Palestine Polytechnic University

College of engineering & technology
Computer & electrical engineering department

Graduation project

Electrical Sleep Inducer

Prepared by:
Alla` A. Shabaneh

Project supervisor
Dr. Ramzi Al-Qawasmi

Hebron – Palestine

June – 2011

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This report is submitted in partial fulfillment of the requirements for the degree of B.Sc. in biomedical engineering

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Dr. Ramzi Al-Qawasmi

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June – 2011

جامعة بوليتكنك فلسطين

الخليل – فلسطين

كلية الهندسة والتكنولوجيا

دائرة الهندسة الكهربائية والحاسوب

اسم المشروع

محفز النوم الكهربائي (جهاز النوم)

الطالبة
آلاء عبد العزيز شبانة

بناء على نظام كلية الهندسة والتكنولوجيا وإشراف ومتابعة المشرف المباشر وموافقة أعضاء اللجنة الممتحنة تم تقديم هذا المشروع إلى دائرة الهندسة الكهربائية والحاسوب وذلك استكمالا لمتطلبات درجة البكالوريوس في الهندسة تخصص الاجهزة الطبية.

توقيع المشرف
د. رمزي القواسمي

...

توقيع اللجنة الممتحنة

....

توقيع رئيس الدائرة
د. رمزي القواسمي

..

الإهداء

إليك جدتي الحبيبة..

التي عانت ولفترة طويلة من الأرق .. ومعاناتها هي التي دفعتني إلى اختيار هذا الموضوع دون سواه ليكون مشروعي للتخرج.. علّني استطيع مساعدتها ومساعدة غيرها على التغلب على هذا المرض

إليك والدي الحبيب..

لن يضيع غراسك الذي غرسته في نفسي وسأظل دوماً ابنتك التي تفخر بها ولن أخيب ظنك بإذن الله

إليك أمي..

يا من للجنة دروبا أنت خطاها.. وللنار حجابا أنت ستائره .. وإن للنجاح سلما رضاك درجاته وللغضب أودية غضبك دلالاته.. فمنّي علي بخطا الجنة .. وأكرميني بستائر النار وتفضلي عليّ بدرجات النجاح والتوفيق على الرغم من تقصيري.

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First all prais is to allah who gave me the ability to complete this project with a satisfing degree of perfection

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Thanks to palestine polytechnic university & every body shared to success my project.

Abstract

Sleeping difficulty, called insomnia, can involve difficulty falling asleep when you first go to bed at night, waking up too early in the morning, and waking up often during the night.

The lack of restful sleep can affect your ability to carry out daily responsibilities because you are too tired or have trouble concentrating. All types of insomnia can lead to daytime drowsiness, poor concentration, tension and nervousness and the inability to feel refreshed and rested in the morning.

Many people experience sleeping well in natural surroundings, into a tent or a wooden hut. This fact is due not only to the healthy atmosphere but also from our unconscious ability to perceive natural Earth’s magnetic fields.

Magnetic field associated with the Earth is called Geo-magnetic fields. It is essentially dipolar (i.e., it has two poles, the northern and southern magnetic poles) on the Earth's surface. Away from the surface, the field becomes distorted.

My project generates this type of Geo-magnetic-fields and the basic aim is to perceive them: in this manner our brain is surrounded by an ideal environment for a sound sleep. And it is also helpful

The goal of this project is to implement a device that generates magnetic fields that is similar to Geo-magnetic fields using preset durations depending on the patient's case.

الملخص

صعوبة الخلود الى النوم او هروب النوم يدعى الأرق ،الذي ينطوي على استعصاء النوم عند الذهاب الى الفراش وتقطعه وانخفاض جودته وبالتالي صعوبة الاستيقاظ صباحاً.

عدم التمتع بنوم مريح يؤثر سلباً على النشاطات اليومية بسبب التعب وصعوبة التركيز. جميع أنواع الأرق تؤدي الى الإغفاء و النعاس بالنهار وقلة التركيز وعدم الشعور بالنشاط خلال النهار والشعور بالتوتر والعصبية مما يؤثر على الشخص في عمله ومجريات سير يومه

العديد من الناس تتمتع بنوم جيد في الطبيعة. وهذة الحقيقة ليست نتيجة فقط للجو الصحي وإنما لزيادة القدرة على استقبال الحقول المغناطيسية الطبيعية المنبعثة من الأرض والتأثر بها.وهذة المجالات المغناطيسية يكون تأثيرها اقوى كلما اقتربنا من الارض.

في هذا المشروع يقوم الجهاز بتوليد هذه المجالات المغناطيسية وبذلك يحيط الدماغ بالجو المثالي للنوم (صوت النوم)، ولا يفيد فقط بالمساعدة على النوم بل ويساعد ايضا في تهدئة الأعصاب.

والهدف من هذا المشروع تطبيق جهاز يمكنه توليد مجالات مغناطيسية مشابهه للمجالات المغناطيسية الأرضية ولفترات زمنية مختلفة حسب حالة المريض وحاجته.

Glossary

CES
Cranial electrotherapy stimulation

Thalamus
The area of the brain that relays sensory information to the cerebral cortex.

Sleep paralysis
The temporary inability to talk or move when falling asleep or waking up. It occurs normally during REM sleep.

Sleep hygiene
The collection of behaviors and environmental conditions that influence the length and quality of sleep

Pons
The brainstem region critical for initiating REM sleep

Electroencephalogram (EEG)
A measurement of the electrical activity associated with brain activity.

Electromyograms (EMG)
A measurement of the electrical activity associated with muscle movements.

Electrooculogram (EOG)
A measurement of the electrical activity associated with eye movements.

Cerebral cortex
The brain's outer layer of gray tissue that is responsible for higher nervous function.

Hypnogram
A graphical summary of the electrical activities occurring during a night's sleep

Insomnia
Sleeplessness; chronic difficulty with sleep onset or maintenance of sleep, or a perception of nonrefreshing sleep.

Sleep hygiene
The collection of behaviors and environmental conditions that influence the length and quality of sleep.

The scalp
The anatomical area bordered by the face interiorly and the neck to the sides and posterior.

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<u>CHAPTER 1</u>

Introduction

1.1 Overview

1.2 Project Objectives

1.3 Literature Review

1.4 The Importance of the Project

1.5 Time plan

1.6 Project cost

1.7 Project contents

1.1.Overview

This project is aimed to design and build a simple device which generates magnetic field similar to geo-magnetic field, the device consists of oscillator to generate square wave signal to drive counter and timer, a radiator coil to generate electromagnetic field and timer to set desired time duration.

The objectives can be summarized as follow:

1- design and build a system which generates geo-magnetic field
2- use different time durations
3- select between two modes

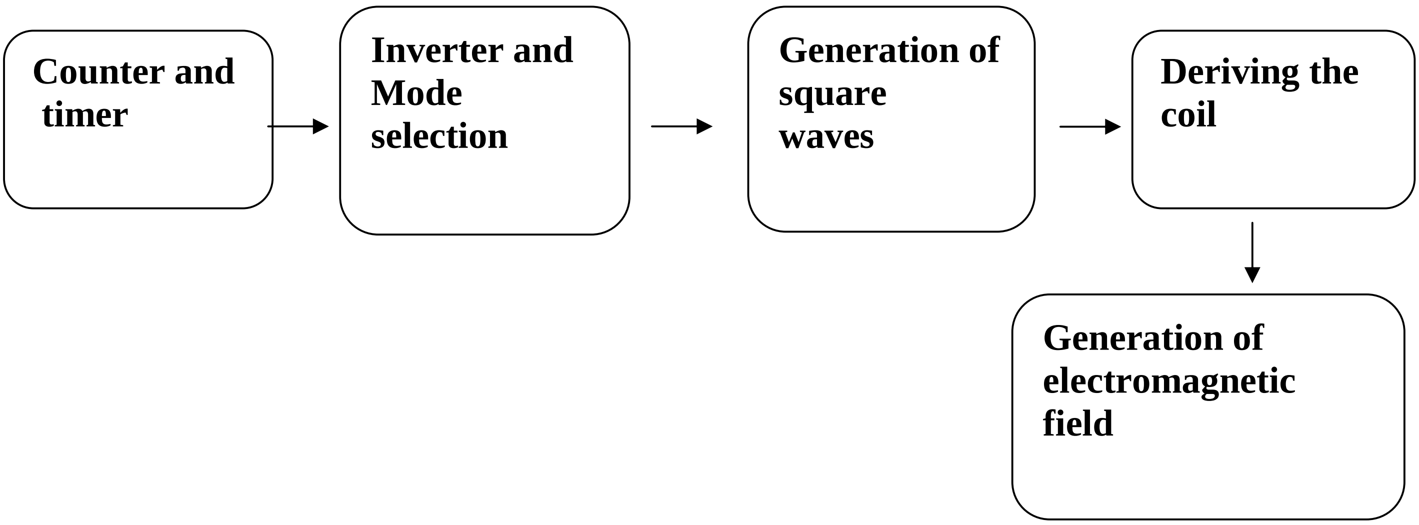


Fig1.1: General Geomagnetic generator block diagram

1.2.project objectives

The main objectives are:

1. to Generate a natural electromagnetic-field
2. Induces a prolonged and sound sleep without drugs
3. to study the physiology of sleep and brain waves (EEG)
4. design and implement a device for generating the desired field with several durations and two modes of operation
5. helping the chronic insomnia patients to enhance their sleeping habits

1.3.literature review

Insomnia is a disorder that can make it hard to fall asleep, hard to stay asleep, or both. With insomnia, you usually awaken feeling unrefreshed, which takes a toll on your ability to function during the day. Insomnia can sap not only your energy level and mood but also your health, work performance and quality of life.

How much sleep is enough varies from person to person. Most adults need seven to eight hours a night. Many adults experience insomnia at some point, but some people have long-term (chronic) insomnia.

a) During the first half of the twentieth century many different methods were used in clinical settings to put patients to sleep Drs. Leduc and Rouxeau of France were the first to experiment with low intensity electrical stimulation of the brain in 1902.

   Initially, this method was called electro sleep as brain stimulation was considered a sleep inducer. There were other names such as transcranial electrotherapy (TCET) and neuroelectric therapy (NET), but research on CES began in the Soviet Union during the 1950s and was introduced in the US about a decade later (Iwanovsky & Dodge, 1968).

b) Electroconvulsive therapy (ECT) for depression, lake of sleep (insomnia) and psychosis was introduced in 1933 by Cerletti and Bibi (1938). ECT typically involved the application of 120 volts with 500 milliamperes at 60 Hz for 0.2 seconds. ECT caused convulsions and a loss of consciousness rather than sleep, for a limited time. Subsequently, the electrical current was reduced to around 30 milliamperes, using 2 volts at 700 Hz. This less intense form of transcranial stimulation was called electroanaesthesia (National Research Council, 1974). Patients remained asleep as long as the current was on, but tended to wake up immediately when the current was turned off

c) Nerve Excitation Models: The introduction of nerve excitation models has widened our understanding of the mechanisms of nerve excitation elicited by magnetic stimulation [Basser and Roth, 1991; Esselle and Stuchly, 1992; Nagarajan and Durand, 1993; Hyodo and Ueno, 1996]. The theoretical nerve excitation models have shown that for neuronal excitation, a negative peak of the spatial gradient of induced electric fields, the activating function, contributes to the depolarization of the membrane. The site of neuronal excitation corresponds to the site of the maximal value of the activating function.

1.4.The importance of the project:

This device helps fighting insomnia. Apart from this it is support relaxation, stress management and induce sleep easily.

- Generates a natural electromagnetic-field
- Simple to use and safe
- Non invasive method
- Make it easier to fall asleep
- Induces a prolonged and sound sleep without drugs
- No side effects

1.5.Time plan

Table 1.1: project time

Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**6**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Give ideas																
Data collection																
Making circuit																
Analysis																
Writing																
Presentation																

1.6. Project Cost:

Table 1.2: project cost

Item	**# of Pisces**	**Price (NIS)**
4060 ripple counter and oscillator	1	8
4093 quad 2 input Schmitt NAND gate	1	7
Diodes (IN4148)	4	2
Switches	4	16
Push button	1	3
Battery PP3 9V	1	9
Resistors (different values)	9	3
PNP transistor (BC327)	1	3
Radiator coil	1	5
Capacitor 47µF	2	2
Capacitor 100nF	1	1
Capacitor 330nF	2	3
Capacitor 15nF	2	3
TOTAL		64

1.7.Project content

Chapter one: Introduction

Chapter two: physiological background

Chapter three: project circuit

Chapter four: conclusions and future work

CHAPTER 2

Physiological Background

2.1 Introduction

There is nothing quite as great as being able to sleep soundly all night long. After a sound sleep the world just seems a little brighter because the importance of a sound sleep to health is the repair of cells in the body as well as forming memories. A sound sleep is often referred to as 'getting your beauty sleep' which is technically true.

Deep sleep literally regulates the body health in adults, the Human Growth Hormone balance, and the skin which is actually the largest organ of the body and also growth in children. Proper sleep patterns are also important for maintaining the immune system of the body and for improving the powers of concentration.

Going without proper sleep happens for a number of reasons. It can be related to overall health levels, stress, anxiety, noise or irregular lifestyle patterns. Whatever the reason there are a number of ways to try to correct sleep patterns including massage therapy and prescription drugs. These may or may not be effective or even safe curatives but the electrical Sleep Inducer offers a health aid that is safe, easy to use and effective in regulating sleep patterns...

2.2 Sleep

Sleep is essential to survival. When we sleep our bodies are restored and healed, memories are built and damaged cells are repaired. Healthy sleeping habits can also improve hormone and immune system functions.

Sleep deprivation can lead to hypertension, emotional and physical stress, depression and obesity, not to mention inability to concentrate and poor performance on work tasks. While there are a number of treatments to regulate sleep, such as massage therapies and sleeping pills, the electrical Sleep Inducer can help you to fall asleep without having to take drugs or drive to see a massage therapist.

Sleep is often thought to help conserve energy, but actually decreases metabolism only about 5–10%, Sleep is generally divided into 2 broad types: nonrapid eye movement (NREM) sleep and REM sleep. Based on EEG changes, NREM is divided further into 4 stages (stage I, stage II, stage III, stage IV).

Very few textbooks for high school students provide any scientific information about changes that occur in the body during sleep and how those changes affect our ability to move and think. Of course, we've heard that a good night's sleep will help us perform better on a test the next day, but is this based on scientific fact, or is it just a continuing myth? The lack of information in textbooks may be due to the fact that sleep research is only recently gaining recognition. A great deal remains to be learned through scientific studies, including an answer to the key question, What is the function of sleep? Although its function remains unclear, research is providing a great deal of information about what happens in the brain and body during sleep and how the body regulates sleep.

The purposes and mechanisms of sleep are only partially clear and are the subject of intense research.

2.2.1 Sleep is a dynamic process

Sleep is not a passive event, but rather an active process involving characteristic physiological changes in the organs of the body. Scientists study sleep by measuring the electrical changes in the brain using **electroencephalograms (EEGs)**. Typically, electrodes are placed on the scalp in a symmetrical pattern. The electrodes measure very small voltages that scientists think are caused by synchronized activity in very large numbers of synapses (nerve connections) in the brain's outer layers (cerebral cortex). EEG data are represented by curves that are classified according to their frequencies. The wavy lines of the EEG are called brain waves.

An **electrooculogram (EOG)** uses electrodes on the skin near the eye to measure changes in voltage as the eye rotates in its socket. Scientists also measure the electrical activity associated with active muscles by using **electromyograms (EMGs)**. In this technique, electrodes are placed on the skin overlaying a muscle. In humans, the electrodes are placed under the chin because muscles in this area demonstrate very dramatic changes during the various stages of sleep.

In practice, EEGs, EOGs, and EMGs are recorded simultaneously on continuously moving chart paper or digitized by a computer and displayed on a high-resolution monitor. This allows the relationships among the three measurements to be seen immediately. The patterns of activity in these three systems provide the basis for classifying the different types of sleep.

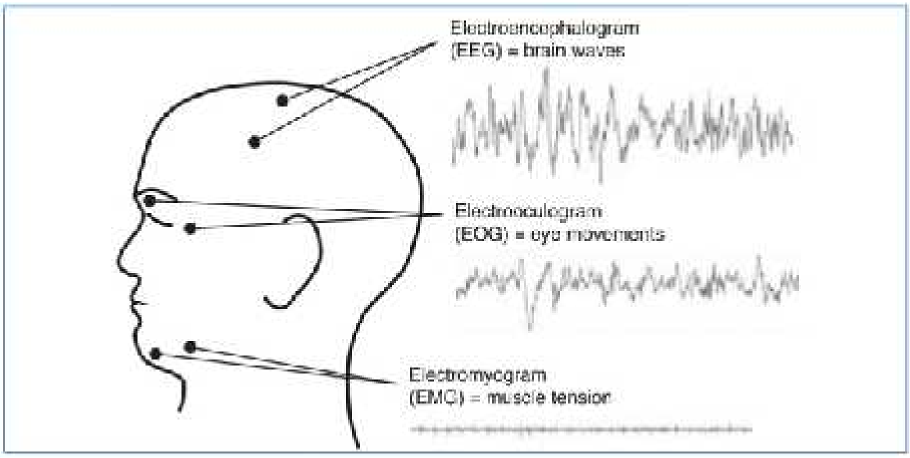


Fig2.1: Placement of electrodes to determine EEG, EOG, and EMG.

Studying these events has led to the identification of two basic stages, or states, of sleep: non rapid eye movement (NREM) and rapid eye movement (REM).

Sleep is a highly organized sequence of events that follows a regular, cyclic program each night. Thus, the EEG, EMG, and EOG patterns change in predictable ways several times during a single sleep period. NREM sleep is divided into four stages according to the amplitude and frequency of brain wave activity.

I - NREM sleep: 4 stages (stage I, stage II, stage III, stage IV)

- Stage I: sleep is also referred to as drowsiness or presleep and is the first or earliest stage of sleep. And usually consists of a combination of drop out of alpha activity and slow rolling eye movements.

  The importance of normal sleep patterns is that they should not be mistaken for pathologic sharp waves. Several normal stage I patterns easily can be mistaken for epileptic sharp waves or spikes, including vertex sharp transients, POSTS, and even fragments of alpha rhythm as it drops out.

- Stage II: is the predominant sleep stage during a normal night's sleep. The distinct and principal EEG criterion to establish stage II sleep is the appearance of sleep spindles or K complexes. The presence of sleep spindles is necessary and sufficient to define stage II sleep. Another characteristic finding of stage II sleep is the appearance of K complexes, but since K complexes are typically associated with a spindle, spindles are the defining features of stage II sleep. Except for slow rolling eye movements, all patterns described under stage I persist in stage II sleep.

  The stigmata of stage II sleep, spindles and K complexes, are usually easy to identify and are less subject to over interpretation or misinterpretation than the patterns of stage I sleep.

- Stages III and IV of sleep are usually grouped together as "slow wave sleep" or "delta sleep." Slow wave sleep (SWS) is usually not seen during routine EEG, which is too brief a recording. However, it is seen during prolonged (>24 h) EEG monitoring.

II - REM sleep:

Rapid eye movement sleep, or REM sleep, accounts for 20–25% of total sleep time in most human adults. The criteria for REM sleep include rapid eye movements as well as a rapid low-voltage EEG. Most memorable dreaming occurs in this stage. At least in mammals, a descending muscular atonia is seen.

The duration of REM sleep increases progressively with each cycle and tends to predominate late in the sleep period into early morning. The occurrence of REM too soon after sleep onset, referred to as SOREMP, is considered pathological.

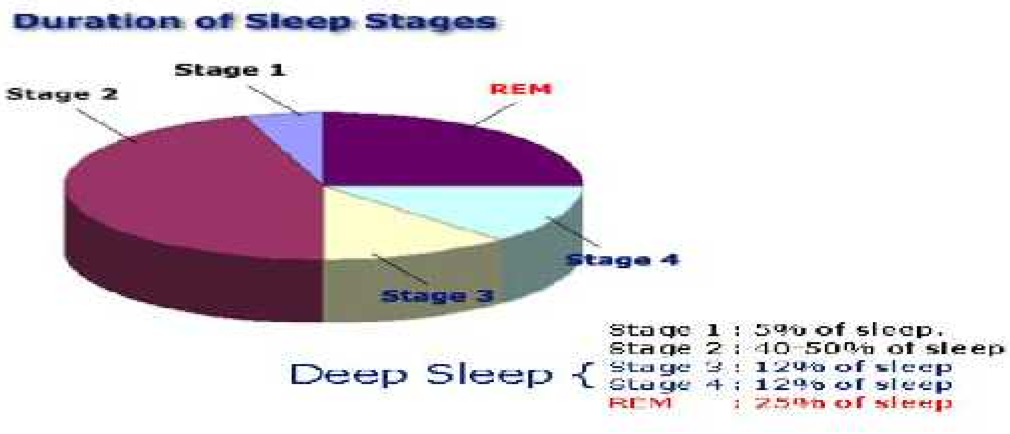


Fig2.2: Duration of sleep stages

In general, the EEG pattern of NREM sleep is slower, often more regular, and usually of higher voltage than that of wakefulness. As sleep gets deeper, the brain waves get slower and have greater amplitude. NREM Stage 1 is very light sleep; NREM Stage 2 has special brain waves called sleep spindles and K complexes; NREM Stages 3 and 4 show increasingly more high-voltage slow waves. In NREM Stage 4, it is extremely hard to be awakened by external stimuli. The muscle activity of NREM sleep is low, but the muscles retain their ability to function. Eye movements normally do not occur during NREM sleep, except for very slow eye movements, usually at the beginning. The body's general physiology during these stages is fairly similar to the wake state.

Sleep is a cyclical process. During sleep, people experience repeated cycles of NREM and REM sleep, beginning with an NREM phase. This cycle lasts approximately 90 to 110 minutes and is repeated four to six times per night. As the night progresses, however, the amount of deep NREM sleep decreases and the amount of REM sleep increase.

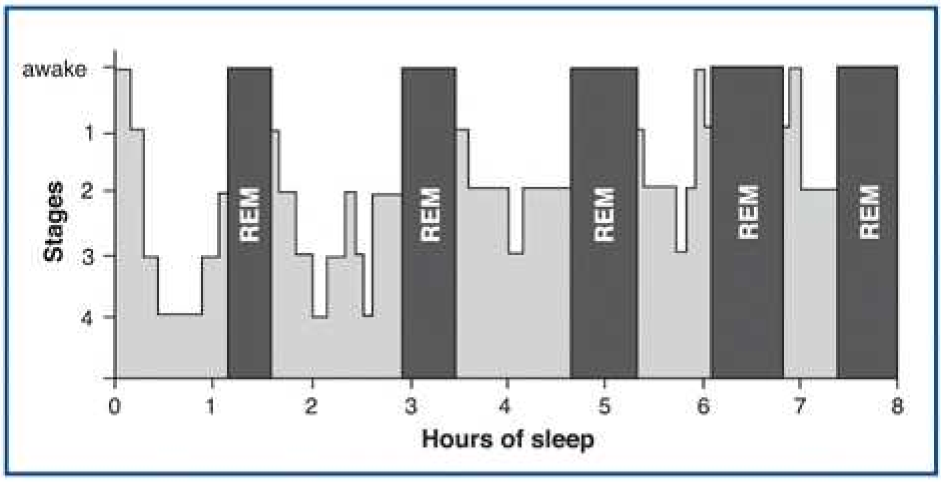


Fig2.3: A typical hypnogram from a young, healthy adult.

The chart in Fig2.3 is called a **hypnogram**. Hypnograms were developed to summarize the voluminous chart recordings of electrical activities (EEG, EOG, and EMG) collected during a night's sleep. Hypnograms provide a simple way to display information originally collected on many feet of chart paper or stored as a large file on a computer.

We can make several observations about the hypnogram in Fig2.3. First, the periods of NREM and REM sleep alternate during the night. Second, the deepest stages of NREM sleep occur in the first part of the night. Third, the episodes of REM sleep are longer as the night progresses. This hypnogram also indicates two periods during the night when the individual awakened (at about six and seven hours into the night).

It is useful to distinguish between sleep and the state induced during general anesthesia or seen in people who are in a coma.

2.2.2 Physiological changes during sleep

Table2 summarizes some basic physiological changes that occur in NREM and REM sleep.

Table 2.1: Comparison of Physiological Changes during NREM and REM sleep [7]

Physiological Process	During NREM	During REM
brain activity	decreases from wakefulness	increases in motor and sensory areas, while other areas are similar to NREM
heart rate	slows from wakefulness	increases and varies compared with NREM
blood pressure	decreases from wakefulness	increases (up to 30 percent) and varies from NREM
blood flow to brain	does not change from wakefulness in most regions	increases by 50 to 200 percent from NREM, depending on brain region
respiration	decreases from wakefulness	increases and varies from NREM, but may show brief stoppages (apnea); coughing suppressed
airway resistance	increases from wakefulness	increases and varies from wakefulness
body temperature	is regulated at lower set point than wakefulness; shivering initiated at lower temperature than during wakefulness	is not regulated; no shivering or sweating; temperature drifts toward that of the local environment

sexual arousal	occurs infrequently	increases from NREM (in both males and females)

2.2.3 Sleep and the brain

Sleep is actively generated in specific brain regions. These sites have been identified through studies involving electrical stimulation, damage to specific brain regions, or other techniques that identify sleep-inducing sites. The basal forebrain, including the hypothalamus, is an important region for controlling NREM sleep and may be the region keeping track of how long we have been awake and how large our sleep debt is.

The brainstem region known as the pons is critical for initiating REM sleep. As depicted in Fig2.4, during REM sleep, the pons sends signals to the visual nuclei of the thalamus and to the cerebral cortex (this region is responsible for most of our thought processes). The pons also sends signals to the spinal cord, causing the temporary paralysis that is characteristic of REM sleep. Other brain sites are also important in the sleep process. For example, the thalamus generates many of the brain rhythms in NREM sleep that we see as EEG patterns.

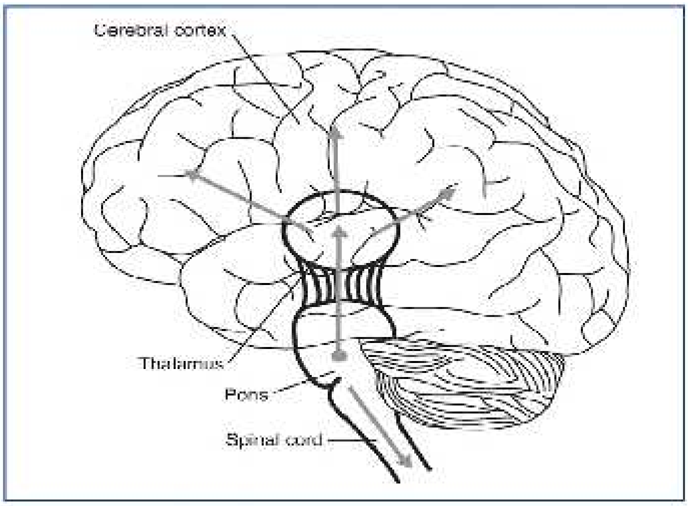


Fig2.4: Pathways of brain activity during REM sleep

2.2.4 Sleep Patterns:

Sleep patterns change during an individual's life. In fact, age affects sleep more than any other natural factor. One of the most prominent age-related changes in sleep is a reduction in the time spent in the deepest stages of NREM (Stages 3 and 4) from childhood through adulthood.

In fact, this change is prominent during adolescence, when about 40 percent of this activity is lost and replaced by Stage 2 NREM sleep. In addition to these changes, the percentage of time spent in REM sleep also changes during development.

Although most humans maintain REM sleep throughout life, brain disorders like Alzheimer's and Parkinson's are characterized by decreasing amounts of REM sleep as the diseases progress. Also, elderly individuals exhibit more variation in the duration and quality of sleep than do younger adults. Elderly people may also exhibit increased sleep fragmentation (arousals from sleep that occur as either short or more extended awakenings).

The following table provides on average the amount of sleep a person needs according to their age.

Table2.2: Sleep Chart by Age [3]

Age	Total Sleep Needed	Additional Notes
1-4 Weeks	15-16 Hours	Newborns are developing their internal biological clocks
1-4 Months	14-15 Hours	Regular sleeping patterns begin and longer night sleeping
4-12 Months	14-15 Hours	Important to establish regular sleeping patterns at this time
1-3 Years	12-14 Hours	Naps remain important to sleep health
3-6 Years	10-12 Hours	Naps will become shorter
7-12 Years	10-11 Hours	Bedtime gets later
12-18 Years	8-9 Hours	Teens may need more sleep
Adults	7-8 Hours	Times will greatly vary
Pregnant	8+	More sleep and naps may be needed

2.2.5 Sleep Disorders:

Problems with sleep can be due to lifestyle choices and can result in problem sleepiness, which is, feeling sleepy at inappropriate times. Environmental noise, temperature changes, changes in sleeping surroundings, and other factors may affect our ability to get sufficient restful sleep. Short-term problem sleepiness may be corrected by getting additional sleep to overcome the sleep deficit. In other cases, problem sleepiness may indicate a sleep disorder requiring medical intervention.

Insomnia, the most prevalent sleep disorder, it is characterized by an inability to fall asleep and/or by waking up during the night and having difficulty going back to sleep

2.2.6 Insomnia:

Insomnia is a sleep disorder that is characterized by difficulty falling and/or staying asleep. People with insomnia have one or more of the following symptoms:

- Difficulty falling asleep
- Waking up often during the night and having trouble going back to sleep
- Waking up too early in the morning
- Feeling tired upon waking

There are two types of insomnia:

1- Primary insomnia.
2- Secondary insomnia.

- **Primary insomnia**:

Means that a person is having sleep problems that are not directly associated with any other health condition or problem.

- **Secondary insomnia*:***

Means that a person is having sleep problems because of something else, such as a health condition; pain; medication they are taking; or a substance they are using (like alcohol).

Insomnia also varies in how long it lasts and how often it occurs. It can be short-term (acute insomnia) or can last a long time (chronic insomnia). It can also come and go, with periods of time when a person has no sleep problems. Acute insomnia can last from one night to a few weeks. Insomnia is called chronic when a person has insomnia at least three nights a week for a month or longer.

According to that insomnia classified as:

1. **Transient insomnia** lasts for less than a week. It can be caused by another disorder, by changes in the sleep environment, by the timing of sleep, severe depression, or by stress.

2. **Acute insomnia** is the inability to consistently sleep well for a period of less than a month.

3. **Chronic insomnia** lasts for longer than a month. It can be caused by another disorder, or it can be a primary disorder. Its effects can vary according to its causes. They might include muscular fatigue, hallucinations, and/or mental fatigue. Some people that live with this disorder see things as if they are happening in slow motion, wherein moving objects seem to blend together. Can cause double vision.

Causes of Insomnia:

- Significant life stress
- Illness.
- Emotional or physical discomfort.

- Environmental factors like noise, light, or extreme temperatures (hot or cold) that interfere with sleep.
- Some medications (for example those used to treat colds, allergies, depression, and asthma) may interfere with sleep.

Causes of chronic insomnia include:

- Depression and/or anxiety
- Chronic stress.
- Pain or discomfort at night.

Symptoms of Insomnia:

- Sleepiness during the day.
- General tiredness.
- Irritability.
- Problems with concentration or memory.

Treatment for Insomnia:

- Often can be prevented or cured by practicing good sleep habits.
- can use sleeping pills for a limited time (If the insomnia makes it hard to function during the day because sleepy and tired)
- Short-acting drugs can help avoid effects such as drowsiness the following day.
- Avoid using over-the-counter sleeping pills for insomnia since they may have undesired side effects and tend to lose their effectiveness over time.
- Try to go to sleep at the same time each night and get up at the same time each morning.
- Try not to take naps during the day because naps may make you less sleepy at night.
- Avoid caffeine, nicotine, and alcohol late in the day.

- Get regular exercise.
- Don't eat a heavy meal late in the day.
- Make your bedroom comfortable , (quiet, no light , no sound ,)
- Follow a routine to help you relax before sleep. Read a book, listen to music, or take a bath.

2. 3 EEG (Electroencephalograph):

Electroencephalography (EEG): s the recording of electrical activity along the scalp. EEG measures voltage fluctuations resulting from ionic current flows within the neurons of the brain.

2.3.1 Different types of normal brain waves:

EEG wave groups:

1. BETA. The electrical activity of the brain is varying within the range of 14 – 26 times per second (or Hz). A different name has been given to frequencies above 26 Hz but it is more usual to refer to these as fast beta waves. Beta is the usual waking rhythm of the brain associated with active thinking, active attention, focus on the outside world or solving concrete problems.

2. ALPHA. The rate of change lies between 8 and 13 Hz. Alpha waves have been thought to indicate both a relaxed awareness and also inattention. A receptive mind.

Alpha is the most prominent rhythm in the whole realm of brain activity and possibly covers a greater range than has been previously accepted. You can regularly see a peak in the beta range as high as 20 Hz, which has the characteristics of an alpha state rather than a beta, and the setting in which such a response appears also leads to the same conclusion. Again, we very often see a response at 75 Hz which appears in an ‘alpha’ setting. Most subjects produce some alpha with the eyes closed and this is why it has been claimed that it is nothing but a waiting or scanning pattern produced by the visual centers of the brain. It is reduced or eliminated by opening the eyes, by hearing unfamiliar sounds, by anxiety or mental concentration. Albert Einstein could solve complex mathematical problems while remaining in the alpha state, though our work suggests that other frequencies, beta and theta would also have been present. Alpha alone seems to indicate an empty mind rather than a relaxed one, a mindless state rather than a passive one, and requires the presence of other frequencies, beta and theta before the usual description of alpha becomes true. Alpha, per se, is not associated with inwardly directed attention, relaxed awareness, or feelings of well being. In my project I'm primarily interested in learning to produce an alpha rhythm (despite the immense amount that has been written about it) rather what I`m interested in experiencing is the particular calm detached state which happens to be accompanied by the alpha rhythm. Training to produce alpha on a biofeedback machine might therefore produce alpha without the sidebands beta and theta and therefore be experienced as a mindless and rather boring state.

3. THETA. Theta waves lie within the range of 4 to 7 Hz. Theta appears as consciousness slips toward drowsiness. Theta has been associated with access to unconscious material, creative inspiration and deep meditation.

Theta is usually accompanied by other frequencies and seems rather to be related to level of arousal. We know that healers and experienced mediators have an alpha which gradually lowers in frequency over long periods of time. The large dominant peak of the 10 to 20 year mediator will almost certainly be found to be around 7 Hz in the so called theta band.

4. DELTA. Delta waves lie within the range of 1/2 to 4 Hz. Delta waves are primarily associated with deep sleep, and in the waking state, were thought to indicate physical defects in the brain.

It is very easy to confuse artifact signals caused by the large muscles of the neck and jaw with the genuine delta response. This is because the muscles are near the surface of the skin and produce large signals whereas the signal which is of interest originates deep in the brain and is severely attenuated in passing through the skull. Nevertheless, with an instant analysis EEG, it is very easy to see when the response is caused by excessive movement.

An EEG records patterns of brain activity. Among the basic waveforms are the alpha, beta, theta, and delta rhythms.

2.3.2 Important Points:

1. Sleep spindles and K complexes occur in stage II of NREM sleep.
2. Sleep spindles are short spindle shaped bursts of alpha waves that occur periodically in NREM sleep.
3. Frequency decreases and amplitude increases as we proceed from alpha to delta, the only exception is beta (highest frequency).

2.3.3 Relation with sleep:

Stage 0 -alpha- close eyes beta-open eyes

stage 1 -alpha +theta

stage 2- theta waves spindles k complexes

stage 3- delta theta and spindle

stage 4-delta

REM sleep-all frequency of waves

2.4Geomagnetic field:

The Earth's magnetic field is generated in the fluid outer core by a self-exciting dynamo process. Electrical currents flowing in the slowly moving molten iron generate the magnetic field. In addition to sources in the Earth's core the magnetic field observable at the Earth's surface has sources in the crust and in the ionosphere and magnetosphere. The geomagnetic field varies on a range of scales and a description of these variations is now made, in the order low frequency to high frequency variations, in both the space and time domains.

Although scientists do not understand all of the details, they know that motions of molten metals in the Earth's core generate our planet's magnetic field. Movement of molten iron and nickel generates electrical and magnetic fields that produce Earth's magnetism. The flows of these molten metals in Earth's outer core are not perfectly steady over time, so Earth's magnetic field changes over time as well.

Earth's magnetic field extends thousands of kilometers (miles) outward into space. The field forms a gigantic magnetic "bubble" in space around Earth. This magnetic bubble is called the magnetosphere. Earth's magnetosphere shields our planet from most particle radiation that flow our way from the Sun and other radiation sources in space. The magnetosphere is not actually a sphere; it is shaped more like a teardrop, with a long "tail" extending away from the Sun.

This geomagnetic field shields us from dangerous gamma rays from the universe and at the same time forms a vital basis of stimulation for important metabolic processes in every cell in our body.

CHAPTER 3

Project Design

3.1 system elements

3.2 Project objectives

3.3 Project circuit

3.3.1 How To Use The Circuit

3.3.2 Operation Of Circuit

3.1 System elements:

- Counter , timer and reset :

To provide different time durations counter is needed, in my project I choose 4060 IC (14 ripple counter and oscillator)

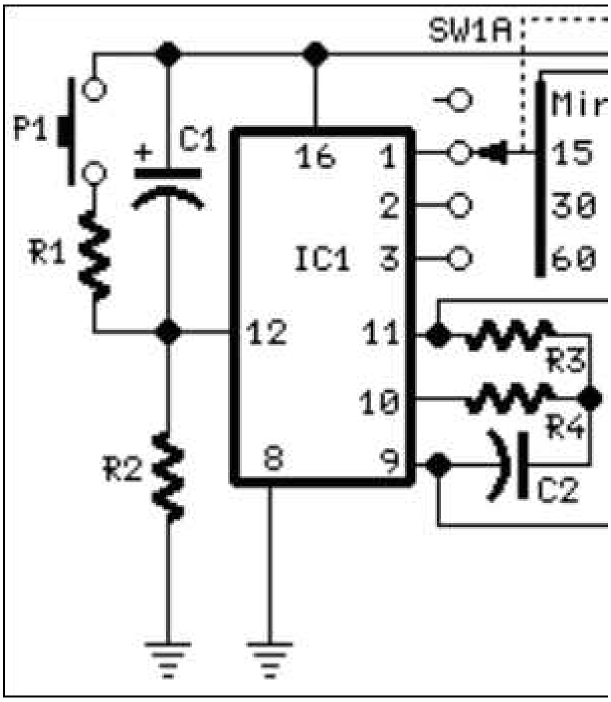


Fig .3.1: counter section

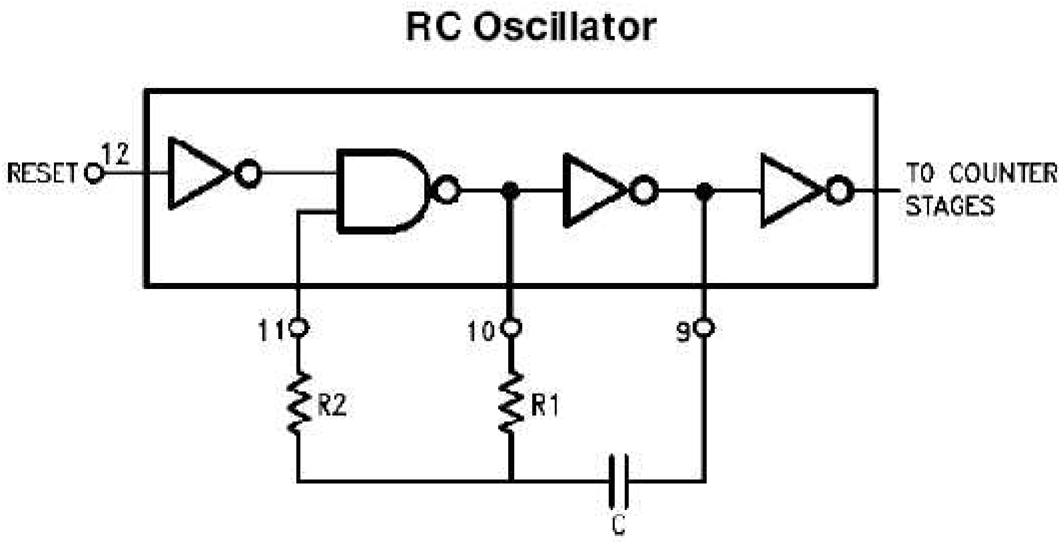


Fig.3.2: oscillator section of 4060 IC

To determine the values of R1 and C, first we determine the smallest desired duration to determine the suitable pin for out put ⟶ Q11

The oscillator's frequency determined according to formula

T= desired period (sec) / (8.5 * 2^a) (a=11)

T = 15*60 /8.5 (2048) = 51.7 * 10^{-3} sec

F= 1 / T

= 1/51.7* 10^{-3} = 19.342222Hz

R3 = 10MΩ, R4 must be << R3, R4= 2.2MΩ

$f_{osc} \approx 1 / 2.3 R1\, C \rightarrow C = 100$ nF

- ✓ Reset section:

Depends on pressing the push button P1 corresponding with charging and discharging of C1.

While P1 not pressed the capacitor C1 charges and the voltage at R2 =0 which means the reset pin is inactive (reset pin is active high).

When P1 is pressed, pin 12 will be supplied with voltage and the IC will reset its operation

R1=1KΩ C1 =47µF

Reset time = 5R1C1 = 0.235 sec

- IC1:4060 14 stage ripple counter and oscillator.

Features of 4060:

- All active components on chip
- RC or crystal oscillator configuration
- Output capability: standard (except for RTC and CTC)
- ICC category: MSI

- Inverter:

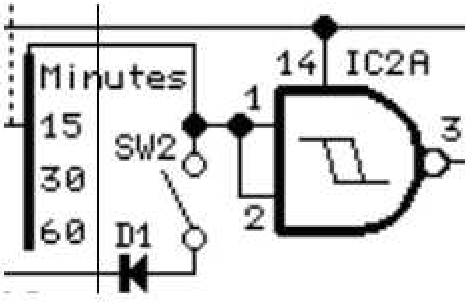


Fig.3.3: inverter and mode selection

This section plays the role of inverting the timing signal with the selected duration since the next stage turned on when the input in one of its terminals is low.

SW2 acts as mode selection, when it's open IC2A terminals take the value from the counter, when SW2 is closed IC2A terminals takes just one clock pulse then the internal oscillator of the previous stage will disabled

- Oscillator:

Oscillators are devices that are used to generate repetitive signals. They produce output signals without an input signal. There are two major types of electronic oscillators: harmonic oscillators and relaxation oscillators.

Harmonic oscillators produce sine wave outputs. Relaxation oscillators produce non-sine wave outputs.

In my project I used 4093 IC (quad 2 input Schmitt NAND gate) to generate two square waves 1.4Hz and 5Hz (the frequencies varies between theta and delta waves of EEG)

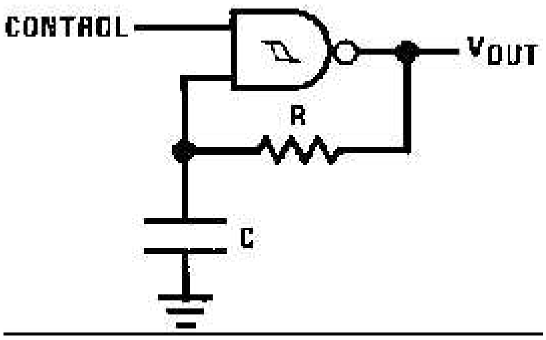
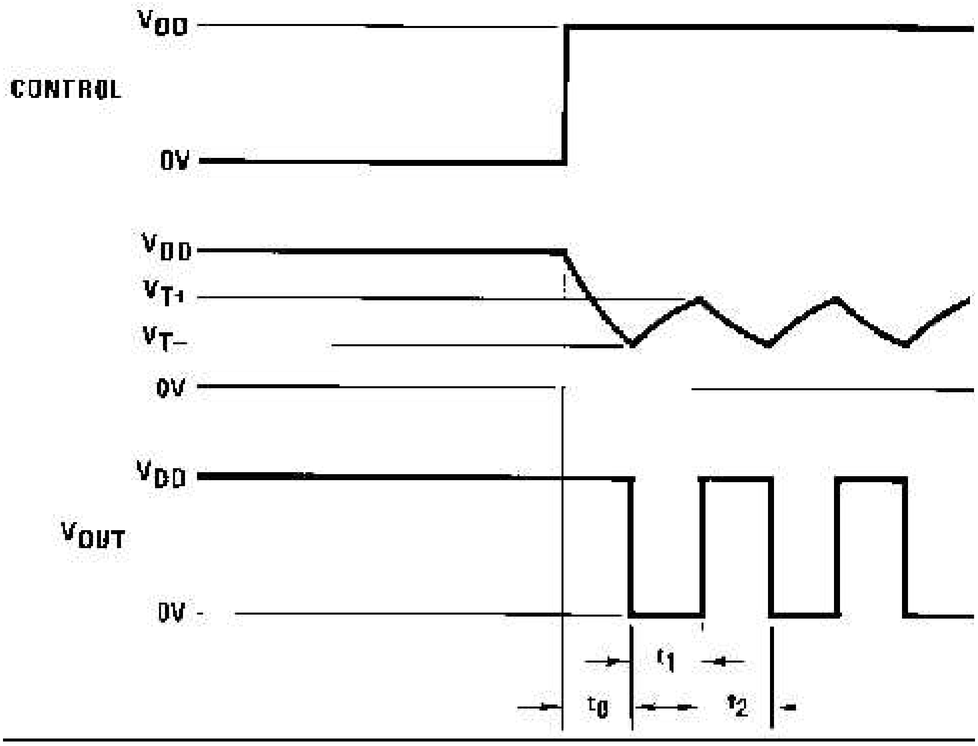


Fig.3.4: Oscillator circuit



$$f = \frac{1}{t_1 + t_2} = \frac{1}{RC \, \ell n \dfrac{(V_T^{\,+})(V_{DD} - V_T^{\,-})}{(V_T^{\,-})(V_{DD} - V_T^{\,+})}}$$

From data sheet:

Vt+ = 6.2 volt

Vt- = 4.1 volt

Vdd = 9 volt

So to generate the required frequency we choose proper values of R and C

For 1.4Hz

Let R= 2.2MΩ then the suitable C=330nF

Similarly to 5Hz wave

R=10 MΩ and C=330nF

- IC2: 4093 Quad 2 input Schmitt NAND gate

  Features of 4093:

  - wide supply voltage range

- noise immunity greater than 50%
- no limit in input rise and fall time

⌖ Status indicator:

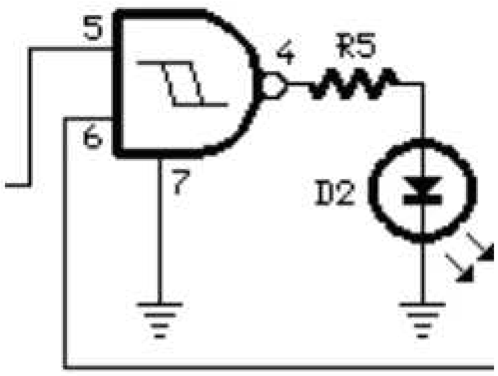


Fig.3.5: indicator circuit

This circuit to give an indication for the device status, pin5 is attached to the internal oscillator pin of 4060IC (pin 9), and pin6 to pin11 of the same IC (square wave signal with frequency 1.4Hz).

During driving the coil the LED will flash quickly, after the time duration is over the LED turned off.

⌖ Driving the coil:

Any electrical coil that is charged will produce an associated electromagnetic field. The higher the current, the stronger the electric field at a given distance from the wire.

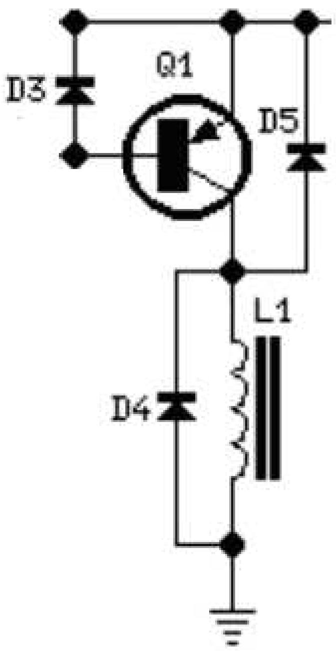


Fig.3.6: coil driver circuit

A PNP transistor acts as switch that allow the two square wave signals after they converted into 60µs pulses to pass through the coil alternatively by means of D3.

D5 and D4 allow the current to pass in one direction so they prevent the transistor from the reversed currents

Features of BC327:

- High current (max. 500 mA)
- Low voltage (max. 45 V).

3.2 Project Objectives:

1) to study the physiology of sleep and brain waves (EEG)
2) be familiar with geomagnetic fields and how to generate it

3) design and implement a device for generating the desired field with several durations and multi modes of operation

3.3 Project circuit:

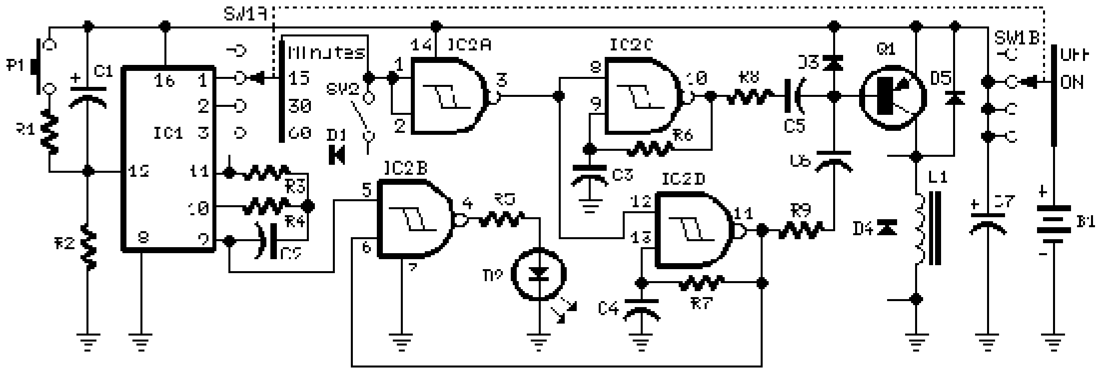


Fig.3.7 Circuit diagram of the project

3.3.1 How To Use The Circuit

- Select a timing option by means of the switch SW1.
- Choose 15, 30 or 60 minutes operation.
- Select “Stop” or “Alternate” mode operation by means of SW2.
- With SW2 closed (Stop mode operation) the electromagnetic radiation stops after the pre-set time is elapsed.
- With SW2 opened (Alternate mode operation) the device operates for the pre-set time, then pauses for the same amount of time: this cycle repeats indefinitely.
- Place the unit under the pillow and enjoy sleeping.
- To reset a cycle press P1 push button.

3.3.2 Operation Of Circuit

- IC2C and IC2D generate two square waves at about 1.4Hz and 5 Hz respectively.

- These wave-forms are converted into 60µS pulses at the same frequencies by means of C5 & C6 and mixed at Q1 Base.
- This transistor drives the Radiator coil with a scalar series of pulses of 60µS length and 9V amplitude.
- IC1, IC2A & IC2B form the timer section.
- C1 & R2 provide auto-reset of IC1 at switch-on.
- The internal oscillator of IC1 drives the 14 stage ripple counter and, after about 15 minutes, output pin 1 goes high. Pin 3 of IC2A goes low and stops IC2C & IC2D oscillation.
- If SW2 is left open (Alternate mode operation), after 15 minutes pin 1 of IC1 goes low, pin 3 of IC2A goes high and oscillators are enabled again.
- If SW2 is closed (Stop mode operation), the first time output pin 1 of IC1 goes high, the internal oscillator of the IC is disabled by means of D1. Therefore the circuit remains off until a reset pulse is applied to pin 12 by means of P1 or when the whole device is switched-off and then restarted.
- The same thing occurs when SW1 is switched on 30 or 60 minutes positions, obviously changing time length.
- IC2B drives pilot LED D2 which operates in the following three modes:
  - *Flashes quickly and almost randomly when the Radiator coil is driven*
  - *Flashes somewhat slowly and regularly when the Radiator coil is pausing during the Alternate mode operation*
  - *Is off when the circuit auto-stops (Stop mode operation)*

CHAPTER 4

Conclusion and Future Work

4.1 Conclusions & Results:

Knowledge and practical experience were gained by developing this project. This project generates type of geo-magnetic-fields and it helps the brain surrounded by an ideal environment for a sound sleep.

This project helps in fighting insomnia. Apart from this it also supports relaxation, stress management and induces sleep easily.

- **Faced problems:**

- In my project for on/off and time duration selection, rotary switch is needed but I couldn't find it so I substitute it with three ordinary switches.

- **Results:**

After the construction of the device, for measuring the produced magnetic field I measure the current and then made my calculations.

The produced current is an alternating current, the resulted values from my device was 0.12mA – 0.16mA

$B= \mu*I *L*N / 4pi *R^2$

Let R= 15cm N=300 turn L= 2pi*r*N

$B= 4pi *10^{-7} *0.12*2pi*0.1*10^{-3}*300*300 / (4pi * (15*10^{-2})^2)$
= 30 ntesla (within the range of Geomagnetic field)

$B= 4pi *10^{-7} *0.16*2pi*0.1*10^{-3}*300*300 / (4pi * (15*10^{-2})^2)$
= 40 ntesla (within the range of Geomagnetic field)

4.2 Future Work:

4.2.1 Magnetic energy Therapy:

The inducing of certain specifically pulsed magnetic energy fields into body tissue causes bioelectric current activity which may assist in the normalizing of electron flow within and between cells in the body. This may help in the temporary relief of pain and also in the repair damaged tissues.

Using extremely-ultra-low frequencies of 0.5 to 18Hz with specially shaped multi-rhythm bio-waveforms of oscillating magnetic energy fields,

The magnetic energy field frequencies must produced within the range of predominant brain frequencies of humans and animals. These are very different to the potentially damaging very high frequencies and waveforms of electro-magnetic radiation fields in the environment.

The explosion of use of magnets is now moving toward a new trend… the introduction of pulsed magnetic fields. Gentle, and easy to use, the cutting-edge concept of pulsed magnetic fields imitates the low magnetic fields that occur naturally in our bodies.

REFERENCES

BOOKS:

[1] Rajeev Bansal , Engineering electromagnetic: application , 2009
[2] Introduction to biomedical equipment technology, fourth edition, Joseph J.Curr & John M.Brown.

RESEARCHS AND PAPERS:

[3] University of California and Sleep Research Society. Basics of sleep behavior. 1997. Retrieved July 17, 2001

[4] National Heart, Lung, and Blood Institute. Insomnia. Bethesda, MD: NHLBI; 1995. (NIH Pub. No. 95-3801)

[5] Rechtschaffen, A.1998. Current perspectives on the function of sleep. Perspectives in Biological Medicine,

[6]Strohl, K.P., Haponik, E.E., Sateia, M.J., Veasey, S., Chervin, R.D., Zee, P., and Papp, K. 2000. The need for a knowledge system in sleep and chronobiology. Academic Medicine.

[7] Kohyama J. Sleep as a window on the developing brain. Current Problems in Pediatrics.

[8] Study on the influence of simulative EEG modulation magnetic field on the discharge of median raphe nuclei [Article in Chinese]

[9] Sleep. 1996 May; Effects of low energy emission therapy in chronic psycho physiological insomnia. Pasche B, Erman M, Hayduk R, Mitler MM, Reite M, Higgs L, Kuster N, Rossel C, Dafni U, Amato D, Barbault A, Lebet JP. Symtonic USA, Inc., New York, New York 10162, USA.

WEBSITES:

[10] www.redcircuits.com

[11]http://healingscience.bioenergeticspectrum.com/healingscienceframe.html?pulsedmagnetictherapy.html

[12] http://www.alpha-stim.lv/box/files/Pdf_dokumenti/Zinatniskie_petijumi/giluladepression.pdf

[12] www.wikipedia.com

[13] http://www.wisconsinengineer.com/articles/14

Appendix A

DATASHEETS

1. **BC327**
2. **4060 IC**
3. **4093 IC**

DATA SHEET

For a complete data sheet, please also download:

- The IC06 74HC/HCT/HCU/HCMOS Logic Family Specifications
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Information
- The IC06 74HC/HCT/HCU/HCMOS Logic Package Outlines

74HC/HCT4060

14-stage binary ripple counter with oscillator

Product specification
File under Integrated Circuits, IC06

December 1990

Philips
Semiconductors

PHILIPS

14-stage binary ripple counter with oscillator — 74HC/HCT4060

FEATURES

- All active components on chip
- RC or crystal oscillator configuration
- Output capability: standard (except for R_{TC} and C_{TC})
- I_{CC} category: MSI

GENERAL DESCRIPTION

The 74HC/HCT4060 are high-speed Si-gate CMOS devices and are pin compatible with "4060" of the "4000B" series. They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT4060 are 14-stage ripple-carry counter/dividers and oscillators with three oscillator terminals (RS, R_{TC} and C_{TC}), ten buffered outputs (Q_3 to Q_9 and Q_{11} to Q_{13}) and an overriding asynchronous master reset (MR).
The oscillator configuration allows design of either RC or crystal oscillator circuits. The oscillator may be replaced by an external clock signal at input RS. In this case keep the other oscillator pins (R_{TC} and C_{TC}) floating.

The counter advances on the negative-going transition of RS. A HIGH level on MR resets the counter (Q_3 to Q_9 and Q_{11} to Q_{13} = LOW), independent of other input conditions.

In the HCT version, the MR input is TTL compatible, but the RS input has CMOS input switching levels and can be driven by a TTL output by using a pull-up resistor to V_{CC}.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f$ = 6 ns

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PHL}/ t_{PLH}	propagation delay	C_L = 15 pF; V_{CC} = 5 V			
	RS to Q_3		31	31	ns
	Q_n to Q_{n+1}		6	6	ns
t_{PHL}	MR to Q_n		17	18	ns
f_{max}	maximum clock frequency		87	88	MHz
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per package	notes 1, 2 and 3	40	40	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

   $P_D = C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o)$ where:

   f_i = input frequency in MHz

   f_o = output frequency in MHz

   $\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs

   C_L = output load capacitance in pF

   V_{CC} = supply voltage in V
2. For HC the condition is V_I = GND to V_{CC}
   For HCT the condition is V_I = GND to V_{CC} – 1.5 V
3. For formula on dynamic power dissipation see next pages.

ORDERING INFORMATION

See *"74HC/HCT/HCU/HCMOS Logic Package Information"*.

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1, 2, 3	Q_{11} to Q_{13}	counter outputs
7, 5, 4, 6, 14, 13, 15	Q_3 to Q_9	counter outputs
8	GND	ground (0 V)
9	C_{TC}	external capacitor connection
10	R_{TC}	external resistor connection
11	RS	clock input/oscillator pin
12	MR	master reset
16	V_{CC}	positive supply voltage

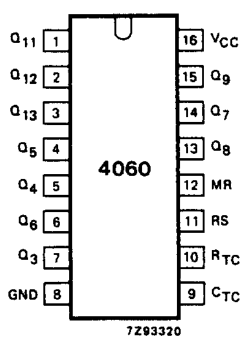


Fig.1 Pin configuration.

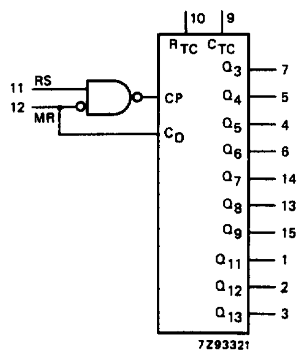


Fig.2 Logic symbol.

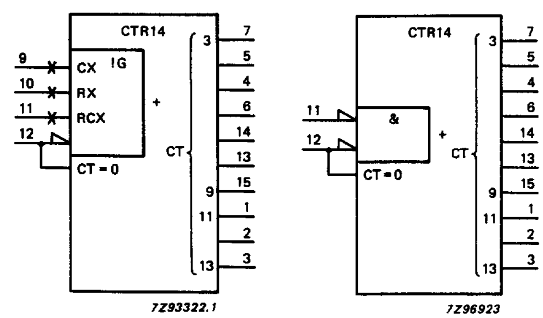


Fig.3 IEC logic symbol.

DYNAMIC POWER DISSIPATION FOR 74HC

PARAMETER	V_{CC} (V)	TYPICAL FORMULA FOR P_D (μW) (note 1)
total dynamic power dissipation when using the on-chip oscillator (P_D)	2.0 4.5 6.0	$C_{PD} \times f_{osc} \times V_{CC}^2 + \sum (C_L \times V_{CC}^2 \times f_o) + 2C_t \times V_{CC}^2 \times f_{osc} + 60 \times V_{CC}$ $C_{PD} \times f_{osc} \times V_{CC}^2 + \sum (C_L \times V_{CC}^2 \times f_o) + 2C_t \times V_{CC}^2 \times f_{osc} + 1\,750 \times V_{CC}$ $C_{PD} \times f_{osc} \times V_{CC}^2 + \sum (C_L \times V_{CC}^2 \times f_o) + 2C_t \times V_{CC}^2 \times f_{osc} + 3\,800 \times V_{CC}$

Note

1. GND = 0 V; T_{amb} = 25 °C

DYNAMIC POWER DISSIPATION FOR 74HCT

PARAMETER	V_{CC} (V)	TYPICAL FORMULA FOR P_D (μW) (note 1)
total dynamic power dissipation when using the on-chip oscillator (P_D)	4.5	$C_{PD} \times f_{osc} \times V_{CC}^2 + \sum (C_L \times V_{CC}^2 \times f_o) + 2C_t \times V_{CC}^2 \times f_{osc} + 1\,750 \times V_{CC}$

Notes

1. GND = 0 V; T_{amb} = 25 °C
2. Where: f_o = output frequency in MHz

   f_{osc} = oscillator frequency in MHz

   $\sum (C_L \times V_{CC}^2 \times f_o)$ = sum of outputs

   C_L = output load capacitance in pF

   C_t = timing capacitance in pF

   V_{CC} = supply voltage in V

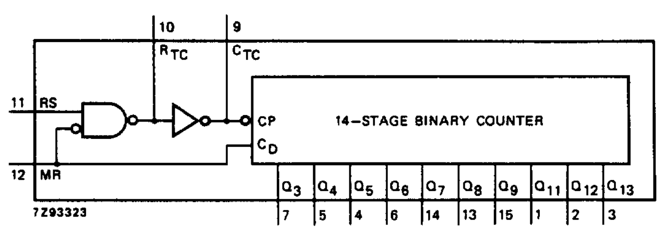


Fig.4 Functional diagram.

APPLICATIONS

- Control counters
- Timers
- Frequency dividers
- Time-delay circuits

14-stage binary ripple counter with oscillator 74HC/HCT4060

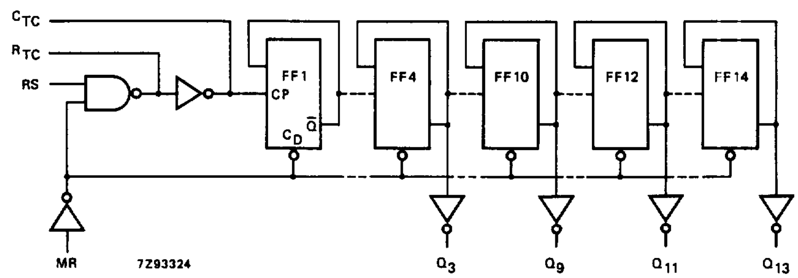


Fig.5 Logic diagram.

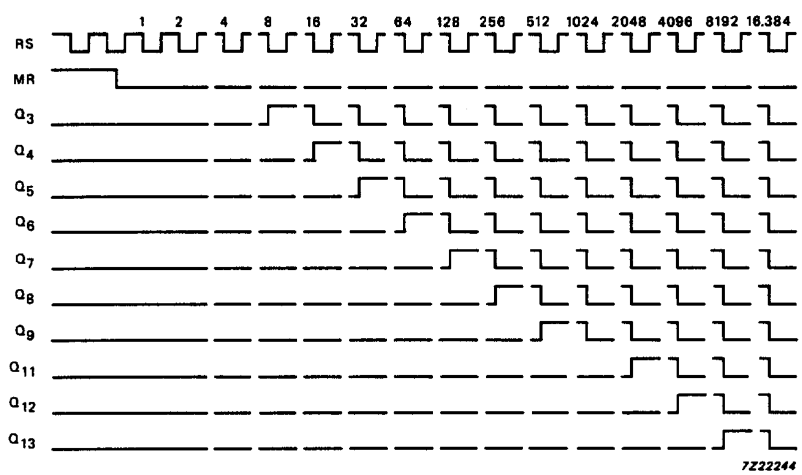


Fig.6 Timing diagram.

DC CHARACTERISTICS FOR 74HC

Output capability: standard (except for R_{TC} and C_{TC})
I_{CC} category: MSI
Voltages are referenced to GND (ground = 0 V)

SYMBOL	PARAMETER	T_{amb} (°C) 74HC +25 min.	typ.	max.	−40 to +85 min.	max.	−40 to +125 min.	max.	UNIT	TEST CONDITIONS V_{CC} (V)	V_I	OTHER
V_{IH}	HIGH level input voltage MR input	1.5 3.15 4.2	1.3 2.4 3.1		1.5 3.15 4.2		1.5 3.15 4.2		V	2.0 4.5 6.0		
V_{IL}	LOW level input voltage MR input		0.8 2.1 2.8	0.5 1.35 1.8		0.5 1.35 1.8		0.5 1.35 1.8	V	2.0 4.5 6.0		
V_{IH}	HIGH level input voltage RS input	1.7 3.6 4.8			1.7 3.6 4.8		1.7 3.6 4.8		V	2.0 4.5 6.0		
V_{IL}	LOW level input voltage RS input			0.3 0.9 1.2		0.3 0.9 1.2		0.3 0.9 1.2	V	2.0 4.5 6.0		
V_{OH}	HIGH level output voltage R_{TC} output	3.98 5.48			3.84 5.34		3.7 5.2		V	4.5 6.0	RS=GND and MR=GND	$-I_O$ = 2.6 mA $-I_O$ = 3.3 mA
		3.98 5.48			3.84 5.34		3.7 5.2		V	4.5 6.0	RS=V_{CC} and MR=V_{CC}	$-I_O$ = 0.65 mA $-I_O$ = 0.85 mA
		1.9 4.4 5.9	2.0 4.5 6.0		1.9 4.4 5.9		1.9 4.4 5.9		V	2.0 4.5 6.0	RS=GND and MR=GND	$-I_O$ = 20 µA $-I_O$ = 20 µA $-I_O$ = 20 µA
		1.9 4.4 5.9	2.0 4.5 6.0		1.9 4.4 5.9		1.9 4.4 5.9		V	2.0 4.5 6.0	RS=V_{CC} and MR=V_{CC}	$-I_O$ = 20 µA $-I_O$ = 20 µA $-I_O$ = 20 µA
V_{OH}	HIGH level output voltage C_{TC} output	3.98 5.48			3.84 5.34		3.7 5.2		V	4.5 6.0	RS=V_{IH} and MR=V_{IL}	$-I_O$ = 3.2 mA $-I_O$ = 4.2 mA
V_{OH}	HIGH level output voltage except R_{TC} output	1.9 4.4 5.9	2.0 4.5 6.0		1.9 4.4 5.9		1.9 4.4 5.9		V	2.0 4.5 6.0	V_{IH} or V_{IL}	$-I_O$ = 20 µA $-I_O$ = 20 µA $-I_O$ = 20 µA
V_{OH}	HIGH level output voltage except R_{TC} and C_{TC} outputs	3.98 5.48			3.84 5.34		3.7 5.2		V	4.5 6.0	V_{IH} or V_{IL}	$-I_O$ = 4.0 mA $-I_O$ = 5.2 mA
V_{OL}	LOW level output voltage R_{TC} output			0.26 0.26		0.33 0.33		0.4 0.4		4.5 6.0	RS=V_{CC} and MR=GND	I_O = 2.6 mA I_O = 3.3 mA
			0 0 0	0.1 0.1 0.1		0.1 0.1 0.1		0.1 0.1 0.1	V	2.0 4.5 6.0	RS=V_{CC} and MR=GND	I_O = 20 µA I_O = 20 µA I_O = 20 µA

SYM-BOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITIONS		
		74HC								V_{CC} (V)	V_I	OTHER
		+25			−40 to +85		−40 to +125					
		min.	typ.	max.	min.	max.	min.	max.				
V_{OL}	LOW level output voltage C_{TC} output			0.26 0.26		0.33 0.33		0.4 0.4	V	4.5 6.0	RS=V_{IL} and MR=V_{IH}	I_O = 3.2 mA I_O = 4.2 mA
V_{OL}	LOW level output voltage except R_{TC} output		0 0 0	0.1 0.1 0.1		0.1 0.1 0.1		0.1 0.1 0.1	V	2.0 4.5 6.0	V_{IH} or V_{IL}	I_O = 20 µA I_O = 20 µA I_O = 20 µA
V_{OL}	LOW level output voltage except R_{TC} and C_{TC} outputs			0.26 0.26		0.33 0.33		0.4 0.4	V	4.5 6.0	V_{IH} or V_{IL}	I_O = 4.0 mA I_O = 5.2 mA
$\pm I_I$	input leakage current			0.1		1.0		1.0	µA	6.0	V_{CC} or GND	
I_{CC}	quiescent supply current			8.0		80.0		160.0	µA	6.0	V_{CC} or GND	I_O = 0

AC CHARACTERISTICS FOR 74HC

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T_{amb} (°C) 74HC +25 min.	typ.	max.	−40 to +85 min.	max.	−40 to +125 min.	max.	UNIT	TEST CONDITIONS V_{CC} (V)	WAVEFORMS
t_{PHL}/ t_{PLH}	propagation delay RS to Q_3		99 36 29	300 60 51		375 75 64		450 90 77	ns	2.0 4.5 6.0	Fig.12
t_{PHL}/ t_{PLH}	propagation delay Q_n to Q_{n+1}		22 8 6	80 16 14		100 20 17		120 24 20	ns	2.0 4.5 6.0	Fig.14
t_{PHL}	propagation delay MR to Q_n		55 20 16	175 35 30		220 44 37		265 53 45	ns	2.0 4.5 6.0	Fig.13
t_{THL}/ t_{TLH}	output transition time		19 7 6	75 15 13		95 19 16		110 22 19	ns	2.0 4.5 6.0	Fig.12
t_W	clock pulse width RS; HIGH or LOW	80 16 14	17 6 5		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig.12
t_W	master reset pulse width MR; HIGH	80 16 14	25 9 7		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig.13
t_{rem}	removal time MR to RS	100 20 17	28 10 8		125 25 21		150 30 26		ns	2.0 4.5 6.0	Fig.13
f_{max}	maximum clock pulse frequency	6.0 30 35	26 80 95		4.8 24 28		4.0 20 24		MHz	2.0 4.5 6.0	Fig.12

DC CHARACTERISTICS FOR 74HCT

Output capability: standard (except for R_{TC} and C_{TC})

I_{CC} category: MSI

Voltages are referenced to GND (ground = 0 V)

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITIONS		
		74HCT								V_{CC} (V)	V_I	OTHER
		+25			−40 to +85		−40 to +125					
		min.	typ.	max.	min.	max.	min.	max.				
V_{IH}	HIGH level input voltage	2.0			2.0		2.0		V	4.5 to 5.5		note 2
V_{IL}	LOW level input voltage			0.8		0.8		0.8	V	4.5 to 5.5		note 2
V_{OH}	HIGH level output voltage R_{TC} output	3.98			3.84		3.7		V	4.5	RS=GND and MR=GND	$-I_O$ = 2.6 mA
		3.98			3.84		3.7		V	4.5	RS = V_{CC} and MR = V_{CC}	$-I_O$ = 0.65 mA
		4.4	4.5		4.4		4.4		V	4.5	RS=GND and MR=GND	$-I_O$ = 20 μA
		4.4	4.5		4.4		4.4		V	4.5	RS=V_{CC} and MR=V_{CC}	$-I_O$ = 20 μA
V_{OH}	HIGH level output voltage C_{TC} output	3.98			3.84		3.7		V	4.5	RS = V_{IH} and MR = V_{IL}	$-I_O$ = 3.2 mA
V_{OH}	HIGH level output voltage except R_{TC} output	4.4	4.5		4.4		4.4		V	4.5	V_{IH} or V_{IL}	$-I_O$ = 20 μA
V_{OH}	HIGH level output voltage except R_{TC} and C_{TC} outputs	3.98			3.84		3.7		V	4.5	V_{IH} or V_{IL}	$-I_O$ = 4.0 mA
V_{OL}	LOW level output voltage R_{TC} output			0.26		0.33		0.4	V	4.5	RS=V_{CC} and MR=GND	I_O = 2.6 mA
			0	0.1		0.1		0.1	V	4.5	RS=V_{CC} and MR=GND	I_O = 20 μA
V_{OL}	LOW level output voltage C_{TC} output			0.26		0.33		0.4	V	4.5	RS = V_{IL} and MR = V_{IH}	I_O = 3.2 mA
V_{OL}	LOW level output voltage except R_{TC} output		0	0.1		0.1		0.1	V	4.5	V_{IH} or V_{IL}	I_O = 20 μA
V_{OL}	LOW level output voltage except R_{TC} and C_{TC} outputs			0.26		0.33		0.4	V	4.5	V_{IH} or V_{IL}	I_O = 4.0 mA
±I	input leakage current			0.1		1.0		1.0	μA	5.5	V_{CC} or GND	
I_{CC}	quiescent supply current			8.0		80.0		160.0	μA	5.5	V_{CC} or GND	I_O = 0
ΔI_{CC}	additional quiescent supply current per input pin for unit load coefficient is 1 (note 1)		100	360		450		490	μA	4.5 to 5.5	V_{CC} − 2.1 V	other inputs at V_{CC} or GND; I_O = 0

Notes

1. The value of additional quiescent supply current (ΔI_{CC}) for a unit load of 1 is given here.
   To determine ΔI_{CC} per input, multiply this value by the unit load coefficient shown in the table below.
2. Only input MR (pin 12) has TTL input switching levels for the HCT versions.

INPUT	UNIT LOAD COEFFICIENT
MR	0.40

AC CHARACTERISTICS FOR 74HCT

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T_{amb} (°C)							UNIT	TEST CONDITIONS	
		74HCT								V_{CC} (V)	WAVEFORMS
		+25			−40 to +85		−40 to +125				
		min.	typ.	max.	min.	max.	min.	max.			
t_{PHL}/ t_{PLH}	propagation delay RS to Q_3		33	66		83		99	ns	4.5	Fig.12
t_{PHL}/ t_{PLH}	propagation delay Q_n to Q_{n+1}		8	16		20		24	ns	4.5	Fig.14
t_{PHL}	propagation delay MR to Q_n		21	44		55		66	ns	4.5	Fig.13
t_{THL}/ t_{TLH}	output transition time		7	15		19		22	ns	4.5	Fig.12
t_W	clock pulse width RS; HIGH or LOW	16	6		20		24		ns	4.5	Fig.12
t_W	master reset pulse width MR; HIGH	16	6		20		24		ns	4.5	Fig.13
t_{rem}	removal time MR to RS	26	13		33		39		ns	4.5	Fig.13
f_{max}	maximum clock pulse frequency	30	80		24		20		MHz	4.5	Fig.12

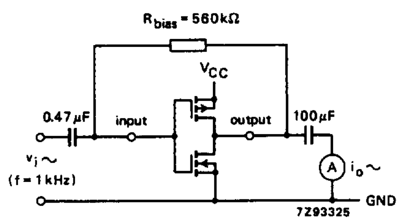


Fig.7 Test set-up for measuring forward transconductance $g_{fs} = di_o / dv_i$ at v_o is constant (see also graph Fig.8); MR = LOW.

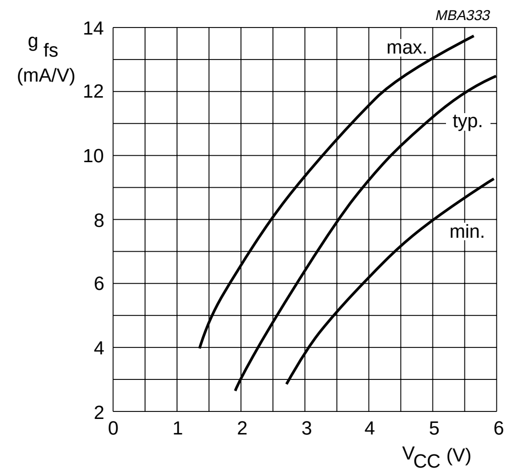


Fig.8 Typical forward transconductance g_{fs} as a function of the supply voltage V_{CC} at T_{amb} = 25 °C.

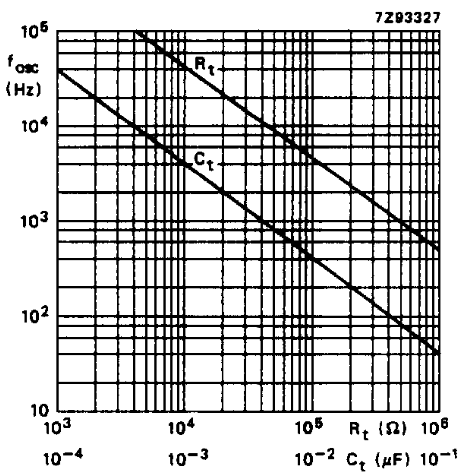
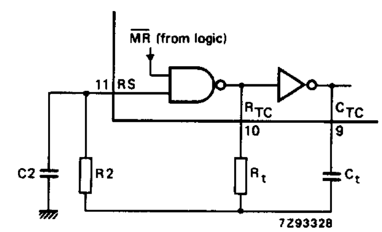


Fig.9 RC oscillator frequency as a function of R_t and C_t at V_{CC} = 2.0 to 6.0 V; T_{amb} = 25 °C. C_t curve at R_t = 100 kΩ; R2 = 200 kΩ. R_t curve at C_t = 1 nF; R2 = 2 × R_t.

RC OSCILLATOR



Typical formula for oscillator frequency:

$$f_{osc} = \frac{1}{2.5 \times R_t \times C_t}$$

Fig.10 Example of a RC oscillator.

TIMING COMPONENT LIMITATIONS

The oscillator frequency is mainly determined by R_tC_t, provided R2 ≈ $2R_t$ and R2C2 << R_tC_t. The function of R2 is to minimize the influence of the forward voltage across the input protection diodes on the frequency. The stray capacitance C2 should be kept as small as possible. In consideration of accuracy, C_t must be larger than the inherent stray capacitance. R_t must be larger than the "ON" resistance in series with it, which typically is 280 Ω at V_{CC} = 2.0 V, 130 Ω at V_{CC} = 4.5 V and 100 Ω at V_{CC} = 6.0 V.

The recommended values for these components to maintain agreement with the typical oscillation formula are:

C_t > 50 pF, up to any practical value,

10 kΩ < R_t < 1 MΩ.

In order to avoid start-up problems, R_t ≥ 1 kΩ.

TYPICAL CRYSTAL OSCILLATOR

In Fig.11, R2 is the power limiting resistor.
For starting and maintaining oscillation a minimum transconductance is necessary, so R2 should not be too large. A practical value for R2 is 2.2 kΩ.

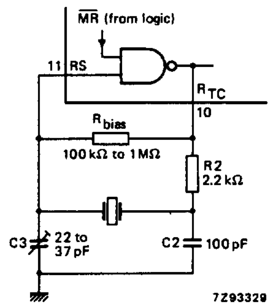
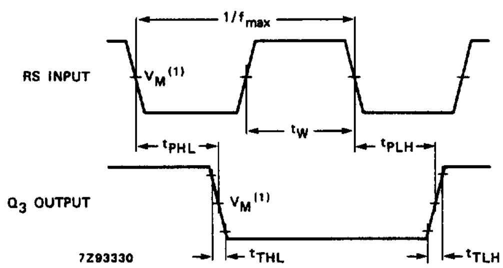


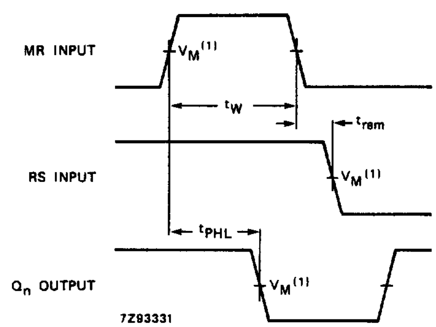
Fig.11 External components connection for a crystal oscillator.

AC WAVEFORMS



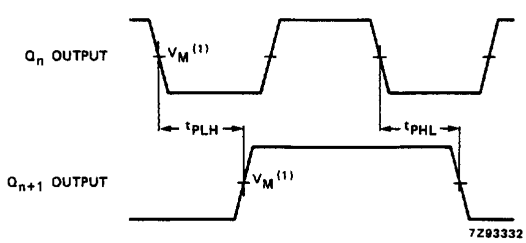
(1) HC : V_M = 50%; V_I = GND to V_{CC}.
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.12 Waveforms showing the clock (RS) to output (Q_3) propagation delays, the clock pulse width, the output transition times and the maximum clock frequency.



(1) HC : V_M = 50%; V_I = GND to V_{CC}.
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.13 Waveforms showing the master reset (MR) pulse width, the master reset to output (Q_n) propagation delays and the master reset to clock (RS) removal time.



(1) HC : V_M = 50%; V_I = GND to V_{CC}.
HCT: V_M = 1.3 V; V_I = GND to 3 V.

Fig.14 Waveforms showing the output (Q_n) to Q_{n+1} propagation delays.

PACKAGE OUTLINES

See *"74HC/HCT/HCU/HCMOS Logic Package Outlines"*.

National Semiconductor

February 1993

CD4093BM/CD4093BC Quad 2-Input NAND Schmitt Trigger

General Description

The CD4093B consists of four Schmitt-trigger circuits. Each circuit functions as a 2-input NAND gate with Schmitt-trigger action on both inputs. The gate switches at different points for positive and negative-going signals. The difference between the positive (V_T+) and the negative voltage (V_T-) is defined as hysteresis voltage (V_H).

All outputs have equal source and sink currents and conform to standard B-series output drive (see Static Electrical Characteristics).

Features

- Wide supply voltage range 3.0V to 15V
- Schmitt-trigger on each input with no external components
- Noise immunity greater than 50%
- Equal source and sink currents
- No limit on input rise and fall time
- Standard B-series output drive
- Hysteresis voltage (any input) $T_A = 25°C$

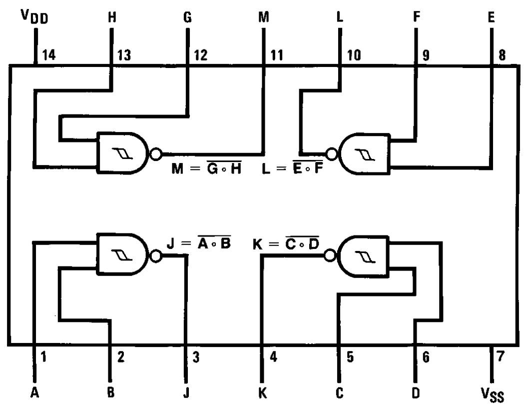
Typical	$V_{DD} = 5.0V$	$V_H = 1.5V$
	$V_{DD} = 10V$	$V_H = 2.2V$
	$V_{DD} = 15V$	$V_H = 2.7V$
Guaranteed		$V_H = 0.1\ V_{DD}$

Applications

- Wave and pulse shapers
- High-noise-environment systems
- Monostable multivibrators
- Astable multivibrators
- NAND logic

Connection Diagram

Dual-In-Line Package



TL/F/5982–1

Top View

Order Number CD4093B

 RRD-B30M105/Printed in U. S. A.

Absolute Maximum Ratings (Notes 1 & 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

DC Supply Voltage (V_{DD})	−0.5 to +18 V_{DC}
Input Voltage (V_{IN})	−0.5 to V_{DD} +0.5 V_{DC}
Storage Temperature Range (T_S)	−65°C to +150°C
Power Dissipation (P_D)	
Dual-In-Line	700 mW
Small Outline	500 mW
Lead Temperature (T_L)	
(Soldering, 10 seconds)	260°C

Recommended Operating Conditions (Note 2)

DC Supply Voltage (V_{DD})	3 to 15 V_{DC}
Input Voltage (V_{IN})	0 to V_{DD} V_{DC}
Operating Temperature Range (T_A)	
CD4093BM	−55°C to +125°C
CD4093BC	−40°C to +85°C

DC Electrical Characteristics CD4093BM (Note 2)

Symbol	Parameter	Conditions	−55°C		+25°C			+125°C		Units
			Min	Max	Min	Typ	Max	Min	Max	
I_{DD}	Quiescent Device Current	V_{DD} = 5V		0.25			0.25		7.5	μA
		V_{DD} = 10V		0.5			0.5		15.0	μA
		V_{DD} = 15V		1.0			1.0		30.0	μA
V_{OL}	Low Level Output Voltage	V_{IN} = V_{DD}, $\lvert I_O \rvert$ < 1 μA								
		V_{DD} = 5V		0.05		0	0.05		0.05	V
		V_{DD} = 10V		0.05		0	0.05		0.05	V
		V_{DD} = 15V		0.05		0	0.05		0.05	V
V_{OH}	High Level Output Voltage	V_{IN} = V_{SS}, $\lvert I_O \rvert$ < 1 μA								
		V_{DD} = 5V	4.95		4.95	5		4.95		V
		V_{DD} = 10V	9.95		9.95	10		9.95		V
		V_{DD} = 15V	14.95		14.95	15		14.95		V
V_T^-	Negative-Going Threshold Voltage (Any Input)	$\lvert I_O \rvert$ < 1 μA								
		V_{DD} = 5V, V_O = 4.5V	1.3	2.25	1.5	1.8	2.25	1.5	2.3	V
		V_{DD} = 10V, V_O = 9V	2.85	4.5	3.0	4.1	4.5	3.0	4.65	V
		V_{DD} = 15V, V_O = 13.5V	4.35	6.75	4.5	6.3	6.75	4.5	6.9	V
V_T^+	Positive-Going Threshold Voltage (Any Input)	$\lvert I_O \rvert$ < 1 μA								
		V_{DD} = 5V, V_O = 0.5V	2.75	3.65	2.75	3.3	3.5	2.65	3.5	V
		V_{DD} = 10V, V_O = 1V	5.5	7.15	5.5	6.2	7.0	5.35	7.0	V
		V_{DD} = 15V, V_O = 1.5V	8.25	10.65	8.25	9.0	10.5	8.1	10.5	V
V_H	Hysteresis ($V_T^+ - V_T^-$) (Any Input)	V_{DD} = 5V	0.5	2.35	0.5	1.5	2.0	0.35	2.0	V
		V_{DD} = 10V	1.0	4.30	1.0	2.2	4.0	0.70	4.0	V
		V_{DD} = 15V	1.5	6.30	1.5	2.7	6.0	1.20	6.0	V
I_{OL}	Low Level Output Current (Note 3)	V_{IN} = V_{DD}								
		V_{DD} = 5V, V_O = 0.4V	0.64		0.51	0.88		0.36		mA
		V_{DD} = 10V, V_O = 0.5V	1.6		1.3	2.25		0.9		mA
		V_{DD} = 15V, V_O = 1.5V	4.2		3.4	8.8		2.4		mA
I_{OH}	High Level Output Current (Note 3)	V_{IN} = V_{SS}								
		V_{DD} = 5V, V_O = 4.6V	−0.64		0.51	−0.88		−0.36		mA
		V_{DD} = 10V, V_O = 9.5V	−1.6		−1.3	−2.25		−0.9		mA
		V_{DD} = 15V, V_O = 13.5V	−4.2		−3.4	−8.8		−2.4		mA
I_{IN}	Input Current	V_{DD} = 15V, V_{IN} = 0V		−0.1		-10^{-5}	−0.1		−1.0	μA
		V_{DD} = 15V, V_{IN} = 15V		0.1		10^{-5}	0.1		1.0	μA

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed; they are not meant to imply that the devices should be operated at these limits. The table of "Recommended Operating Conditions" and "Electrical Characteristics" provides conditions for actual device operation.

Note 2: V_{SS} = 0V unless otherwise specified.

Note 3: I_{OH} and I_{OL} are tested one output at a time.

DC Electrical Characteristics CD4093BC (Note 2)

Symbol	Parameter	Conditions	−40°C		+25°C			+85°C		Units
			Min	Max	Min	Typ	Max	Min	Max	
I_{DD}	Quiescent Device Current	$V_{DD} = 5V$		1.0			1.0		7.5	μA
		$V_{DD} = 10V$		2.0			2.0		15.0	μA
		$V_{DD} = 15V$		4.0			4.0		30.0	μA
V_{OL}	Low Level Output Voltage	$V_{IN} = V_{DD}$, $\lvert I_O \rvert < 1\ \mu A$								
		$V_{DD} = 5V$		0.05		0	0.05		0.05	V
		$V_{DD} = 10V$		0.05		0	0.05		0.05	V
		$V_{DD} = 15V$		0.05		0	0.05		0.05	V
V_{OH}	High Level Output Voltage	$V_{IN} = V_{SS}$, $\lvert I_O \rvert < 1\ \mu A$								
		$V_{DD} = 5V$	4.95		4.95	5		4.95		V
		$V_{DD} = 10V$	9.95		9.95	10		9.95		V
		$V_{DD} = 15V$	14.95		14.95	15		14.95		V
V_T^-	Negative-Going Threshold Voltage (Any Input)	$\lvert I_O \rvert < 1\ \mu A$								
		$V_{DD} = 5V, V_O = 4.5V$	1.3	2.25	1.5	1.8	2.25	1.5	2.3	V
		$V_{DD} = 10V, V_O = 9V$	2.85	4.5	3.0	4.1	4.5	3.0	4.65	V
		$V_{DD} = 15V, V_O = 13.5V$	4.35	6.75	4.5	6.3	6.75	4.5	6.9	V
V_T^+	Positive-Going Threshold Voltage (Any Input)	$\lvert I_O \rvert < 1\ \mu A$								
		$V_{DD} = 5V, V_O = 0.5V$	2.75	3.6	2.75	3.3	3.5	2.65	3.5	V
		$V_{DD} = 10V, V_O = 1V$	5.5	7.15	5.5	6.2	7.0	5.35	7.0	V
		$V_{DD} = 15V, V_O = 1.5V$	8.25	10.65	8.25	9.0	10.5	8.1	10.5	V
V_H	Hysteresis ($V_T^+ - V_T^-$) (Any Input)	$V_{DD} = 5V$	0.5	2.35	0.5	1.5	2.0	0.35	2.0	V
		$V_{DD} = 10V$	1.0	4.3	1.0	2.2	4.0	0.70	4.0	V
		$V_{DD} = 15V$	1.5	6.3	1.5	2.7	6.0	1.20	6.0	V
I_{OL}	Low Level Output Current (Note 3)	$V_{IN} = V_{DD}$								
		$V_{DD} = 5V, V_O = 0.4V$	0.52		0.44	0.88		0.36		mA
		$V_{DD} = 10V, V_O = 0.5V$	1.3		1.1	2.25		0.9		mA
		$V_{DD} = 15V, V_O = 1.5V$	3.6		3.0	8.8		2.4		mA
I_{OH}	High Level Output Current (Note 3)	$V_{IN} = V_{SS}$								
		$V_{DD} = 5V, V_O = 4.6V$	−0.52		0.44	−0.88		−0.36		mA
		$V_{DD} = 10V, V_O = 9.5V$	−1.3		−1.1	−2.25		−0.9		mA
		$V_{DD} = 15V, V_O = 13.5V$	−3.6		−3.0	−8.8		−2.4		mA
I_{IN}	Input Current	$V_{DD} = 15V, V_{IN} = 0V$		−0.3		-10^{-5}	−0.3		−1.0	μA
		$V_{DD} = 15V, V_{IN} = 15V$		0.3		10^{-5}	0.3		1.0	μA

AC Electrical Characteristics*

$T_A = 25°C$, $C_L = 50$ pF, $R_L = 200k$, Input t_r, $t_f = 20$ ns, unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Units
t_{PHL}, t_{PLH}	Propagation Delay Time	$V_{DD} = 5V$		300	450	ns
		$V_{DD} = 10V$		120	210	ns
		$V_{DD} = 15V$		80	160	ns
t_{THL}, t_{TLH}	Transition Time	$V_{DD} = 5V$		90	145	ns
		$V_{DD} = 10V$		50	75	ns
		$V_{DD} = 15V$		40	60	ns
C_{IN}	Input Capacitance	(Any Input)		5.0	7.5	pF
C_{PD}	Power Dissipation Capacitance	(Per Gate)		24		pF

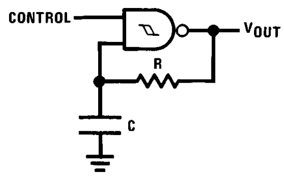
*AC Parameters are guaranteed by DC correlated testing.

Note 2: $V_{SS} = 0V$ unless otherwise specified.

Note 3: I_{OH} and I_{OL} are tested one output at a time.

Typical Applications

Gated Oscillator



TL/F/5982-2

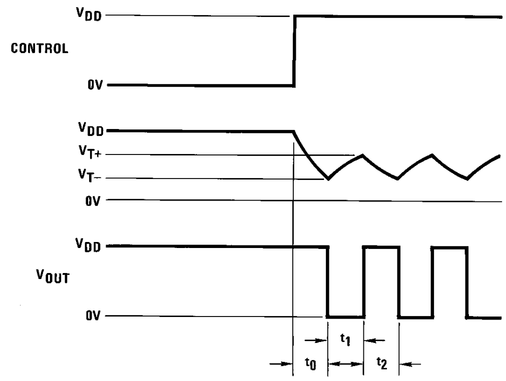
Assume $t_1 + t_2 >> t_{PHL} + t_{PLH}$ then:

$t_0 = RC \ \ell n \ [V_{DD}/V_{T^-}]$

$t_1 = RC \ \ell n \ [(V_{DD} - V_{T^-})/(V_{DD} - V_{T^+})]$

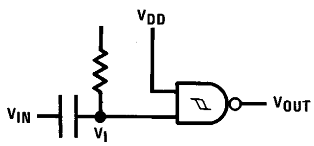
$t_2 = RC \ \ell n \ [V_{T^+}/V_{T^-}]$

$$f = \frac{1}{t_1 + t_2} = \frac{1}{RC \ \ell n \frac{(V_{T^+})(V_{DD} - V_{T^-})}{(V_{T^-})(V_{DD} - V_{T^+})}}$$

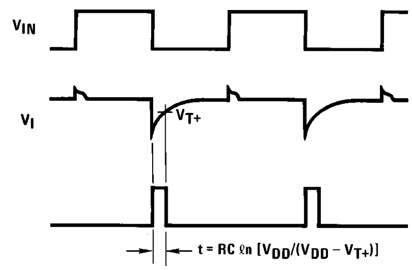


TL/F/5982-3

Gated One-Shot

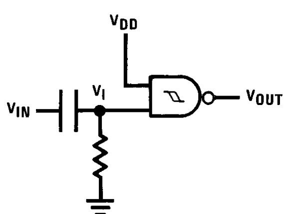


TL/F/5982-4

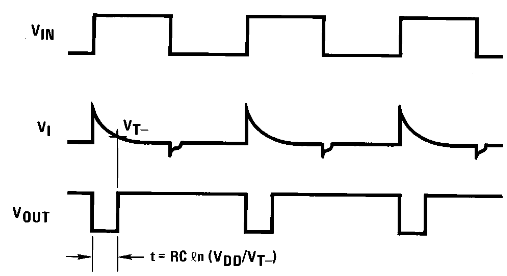


TL/F/5982-5

(a) Negative-Edge Triggered



TL/F/5982-6

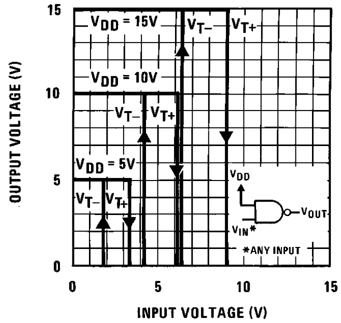


TL/F/5982-7

(b) Positive-Edge Triggered

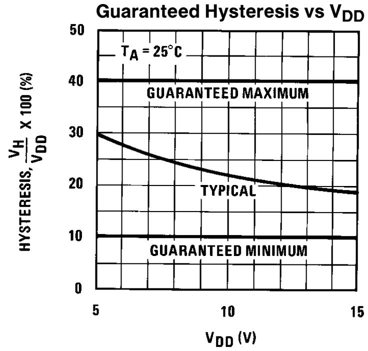
Typical Performance Characteristics

Typical Transfer Characteristics



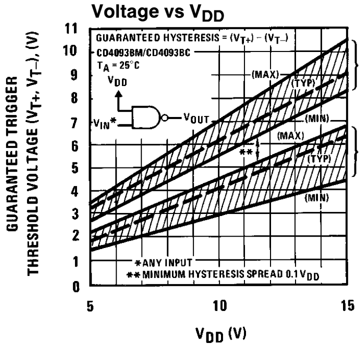
TL/F/5982–8

Guaranteed Hysteresis vs V_{DD}



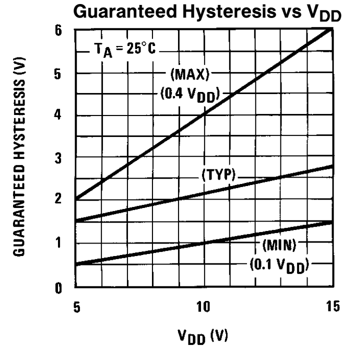
TL/F/5982–9

Guaranteed Trigger Threshold Voltage vs V_{DD}



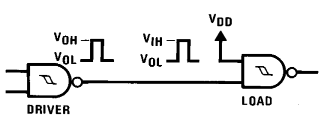
TL/F/5982–10

Guaranteed Hysteresis vs V_{DD}



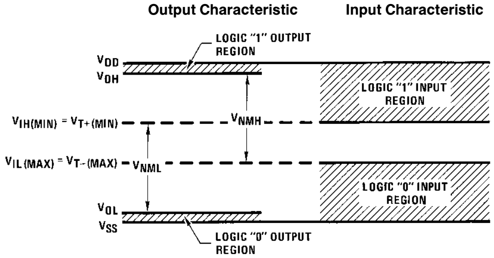
TL/F/5982–11

Input and Output Characteristics



TL/F/5982–12

Output Characteristic **Input Characteristic**

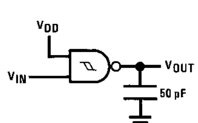


TL/F/5982–13

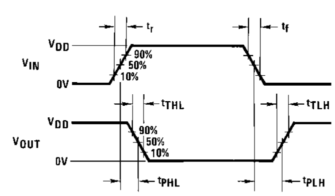
$V_{NML} = V_{IH(MIN)} - V_{OL} \cong V_{IH(MIN)} = V_{T^+(MIN)}$

$V_{NMH} = V_{OH} - V_{IL(MAX)} \cong V_{DD} - V_{IL(MAX)} = V_{DD} - V_{T^-(MAX)}$

AC Test Circuits and Switching Time Waveforms

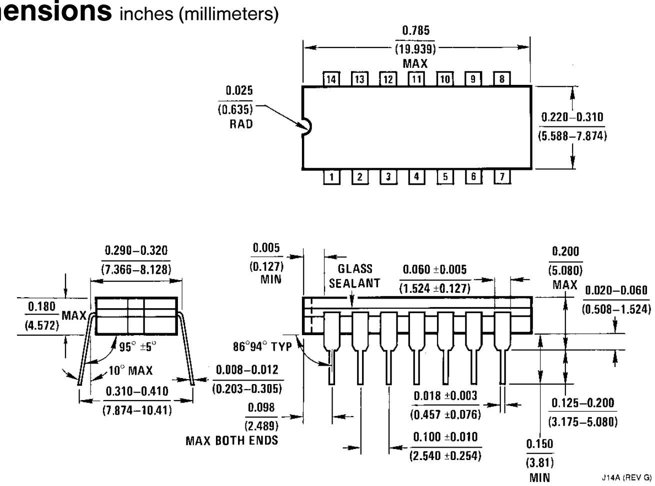


TL/F/5982–14

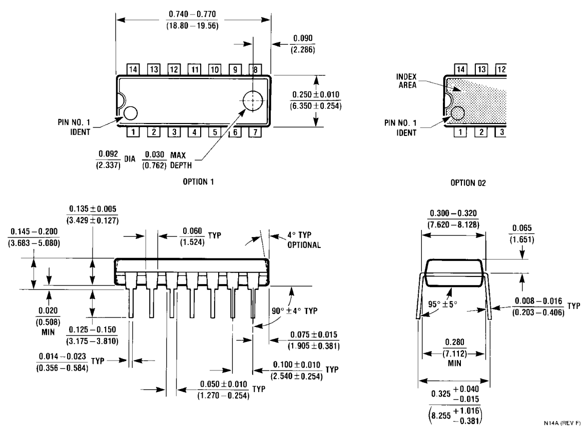


TL/F/5982–15

Physical Dimensions inches (millimeters)



Ceramic Dual-In-Line Package (J)
Order Number CD4093BMJ or CD4093BCJ
NS Package Number J14A



Molded Dual-In-Line Package (N)
Order Number CD4093BM or CD4093BCN
NS Package Number N14A

National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
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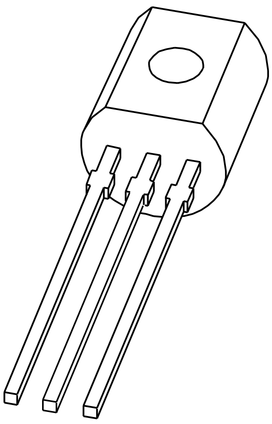
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408

DATA SHEET



BC327
PNP general purpose transistor

Product specification
Supersedes data of 1997 Mar 10

1999 Apr 15

Philips Semiconductors

PHILIPS

PNP general purpose transistor BC327

FEATURES

- High current (max. 500 mA)
- Low voltage (max. 45 V).

APPLICATIONS

- General purpose switching and amplification, e.g. driver and output stages of audio amplifiers.

DESCRIPTION

PNP transistor in a TO-92; SOT54 plastic package.
NPN complement: BC337.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector

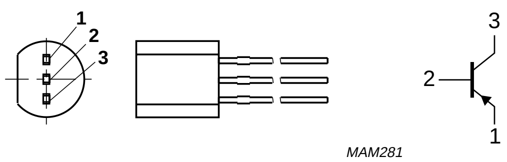


Fig.1 Simplified outline (TO-92; SOT54) and symbol.

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter	–	–50	V
V_{CEO}	collector-emitter voltage	open base	–	–45	V
V_{EBO}	emitter-base voltage	open collector	–	–5	V
I_C	collector current (DC)		–	–500	mA
I_{CM}	peak collector current		–	–1	A
I_{BM}	peak base current		–	–200	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C; note 1	–	625	mW
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	150	°C
T_{amb}	operating ambient temperature		–65	+150	°C

Note

1. Transistor mounted on an FR4 printed-circuit board.

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	note 1	0.2	K/mW

Note

1. Transistor mounted on an FR4 printed-circuit board.

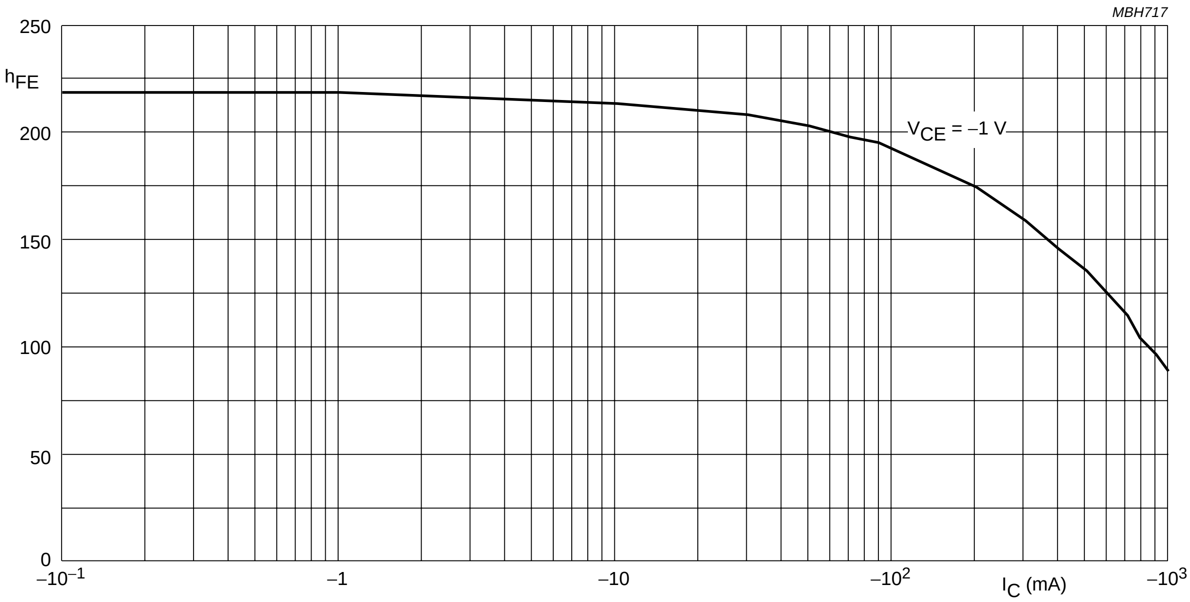
CHARACTERISTICS

T_j = 25 °C unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN.	TYP.	MAX.	UNIT
I_{CBO}	collector cut-off current	I_E = 0; V_{CB} = –20 V	–	–	–100	nA
		I_E = 0; V_{CB} = –20 V; T_j = 150 °C	–	–	–5	μA
I_{EBO}	emitter cut-off current	I_C = 0; V_{EB} = –5 V	–	–	–100	nA
h_{FE}	DC current gain	I_C = –100 mA; V_{CE} = –1 V; see Figs 2, 3 and 4				
	BC327		100	–	600	
	BC327-16		100	–	250	
	BC327-25		160	–	400	
	BC327-40		250	–	600	
h_{FE}	DC current gain	I_C = –500 mA; V_{CE} = –1 V; see Figs 2, 3 and 4	40	–	–	
V_{CEsat}	collector-emitter saturation voltage	I_C = –500 mA; I_B = –50 mA	–	–	–700	mV
V_{BE}	base-emitter voltage	I_C = –500 mA; V_{CE} = –1 V; note 1	–	–	–1.2	V
C_c	collector capacitance	$I_E = i_e$ = 0; V_{CB} = –10 V; f = 1 MHz	–	10	–	pF
f_T	transition frequency	I_C = –10 mA; V_{CE} = –5 V; f = 100 MHz	80	–	–	MHz

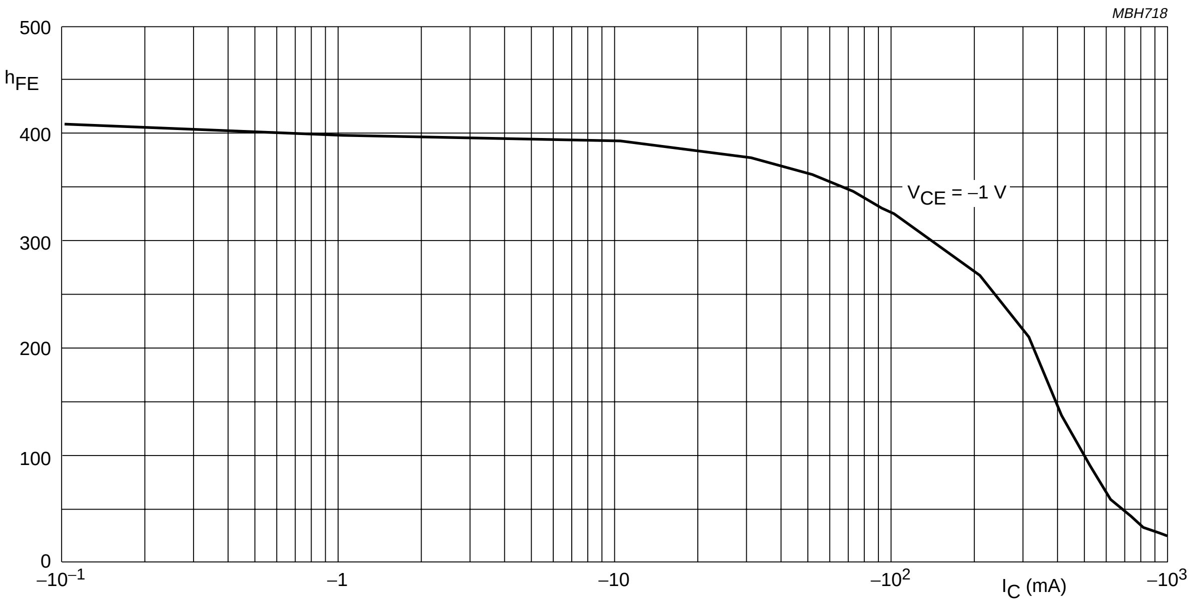
Note

1. V_{BE} decreases by about –2 mV/K with increasing temperature.



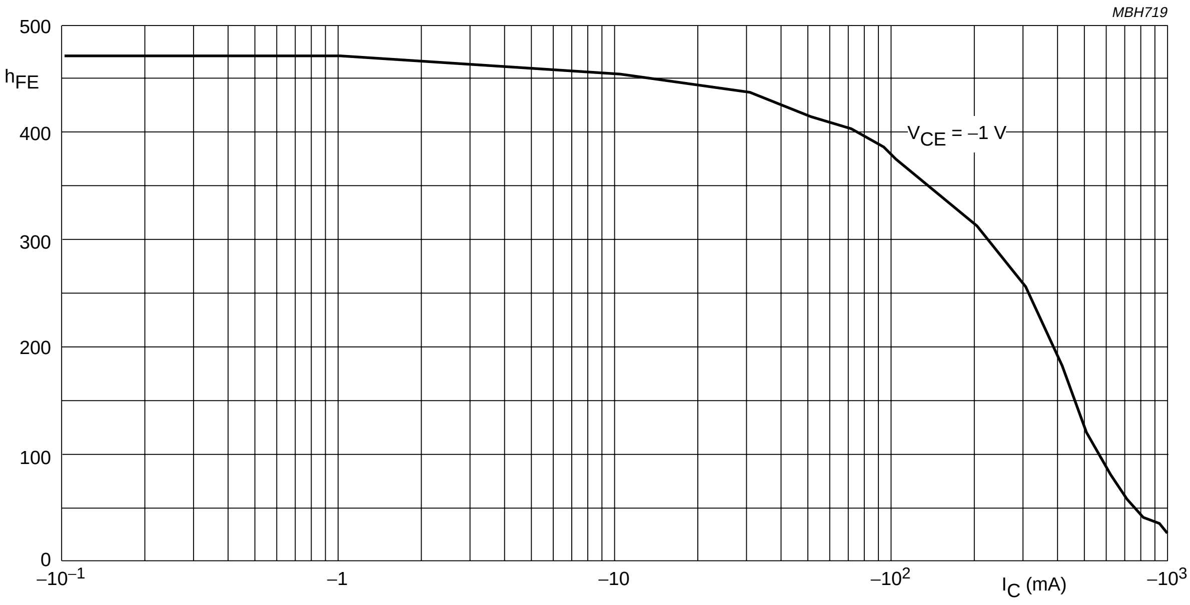
BC327-16.

Fig.2 DC current gain; typical values.



BC327-25.

Fig.3 DC current gain; typical values.

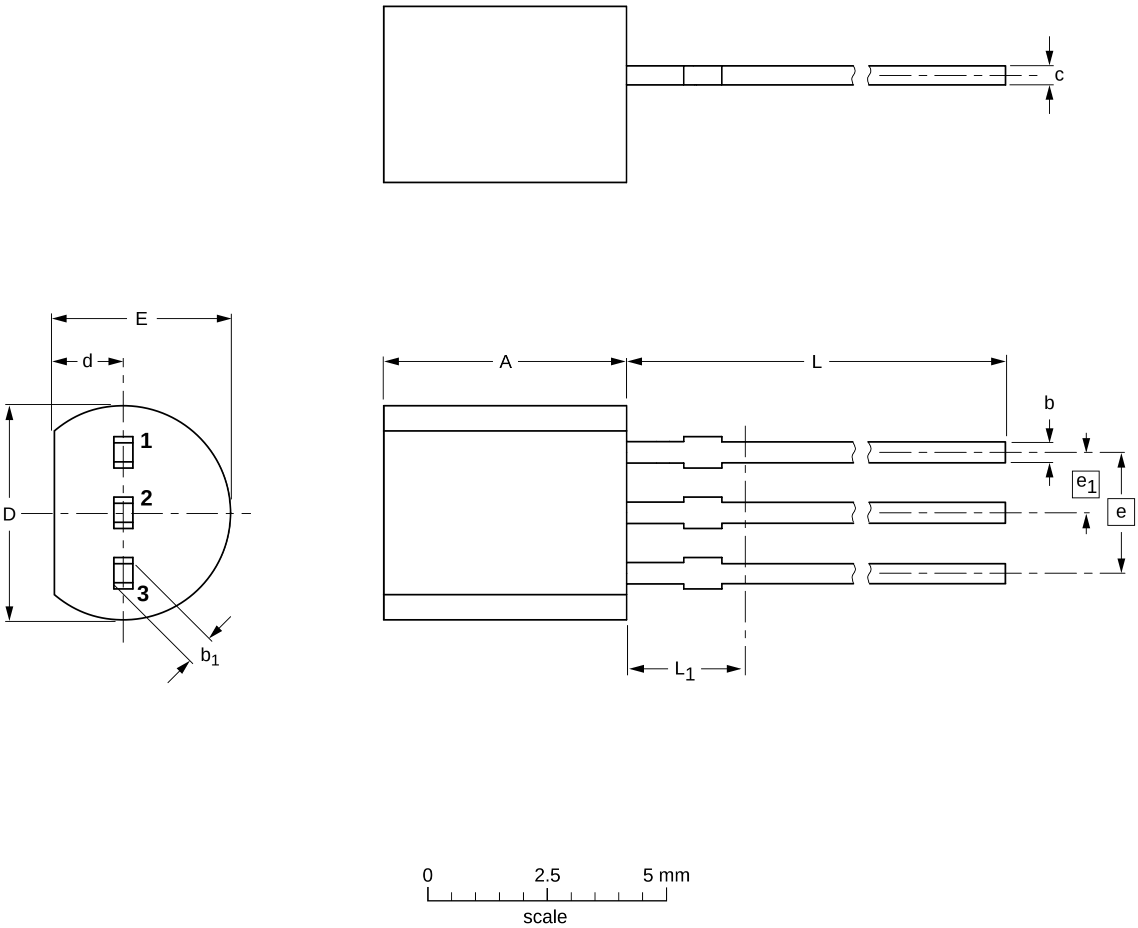


BC327-40.

Fig.4 DC current gain; typical values.

PACKAGE OUTLINE

Plastic single-ended leaded (through hole) package; 3 leads **SOT54**

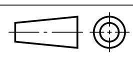


DIMENSIONS (mm are the original dimensions)

UNIT	A	b	b_1	c	D	d	E	e	e_1	L	L_1(1)
mm	5.2 5.0	0.48 0.40	0.66 0.56	0.45 0.40	4.8 4.4	1.7 1.4	4.2 3.6	2.54	1.27	14.5 12.7	2.5

Note

1. Terminal dimensions within this zone are uncontrolled to allow for flow of plastic and terminal irregularities.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT54		TO-92	SC-43			97-02-28

DEFINITIONS

Data sheet status	
Objective specification	This data sheet contains target or goal specifications for product development.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later.
Product specification	This data sheet contains final product specifications.
Limiting values	
Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.	
Application information	
Where application information is given, it is advisory and does not form part of the specification.	

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Argentina: see South America

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Austria: Computerstr. 6, A-1101 WIEN, P.O. Box 213,
Tel. +43 1 60 101 1248, Fax. +43 1 60 101 1210

Belarus: Hotel Minsk Business Center, Bld. 3, r. 1211, Volodarski Str. 6,
220050 MINSK, Tel. +375 172 20 0733, Fax. +375 172 20 0773

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Bulgaria: Philips Bulgaria Ltd., Energoproject, 15th floor,
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Tel. +1 800 234 7381, Fax. +1 800 943 0087

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Denmark: Sydhavnsgade 23, 1780 COPENHAGEN V,
Tel. +45 33 29 3333, Fax. +45 33 29 3905

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Tel. +358 9 615 800, Fax. +358 9 6158 0920

France: 51 Rue Carnot, BP317, 92156 SURESNES Cedex,
Tel. +33 1 4099 6161, Fax. +33 1 4099 6427

Germany: Hammerbrookstraße 69, D-20097 HAMBURG,
Tel. +49 40 2353 60, Fax. +49 40 2353 6300

Hungary: see Austria

India: Philips INDIA Ltd, Band Box Building, 2nd floor,
254-D, Dr. Annie Besant Road, Worli, MUMBAI 400 025,
Tel. +91 22 493 8541, Fax. +91 22 493 0966

Indonesia: PT Philips Development Corporation, Semiconductors Division,
Gedung Philips, Jl. Buncit Raya Kav.99-100, JAKARTA 12510,
Tel. +62 21 794 0040 ext. 2501, Fax. +62 21 794 0080

Ireland: Newstead, Clonskeagh, DUBLIN 14,
Tel. +353 1 7640 000, Fax. +353 1 7640 200

Israel: RAPAC Electronics, 7 Kehilat Saloniki St, PO Box 18053,
TEL AVIV 61180, Tel. +972 3 645 0444, Fax. +972 3 649 1007

Italy: PHILIPS SEMICONDUCTORS, Piazza IV Novembre 3,
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Japan: Philips Bldg 13-37, Kohnan 2-chome, Minato-ku,
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Korea: Philips House, 260-199 Itaewon-dong, Yongsan-ku, SEOUL,
Tel. +82 2 709 1412, Fax. +82 2 709 1415

Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA, SELANGOR,
Tel. +60 3 750 5214, Fax. +60 3 757 4880

Mexico: 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905,
Tel. +9-5 800 234 7381, Fax +9-5 800 943 0087

Middle East: see Italy

Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB,
Tel. +31 40 27 82785, Fax. +31 40 27 88399

New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND,
Tel. +64 9 849 4160, Fax. +64 9 849 7811

Norway: Box 1, Manglerud 0612, OSLO,
Tel. +47 22 74 8000, Fax. +47 22 74 8341

Pakistan: see Singapore

Philippines: Philips Semiconductors Philippines Inc.,
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Metro MANILA, Tel. +63 2 816 6380, Fax. +63 2 817 3474

Poland: Ul. Lukiska 10, PL 04-123 WARSZAWA,
Tel. +48 22 612 2831, Fax. +48 22 612 2327

Portugal: see Spain

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Russia: Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW,
Tel. +7 095 755 6918, Fax. +7 095 755 6919

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Tel. +65 350 2538, Fax. +65 251 6500

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Tel. +27 11 470 5911, Fax. +27 11 470 5494

South America: Al. Vicente Pinzon, 173, 6th floor,
04547-130 SÃO PAULO, SP, Brazil,
Tel. +55 11 821 2333, Fax. +55 11 821 2382

Spain: Balmes 22, 08007 BARCELONA,
Tel. +34 93 301 6312, Fax. +34 93 301 4107

Sweden: Kottbygatan 7, Akalla, S-16485 STOCKHOLM,
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Taiwan: Philips Semiconductors, 6F, No. 96, Chien Kuo N. Rd., Sec. 1,
TAIPEI, Taiwan Tel. +886 2 2134 2886, Fax. +886 2 2134 2874

Thailand: PHILIPS ELECTRONICS (THAILAND) Ltd.,
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Tel. +66 2 745 4090, Fax. +66 2 398 0793

Turkey: Talatpasa Cad. No. 5, 80640 GÜLTEPE/ISTANBUL,
Tel. +90 212 279 2770, Fax. +90 212 282 6707

Ukraine: PHILIPS UKRAINE, 4 Patrice Lumumba str., Building B, Floor 7,
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United Kingdom: Philips Semiconductors Ltd., 276 Bath Road, Hayes,
MIDDLESEX UB3 5BX, Tel. +44 181 730 5000, Fax. +44 181 754 8421

United States: 811 East Arques Avenue, SUNNYVALE, CA 94088-3409,
Tel. +1 800 234 7381, Fax. +1 800 943 0087

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