time was needed to stabilize sensor #4 (i.e. TGS813) which varied by 0.1 volts. This test was repeatedly conducted with constant gas injections of methane.

### 4.3.3 Micropipette Method

Figure 4-8 is intended to show various response curves due to different injected volumes by use of the micropipette technique. As the amount of measureand is increased, the steady state takes more time to reach. In the case of 100 μL the curve is on the verge of leveling-off at around 1000 samples (approximately 1 minute). This is due to the slow evaporation rate of the liquid. In the lower case, the settling finds itself after 200 samples (approximately 15 seconds). This is in contrast to the gas flow type method which typically establishes stable readings by 5 seconds after termination of the injection period.

### 4.3.4 Experimental Reproducibility Employing a Flow Meter

The biggest advantage of the single gas flow-type injector employing a flow meter over the simple micropipette injecting technique is that a much higher accuracy can be achieved for a selected gas concentration. For example, the column under sensor #1 in figure 4-9 represents the repeated experimental values for the TGS822 sensor and the average over four trials is equal to 2.905 ± 0.006 volts. These values represent a 0.2% tolerance in comparison to the micropipette technique which varied over 5%.

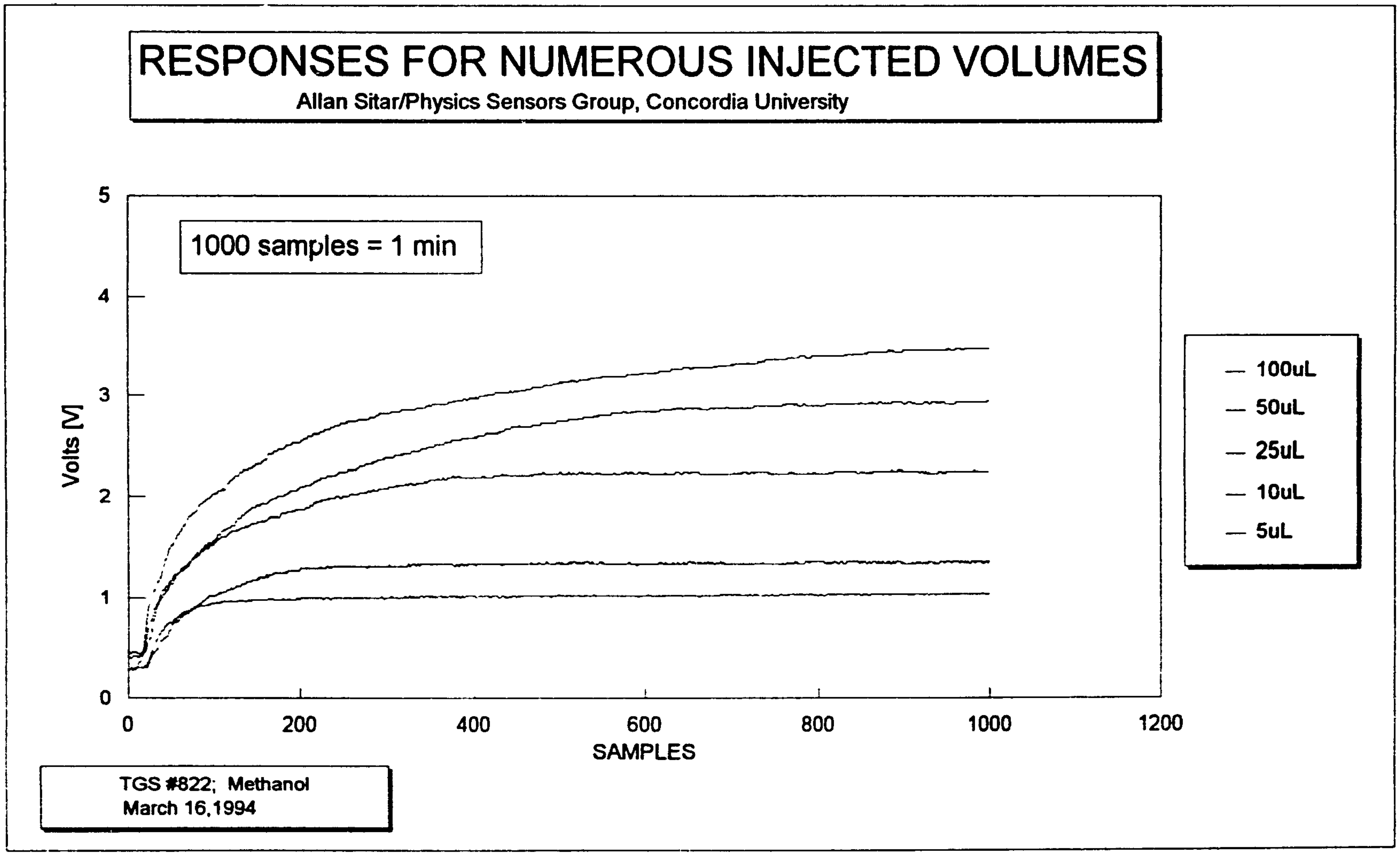



FIGURE 4-8. Responses for Numerous Injected Volumes.

TABLE 4-9. Experimental Reproducibility Employing a Flow Meter.

| TRIAL | sensor 1 | sensor 2 | sensor 3 | sensor 4 |
|---|---|---|---|---|
| 1 | 2 90 | 3.00 | 1.85 | 3.86 |
| 2 | 2.92 | 3.04 | 1.88 | 3.88 |
| 3 | 2.91 | 3 03 | 1.87 | 3.88 |
| 4 | 2.90 | 3 02 | 1.89 | 3.86 |
| average | 2.90 | 3.02 | 1.87 | 3.87 |

| | |
|---|---|
| Flow rate: | 23.9 [sccm] |
| Inj. Time: | 5.0 [s] |
| Temp: | 21 [C] |
| RH: | 46 [%] |

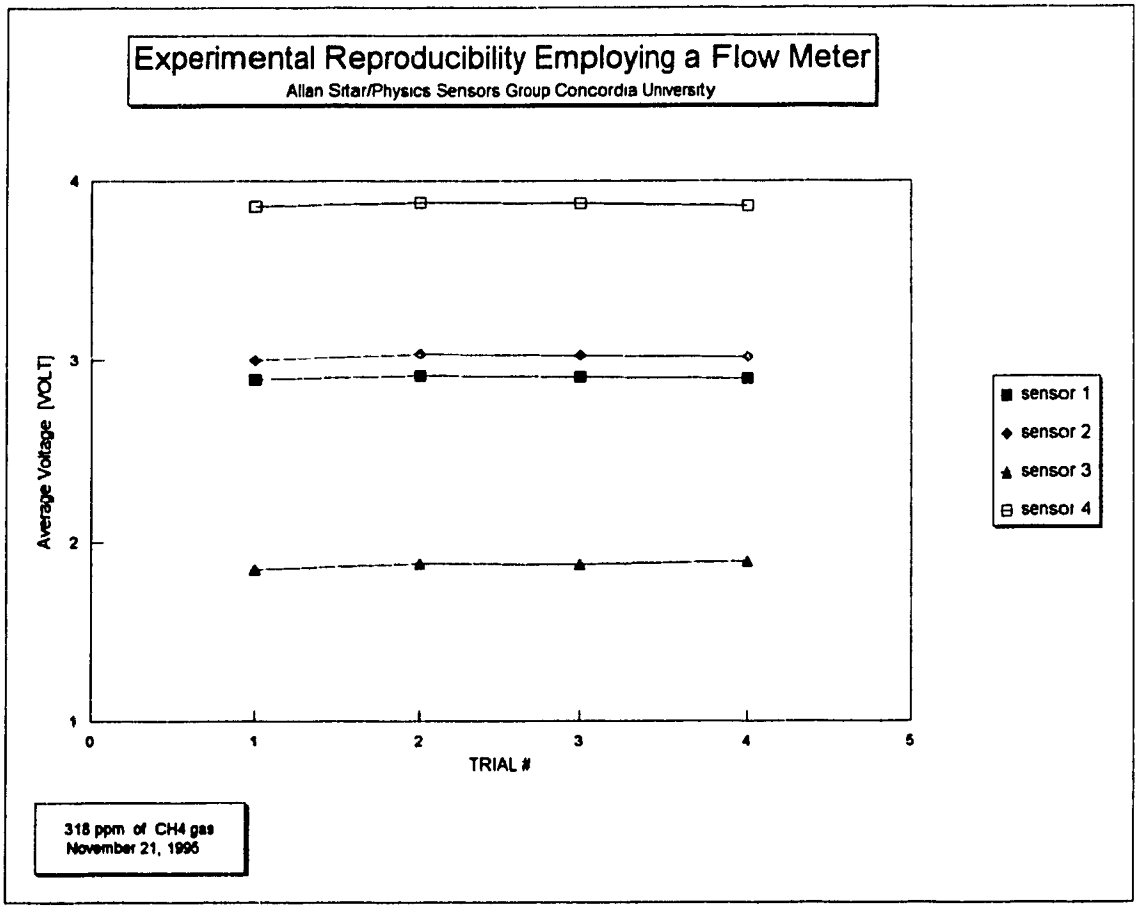



FIGURE 4-9. Experimental Reproducibility Employing a Flow Meter

### 4.3.5 Reproducibility with Time

Although the four TGS sensors selected are specialized for combustible gases it seems that four of them present different drift characteristics. As shown in figure 4-10 four experiments were conducted and then repeated 3 1/2 hours later under the same conditions. Sensor #1 (i.e TGS822) seemed to uniformly raise its voltage response where as sensor #4 (i.e. TGS813) tended to uniformly lower its response. Both cases are of small voltage differences of about 0.1 volts whereas a larger drift of about 0.35 volts occurred for sensor #3 (i.e. TGS812). This is in contrast to the second sensor (i e TGS816) which remained the same throughout.

Reproducibility on the other graph demonstrates that a good repeatability should occur for all sensors in general except that of #3. Experiments were separated by 17 days in this case. Again, here a voltage difference of about 0.35 volts exists while perhaps sensor #2 shifted slightly to about 0 05 volts lower One speculation is that the 8% difference in ambient relative humidity that probably affected these two sensors only But this is highly unlikely since other independent tests confirm that all sensors are affected by relative humidity especially at higher ranges.

### 4.3.6 Humidity Responses

One physical entity that affects nearly all solid-state devices in some way is the ambient humidity. In this project the relative humidity was not possible to vary; however it was monitored. For the most part the ambient humidity did stay relatively steady throughout the data collection. A small test was conducted to see in which direction the sensors would respond to humidity changes. Three experiments confirm that with the presence of increasing relative humidity the sensor's response would increase as well,

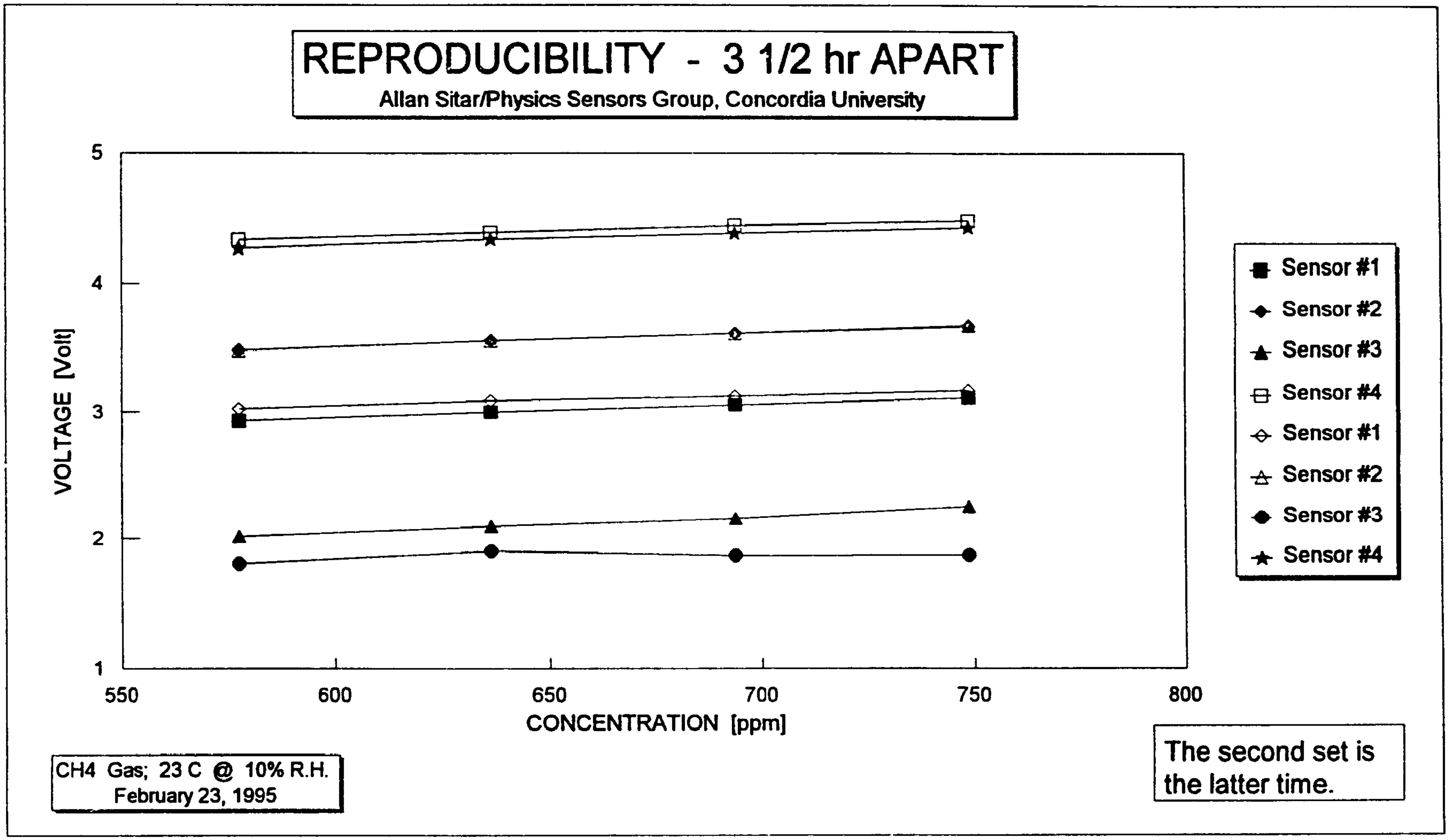



FIGURE 4-10. Reproducibility - 3 1/2 hr Apart.

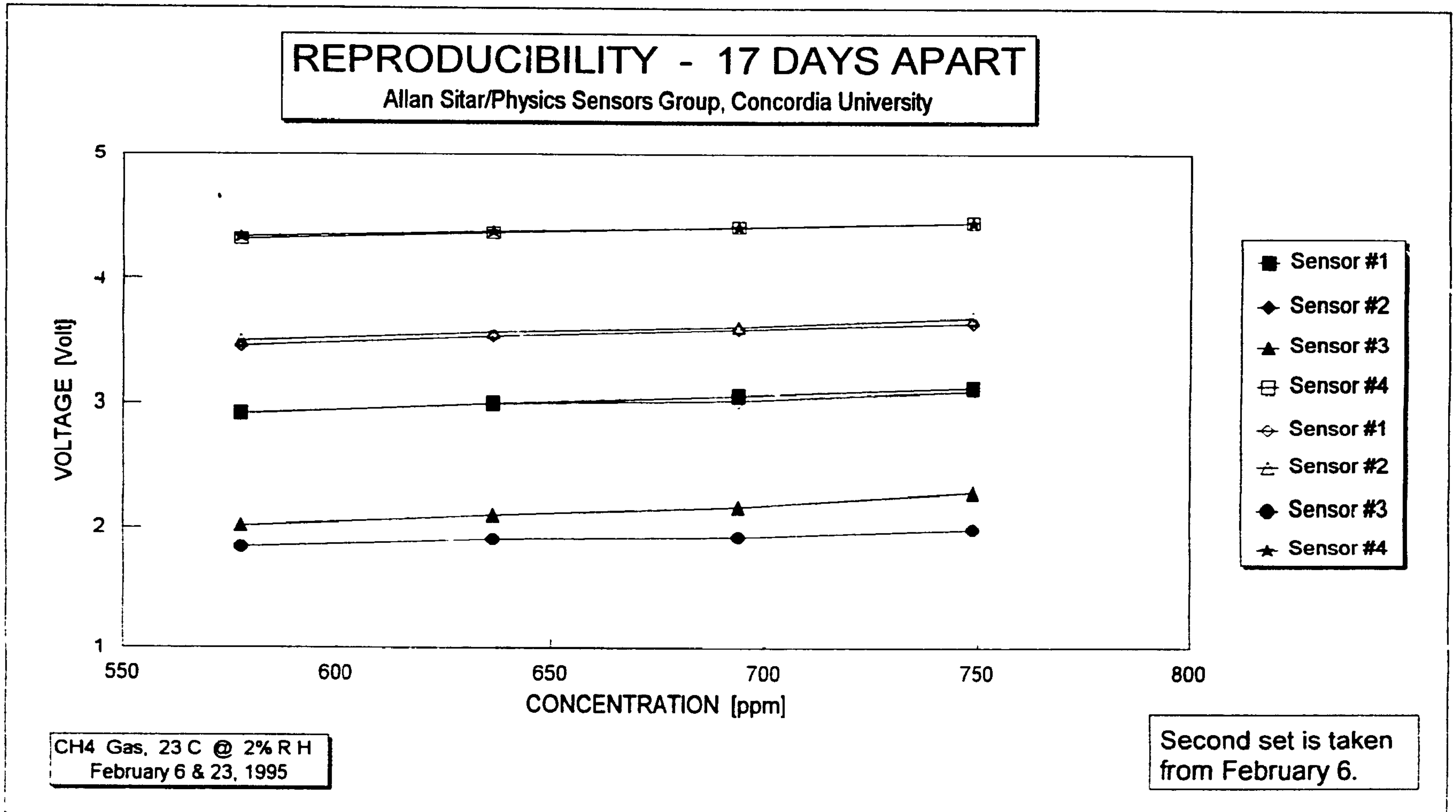



FIGURE 4-11. Reproducibility - 17 Days Apart.

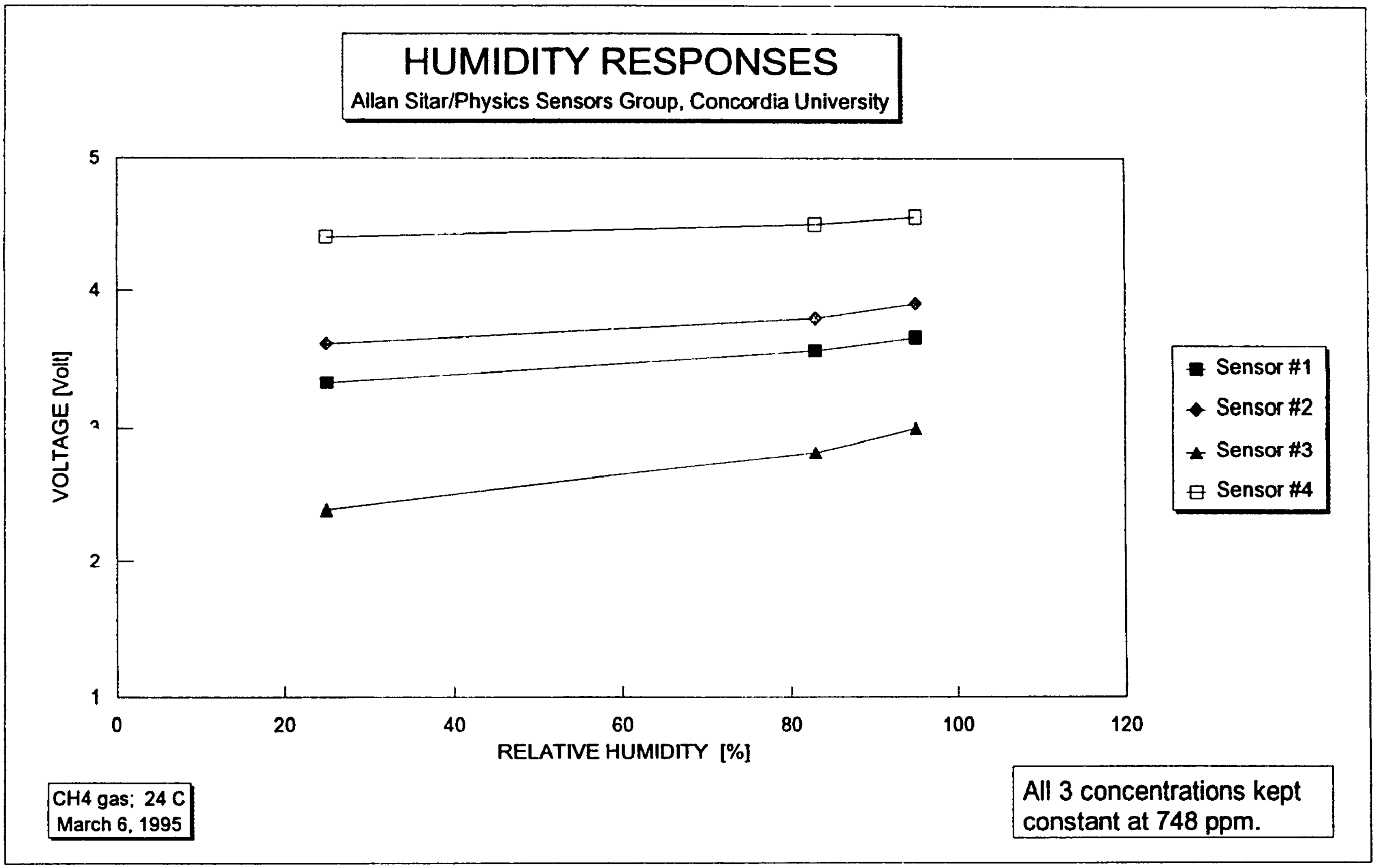



FIGURE 4-12. Humidity Responses.

while keeping other physical parameters constant. In order to simulate envircnmental conditions some mechanism to vary the relative humidity would then be essential for a detailed study.

## 4.4 Error Discussion

In relation to those tables and graphs listed in the sections of this chapter, some comment is due to be made concerning error bars.

The temperature and relative humidity are monitored by a probe with the temperature's output specified to have an accuracy of 1 °C. For humidity, the accuracy is 3% in the range below 25 °C. The sensor's output, after being digitized by the 8-bit ADC, has a resolution of 0.02 volts (i e. 256 parts in 5 volts). In this case, error bars on the graphs would be nearly impossible to plot. The sampled time in seconds achieves its high accuracy by the computer's timer (i.e. somewhere in the order of nanoseconds). Because of the flow-meter's manual imprecision, it is estimated that the input concentration is tolerant to 5 ppms. Again, this is not possible to display on the graphs.

## 4.5 Neural Network Results

An input data file set (called NORM.DAT) was created for the training of the net and is given in appendix V The values are normalized so they lie within the range [0,1]. In the file every four elemental-set pattern is followed by an adjacent four elements which correspond to the desired or target output for such a pattern. The output values defined are either 0.9 (yes) or 0.1 (no). By noting that out of 60 patterns (i.e. 15 rows each for methane, propane, ethylene and ethane) the sequence is defined so methane corresponds to column number one (0.9 0.1 0.1 0.1), propane column two (0 1 0.9 0.1 0.1) and so on. The 0.9 value shifts positions to the right after every subsequent 15 sets, redefining the new gas as the target substance. For example, if a pattern contained (in arbitrary values).

$$\{\ 0.926\ \ 0.978\ \ 0.808\ \ 1.000\ \ 0.1\ \ 0.9\ \ 0.1\ \ 0.1\ \} \qquad (2.5.2)$$

it would imply that the target gas is that of propane since the value 0.9 is in the second position of the latter four elements of the above set (see Appendix V). Naturally, it is hoped that after training the complete data set, the system has learnt and the outcome (or output) should be very close to the programmed target values. The resulting learnt system can also be seen in listed in appendix V (created by the neural network program as NORM_V.DAT).

Next, a sample set consisting of 16 patterns (4 arbitrary selected concentrations common to the four gases) was then used to test the learnt system. As a result, every target gas was correctly identified (100%) after being matched to the learnt system.

While running the neural network program, a series of input parameters and learning rules used for network architecture and network optimization, prompts the user for: filename for input data; momentum rate; learning rate; maximum total error; maximum number of iterations; number of hidden layers; etc In most cases, the default values were selected. It can be seen that with further studies an optimal network can be achieved by selecting different input parameters [12].

The ideal output from the network is shown in Table 4-6, as well as that achieved after learning the data. In each case the inferred combustible gas is correct.

TABLE 4-6. *Results of Concordia's electronic nose for 4 combustible gases.*

| | **Ideal Output** | **Observed Output** | **Inference** |
|---|---|---|---|
| Methane | 0.9 0.1 0.1 0.1 | 0.893 0.098 0.000 0.110 | Methane |
| Propane | 0.1 0.9 0.1 0.1 | 0.100 0.905 0.100 0.094 | Propane |
| Ethylene | 0.1 0.1 0.9 0.1 | 0.100 0.112 0.887 0.101 | Ethylene |
| Ethane | 0.1 0.1 0.1 0.9 | 0.100 0.119 0.100 0.882 | Ethane |

## 5.0 CONCLUSION

It was shown that with highly discriminating metal oxide semiconductor sensors linked to a microcomputer for information processing that a system of *smart* gas sensing is feasible The Concordia built electronic nose was able to sense four individual combustible gases and create patterns for different injected gas quantities. By collecting information into a database, a neural network system was introduced and applied to it. After training the network, a sample of known data was used to test the system and discrimination among the individual gases was 100% successful.

This demonstrated success is necessary if one were to lead the project into greater complexity. For example, vapours with many constituents could be used for selectivity (e.g. gas mixtures), with their applications geared towards industry. The idea of gas mixtures could highly complicate the electronic nose analysis because infinitely many patterns could then develop. Such a system would only be possible if the physical parameters such as temperature and relative humidity could be controlled, or their affects somehow allowed for in the analysis.

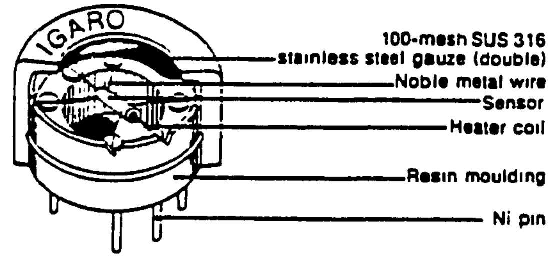
It was shown from the humidity experiments that the voltage responses for all four sensors do vary identically and for further research on gas sensing, ambient humidity would have to be controllable. This is perhaps true for the temperature parameter as well, although no testing was done to confirm this.

It was seen that three out of four Taguchi gas sensors behaved quite comfortably within the governed programmed concentration range. The exception is that of sensor #3 (i.e. TGS812) which seemed to produce rough responsive curves, especially in that of propane gas These facts are contrary to Figaro's technical notes (10/85) in that the general purpose TGS812 was supposed to be highly sensitive to propane, butane and carbon dioxide. For future analysis on combustible gases, it would be wise to acquire another TGS sensor in the place of the TGS812

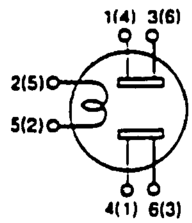
## APPENDIX I

Structure and Configuration of the TGS #812

## Structure and Configuration of the TGS 812



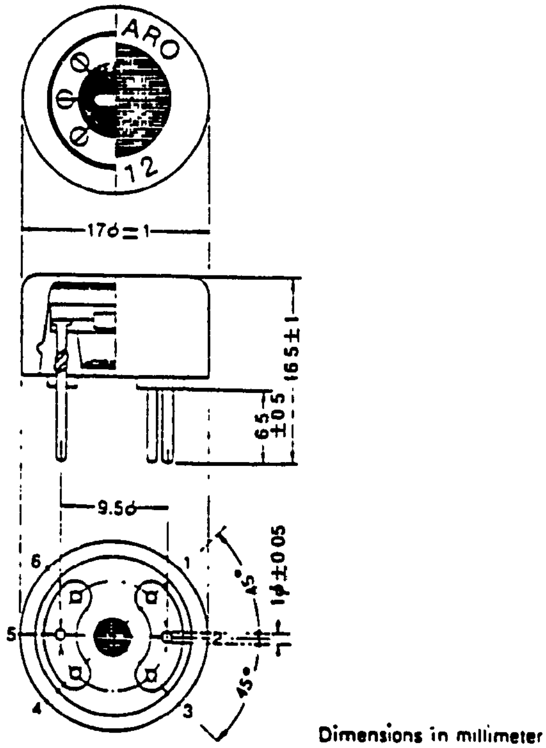

**TGS 812 CONFIGURATION.**




**TGS 812 DIAGRAM OF THE ELECTRIC CIRCUIT.**

◆**Remarks:**

Pins numbered 1 and 3 are connected internally.
Pins numbered 4 and 6 are connected internally.

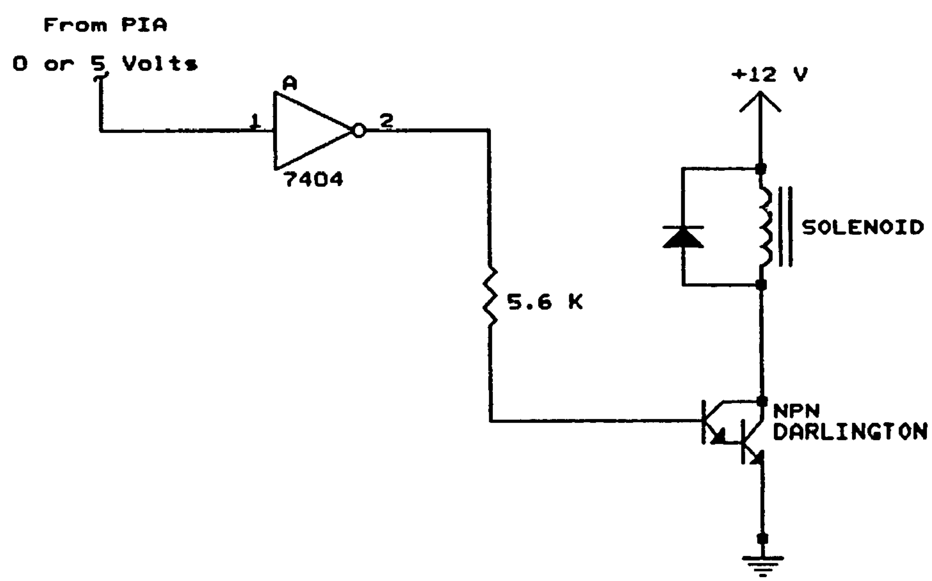



**TGS 812 STRUCTURAL SPECIFICATIONS.**

# APPENDIX II

Circuit Diagrams

# -SOLENOID ACTIVATION CIRCUITRY-

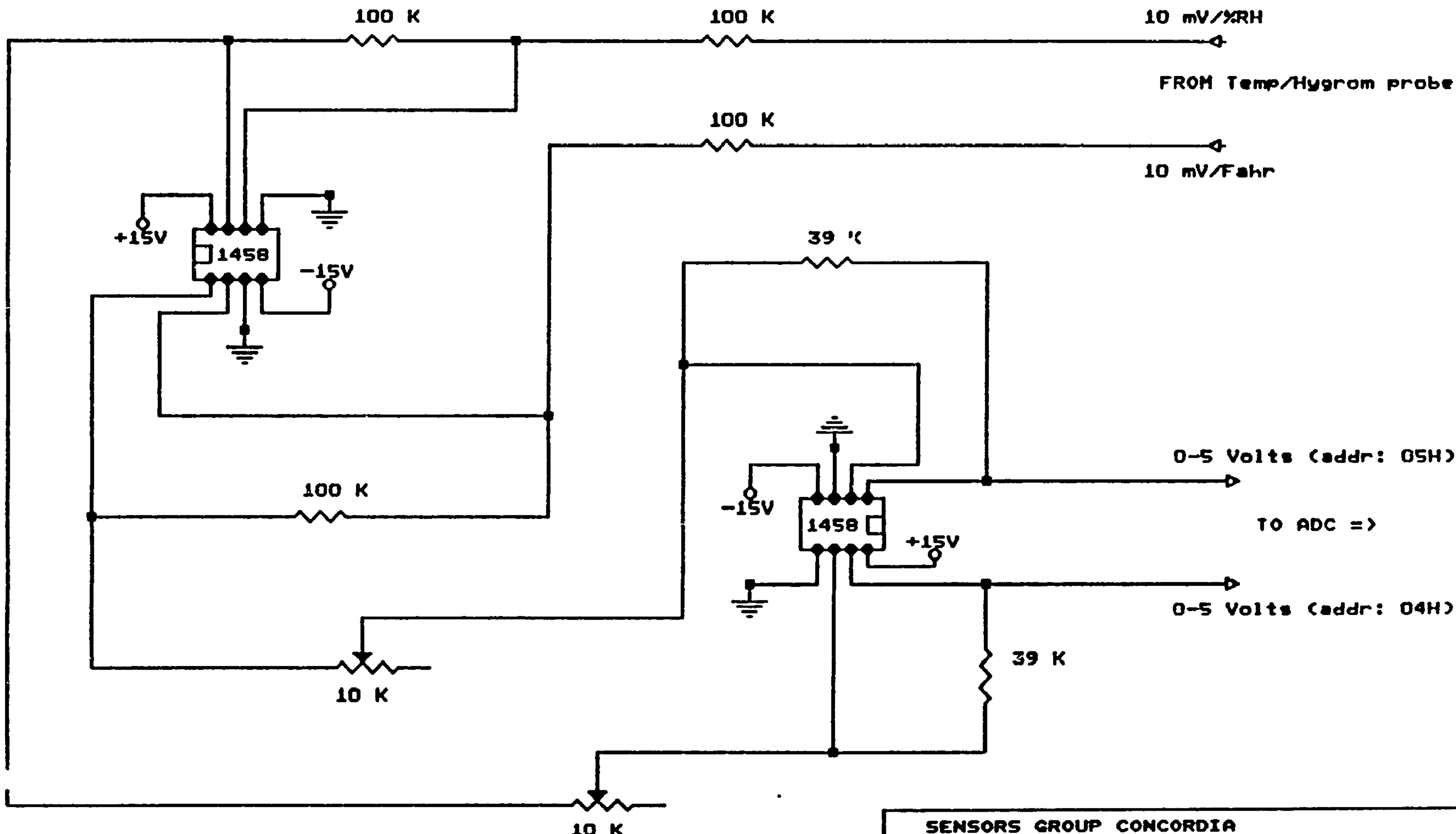



## NOTE:

1. THREE-WAY, 12 V (3 W) SOLENOID VALVE.
   TO PREVENT COIL DAMAGE, REDUCE VOLTAGE 67%
   WHEN ENERGIZED LONGER THAN TWO MINUTES.

| | | |
|---|---|---|
| SENSORS GROUP CONCORDIA<br>Drawing by: ALLAN SITAR<br>Graduate Physics, Concordia University | | |
| Title<br>-SOLENOID ACTIVATION CIRCUITRY- | | |
| Size<br>A | Document Number<br>SOLENOID-NOSE-02-AS | REV<br>AS |
| Date: February 24, 1995 | Sheet 1 of 1 | |

# -TEMPERATURE/HYGROMETER PROBE ANALYZER CIRCUIT-




SENSORS GROUP CONCORDIA
Drawing by: ALLAN SITAR
Graduate Physics, Concordia University

| Title | | |
|---|---|---|
| -TEMP/HYGROM PROBE ANALYZER CIRCUIT- | | |
| Size | Document Number | REV |
| A | THERM/HYGROM-NOSE-03-AS | AS |
| Date: February 24, 1995 | Sheet 1 of 1 | |

# APPENDIX III

C and Assembly Source Programs

```
/* This is the main program [E-NOSE.cpp] which operates the testing */
/* of Taguchi sensors */

#include <stdio.h>
#include <stdlib.h>
#include <conio.h>
#include <time.h>
#include <dos.h>
#define  SENSOR  3

void fileprompt(void);
void outportb(int,int);
int  injectime(void);
int  data(int);

extern"C"                                    /* needed when calling functions    */
                                             /*  from subroutines elsewhere      */
{   int far almain();  }                     /* calls assembly function          */
                                             /*  prlport.asm                     */

void main(void)      /***************MAIN*********************************/

{
 int      sensornum;
 int      num;
 int      count;
 float    time;
 float    temptvalue;
 float    humidvalue;
 float    temp_F;
 float    temp_C;
 float    humidity;
 float    val[SENSOR];
 float    value[SENSOR];
 float    avg[SENSOR];
 char     filename[12];
 static   float sum[SENSOR];
 FILE     *fptr;
 clock_t start,end;


 fileprompt();                               /* select a name for the file       */
 fptr = fopen(gets(filename),"w");           /* open file                        */

 num = injectime();                    /* invoke an injection time(s)            */
 almain();                             /* initialize the peripheral parallel port */
 outportb(0x0104,0x03);                /* activate solenoid valve and fan        */
 start = clock();                      /* begin time                             */

 do{
        end=clock();
        time=(end-start)/CLK_TCK;
   }    while (time < num);
```

```
printf("\nThe compiler stopped time at ... %2.4f\n\n", time);
outportb(0x0104,0x07);                    /* deactivate solenoid valve but continue fan */

for (count=1; count<=1000; count++)                   /* read sensor response    */
  { printf("Reading # %3d   ", count);                /* display results and     */
     fprintf(fptr, "Reading # %3d   ", count);        /*  print to file          */

     for (sensornum=0; sensornum <= SENSOR; sensornum++)
         { value[sensornum] = data(sensornum);
           val[sensornum] = (float) value[sensornum]/255*5;

             if (count > 500)                           /* curve has stabilized    */
               sum[sensornum] += val[sensornum];               /* begin adding  */
                                                               /* for an avg    */
             printf(" %.3f ", val[sensornum]);
             fprintf(fptr, " %.3f ", val[sensornum]);
         }

     end = clock();
     time = (end-start)/CLK_TCK;                       /* read clock in seconds   */

     printf("    Volts at     %2.2f sec \n", time);
     fprintf(fptr, "    Volts at     %2.2f sec \n", time);
  }

printf("\n\nAVG  VOLTAGE    ");
fprintf(fptr, "\n\nAVG  VOLTAGE    ");

for (sensornum=0; sensornum <= SENSOR; sensornum++)
  {    avg[sensornum] = sum[sensornum]/500;
       printf("%.3f  ", avg[sensornum]);
       fprintf(fptr, "%.3f  ", avg[sensornum]);
  }

temptvalue      = data(4);
humidvalue      = data(5);
temp_F          = temptvalue/255*100;
temp_C          = (temp_F - 32.00)*5/9;
humidity        = humidvalue/255*100;
printf("\n\nTemperature is:  %3.2f [C]     ", temp_C);
printf("and   Relative Humidity:  %3.2f [%]\n\n", humidity);
fprintf(fptr,"\n\nTemperature is:  %3.2f [C]     ", temp_C);
fprintf(fptr,"and   Relative Humidity:  %3.2f [%]\n\n", humidity);

fclose(fptr);
}

/*****************************FUNCTIONS**************************************/

/* User enters a filename for the experiment */

void fileprompt(void)
{
  printf("\nPlease type in a new filename with the corresponding .txt ");
```

```
  printf("extention added to it:\n\n");
  printf("Filename:  ");
}

/* User enters a numeric integer for time (in sec) for solenoid activation */

int injectime(void)
{
  int time;

  printf("\n\nNow, please enter a time value in seconds:  ");
  scanf("%d",&time);
  printf("\nThe selected value was ...    %d\n",time);
  return(time);
}

/* data acquisition for the 4 sensors */

int data(int senum)
{
  outportb(0x0151, senum);
  #pragma inline

                asm mov         dx,0150h
        lp1:
                asm in          al,dx
                asm and         al,80h
                asm js          lp1

  return(inportb(0x0151));
}
```

```
VERSION M400
;
TITLE       This assembly routine [PRLPORT.asm], called from main,
;           initializes the Peripheral Interface Adapter (PIA).
data segment

data ends

code segment public
assume cs:code,ds:data

PUBLIC _almain

_almain proc   far
        push   bp
        mov    bp,sp
        push   ds
        push   es
        mov    ax,data
        mov    ds,ax
        mov    es,ax

;    initialize the Peripheral Parallel Port

        mov    al,00h
        mov    dx,0105h      ;select PIA1 (port A)
        out    dx,al          ;DDRA selected
;
        mov    al,255
        mov    dx,0104h      ;FF => DDRA output
        out    dx,al
;
        mov    al,04h
        mov    dx,0105h      ;PRA access (data)
        out    dx,al
;
;    set all lines OFF accept 1st one needed to supply +5V to 74LS04
;
        mov    al,01h
        mov    dx,0104h
        out    dx,al
;
        pop    es
        pop    ds
        pop    bp
        ret
;
_almain  endp

code   ends
end    _almain
```

# APPENDIX IV

Sample Data Sheet (Methane)

| | | | | | | |
|---|---|---|---|---|---|---|
| Reading # 1 | 2.333 | 3.020 | 1.490 | 3.804 | Volts at | 5.05 sec |
| Reading # 2 | 2.353 | 3.020 | 1.510 | 3.824 | Volts at | 5.11 sec |
| Reading # 3 | 2.353 | 3.020 | 1.510 | 3.824 | Volts at | 5.16 sec |
| Reading # 4 | 2.373 | 3.039 | 1.510 | 3.843 | Volts at | 5.22 sec |
| Reading # 5 | 2.373 | 3.039 | 1.510 | 3.863 | Volts at | 5.22 sec |
| Reading # 6 | 2.373 | 3.059 | 1.510 | 3.863 | Volts at | 5.27 sec |
| Reading # 7 | 2.392 | 3.059 | 1.529 | 3.863 | Volts at | 5.33 sec |
| Reading # 8 | 2.412 | 3.078 | 1.529 | 3.882 | Volts at | 5.44 sec |
| Reading # 9 | 2.412 | 3.078 | 1.529 | 3.882 | Volts at | 5.49 sec |
| Reading # 10 | 2.431 | 3.098 | 1.529 | 3.902 | Volts at | 5.55 sec |
| Reading # 11 | 2.431 | 3.098 | 1.529 | 3.902 | Volts at | 5.60 sec |
| Reading # 12 | 2.451 | 3.098 | 1.529 | 3.902 | Volts at | 5.66 sec |
| Reading # 13 | 2.451 | 3.118 | 1.529 | 3.922 | Volts at | 5.71 sec |
| Reading # 14 | 2.451 | 3.118 | 1.549 | 3.922 | Volts at | 5.77 sec |
| Reading # 15 | 2.451 | 3.137 | 1.529 | 3.941 | Volts at | 5.82 sec |
| Reading # 16 | 2.471 | 3.137 | 1.549 | 3.941 | Volts at | 5.88 sec |
| Reading # 17 | 2.471 | 3.157 | 1.549 | 3.941 | Volts at | 5.93 sec |
| Reading # 18 | 2.490 | 3.157 | 1.549 | 3.941 | Volts at | 5.99 sec |
| Reading # 19 | 2.490 | 3.157 | 1.549 | 3.961 | Volts at | 5.99 sec |
| Reading # 20 | 2.490 | 3.157 | 1.549 | 3.961 | Volts at | 6.04 sec |
| Reading # 21 | 2.490 | 3.176 | 1.549 | 3.961 | Volts at | 6.10 sec |
| Reading # 22 | 2.510 | 3.176 | 1.569 | 3.980 | Volts at | 6.21 sec |
| Reading # 23 | 2.510 | 3.176 | 1.549 | 3.980 | Volts at | 6.26 sec |
| Reading # 24 | 2.529 | 3.176 | 1.549 | 4.000 | Volts at | 6.32 sec |
| Reading # 25 | 2.529 | 3.176 | 1.549 | 3.980 | Volts at | 6.37 sec |
| Reading # 26 | 2.529 | 3.196 | 1.569 | 4.000 | Volts at | 6.37 sec |
| Reading # 27 | 2.529 | 3.196 | 1.569 | 4.000 | Volts at | 6.43 sec |
| Reading # 28 | 2.549 | 3.196 | 1.569 | 4.000 | Volts at | 6.48 sec |
| Reading # 29 | 2.549 | 3.196 | 1.569 | 4.020 | Volts at | 6.59 sec |
| Reading # 30 | 2.569 | 3.196 | 1.569 | 4.020 | Volts at | 6.65 sec |
| Reading # 31 | 2.549 | 3.196 | 1.588 | 4.020 | Volts at | 6.70 sec |
| Reading # 32 | 2.569 | 3.196 | 1.569 | 4.020 | Volts at | 6.70 sec |
| Reading # 33 | 2.569 | 3.196 | 1.588 | 4.020 | Volts at | 6.76 sec |
| Reading # 34 | 2.569 | 3.196 | 1.588 | 4.020 | Volts at | 6.81 sec |
| Reading # 35 | 2.588 | 3.196 | 1.588 | 4.020 | Volts at | 6.87 sec |
| Reading # 36 | 2.569 | 3.216 | 1.588 | 4.039 | Volts at | 6.98 sec |
| Reading # 37 | 2.588 | 3.216 | 1.588 | 4.039 | Volts at | 7.03 sec |
| Reading # 38 | 2.588 | 3.216 | 1.588 | 4.039 | Volts at | 7.09 sec |
| Reading # 39 | 2.588 | 3.216 | 1.588 | 4.039 | Volts at | 7.09 sec |
| Reading # 40 | 2.588 | 3.216 | 1.588 | 4.039 | Volts at | 7.14 sec |
| Reading # 41 | 2.588 | 3.216 | 1.588 | 4.039 | Volts at | 7.20 sec |
| Reading # 42 | 2.588 | 3.216 | 1.588 | 4.039 | Volts at | 7.25 sec |
| Reading # 43 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.31 sec |
| Reading # 44 | 2.608 | 3.216 | 1.588 | 4.059 | Volts at | 7.42 sec |
| Reading # 45 | 2.608 | 3.216 | 1.588 | 4.059 | Volts at | 7.42 sec |
| Reading # 46 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.47 sec |
| Reading # 47 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.53 sec |
| Reading # 48 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.58 sec |
| Reading # 49 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.64 sec |
| Reading # 50 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.69 sec |
| Reading # 51 | 2.627 | 3.216 | 1.608 | 4.059 | Volts at | 7.75 sec |
| Reading # 52 | 2.608 | 3.216 | 1.608 | 4.059 | Volts at | 7.80 sec |
| Reading # 53 | 2.627 | 3.216 | 1.608 | 4.059 | Volts at | 7.86 sec |
| Reading # 54 | 2.627 | 3.216 | 1.627 | 4.059 | Volts at | 7.91 sec |
| Reading # 55 | 2.627 | 3.216 | 1.608 | 4.059 | Volts at | 7.97 sec |
| Reading # 56 | 2.627 | 3.216 | 1.608 | 4.059 | Volts at | 8.02 sec |
| Reading # 57 | 2.627 | 3.235 | 1.608 | 4.059 | Volts at | 8.08 sec |
| Reading # 58 | 2.627 | 3.216 | 1.608 | 4.059 | Volts at | 8.13 sec |
| Reading # 59 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.19 sec |
| Reading # 60 | 2.627 | 3.216 | 1.608 | 4.059 | Volts at | 8.24 sec |
| Reading # 61 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.30 sec |
| Reading # 62 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.35 sec |
| Reading # 63 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.35 sec |
| Reading # 64 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.41 sec |
| Reading # 65 | 2.627 | 3.235 | 1.627 | 4.078 | Volts at | 8.52 sec |
| Reading # 66 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.57 sec |
| Reading # 67 | 2.627 | 3.235 | 1.627 | 4.078 | Volts at | 8.63 sec |
| Reading # 68 | 2.627 | 3.235 | 1.627 | 4.078 | Volts at | 8.68 sec |
| Reading # 69 | 2.647 | 3.216 | 1.627 | 4.078 | Volts at | 8.68 sec |
| Reading # 70 | 2.647 | 3.235 | 1.627 | 4.078 | Volts at | 8.74 sec |
| Reading # 71 | 2.647 | 3.235 | 1.627 | 4.078 | Volts at | 8.79 sec |

| | | | | | | |
|---|---|---|---|---|---|---|
| Reading # 72 | 2.627 | 3.216 | 1.627 | 4.078 | Volts at | 8.90 sec |
| Reading # 73 | 2.647 | 3.216 | 1.627 | 4.078 | Volts at | 8.90 sec |
| Reading # 74 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 8.96 sec |
| Reading # 75 | 2.647 | 3.216 | 1.627 | 4.078 | Volts at | 9.01 sec |
| Reading # 76 | 2.647 | 3.216 | 1.627 | 4.078 | Volts at | 9.07 sec |
| Reading # 77 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.12 sec |
| Reading # 78 | 2.647 | 3.235 | 1.627 | 4.078 | Volts at | 9.18 sec |
| Reading # 79 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.29 sec |
| Reading # 80 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.29 sec |
| Reading # 81 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.34 sec |
| Reading # 82 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.40 sec |
| Reading # 83 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.45 sec |
| Reading # 84 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.51 sec |
| Reading # 85 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.56 sec |
| Reading # 86 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.62 sec |
| Reading # 87 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.67 sec |
| Reading # 88 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.73 sec |
| Reading # 89 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.78 sec |
| Reading # 90 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.84 sec |
| Reading # 91 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 9.89 sec |
| Reading # 92 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 9.95 sec |
| Reading # 93 | 2.647 | 3.216 | 1.667 | 4.078 | Volts at | 10.00 sec |
| Reading # 94 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 10.05 sec |
| Reading # 95 | 2.647 | 3.216 | 1.667 | 4.078 | Volts at | 10.11 sec |
| Reading # 96 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 10.16 sec |
| Reading # 97 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 10.22 sec |
| Reading # 98 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 10.27 sec |
| Reading # 99 | 2.647 | 3.235 | 1.667 | 4.078 | Volts at | 10.33 sec |
| Reading # 100 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 10.38 sec |
| Reading # 101 | 2.647 | 3.235 | 1.667 | 4.098 | Volts at | 10.44 sec |
| Reading # 102 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 10.49 sec |
| Reading # 103 | 2.647 | 3.216 | 1.647 | 4.078 | Volts at | 10.55 sec |
| Reading # 104 | 2.647 | 3.216 | 1.667 | 4.098 | Volts at | 10.60 sec |
| Reading # 105 | 2.667 | 3.216 | 1.667 | 4.098 | Volts at | 10.66 sec |
| Reading # 106 | 2.647 | 3.235 | 1.647 | 4.078 | Volts at | 10.66 sec |
| Reading # 107 | 2.647 | 3.235 | 1.667 | 4.078 | Volts at | 10.77 sec |
| Reading # 108 | 2.647 | 3.235 | 1.667 | 4.078 | Volts at | 10.82 sec |
| Reading # 109 | 2.647 | 3.216 | 1.667 | 4.078 | Volts at | 10.88 sec |
| Reading # 110 | 2.667 | 3.216 | 1.647 | 4.098 | Volts at | 10.93 sec |
| Reading # 111 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 10.93 sec |
| Reading # 112 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 10.99 sec |
| Reading # 113 | 2.647 | 3.235 | 1.667 | 4.098 | Volts at | 11.04 sec |
| Reading # 114 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 11.15 sec |
| Reading # 115 | 2.647 | 3.235 | 1.667 | 4.078 | Volts at | 11.15 sec |
| Reading # 116 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 11.21 sec |
| Reading # 117 | 2.647 | 3.216 | 1.667 | 4.078 | Volts at | 11.26 sec |
| Reading # 118 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 11.32 sec |
| Reading # 119 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 11.37 sec |
| Reading # 120 | 2.667 | 3.235 | 1.667 | 4.098 | Volts at | 11.43 sec |
| Reading # 121 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 11.48 sec |
| Reading # 122 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 11.54 sec |
| Reading # 123 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 11.59 sec |
| Reading # 124 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 11.65 sec |
| Reading # 125 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 11.70 sec |
| Reading # 126 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 11.76 sec |
| Reading # 127 | 2.667 | 3.216 | 1.667 | 4.098 | Volts at | 11.81 sec |
| Reading # 128 | 2.667 | 3.216 | 1.686 | 4.078 | Volts at | 11.87 sec |
| Reading # 129 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 11.92 sec |
| Reading # 130 | 2.667 | 3.216 | 1.686 | 4.078 | Volts at | 11.98 sec |
| Reading # 131 | 2.667 | 3.216 | 1.686 | 4.078 | Volts at | 12.03 sec |
| Reading # 132 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 12.09 sec |
| Reading # 133 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 12.14 sec |
| Reading # 134 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 12.20 sec |
| Reading # 135 | 2.667 | 3.216 | 1.667 | 4.098 | Volts at | 12.25 sec |
| Reading # 136 | 2.667 | 3.216 | 1.686 | 4.078 | Volts at | 12.31 sec |
| Reading # 137 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 12.36 sec |
| Reading # 138 | 2.667 | 3.216 | 1.686 | 4.078 | Volts at | 12.42 sec |
| Reading # 139 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 12.47 sec |
| Reading # 140 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 12.47 sec |
| Reading # 141 | 2.667 | 3.235 | 1.686 | 4.078 | Volts at | 12.53 sec |
| Reading # 142 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 12.64 sec |

| | | | | | | |
|---|---|---|---|---|---|---|
| Reading # 143 | 2.667 | 3.216 | 1.667 | 4.078 | Volts at | 12 69 sec |
| Reading # 144 | 2.667 | 3.235 | 1.667 | 4.078 | Volts at | 12 75 sec |
| Reading # 145 | 2 667 | 3.216 | 1.667 | 4 098 | Volts at | 12.75 sec |
| Reading # 146 | 2.667 | 3.216 | 1.667 | 4.098 | Volts at | 12.80 sec |
| Reading # 147 | 2.667 | 3.216 | 1 667 | 4.098 | Volts at | 12.86 sec |
| Reading # 148 | 2 667 | 3.235 | 1 667 | 4.098 | Volts at | 12.91 sec |
| Reading # 149 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 12.97 sec |
| Reading # 150 | 2.667 | 3.216 | 1.667 | 4 098 | Volts at | 13 02 sec |
| Reading # 151 | 2.667 | 3.216 | 1 667 | 4.098 | Volts at | 13.08 sec |
| Reading # 152 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 13.13 sec |
| Reading # 153 | 2.667 | 3 235 | 1.667 | 4.098 | Volts at | 13.19 sec |
| Reading # 154 | 2.667 | 3.216 | 1.686 | 4 098 | Volts at | 13.24 sec |
| Reading # 155 | 2.667 | 3.216 | 1.686 | 4.078 | Volts at | 13.30 sec |
| Reading # 156 | 2.667 | 3.235 | 1.686 | 4 098 | Volts at | 13.35 sec |
| Reading # 157 | 2.667 | 3 235 | 1.667 | 4 078 | Volts at | 13.41 sec |
| Reading # 158 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 13 46 sec |
| Reading # 159 | 2.667 | 3.235 | 1.686 | 4 098 | Volts at | 13.52 sec |
| Reading # 160 | 2.667 | 3.216 | 1.667 | 4.098 | Volts at | 13.57 sec |
| Reading # 161 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 13.63 sec |
| Reading # 162 | 2.667 | 3 216 | 1.667 | 4.098 | Volts at | 13.68 sec |
| Reading # 163 | 2.667 | 3.216 | 1 667 | 4.098 | Volts at | 13.74 sec |
| Reading # 164 | 2.667 | 3.235 | 1 667 | 4.098 | Volts at | 13 79 sec |
| Reading # 165 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 13.85 sec |
| Reading # 166 | 2.667 | 3.235 | 1 667 | 4 078 | Volts at | 13.90 sec |
| Reading # 167 | 2.667 | 3.216 | 1 686 | 4 078 | Volts at | 13 96 sec |
| Reading # 168 | 2 667 | 3 216 | 1.667 | 4 078 | Volts at | 13 96 sec |
| Reading # 169 | 2 667 | 3 216 | 1 686 | 4.098 | Volts at | 14 01 sec |
| Reading # 170 | 2.667 | 3 216 | 1.686 | 4 098 | Volts at | 14 12 sec |
| Reading # 171 | 2 667 | 3 216 | 1 686 | 4 078 | Volts at | 14 18 sec |
| Reading # 172 | 2 667 | 3.235 | 1.686 | 4.098 | Volts at | 14 18 sec |
| Reading # 173 | 2 667 | 3 216 | 1 686 | 4 098 | Volts at | 14 23 sec |
| Reading # 174 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 14 29 sec |
| Reading # 175 | 2.667 | 3.216 | 1.686 | 4 078 | Volts at | 14 34 sec |
| Reading # 176 | 2.667 | 3.216 | 1.686 | 4 078 | Volts at | 14 40 sec |
| Reading # 177 | 2.667 | 3.216 | 1 686 | 4.098 | Volts at | 14 45 sec |
| Reading # 178 | 2.667 | 3.235 | 1 686 | 4.098 | Volts at | 14 51 sec |
| Reading # 179 | 2 667 | 3 216 | 1.686 | 4.098 | Volts at | 14 56 sec |
| Reading # 180 | 2 667 | 3 216 | 1.686 | 4.098 | Volts at | 14.62 sec |
| Reading # 181 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 14 67 sec |
| Reading # 182 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 14 73 sec |
| Reading # 183 | 2 667 | 3.216 | 1 686 | 4 098 | Volts at | 14 78 sec |
| Reading # 184 | 2 667 | 3.216 | 1.686 | 4 078 | Volts at | 14.84 sec |
| Reading # 185 | 2.667 | 3 216 | 1.686 | 4.098 | Volts at | 14.89 sec |
| Reading # 186 | 2 667 | 3 216 | 1.686 | 4 098 | Volts at | 14.95 sec |
| Reading # 187 | 2 667 | 3 216 | 1.686 | 4.098 | Volts at | 15 00 sec |
| Reading # 188 | 2.667 | 3 216 | 1 686 | 4 078 | Volts at | 15.05 sec |
| Reading # 189 | 2 667 | 3.235 | 1.686 | 4.098 | Volts at | 15.11 sec |
| Reading # 190 | 2.667 | 3.235 | 1.686 | 4 098 | Volts at | 15.16 sec |
| Reading # 191 | 2 667 | 3.216 | 1.686 | 4.098 | Volts at | 15.22 sec |
| Reading # 192 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 15.27 sec |
| Reading # 193 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 15.33 sec |
| Reading # 194 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 15.38 sec |
| Reading # 195 | 2.667 | 3.235 | 1.686 | 4.098 | Volts at | 15.44 sec |
| Reading # 196 | 2.667 | 3.216 | 1.686 | 4 098 | Volts at | 15.44 sec |
| Reading # 197 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 15.49 sec |
| Reading # 198 | 2.667 | 3 216 | 1.686 | 4 098 | Volts at | 15.55 sec |
| Reading # 199 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 15 66 sec |
| Reading # 200 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 15 71 sec |
| Reading # 201 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 15.71 sec |
| Reading # 202 | 2.667 | 3 216 | 1.686 | 4 098 | Volts at | 15.77 sec |
| Reading # 203 | 2 667 | 3 216 | 1.686 | 4 098 | Volts at | 15 82 sec |
| Reading # 204 | 2 667 | 3.216 | 1.686 | 4 098 | Volts at | 15 88 sec |
| Reading # 205 | 2 667 | 3 235 | 1.686 | 4 098 | Volts at | 15.93 sec |
| Reading # 206 | 2.667 | 3.235 | 1.686 | 4.098 | Volts at | 15 99 sec |
| Reading # 207 | 2.667 | 3.216 | 1.686 | 4 098 | Volts at | 16 04 sec |
| Reading # 208 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 16.10 sec |
| Reading # 209 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 16.15 sec |
| Reading # 210 | 2 667 | 3.216 | 1.686 | 4.098 | Volts at | 16.21 sec |
| Reading # 211 | 2.686 | 3.235 | 1.667 | 4 098 | Volts at | 16.26 sec |
| Reading # 212 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 16 32 sec |
| Reading # 213 | 2.667 | 3.216 | 1.686 | 4 098 | Volts at | 1[illegible]7 sec |

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|---|---|---|---|---|---|---|
| Reading # 214 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 16 43 sec |
| Reading # 215 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 16 48 sec |
| Reading # 216 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 16.54 sec |
| Reading # 217 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 16 59 sec |
| Reading # 218 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 16.65 sec |
| Reading # 219 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 16.65 sec |
| Reading # 220 | 2.667 | 3.235 | 1.686 | 4.098 | Volts at | 16.76 sec |
| Reading # 221 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 16.81 sec |
| Reading # 222 | 2 667 | 3 216 | 1.686 | 4 098 | Volts at | 16 87 sec |
| Reading # 223 | 2.686 | 3 235 | 1.686 | 4 098 | Volts at | 16.87 sec |
| Reading # 224 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 16 92 sec |
| Reading # 225 | 2.667 | 3.216 | 1.686 | 4 098 | Volts at | 16 98 sec |
| Reading # 226 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 17.03 sec |
| Reading # 227 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 17 14 sec |
| Reading # 228 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 17.14 sec |
| Reading # 229 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 17 20 sec |
| Reading # 230 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 17.25 sec |
| Reading # 231 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 17.31 sec |
| Reading # 232 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 17.36 sec |
| Reading # 233 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 17 42 sec |
| Reading # 234 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 17.47 sec |
| Reading # 235 | 2.667 | 3.235 | 1.686 | 4 098 | Volts at | 17.53 sec |
| Reading # 236 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 17 58 sec |
| Reading # 237 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 17.64 sec |
| Reading # 238 | 2 667 | 3.216 | 1.686 | 4 098 | Volts at | 17 69 sec |
| Reading # 239 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 17 75 sec |
| Reading # 240 | 2 667 | 3 216 | 1 686 | 4 098 | Volts at | 17 80 sec |
| Reading # 241 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 17.86 sec |
| Reading # 242 | 2.667 | 3.235 | 1.686 | 4.098 | Volts at | 17 91 sec |
| Reading # 243 | 2 686 | 3 216 | 1.686 | 4.098 | Volts at | 17.97 sec |
| Reading # 244 | 2.667 | 3 216 | 1.686 | 4.098 | Volts at | 18 02 sec |
| Reading # 245 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 18 08 sec |
| Reading # 246 | 2 667 | 3.216 | 1 686 | 4.098 | Volts at | 18.08 sec |
| Reading # 247 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 18 13 sec |
| Reading # 248 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 18.24 sec |
| Reading # 249 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 18 30 sec |
| Reading # 250 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 18.30 sec |
| Reading # 251 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 18 35 sec |
| Reading # 252 | 2 686 | 3.21ᶠ | 1 686 | 4.098 | Volts at | 18 41 sec |
| Reading # 253 | 2 667 | 3 235 | 1 686 | 4.098 | Volts at | 18 46 sec |
| Reading # 254 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 18.52 sec |
| Reading # 255 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 18.57 sec |
| Reading # 256 | 2.686 | 3 216 | 1 686 | 4.098 | Volts at | 18.63 sec |
| Reading # 257 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 18 68 sec |
| Reading # 258 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 18 74 sec |
| Reading # 259 | 2 667 | 3.216 | 1 686 | 4 098 | Volts at | 18 79 sec |
| Reading # 260 | 2 667 | 3 235 | 1 686 | 4 098 | Volts at | 18 85 sec |
| Reading # 261 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 18 90 sec |
| Reading # 262 | 2.667 | 3 216 | 1 686 | 4 098 | Volts at | 18 96 sec |
| Reading # 263 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 19.01 sec |
| Reading # 264 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 19 07 sec |
| Reading # 265 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 19.12 sec |
| Reading # 266 | 2.667 | 3.216 | 1.686 | 4 098 | Volts at | 19 18 sec |
| Reading # 267 | 2.667 | 3 216 | 1.686 | 4.098 | Volts at | 19.23 sec |
| Reading # 268 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 19.23 sec |
| Reading # 269 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 19 34 sec |
| Reading # 270 | 2.667 | 3.216 | 1.686 | 4.098 | Volts at | 19 40 sec |
| Reading # 271 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 19 45 sec |
| Reading # 272 | 2.686 | 3 216 | 1.686 | 4 078 | Volts at | 19.51 sec |
| Reading # 273 | 2.667 | 3 216 | 1.686 | 4.098 | Volts at | 19 56 sec |
| Reading # 274 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 19 56 sec |
| Reading # 275 | 2 667 | 3.216 | 1.686 | 4 098 | Vo'ᶦs at | 19.62 sec |
| Reading # 276 | 2.686 | 3.235 | 1.686 | 4 098 | Volts ɪ | 19 73 sec |
| Reading # 277 | 2.686 | 3 235 | 1.686 | 4 098 | Volts at | 19 78 sec |
| Reading # 278 | 2.686 | 3 216 | 1.686 | 4.098 | Volts at | 19 78 sec |
| Reading # 279 | 2.667 | 3.216 | 1 686 | 4 098 | Volts at | 19 84 sec |
| Reading # 280 | 2.667 | 3.235 | 1.686 | 4 098 | Volts at | 19 89 sec |
| Reading # 281 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 19 95 sec |
| Reading # 282 | 2 667 | 3 216 | 1.686 | 4.098 | Volts at | ?0 00 sec |
| Reading # 283 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 20 05 sec |
| Reading # 284 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 20.11 sec |

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|---|---|---|---|---|---|---|
| Reading # 285 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 20 16 sec |
| Reading # 286 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 20.22 sec |
| Reading # 287 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 20 27 sec |
| Reading # 288 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 20.33 sec |
| Reading # 289 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 20.38 sec |
| Reading # 290 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 20 44 sec |
| Reading # 291 | 2 667 | 3.235 | 1 686 | 4.098 | Volts at | 20 49 sec |
| Reading # 292 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 20 55 sec |
| Reading # 293 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 20.60 sec |
| Reading # 294 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 20.66 sec |
| Reading # 295 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 20.71 sec |
| Reading # 296 | 2 667 | 3.216 | 1.686 | 4.098 | Volts at | 20.71 sec |
| Reading # 297 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 20 82 sec |
| Reading # 298 | 2 686 | 3 216 | 1 686 | 4.098 | Volts at | 20 88 sec |
| Reading # 299 | 2.686 | 3 216 | 1 686 | 4.098 | Volts at | 20.93 sec |
| Reading # 300 | 2 686 | 3 216 | 1.706 | 4 098 | Volts at | 20 99 sec |
| Reading # 301 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 20 99 sec |
| Reading # 302 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 21 04 sec |
| Reading # 303 | 2 686 | 3 216 | 1 686 | 4.098 | Volts at | 21 10 sec |
| Reading # 304 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 21 21 sec |
| Reading # 305 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 21 21 sec |
| Reading # 306 | 2.667 | 3 235 | 1 706 | 4.098 | Volts at | 21 26 sec |
| Reading # 307 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 21 32 sec |
| Reading # 308 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 21 37 sec |
| Reading # 309 | 2.667 | 3 216 | 1.686 | 4 098 | Volts at | 21.43 sec |
| Reading # 310 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 21 48 sec |
| Reading # 311 | 2 667 | 3.216 | 1 686 | 4 098 | Volts at | 21 54 sec |
| Reading # 312 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 21 59 sec |
| Reading # 313 | 2 667 | 3 216 | 1 686 | 4 098 | Volts at | 21 65 sec |
| Reading # 314 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 21 70 sec |
| Reading # 315 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 21 76 sec |
| Reading # 316 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 21 81 sec |
| Reading # 317 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 21 87 sec |
| Reading # 318 | 2 667 | 3.235 | 1 686 | 4 098 | Volts at | 21 92 sec |
| Reading # 319 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 21 98 sec |
| Reading # 320 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 22.03 sec |
| Reading # 321 | 2.667 | 3.216 | 1 686 | 4.098 | Volts at | 22 09 sec |
| Reading # 322 | 2 667 | 3.216 | 1 686 | 4 098 | Volts at | 22 14 sec |
| Reading # 323 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 22 14 sec |
| Reading # 324 | 2.667 | 3 235 | 1.686 | 4.098 | Volts at | 22.20 sec |
| Reading # 325 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 22 31 sec |
| Reading # 326 | 2.686 | 3 216 | 1.686 | 4.098 | Volts at | 22 36 sec |
| Reading # 327 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 22 42 sec |
| Reading # 328 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 22.42 sec |
| Reading # 329 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 22 47 sec |
| Reading # 330 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 22 53 sec |
| Reading # 331 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 22 58 sec |
| Reading # 332 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 22 64 sec |
| Reading # 333 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 22 69 sec |
| Reading # 334 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 22 75 sec |
| Reading # 335 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 22 80 sec |
| Reading # 336 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 22 86 sec |
| Reading # 337 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 22.91 sec |
| Reading # 338 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 22 97 sec |
| Reading # 339 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 23 02 sec |
| Reading # 340 | 2 686 | 3.216 | 1 706 | 4 098 | Volts at | 23 08 sec |
| Reading # 341 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 23.13 sec |
| Reading # 342 | 2.686 | 3 216 | 1.686 | 4.098 | Volts at | 23.19 sec |
| Reading # 343 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 23.24 sec |
| Reading # 344 | 2.686 | 3 235 | 1.686 | 4 098 | Volts at | 23.30 sec |
| Reading # 345 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 23.35 sec |
| Reading # 346 | 2 667 | 3.216 | 1 686 | 4.098 | Volts at | 23 41 sec |
| Reading # 347 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 23 46 sec |
| Reading # 348 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 23.52 sec |
| Reading # 349 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 23 57 sec |
| Reading # 350 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 23 57 sec |
| Reading # 351 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 23.63 sec |
| Reading # 352 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 23.68 sec |
| Reading # 353 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 23.79 sec |
| Reading # 354 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 23.85 sec |
| Reading # 355 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 23.85 sec |

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| Reading # 356 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 23 90 sec |
| Reading # 357 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 23 96 sec |
| Reading # 358 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 24.01 sec |
| Reading # 359 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 24.07 sec |
| Reading # 360 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 24.12 sec |
| Reading # 361 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 24.18 sec |
| Reading # 362 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 24 23 sec |
| Reading # 363 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 24.29 sec |
| Reading # 364 | 2 686 | 3.235 | 1 706 | 4.098 | Volts at | 24.34 sec |
| Reading # 365 | 2.686 | 3 216 | 1.686 | 4.098 | Volts at | 24 40 sec |
| Reading # 366 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 24 45 sec |
| Reading # 367 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 24.51 sec |
| Reading # 368 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 24 56 sec |
| Reading # 369 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 24 62 sec |
| Reading # 370 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 24.67 sec |
| Reading # 371 | 2.686 | 3 216 | 1 686 | 4.098 | Volts at | 24 73 sec |
| Reading # 372 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 24 78 sec |
| Reading # 373 | 2 686 | 3 216 | 1 686 | 4.078 | Volts at | 24 78 sec |
| Reading # 374 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 24.89 sec |
| Reading # 375 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 24 95 sec |
| Reading # 376 | 2 686 | 3.235 | 1.706 | 4.098 | Volts at | 25.00 sec |
| Reading # 377 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 25 00 sec |
| Reading # 378 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 25 05 sec |
| Reading # 379 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 25 11 sec |
| Reading # 380 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 25 16 sec |
| Reading # 381 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 25.27 sec |
| Reading # 382 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 25 33 sec |
| Reading # 383 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 25 33 sec |
| Reading # 384 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 25.38 sec |
| Reading # 385 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 25 44 sec |
| Reading # 386 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 25 49 sec |
| Reading # 387 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 25 55 sec |
| Reading # 388 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 25 60 sec |
| Reading # 389 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 25 66 sec |
| Reading # 390 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 25 71 sec |
| Reading # 391 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 25 77 sec |
| Reading # 392 | 2 686 | 3.235 | 1.706 | 4 098 | Volts at | 25 82 sec |
| Reading # 393 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 25 88 sec |
| Reading # 394 | 2.686 | 3 216 | 1 706 | 4 098 | Volts at | 25 93 sec |
| Reading # 395 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 25.99 sec |
| Reading # 396 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 26 04 sec |
| Reading # 397 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 26 10 sec |
| Reading # 398 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 26 15 sec |
| Reading # 399 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 26.21 sec |
| Reading # 400 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 26 26 sec |
| Reading # 401 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 26 32 sec |
| Reading # 402 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 26 37 sec |
| Reading # 403 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 26 43 sec |
| Reading # 404 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 26 48 sec |
| Reading # 405 | 2 686 | 3 216 | 1.686 | 4.098 | Volts at | 26 54 sec |
| Reading # 406 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 26 54 sec |
| Reading # 407 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 26 59 sec |
| Reading # 408 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 26 65 sec |
| Reading # 409 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 26.76 sec |
| Reading # 410 | 2 686 | 3 216 | 1.686 | 4.098 | Volts at | 26 81 sec |
| Reading # 411 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 26 81 sec |
| Reading # 412 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 26 87 sec |
| Reading # 413 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 26 92 sec |
| Reading # 414 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 26 98 sec |
| Reading # 415 | 2 686 | 3 235 | 1 706 | 4 098 | Volts at | 27 03 sec |
| Reading # 416 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 27 09 sec |
| Reading # 417 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 27.14 sec |
| Reading # 418 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 27 20 sec |
| Reading # 419 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 27 25 sec |
| Reading # 420 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 27 31 sec |
| Reading # 421 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 27 36 sec |
| Reading # 422 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 27 42 sec |
| Reading # 423 | 2.686 | 3 216 | 1 686 | 4 118 | Volts at | 27 47 sec |
| Reading # 424 | 2.686 | 3 235 | 1.706 | 4.098 | Volts at | 27 53 sec |
| Reading # 425 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 27 58 sec |
| Reading # 426 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 27 64 sec |

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|---|---|---|---|---|---|---|
| Reading # 427 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 27 69 sec |
| Reading # 428 | 2.686 | 3 216 | 1 686 | 4.098 | Volts at | 27 75 sec |
| Reading # 429 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 27 75 sec |
| Reading # 430 | 2.686 | 3 216 | 1 686 | 4.098 | Volts at | 27 86 sec |
| Reading # 431 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 27 91 sec |
| Reading # 432 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 27.97 sec |
| Reading # 433 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 27 97 sec |
| Reading # 434 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 28 02 sec |
| Reading # 435 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 28 08 sec |
| Reading # 436 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 28.13 sec |
| Reading # 437 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 28 24 sec |
| Reading # 438 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 28.24 sec |
| Reading # 439 | 2 686 | 3 216 | 1.686 | 4.118 | Volts at | 28 30 sec |
| Reading # 440 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 28.35 sec |
| Reading # 441 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 28 41 sec |
| Reading # 442 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 28 46 sec |
| Reading # 443 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 28 52 sec |
| Reading # 444 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 28 57 sec |
| Reading # 445 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 28 63 sec |
| Reading # 446 | 2.686 | 3 216 | 1.686 | 4.098 | Volts at | 28 68 sec |
| Reading # 447 | 2 686 | 3 216 | 1 686 | 4 118 | Volts at | 28 74 sec |
| Reading # 448 | 2 686 | 3 216 | 1.686 | 4.098 | Volts at | 28 79 sec |
| Reading # 449 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 28 85 sec |
| Reading # 450 | 2 686 | 3 216 | 1 686 | 4.098 | Volts at | 28.90 sec |
| Reading # 451 | 2.686 | 3 216 | 1 686 | 4 118 | Volts at | 28 96 sec |
| Reading # 452 | 2.686 | 3 216 | 1 686 | 4 118 | Volts at | 29 01 sec |
| Reading # 453 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 29.07 sec |
| Reading # 454 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 29 12 sec |
| Reading # 455 | 2 686 | 3.216 | 1 686 | 4.118 | Volts at | 29 18 sec |
| Reading # 456 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 29 18 sec |
| Reading # 457 | 2 686 | 3.216 | 1 686 | 4 118 | Volts at | 29 23 sec |
| Reading # 458 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 29 34 sec |
| Reading # 459 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 29 40 sec |
| Reading # 460 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 29 40 sec |
| Reading # 461 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 29 45 sec |
| Reading # 462 | 2 686 | 3 216 | 1 686 | 4 118 | Volts at | 29 51 sec |
| Reading # 463 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 29 56 sec |
| Reading # 464 | 2 686 | 3.216 | 1 686 | 4 118 | Volts at | 29 62 sec |
| Reading # 465 | 2 686 | 3 216 | 1 686 | 4 118 | Volts at | 29 67 sec |
| Reading # 466 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 29 73 sec |
| Reading # 467 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 29 78 sec |
| Reading # 468 | 2 686 | 3 235 | 1 686 | 4.098 | Volts at | 29 84 sec |
| Reading # 469 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 29 89 sec |
| Reading # 470 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 29 95 sec |
| Reading # 471 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 30.00 sec |
| Reading # 472 | 2 686 | 3.216 | 1.686 | 4.118 | Volts at | 30 05 sec |
| Reading # 473 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 30 11 sec |
| Reading # 474 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 30.16 sec |
| Reading # 475 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 30.22 sec |
| Reading # 476 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 30.27 sec |
| Reading # 477 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 30 33 sec |
| Reading # 478 | 2.686 | 3 235 | 1 686 | 4.118 | Volts at | 30.33 sec |
| Reading # 479 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 30.44 sec |
| Reading # 480 | 2.686 | 3 235 | 1 686 | 4.118 | Volts at | 30 49 sec |
| Reading # 481 | 2.686 | 3.216 | 1.686 | 4.118 | Volts at | 30.55 sec |
| Reading # 482 | 2 686 | 3.216 | 1.686 | 4 118 | Volts at | 30.60 sec |
| Reading # 483 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 30.60 sec |
| Reading # 484 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 30.66 sec |
| Reading # 485 | 2.686 | 3.216 | 1 686 | 4 118 | Volts at | 30 71 sec |
| Reading # 486 | 2.686 | 3 216 | 1.686 | 4 118 | Volts at | 30 82 sec |
| Reading # 487 | 2 686 | 3 216 | 1 686 | 4.118 | Volts at | 30 82 sec |
| Reading # 488 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 30 88 sec |
| Reading # 489 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 30 93 sec |
| Reading # 490 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 30 99 sec |
| Reading # 491 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 31 04 sec |
| Reading # 492 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 31 10 sec |
| Reading # 493 | 2 686 | 3 216 | 1 686 | 4 118 | Volts at | 31 21 sec |
| Reading # 494 | 2 686 | 3 216 | 1.686 | 4 118 | Volts at | 31 21 sec |
| Reading # 495 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 31 26 sec |
| Reading # 496 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 31 32 sec |
| Reading # 497 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 31.37 sec |

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|---|---|---|---|---|---|---|
| Reading # 498 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 31.43 sec |
| Reading # 499 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 31.48 sec |
| Reading # 500 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 31 54 sec |
| Reading # 501 | 2.686 | 3.216 | 1.686 | 4 118 | Volts at | 31.59 sec |
| Reading # 502 | 2.686 | 3.216 | 1.686 | 4.118 | Volts at | 31.65 sec |
| Reading # 503 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 31 70 sec |
| Reading # 504 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 31.76 sec |
| Reading # 505 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 31.81 sec |
| Reading # 506 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 31.87 sec |
| Reading # 507 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 31.92 sec |
| Reading # 508 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 31.98 sec |
| Reading # 509 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 32.03 sec |
| Reading # 510 | 2.686 | 3.216 | 1.686 | 4 118 | Volts at | 32 09 sec |
| Reading # 511 | 2 686 | 3 216 | 1.686 | 4 098 | Volts at | 32 14 sec |
| Reading # 512 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 32.20 sec |
| Reading # 513 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 32 25 sec |
| Reading # 514 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 32.31 sec |
| Reading # 515 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 32.36 sec |
| Reading # 516 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 32 42 sec |
| Reading # 517 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 32 47 sec |
| Reading # 518 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 32 53 sec |
| Reading # 519 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 32 58 sec |
| Reading # 520 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 32 64 sec |
| Reading # 521 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 32 69 sec |
| Reading # 522 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 32 75 sec |
| Reading # 523 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 32 80 sec |
| Reading # 524 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 32 86 sec |
| Reading # 525 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 32 91 sec |
| Reading # 526 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 32 97 sec |
| Reading # 527 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 32 97 sec |
| Reading # 528 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 33 08 sec |
| Reading # 529 | 2.686 | 3.216 | 1 686 | 4.098 | Volts at | 33 13 sec |
| Reading # 530 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 33.19 sec |
| Reading # 531 | 2.686 | 3 216 | 1.686 | 4 118 | Volts at | 33 24 sec |
| Reading # 532 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 33 30 sec |
| Reading # 533 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 33 35 sec |
| Reading # 534 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 33.41 sec |
| Reading # 535 | 2 686 | 3 216 | 1.686 | 4 118 | Volts at | 33 46 sec |
| Reading # 536 | 2.686 | 3.216 | 1.686 | 4 098 | Volts at | 33.52 sec |
| Reading # 537 | 2.686 | 3.216 | 1 686 | 4.118 | Volts at | 33.57 sec |
| Reading # 538 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 33 63 sec |
| Reading # 539 | 2.686 | 3 216 | 1.686 | 4.118 | Volts at | 33.63 sec |
| Reading # 540 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 33 68 sec |
| Reading # 541 | 2 686 | 3 235 | 1 686 | 4.098 | Volts at | 33 74 sec |
| Reading # 542 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 33.85 sec |
| Reading # 543 | 2.686 | 3 216 | 1.686 | 4 118 | Volts at | 33.90 sec |
| Reading # 544 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 33 96 sec |
| Reading # 545 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 34 01 sec |
| Reading # 546 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 34 01 sec |
| Reading # 547 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 34 07 sec |
| Reading # 548 | 2 686 | 3.235 | 1.686 | 4 118 | Volts at | 34 12 sec |
| Reading # 549 | 2 686 | 3.235 | 1.686 | 4.118 | Volts at | 34 23 sec |
| Reading # 550 | 2.686 | 3 216 | 1 686 | 4.118 | Volts at | 34.23 sec |
| Reading # 551 | 2 686 | 3 216 | 1 686 | 4 098 | Volts at | 34 29 sec |
| Reading # 552 | 2 686 | 3.235 | 1 686 | 4.098 | Volts at | 34 34 sec |
| Reading # 553 | 2.686 | 3 235 | 1.686 | 4 098 | Volts at | 34.40 sec |
| Reading # 554 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 34.45 sec |
| Reading # 555 | 2.686 | 3.216 | 1 686 | 4.118 | Volts at | 34 51 sec |
| Reading # 556 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 34 62 sec |
| Reading # 557 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 34 62 sec |
| Reading # 558 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 34 67 sec |
| Reading # 559 | 2 686 | 3 235 | 1.686 | 4.098 | Volts at | 34 73 sec |
| Reading # 560 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 34 78 sec |
| Reading # 561 | 2.686 | 3.216 | 1.686 | 4.098 | Volts at | 34.84 sec |
| Reading # 562 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 34 89 sec |
| Reading # 563 | 2.686 | 3 235 | 1.686 | 4.118 | Volts at | 34 95 sec |
| Reading # 564 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 35.00 sec |
| Reading # 565 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 35.05 sec |
| Reading # 566 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 35 11 sec |
| Reading # 567 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 35 16 sec |
| Reading # 568 | 2 686 | 3.216 | 1.686 | 4.098 | Volts at | 35.22 sec |

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|---|---|---|---|---|---|---|
| Reading # 569 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 35.27 sec |
| Reading # 570 | 2 686 | 3.216 | 1.686 | 4 098 | Volts at | 35.33 sec |
| Reading # 571 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 35.38 sec |
| Reading # 572 | 2.686 | 3 216 | 1.686 | 4 098 | Volts at | 35 44 sec |
| Reading # 573 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 35 49 sec |
| Reading # 574 | 2 686 | 3.216 | 1 686 | 4.098 | Volts at | 35 55 sec |
| Reading # 575 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 35.60 sec |
| Reading # 576 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 35.66 sec |
| Reading # 577 | 2 686 | 3.235 | 1 686 | 4.098 | Volts at | 35.71 sec |
| Reading # 578 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 35.77 sec |
| Reading # 579 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 35.82 sec |
| Reading # 580 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 35.88 sec |
| Reading # 581 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 35.93 sec |
| Reading # 582 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 35 93 sec |
| Reading # 583 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 35 99 sec |
| Reading # 584 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 36 10 sec |
| Reading # 585 | 2.686 | 3.216 | 1 686 | 4.118 | Volts at | 36.15 sec |
| Reading # 586 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 36 21 sec |
| Reading # 587 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 36.26 sec |
| Reading # 588 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 36 32 sec |
| Reading # 589 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 36.37 sec |
| Reading # 590 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 36 37 sec |
| Reading # 591 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 36 48 sec |
| Reading # 592 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 36 54 sec |
| Reading # 593 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 36 59 sec |
| Reading # 594 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 36.65 sec |
| Reading # 595 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 36.70 sec |
| Reading # 596 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 36 70 sec |
| Reading # 597 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 36.76 sec |
| Reading # 598 | 2 686 | 3 235 | 1 686 | 4.118 | Volts at | 36.87 sec |
| Reading # 599 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 36 92 sec |
| Reading # 600 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 36 92 sec |
| Reading # 601 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 36 98 sec |
| Reading # 602 | 2 686 | 3.235 | 1.686 | 4.118 | Volts at | 37 03 sec |
| Reading # 603 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 37 09 sec |
| Reading # 604 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 37 14 sec |
| Reading # 605 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 37 20 sec |
| Reading # 606 | 2 686 | 3.235 | 1 667 | 4 098 | Volts at | 37 25 sec |
| Reading # 607 | 2.686 | 3 216 | 1.686 | 4.118 | Volts at | 37.31 sec |
| Reading # 608 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 37.36 sec |
| Reading # 609 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 37.42 sec |
| Reading # 610 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 37 47 sec |
| Reading # 611 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 37.53 sec |
| Reading # 612 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 37.58 sec |
| Reading # 613 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 37.64 sec |
| Reading # 614 | 2 686 | 3.235 | 1 686 | 4.098 | Volts at | 37.69 sec |
| Reading # 615 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 37.75 sec |
| Reading # 616 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 37 80 sec |
| Reading # 617 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 37.86 sec |
| Reading # 618 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 37 91 sec |
| Reading # 619 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 37.97 sec |
| Reading # 620 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 38 02 sec |
| Reading # 621 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 38 08 sec |
| Reading # 622 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 38.13 sec |
| Reading # 623 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 38 19 sec |
| Reading # 624 | 2.686 | 3 216 | 1 686 | 4 098 | Volts at | 38.24 sec |
| Reading # 625 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 38.30 sec |
| Reading # 626 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 38.35 sec |
| Reading # 627 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 38 41 sec |
| Reading # 628 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 38 46 sec |
| Reading # 629 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 38 52 sec |
| Reading # 630 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 38.52 sec |
| Reading # 631 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 38.57 sec |
| Reading # 632 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 38 63 sec |
| Reading # 633 | 2 686 | 3.216 | 1 686 | 4 098 | Volts at | 38 74 sec |
| Reading # 634 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 38 79 sec |
| Reading # 635 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 38 79 sec |
| Reading # 636 | 2.686 | 3 235 | 1 686 | 4 098 | Volts at | 38.85 sec |
| Reading # 637 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 38.90 sec |
| Reading # 638 | 2 686 | 3.235 | 1.686 | 4 118 | Volts at | 38 96 sec |
| Reading # 639 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 39 01 sec |

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| Reading # 640 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 39.12 sec |
| Reading # 641 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 39.12 sec |
| Reading # 642 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 39 18 sec |
| Reading # 643 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 39.23 sec |
| Reading # 644 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 39.29 sec |
| Reading # 645 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 39.34 sec |
| Reading # 646 | 2.706 | 3 235 | 1 686 | 4 098 | Volts at | 39.40 sec |
| Reading # 647 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 39 45 sec |
| Reading # 648 | 2 686 | 3.235 | 1 686 | 4.118 | Volts at | 39.51 sec |
| Reading # 649 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 39 56 sec |
| Reading # 650 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 39.62 sec |
| Reading # 651 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 39.67 sec |
| Reading # 652 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 39.73 sec |
| Reading # 653 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 39.78 sec |
| Reading # 654 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 39.84 sec |
| Reading # 655 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 39.89 sec |
| Reading # 656 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 39.95 sec |
| Reading # 657 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 40.00 sec |
| Reading # 658 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 40.05 sec |
| Reading # 659 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 40.11 sec |
| Reading # 660 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 40.11 sec |
| Reading # 661 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 40.22 sec |
| Reading # 662 | 2.686 | 3.216 | 1 686 | 4.118 | Volts at | 40 27 sec |
| Reading # 663 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 40.33 sec |
| Reading # 664 | 2.686 | 3 235 | 1 686 | 4.118 | Volts at | 40 33 sec |
| Reading # 665 | 2.686 | 3.216 | 1 686 | 4 098 | Volts at | 40.38 sec |
| Reading # 666 | 2.686 | 3.216 | 1 686 | 4 118 | Volts at | 40.44 sec |
| Reading # 667 | 2.686 | 3.216 | 1 686 | 4 118 | Volts at | 40.49 sec |
| Reading # 668 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 40.60 sec |
| Reading # 669 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 40.66 sec |
| Reading # 670 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 40.71 sec |
| Reading # 671 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 40 77 sec |
| Reading # 672 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 40 77 sec |
| Reading # 673 | 2 686 | 3.216 | 1.686 | 4 118 | Volts at | 40 82 sec |
| Reading # 674 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 40 88 sec |
| Reading # 675 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 40 99 sec |
| Reading # 676 | 2 686 | 3.235 | 1.686 | 4 118 | Volts at | 40 99 sec |
| Reading # 677 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 41 04 sec |
| Reading # 678 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 41 10 sec |
| Reading # 679 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 41 15 sec |
| Reading # 680 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 41 21 sec |
| Reading # 681 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 41 26 sec |
| Reading # 682 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 41.32 sec |
| Reading # 683 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 41 37 sec |
| Reading # 684 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 41 43 sec |
| Reading # 685 | 2.686 | 3.235 | 1.667 | 4 118 | Volts at | 41.48 sec |
| Reading # 686 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 41 54 sec |
| Reading # 687 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 41.59 sec |
| Reading # 688 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 41 65 sec |
| Reading # 689 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 41 70 sec |
| Reading # 690 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 41 76 sec |
| Reading # 691 | 2 686 | 3 235 | 1 667 | 4.098 | Volts at | 41 81 sec |
| Reading # 692 | 2.686 | 3 216 | 1 686 | 4.118 | Volts at | 41.87 sec |
| Reading # 693 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 41 92 sec |
| Reading # 694 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 41.98 sec |
| Reading # 695 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 42 03 sec |
| Reading # 696 | 2.686 | 3.235 | 1.667 | 4 098 | Volts at | 42 03 sec |
| Reading # 697 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 42.14 sec |
| Reading # 698 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 42.20 sec |
| Reading # 699 | 2.686 | 3 235 | 1.686 | 4.118 | Volts at | 42 25 sec |
| Reading # 700 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 42 31 sec |
| Reading # 701 | 2 686 | 3 235 | 1.686 | 4.098 | Volts at | 42 36 sec |
| Reading # 702 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 42 42 sec |
| Reading # 703 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 42 42 sec |
| Reading # 704 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 42 53 sec |
| Reading # 705 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 42 58 sec |
| Reading # 706 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 42 64 sec |
| Reading # 707 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 42 69 sec |
| Reading # 708 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 42 69 sec |
| Reading # 709 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 42 75 sec |
| Reading # 710 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 42.80 sec |

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|---|---|---|---|---|---|---|
| Reading # 711 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 42.91 sec |
| Reading # 712 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 42.91 sec |
| Reading # 713 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 42.97 sec |
| Reading # 714 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 43.02 sec |
| Reading # 715 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.08 sec |
| Reading # 716 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.13 sec |
| Reading # 717 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 43.19 sec |
| Reading # 718 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.24 sec |
| Reading # 719 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.30 sec |
| Reading # 720 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.35 sec |
| Reading # 721 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.41 sec |
| Reading # 722 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.46 sec |
| Reading # 723 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.52 sec |
| Reading # 724 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.57 sec |
| Reading # 725 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.63 sec |
| Reading # 726 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.68 sec |
| Reading # 727 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.74 sec |
| Reading # 728 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.79 sec |
| Reading # 729 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.85 sec |
| Reading # 730 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.90 sec |
| Reading # 731 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 43.96 sec |
| Reading # 732 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.01 sec |
| Reading # 733 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 44.07 sec |
| Reading # 734 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.12 sec |
| Reading # 735 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 44.18 sec |
| Reading # 736 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.23 sec |
| Reading # 737 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 44.29 sec |
| Reading # 738 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 44.29 sec |
| Reading # 739 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.40 sec |
| Reading # 740 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 44.45 sec |
| Reading # 741 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 44.51 sec |
| Reading # 742 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.51 sec |
| Reading # 743 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.56 sec |
| Reading # 744 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.62 sec |
| Reading # 745 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.67 sec |
| Reading # 746 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.73 sec |
| Reading # 747 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 44.78 sec |
| Reading # 748 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.84 sec |
| Reading # 749 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.89 sec |
| Reading # 750 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 44.95 sec |
| Reading # 751 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 45.00 sec |
| Reading # 752 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.05 sec |
| Reading # 753 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.11 sec |
| Reading # 754 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.16 sec |
| Reading # 755 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 45.22 sec |
| Reading # 756 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 45.27 sec |
| Reading # 757 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.33 sec |
| Reading # 758 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 45.38 sec |
| Reading # 759 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.44 sec |
| Reading # 760 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 45.49 sec |
| Reading # 761 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 45.55 sec |
| Reading # 762 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.60 sec |
| Reading # 763 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.66 sec |
| Reading # 764 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.71 sec |
| Reading # 765 | 2.686 | 3.235 | 1.667 | 4.098 | Volts at | 45.77 sec |
| Reading # 766 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.82 sec |
| Reading # 767 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 45.88 sec |
| Reading # 768 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 45.93 sec |
| Reading # 769 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 45.99 sec |
| Reading # 770 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 46.04 sec |
| Reading # 771 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 46.10 sec |
| Reading # 772 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 46.10 sec |
| Reading # 773 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 46.15 sec |
| Reading # 774 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 46.26 sec |
| Reading # 775 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 46.32 sec |
| Reading # 776 | 2.706 | 3.235 | 1.686 | 4.098 | Volts at | 46.32 sec |
| Reading # 777 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 46.37 sec |
| Reading # 778 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 46.43 sec |
| Reading # 779 | 2.706 | 3.235 | 1.667 | 4.098 | Volts at | 46.48 sec |
| Reading # 780 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 46.54 sec |
| Reading # 781 | 2.686 | 3.235 | 1.667 | 4.098 | Volts at | 46.59 sec |

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|---|---|---|---|---|---|---|
| Reading # 782 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 46 65 sec |
| Reading # 783 | 2.686 | 3.235 | 1.686 | 4 098 | Volts at | 46.70 sec |
| Reading # 784 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 46.76 sec |
| Reading # 785 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 46.81 sec |
| Reading # 786 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 46 87 sec |
| Reading # 787 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 46.92 sec |
| Reading # 788 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 46 98 sec |
| Reading # 789 | 2.686 | 3.235 | 1 667 | 4 118 | Volts at | 47 03 sec |
| Reading # 790 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 47.09 sec |
| Reading # 791 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 47 14 sec |
| Reading # 792 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 47 20 sec |
| Reading # 793 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 47.25 sec |
| Reading # 794 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 47.31 sec |
| Reading # 795 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 47.36 sec |
| Reading # 796 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 47.42 sec |
| Reading # 797 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 47.47 sec |
| Reading # 798 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 47.53 sec |
| Reading # 799 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 47.53 sec |
| Reading # 800 | 2.686 | 3 235 | 1.667 | 4.118 | Volts at | 47.58 sec |
| Reading # 801 | 2.686 | 3.235 | 1 667 | 4.118 | Volts at | 47.64 sec |
| Reading # 802 | 2 686 | 3.235 | 1 686 | 4 118 | Volts at | 47 75 sec |
| Reading # 803 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 47 80 sec |
| Reading # 804 | 2 686 | 3 216 | 1 667 | 4 118 | Volts at | 47 80 sec |
| Reading # 805 | 2 706 | 3 235 | 1 667 | 4 118 | Volts at | 47 86 sec |
| Reading # 806 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 47 91 sec |
| Reading # 807 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 47 97 sec |
| Reading # 808 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 48 02 sec |
| Reading # 809 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 48 13 sec |
| Reading # 810 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 48 19 sec |
| Reading # 811 | 2.706 | 3.235 | 1 667 | 4.118 | Volts at | 48.19 sec |
| Reading # 812 | 2.706 | 3.235 | 1 686 | 4.118 | Volts at | 48.24 sec |
| Reading # 813 | 2 686 | 3.235 | 1.686 | 4.118 | Volts at | 48 30 sec |
| Reading # 814 | 2.706 | 3.235 | 1.686 | 4 118 | Volts at | 48 35 sec |
| Reading # 815 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 48 41 sec |
| Reading # 816 | 2.706 | 3.235 | 1.686 | 4 118 | Volts at | 48 46 sec |
| Reading # 817 | 2 686 | 3 235 | 1 667 | 4.118 | Volts at | 48 52 sec |
| Reading # 818 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 48 57 sec |
| Reading # 819 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 48 63 sec |
| Reading # 820 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 48 68 sec |
| Reading # 821 | 2.686 | 3 235 | 1 686 | 4.118 | Volts at | 48.74 sec |
| Reading # 822 | 2.686 | 3.235 | 1 667 | 4 118 | Volts at | 48 79 sec |
| Reading # 823 | 2 686 | 3 235 | 1 667 | 4.098 | Volts at | 48 85 sec |
| Reading # 824 | 2.686 | 3 235 | 1.686 | 4 098 | Volts at | 48.90 sec |
| Reading # 825 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 48.96 sec |
| Reading # 826 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 49.01 sec |
| Reading # 827 | 2.706 | 3 235 | 1.686 | 4.118 | Volts at | 49 07 sec |
| Reading # 828 | 2.686 | 3.235 | 1 667 | 4.118 | Volts at | 49 12 sec |
| Reading # 829 | 2.686 | 3.235 | 1.667 | 4 118 | Volts at | 49 12 sec |
| Reading # 830 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 49.23 sec |
| Reading # 831 | 2.706 | 3.235 | 1 686 | 4 118 | Volts at | 49 29 sec |
| Reading # 832 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 49.34 sec |
| Reading # 833 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 49.40 sec |
| Reading # 834 | 2.686 | 3 235 | 1 686 | 4.098 | Volts at | 49.40 sec |
| Reading # 835 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 49 45 sec |
| Reading # 836 | 2 706 | 3 235 | 1 667 | 4 118 | Volts at | 49 51 sec |
| Reading # 837 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 49 62 sec |
| Reading # 838 | 2 706 | 3 235 | 1.686 | 4 118 | Volts at | 49 67 sec |
| Reading # 839 | 2.686 | 3 235 | 1 667 | 4.118 | Volts at | 49 73 sec |
| Reading # 840 | 2.706 | 3.235 | 1.667 | 4 118 | Volts at | 49 78 sec |
| Reading # 841 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 49.78 sec |
| Reading # 842 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 49 84 sec |
| Reading # 843 | 2.706 | 3 235 | 1.686 | 4.118 | Volts at | 49.89 sec |
| Reading # 844 | 2.686 | 3.235 | 1 667 | 4.118 | Volts at | 50.00 sec |
| Reading # 845 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 50.00 sec |
| Reading # 846 | 2.686 | 3 235 | 1.667 | 4.118 | Volts at | 50.05 sec |
| Reading # 847 | 2 686 | 3.235 | 1.667 | 4 118 | Volts at | 50.11 sec |
| Reading # 848 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 50.16 sec |
| Reading # 849 | 2.686 | 3.235 | 1 686 | 4 098 | Volts at | 50.22 sec |
| Reading # 850 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 50 27 sec |
| Reading # 851 | 2.706 | 3.235 | 1 686 | 4 118 | Volts at | 50 33 sec |
| Reading # 852 | 2 686 | 3.235 | 1 667 | 4.118 | Volts at | 50 38 sec |

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|---|---|---|---|---|---|---|
| Reading # 853 | 2 686 | 3.235 | 1.686 | 4.118 | Volts at | 50.44 sec |
| Reading # 854 | 2 686 | 3.235 | 1.686 | 4 098 | Volts at | 50.49 sec |
| Reading # 855 | 2 706 | 3.235 | 1 667 | 4 118 | Volts at | 50 55 sec |
| Reading # 856 | 2 706 | 3 235 | 1 686 | 4.118 | Volts at | 50 60 sec |
| Reading # 857 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 50.66 sec |
| Reading # 858 | 2 686 | 3 235 | 1 667 | 4 098 | Volts at | 50 71 sec |
| Reading # 859 | 2.706 | 3.235 | 1 686 | 4.118 | Volts at | 50.77 sec |
| Reading # 860 | 2 686 | 3.235 | 1 686 | 4 098 | Volts at | 50.82 sec |
| Reading # 861 | 2 706 | 3.235 | 1.667 | 4 118 | Volts at | 50 88 sec |
| Reading # 862 | 2 686 | 3.235 | 1 667 | 4.098 | Volts at | 50 93 sec |
| Reading # 863 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 50 99 sec |
| Reading # 864 | 2 706 | 3.235 | 1.686 | 4 098 | Volts at | 50.99 sec |
| Reading # 865 | 2.686 | 3.235 | 1 686 | 4.098 | Volts at | 51 10 sec |
| Reading # 866 | 2.686 | 3 235 | 1.686 | 4.098 | Volts at | 51 15 sec |
| Reading # 867 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 51.21 sec |
| Reading # 868 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 51 26 sec |
| Reading # 869 | 2 706 | 3.235 | 1.686 | 4 118 | Volts at | 51 32 sec |
| Reading # 870 | 2 686 | 3.235 | 1.667 | 4 118 | Volts at | 51 37 sec |
| Reading # 871 | 2.686 | 3.235 | 1 667 | 4.118 | Volts at | 51.37 sec |
| Reading # 872 | 2 686 | 3.235 | 1.667 | 4.118 | Volts at | 51.48 sec |
| Reading # 873 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 51.54 sec |
| Reading # 874 | 2 686 | 3.235 | 1 686 | 4.098 | Volts at | 51 59 sec |
| Reading # 875 | 2.686 | 3 235 | 1.667 | 4 098 | Volts at | 51.59 sec |
| Reading # 876 | 2.686 | 3 235 | 1.667 | 4 118 | Volts at | 51 65 sec |
| Reading # 877 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 51 70 sec |
| Reading # 878 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 51 76 sec |
| Reading # 879 | 2 706 | 3 235 | 1 667 | 4.118 | Volts at | 51 81 sec |
| Reading # 880 | 2 686 | 3 235 | 1 667 | 4 098 | Volts at | 51 87 sec |
| Reading # 881 | 2 686 | 3 235 | 1 686 | 4 098 | Volts at | 51 92 sec |
| Reading # 882 | 2 706 | 3 235 | 1.686 | 4 118 | Volts at | 51 98 sec |
| Reading # 883 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 52 03 sec |
| Reading # 884 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 52 09 sec |
| Reading # 885 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 52 14 sec |
| Reading # 886 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 52 20 sec |
| Reading # 887 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 52 25 sec |
| Reading # 888 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 52 31 sec |
| Reading # 889 | 2 686 | 3 235 | 1.686 | 4 098 | Volts at | 52 36 sec |
| Reading # 890 | 2 686 | 3 235 | 1 667 | 4.118 | Volts at | 52 42 sec |
| Reading # 891 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 52 47 sec |
| Reading # 892 | 2 686 | 3 235 | 1 667 | 4 098 | Volts at | 52 53 sec |
| Reading # 893 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 52 58 sec |
| Reading # 894 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 52 64 sec |
| Reading # 895 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 52 69 sec |
| Reading # 896 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 52 75 sec |
| Reading # 897 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 52 80 sec |
| Reading # 898 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 52 86 sec |
| Reading # 899 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 52.86 sec |
| Reading # 900 | 2.686 | 3 235 | 1 686 | 4.118 | Volts at | 52 97 sec |
| Reading # 901 | 2 706 | 3.235 | 1 667 | 4 118 | Volts at | 53 02 sec |
| Reading # 902 | 2.686 | 3 235 | 1 686 | 4 118 | Volts at | 53.08 sec |
| Reading # 903 | 2.686 | 3.235 | 1.686 | 4 118 | Volts at | 53.13 sec |
| Reading # 904 | 2 686 | 3 235 | 1 667 | 4.118 | Volts at | 53.13 sec |
| Reading # 905 | 2 686 | 3.235 | 1 686 | 4.118 | Volts at | 53.19 sec |
| Reading # 906 | 2 706 | 3 235 | 1 686 | 4.118 | Volts at | 53.24 sec |
| Reading # 907 | 2.706 | 3 235 | 1.686 | 4 118 | Volts at | 53 35 sec |
| Reading # 908 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 53.41 sec |
| Reading # 909 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 53 41 sec |
| Reading # 910 | 2 706 | 3 235 | 1 667 | 4 118 | Volts at | 53 46 sec |
| Reading # 911 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 53 52 sec |
| Reading # 912 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 53 57 sec |
| Reading # 913 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 53 63 sec |
| Reading # 914 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 53 68 sec |
| Reading # 915 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 53 74 sec |
| Reading # 916 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 53.79 sec |
| Reading # 917 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 53 85 sec |
| Reading # 918 | 2 686 | 3 235 | 1 667 | 4.118 | Volts at | 53 90 sec |
| Reading # 919 | 2.686 | 3 235 | 1 686 | 4.118 | Volts at | 53 96 sec |
| Reading # 920 | 2.706 | 3 235 | 1 686 | 4 118 | Volts at | 54.01 sec |
| Reading # 921 | 2 686 | 3 235 | 1 686 | 4 118 | Volts at | 54 07 sec |
| Reading # 922 | 2 706 | 3 235 | 1 686 | 4 118 | Volts at | 54 12 sec |
| Reading # 923 | 2 686 | 3 235 | 1 667 | 4 098 | Volts at | 54 18 sec |

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|---|---|---|---|---|---|---|
| Reading # 924 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 54.23 sec |
| Reading # 925 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 54.29 sec |
| Reading # 926 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 54.34 sec |
| Reading # 927 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 54.40 sec |
| Reading # 928 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 54 45 sec |
| Reading # 929 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 54.51 sec |
| Reading # 930 | 2.706 | 3.235 | 1.667 | 4 118 | Volts at | 54 56 sec |
| Reading # 931 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 54 62 sec |
| Reading # 932 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 54 67 sec |
| Reading # 933 | 2.686 | 3.235 | 1 667 | 4 098 | Volts at | 54 73 sec |
| Reading # 934 | 2 686 | 3 235 | 1.667 | 4.118 | Volts at | 54.73 sec |
| Reading # 935 | 2 706 | 3.235 | 1.667 | 4 118 | Volts at | 54 84 sec |
| Reading # 936 | 2 706 | 3.235 | 1.667 | 4.118 | Volts at | 54.89 sec |
| Reading # 937 | 2.706 | 3.235 | 1.667 | 4 118 | Volts at | 54.95 sec |
| Reading # 938 | 2 686 | 3.235 | 1.667 | 4.118 | Volts at | 55.00 sec |
| Reading # 939 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 55.00 sec |
| Reading # 940 | 2.686 | 3.235 | 1 686 | 4.118 | Volts at | 55.05 sec |
| Reading # 941 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 55.11 sec |
| Reading # 942 | 2 686 | 3.235 | 1.667 | 4.118 | Volts at | 55.22 sec |
| Reading # 943 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 55.22 sec |
| Reading # 944 | 2.686 | 3.235 | 1.667 | 4 118 | Volts at | 55.27 sec |
| Reading # 945 | 2 706 | 3.235 | 1.667 | 4.118 | Volts at | 55 33 sec |
| Reading # 946 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 55 38 sec |
| Reading # 947 | 2 706 | 3.235 | 1 667 | 4.118 | Volts at | 55 44 sec |
| Reading # 948 | 2.686 | 3.235 | 1 667 | 4 118 | Volts at | 55 49 sec |
| Reading # 949 | 2 686 | 3 235 | 1.686 | 4 118 | Volts at | 55 60 sec |
| Reading # 950 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 55 60 sec |
| Reading # 951 | 2.686 | 3 235 | 1 667 | 4 118 | Volts at | 55 66 sec |
| Reading # 952 | 2 686 | 3.235 | 1 667 | 4 118 | Volts at | 55 71 sec |
| Reading # 953 | 2.706 | 3 235 | 1.686 | 4 118 | Volts at | 55.77 sec |
| Reading # 954 | 2.706 | 3.235 | 1 667 | 4 118 | Volts at | 55 82 sec |
| Reading # 955 | 2.706 | 3.235 | 1.667 | 4 118 | Volts at | 55.88 sec |
| Reading # 956 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 55 93 sec |
| Reading # 957 | 2 686 | 3.235 | 1.667 | 4 118 | Volts at | 55.99 sec |
| Reading # 958 | 2.706 | 3.235 | 1.667 | 4 118 | Volts at | 56 04 sec |
| Reading # 959 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 56 10 sec |
| Reading # 960 | 2.686 | 3 235 | 1.667 | 4 118 | Volts at | 56 15 sec |
| Reading # 961 | 2.686 | 3.235 | 1 667 | 4.118 | Volts at | 56 21 sec |
| Reading # 962 | 2.706 | 3.235 | 1 667 | 4 118 | Volts at | 56 26 sec |
| Reading # 963 | 2.686 | 3.235 | 1 686 | 4 118 | Volts at | 56 32 sec |
| Reading # 964 | 2.686 | 3.235 | 1 667 | 4 118 | Volts at | 56 37 sec |
| Reading # 965 | 2.686 | 3 235 | 1.686 | 4 118 | Volts at | 56 43 sec |
| Reading # 966 | 2 706 | 3.235 | 1.667 | 4.118 | Volts at | 56 48 sec |
| Reading # 967 | 2 686 | 3 235 | 1 667 | 4 118 | Volts at | 56 54 sec |
| Reading # 968 | 2 706 | 3 235 | 1 686 | 4.118 | Volts at | 56 54 sec |
| Reading # 969 | 2.706 | 3.235 | 1.667 | 4 118 | Volts at | 56 59 sec |
| Reading # 970 | 2.706 | 3.235 | 1 667 | 4 098 | Volts at | 56 70 sec |
| Reading # 971 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 56 76 sec |
| Reading # 972 | 2 706 | 3 235 | 1.686 | 4.098 | Volts at | 56.81 sec |
| Reading # 973 | 2.686 | 3.235 | 1 667 | 4 098 | Volts at | 56 81 sec |
| Reading # 974 | 2.686 | 3.235 | 1.686 | 4.098 | Volts at | 56.87 sec |
| Reading # 975 | 2.686 | 3.235 | 1.667 | 4.098 | Volts at | 56.92 sec |
| Reading # 976 | 2.706 | 3.235 | 1.686 | 4.118 | Volts at | 56.98 sec |
| Reading # 977 | 2.686 | 3.235 | 1.667 | 4.098 | Volts at | 57.09 sec |
| Reading # 978 | 2 686 | 3 235 | 1.667 | 4 098 | Volts at | 57 14 sec |
| Reading # 979 | 2.686 | 3.235 | 1.667 | 4 098 | Volts at | 57 20 sec |
| Reading # 980 | 2 706 | 3 235 | 1.667 | 4.098 | Volts at | 57 20 sec |
| Reading # 981 | 2.706 | 3 235 | 1.667 | 4.098 | Volts at | 57 25 sec |
| Reading # 982 | 2.706 | 3.235 | 1 667 | 4 098 | Volts at | 57 31 sec |
| Reading # 983 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 57 36 sec |
| Reading # 984 | 2 686 | 3.235 | 1.667 | 4.098 | Volts at | 57 42 sec |
| Reading # 985 | 2.706 | 3.235 | 1.667 | 4.118 | Volts at | 57.47 sec |
| Reading # 986 | 2 686 | 3.235 | 1.667 | 4.118 | Volts at | 57.53 sec |
| Reading # 987 | 2.686 | 3.235 | 1 667 | 4 098 | Volts at | 57.58 sec |
| Reading # 988 | 2.686 | 3.235 | 1.686 | 4.118 | Volts at | 57.64 sec |
| Reading # 989 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 57 69 sec |
| Reading # 990 | 2.706 | 3.235 | 1.686 | 4.098 | Volts at | 57.75 sec |
| Reading # 991 | 2.686 | 3.235 | 1.667 | 4 098 | Volts at | 57.80 sec |
| Reading # 992 | 2.686 | 3.235 | 1 667 | 4 118 | Volts at | 57 86 sec |
| Reading # 993 | 2 706 | 3.235 | 1.686 | 4 098 | Volts at | 57 91 sec |
| Reading # 994 | 2 686 | 3 235 | 1 667 | 4 098 | Volts at | 57 97 sec |

| | | | | | | |
|---|---|---|---|---|---|---|
| Reading # 995 | 2 706 | 3.235 | 1.667 | 4 098 | Volts at | 58.02 sec |
| Reading # 996 | 2 686 | 3.235 | 1.686 | 4.098 | Volts at | 58 08 sec |
| Reading # 997 | 2 686 | 3.235 | 1.667 | 4.098 | Volts at | 58.13 sec |
| Reading # 998 | 2 706 | 3 235 | 1.686 | 4.118 | Volts at | 58.19 sec |
| Reading # 999 | 2.686 | 3.235 | 1.667 | 4.118 | Volts at | 58.24 sec |
| Reading # 1000 | 2.706 | 3 235 | 1.667 | 4.118 | Volts at | 58.30 sec |

AVG VOLTAGE 2.689 3 234 1.681 4.111

Temperature is 24.71 [C] and Relative Humidity 1 87 [%]

# APPENDIX V

Neural Network Learning and Sample Outputs

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.692256 | 0.829006 | 0.443151 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.682558 | 0.819476 | 0.431993 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.682522 | 0.816568 | 0.430815 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.674033 | 0.808011 | 0.419890 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.667447 | 0.803183 | 0.413059 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.662062 | 0.794475 | 0.410812 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.654099 | 0.786670 | 0.408903 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.647950 | 0.779876 | 0.399503 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.638227 | 0.769152 | 0.396106 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.632831 | 0.748348 | 0.392281 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.629426 | 0.743892 | 0.399122 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.625546 | 0.735234 | 0.407332 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.618290 | 0.718789 | 0.406991 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.625526 | 0.692847 | 0.454067 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |
| 0.642424 | 0.683333 | 0.478409 | 1.000000 | 0.9 | 0.1 | 0.1 | 0.1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.925503 | 0.978076 | 0.807830 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.932307 | 0.980983 | 0.811863 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.936180 | 0.985308 | 0.800505 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.943862 | 0.986956 | 0.820871 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.950012 | 0.989813 | 0.819948 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.957787 | 0.994663 | 0.819020 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.968238 | 0.997519 | 0.830273 | 1.000000 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.966828 | 1.000000 | 0.826742 | 0.995917 | 0.1 | 0.9 | 0.1 | 0.1 |
| 0.983447 | 1.000000 | 0.834472 | 0.991855 | 0.1 | 0.9 | 0.1 | 0.1 |
| 1.000000 | 0.999457 | 0.854856 | 0.986706 | 0.1 | 0.9 | 0.1 | 0.1 |
| 1.000000 | 0.983203 | 0.815789 | 0.966405 | 0.1 | 0.9 | 0.1 | 0.1 |
| 1.000000 | 0.955614 | 0.821294 | 0.935596 | 0.1 | 0.9 | 0.1 | 0.1 |
| 1.000000 | 0.915475 | 0.816967 | 0.898695 | 0.1 | 0.9 | 0.1 | 0.1 |
| 1.000000 | 0.876367 | 0.818363 | 0.870401 | 0.1 | 0.9 | 0.1 | 0.1 |
| 1.000000 | 0.831289 | 0.824601 | 0.850242 | 0.1 | 0.9 | 0.1 | 0.1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1.000000 | 0.884963 | 0.976310 | 0.856254 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.867365 | 0.978432 | 0.841363 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.854281 | 0.979154 | 0.827565 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.840715 | 0.980089 | 0.810037 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.825465 | 0.981606 | 0.794809 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.805881 | 0.981904 | 0.774008 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.783223 | 0.982143 | 0.751246 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.765051 | 0.984686 | 0.729390 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.734651 | 0.985553 | 0.701083 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.701360 | 0.987260 | 0.668970 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.664322 | 0.987690 | 0.636184 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.628127 | 0.988957 | 0.607618 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.572302 | 1.000000 | 0.568070 | 0.1 | 0.1 | 0.9 | 0.1 |
| 1.000000 | 0.538405 | 0.997292 | 0.544313 | 0.1 | 0.1 | 0.9 | 0.1 |
| 0.997103 | 0.489860 | 1.000000 | 0.520147 | 0.1 | 0.1 | 0.9 | 0.1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.875895 | 0.917193 | 0.771808 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.877018 | 0.916737 | 0.772090 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.874303 | 0.916988 | 0.762548 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.875379 | 0.918075 | 0.757911 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.873767 | 0.920009 | 0.750822 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.872194 | 0.919538 | 0.752167 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.873587 | 0.917006 | 0.747626 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.875376 | 0.915838 | 0.752370 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.873166 | 0.910317 | 0.747042 | 1.000000 | 0.1 | 0.1 | 0.1 | 0 9 |
| 0.875488 | 0.909424 | 0.739746 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.876556 | 0.901956 | 0.738633 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.876066 | 0.891525 | 0.727345 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.874964 | 0.874964 | 0.735811 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.868946 | 0.849003 | 0.718582 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |
| 0.863464 | 0.824404 | 0.719668 | 1.000000 | 0.1 | 0.1 | 0.1 | 0.9 |

60 4 4 0.900000 0.700000 1 4000
4 3 4
4000 0.001741

| | | | |
|---|---|---|---|
| 0.895410 | 0.097833 | 0.000011 | 0.106861 |
| 0.897883 | 0.097952 | 0.000010 | 0.104215 |
| 0.898058 | 0.097961 | 0.000010 | 0.104028 |
| 0.899513 | 0.098033 | 0.000010 | 0.102474 |
| 0.900188 | 0.098066 | 0.000010 | 0.101753 |
| 0.900489 | 0.098082 | 0.000010 | 0.101431 |
| 0.900780 | 0.098096 | 0.000010 | 0.101121 |
| 0.901227 | 0.098119 | 0.000009 | 0.100644 |
| 0.901462 | 0.098131 | 0.000009 | 0.100392 |
| 0.901640 | 0.098140 | 0.000009 | 0.100203 |
| 0.901551 | 0.098135 | 0.000009 | 0.100297 |
| 0.901436 | 0.098129 | 0.000009 | 0.100420 |
| 0.901560 | 0.098136 | 0.000009 | 0.100288 |
| 0.899700 | 0.098042 | 0.000010 | 0.102274 |
| 0.896388 | 0.097880 | 0.000011 | 0.105814 |

| | | | |
|---|---|---|---|
| 0.100048 | 0.863157 | 0.094124 | 0.143289 |
| 0.100070 | 0.880206 | 0.093895 | 0.125728 |
| 0.100086 | 0.881243 | 0.093724 | 0.124804 |
| 0.100092 | 0.897725 | 0.093688 | 0.107568 |
| 0.100098 | 0.901301 | 0.093588 | 0.103909 |
| 0.100104 | 0.904962 | 0.093479 | 0.100164 |
| 0.100103 | 0.908442 | 0.093577 | 0.096411 |
| 0.100105 | 0.908901 | 0.093527 | 0.095975 |
| 0.100102 | 0.910629 | 0.093688 | 0.094005 |
| 0.100098 | 0.910804 | 0.094515 | 0.093014 |
| 0.100103 | 0.911214 | 0.093654 | 0.093423 |
| 0.100099 | 0.910243 | 0.094911 | 0.093204 |
| 0.100096 | 0.907115 | 0.098072 | 0.093341 |
| 0.100093 | 0.898117 | 0.107094 | 0.093744 |
| 0.100086 | 0.867457 | 0.137200 | 0.095179 |

| | | | |
|---|---|---|---|
| 0.100043 | 0.129648 | 0.869065 | 0.100682 |
| 0.100041 | 0.113870 | 0.884691 | 0.100977 |
| 0.100040 | 0.106594 | 0 891913 | 0.101124 |
| 0.100039 | 0.101254 | 0.897221 | 0.101236 |
| 0.100039 | 0.098094 | 0.900364 | 0.101306 |
| 0.100038 | 0.095910 | 0.902537 | 0.101355 |
| 0.100038 | 0.094640 | 0.903802 | 0.101384 |
| 0.100038 | 0.093989 | 0.904451 | 0.101397 |
| 0.100038 | 0.093606 | 0.904833 | 0.101406 |
| 0.100038 | 0.093435 | 0.905004 | 0.101410 |
| 0.100038 | 0.093373 | 0.905065 | 0.101411 |
| 0.100038 | 0.093351 | 0.905087 | 0.101413 |
| 0.100038 | 0.093339 | 0.905097 | 0.101415 |
| 0.100038 | 0.093334 | 0.905099 | 0.101419 |
| 0.100038 | 0.093319 | 0.905100 | 0 101434 |

| | | | |
|---|---|---|---|
| 0.099515 | 0.120078 | 0.100779 | 0.880484 |
| 0.099511 | 0.121202 | 0.100776 | 0.879383 |
| 0.099602 | 0 110527 | 0.100682 | 0.889826 |
| 0.099651 | 0.109644 | 0 100568 | 0 890665 |
| 0.099756 | 0.105683 | 0 100380 | 0.894479 |
| 0.099744 | 0.104700 | 0 100424 | 0 895453 |
| 0.099808 | 0.101321 | 0 100333 | 0 898727 |
| 0.099723 | 0.104117 | 0.100484 | 0.896045 |
| 0.099825 | 0.096329 | 0.100386 | 0.903625 |
| 0.099948 | 0.094526 | 0.100135 | 0.905304 |
| 0.099973 | 0.091260 | 0.100143 | 0.908502 |
| 0.100307 | 0.086019 | 0.099518 | 0.913404 |
| 0.100124 | 0.083888 | 0.099980 | 0 915646 |
| 0.100986 | 0.080913 | 0.098207 | 0 917897 |
| 0.101221 | 0.080320 | 0.097758 | 0.918276 |

Enter file name for patterns to be processed: sample.dat

Enter number of patterns for processing: 16

sample 0 output 0 = 0.892761
sample 0 output 1 = 0.097707
sample 0 output 2 = 0.000012
sample 0 output 3 = 0.109696

sample 1 output 0 = 0.897439
sample 1 output 1 = 0.097931
sample 1 output 2 = 0.000010
sample 1 output 3 = 0.104690

sample 2 output 0 = 0.899991
sample 2 output 1 = 0.098057
sample 2 output 2 = 0.000010
sample 2 output 3 = 0.101963

sample 3 output 0 = 0.899898
sample 3 output 1 = 0.098052
sample 3 output 2 = 0.000010
sample 3 output 3 = 0.102062

sample 4 output 0 = 0.100093
sample 4 output 1 = 0.904932
sample 4 output 2 = 0.100010
sample 4 output 3 = 0.093688

sample 5 output 0 = 0.100092
sample 5 output 1 = 0.901128
sample 5 output 2 = 0.104453
sample 5 output 3 = 0.093278

sample 6 output 0 = 0.100089
sample 6 output 1 = 0.877610
sample 6 output 2 = 0.129171
sample 6 output 3 = 0.093292

sample 7 output 0 = 0.100068
sample 7 output 1 = 0.553173
sample 7 output 2 = 0.453855
sample 7 output 3 = 0.096596

sample 8 output 0 = 0.100041
sample 8 output 1 = 0.111983
sample 8 output 2 = 0.886569
sample 8 output 3 = 0.101009

sample 9 output 0 = 0.100039
sample 9 output 1 = 0.098785
sample 9 output 2 = 0.899680
sample 9 output 3 = 0.101286

sample 10 output 0 = 0.100038
sample 10 output 1 = 0.093873
sample 10 output 2 = 0.904570
sample 10 output 3 = 0.101397

sample 11 output 0 = 0.100038
sample 11 output 1 = 0.093347
sample 11 output 2 = 0.905092
sample 11 output 3 = 0.101411

sample 12 output 0 = 0.099837
sample 12 output 1 = 0.118562
sample 12 output 2 = 0 099990
sample 12 output 3 = 0 881741

sample 13 output 0 = 0.099980
sample 13 output 1 = 0.116881
sample 13 output 2 = 0.099689
sample 13 output 3 = 0.883254

sample 14 output 0 = 0.100034
sample 14 output 1 = 0.116303
sample 14 output 2 = 0.099576
sample 14 output 3 = 0.883770

sample 15 output 0 = 0.099657
sample 15 output 1 = 0.111790
sample 15 output 2 = 0.100502
sample 15 output 3 = 0.888571

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