

**The Pocket Professional™**

**Electrical Engineering Reference Pac**

**Owner's Manual**

**SPARCOM®**

**Edition 2 August 1991**

**Manual Reorder No. 11061-A    Software Reorder No. 10061-1A**



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# Electrical Engineering Reference Pac Changes

The following changes were made to the Electrical Engineering Reference Pac for version 2.5:

- ✓ Browser: Cursor movement and scrolling speed have been increased.
- ✓ Constant Library: Constants have been updated to conform to latest accepted values.

**HP 48GX USERS ONLY:** You should install the application card in Port 1 for two reasons:





1. Application cards installed in Port 1 will execute ~ 20% faster than those installed in Port 2.
2. Application cards installed in Port 2 may experience long pauses (~ 5-10 seconds or more) intermittently during operation. This is not a software defect. It is caused by the new memory architecture of the extended HP 48GX Port 2, which is different from the HP 48SX Port 2. Such pauses will not occur if the application card is operated from Port 1 of the HP 48GX or if it is operated from either port of the HP 48SX.


# Electrical Engineering Reference Pac Manual Changes



These changes apply to the Electrical Engineering Reference Pac Manual, Edition 2, August 1991.





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## Changes for the HP 48GX

General: To display all libraries on the HP 48GX, press   instead of  .

General: On the HP 48GX, the  key has been replaced by CANCEL.

General: To perform a screen dump on the HP 48GX, press  -  instead of  - .

General: To display an item too wide for the display on the HP 48GX, press   instead of  .

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## Changes for Version 2.5

Page 1-8: Using the Search Mode: The search mode is now case-insensitive.

Page 5-7: Decibel Conversions: 2nd picture should display -10.4575749056.

Page 9-4: Constants Library: 2nd picture should include, "h (Planck)," with an updated value of 6.6260755E-34\_J\*s.

Page 9-5: Standard Prefixes: Picture should indicate prefixes as 1E18, 1E15, ....

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# Chapter 1

# Getting Started

## In This Chapter

- ☐ Welcome
- ☐ Installing and Removing the Pocket Professional
- ☐ Using the Main Menu
- ☐ Using the Reference Library
- ☐ Summary of Functions

---

## Welcome

Sparcom's Pocket Professional software is the first of its kind, developed to provide speed, efficiency and portability to students and professionals in the technical fields. The Pocket Professional™ Electrical Engineering Reference Pac instantly transforms the HP 48SX calculator into an electronic handbook, containing over 100 tables of data commonly used by electrical and electronics engineers. The information is organized into an seven-category menu tree with topics and subtopics listed in an easy-to-use "browser" menu format.

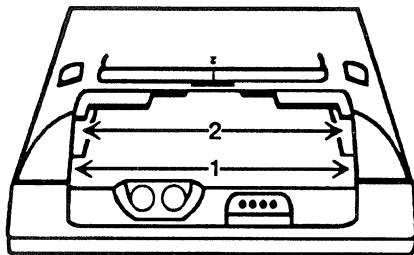
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## Installing and Removing the Pocket Professional

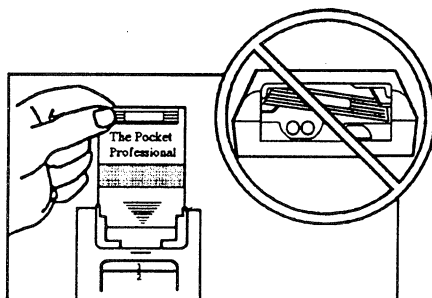
The HP 48SX has two ports for installing plug-in cards. You can install your Electrical Engineering Reference Pac in either port. Be sure to **turn off the calculator** while installing or removing the card. Otherwise, user memory may be erased.

### To Install the Card

1. Turn off the calculator. Do not press **ON** until you have completed the installation procedure.
2. Remove the port cover. Press against the grip lines and push forward. Lift the cover to expose the two plug-in ports.



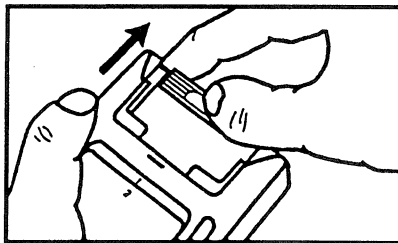
3. Select either empty port for the Pocket Professional card.
4. Position the card just outside the slot. Point the triangular arrow on the card toward the calculator port opening, as shown below.
5. Slide the card firmly into the slot. After you first feel resistance, push the card about 1/4 inch further, until it is fully seated.



6. Replace the port cover.

## To Remove the Card

1. Turn the calculator off. Do not press **ON** until you have completed the procedure.
2. Remove the port cover. Press against the card's grip and slide the card out of the port.

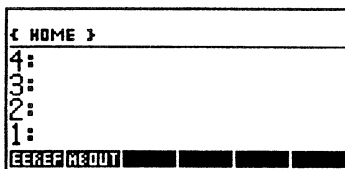


3. Replace the port cover.

## To Access the Reference Pac

After you turn your calculator **[ON]**, there are three ways to access the Electrical Engineering Reference Pac.

**First Method:** Press **[←] [LIBRARY]** to display all libraries available to the HP 48SX. Press the **EEREF** “softkey” (the corresponding blank menu key on the top row of the HP 48SX keyboard) to start the Electrical Engineering Reference Pac.



Pressing the second softkey available at this level, **ABOUT**, displays the revision number of the software. Pressing the **[ATN]** key exits the revision screen and returns you to the screen shown above.

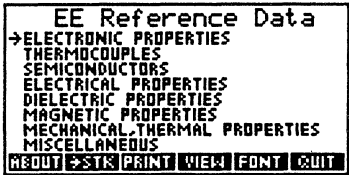
**Second Method:** Type in the letters EEREF (using alpha entry mode, as described in the *HP 48SX Owner's Manual*) and press **[ENTER]**.

**Third Method:** Add the command EEREF to the CST (custom) menu (for more information, refer to Chapter 15 of the *HP-48SX Owner's Manual*, “Customizing the Calculator”). After the command has been added, press

**CST**, then press **EEREF** to start the Electrical Engineering Reference application.

## Using the Main Menu

After you start the Electrical Engineering Reference Pac, the main menu screen appears:



The main menu lists the main categories of the entire electrical engineering reference database in a “browser” menu format. “Browser” refers to the ability to use the cursor keys (**▲**, **▼**) to move the pointer to the menu item you wish to select and to press **ENTER** to call that menu item to the screen. The row of “softkeys” along the bottom of the screen may give you options that relate to the information displayed on any given screen.

**Because the size of the calculator screen is limited, the names of constants and properties are usually abbreviated throughout the reference pac. This manual includes “translations” of these abbreviations where appropriate.**











The items in the main menu are described below:

Electronic Properties	Properties of electronic materials and devices
Thermocouples	Temperature vs. Voltage computation of E, J, K, T, and S type thermocouples





Semiconductors	Properties of selected semiconductors such as Silicon, GaAs, III-V, and II-VI compounds
Electrical Properties	Selected properties of general electrical engineering materials
Dielectric Properties	Selected properties of dielectric materials
Magnetic Properties	Selected properties of magnetic materials
Mechanical, Thermal Properties	Mechanical and thermal properties of selected materials
Miscellaneous	Contains ASCII table, Constants library, common Prefixes and Greek Alphabet

Each main category of the reference pac contains several topics and subtopics. They are described in detail in Chapter 2. The information contained in each topic is based on data extracted from the sources listed in Appendix B. Values given in the Electrical Engineering Reference Pac may vary slightly from values listed by sources not documented in this manual.

## Moving Around the Screen

Use the  and  keys to move the pointer up and down in the menu list. Pressing   moves the pointer to the bottom of the screen, or pages down if the pointer is already at the bottom of the screen. Pressing   moves to the top of the screen or pages up if the pointer is already at the top of the screen. Pressing   moves the pointer to the bottom of the list or   moves to the top of the list.

## Viewing Items Too Wide for the Display

If the text of a topic or subtopic is too wide to fit within the display, an ellipsis (...) appears at the end of the line. Press   to display the rest of the text. Press  or  to return the display to the beginning of the line.

## Changing the Font Size

The default font for the Electrical Engineering Reference Pac displays information in condensed, uppercase letters only. Pressing **FONT** displays the information in a larger font, which is case-sensitive. The font size stays large until you press **FONT** again:

```

▼ EE Reference Data
→Electronic Properties
  Thermocouples
  Semiconductors
  Electrical Properties
  Dielectric Properties
  Magnetic Properties
MAIN → STK PRINT VIEW FONT QUIT
  
```

---

## Example: Using the Reference Pac

Suppose you need the bandgap of silicon in order to calculate doping concentrations for a new device you are designing. At the main menu, move the pointer to SEMICONDUCTORS and press **ENTER**. The list of topics filed under the semiconductors category appears:

```


Semiconductors
→PROPERTIES OF SI
  PROPERTIES OF GAAS
  DONORS IN SILICON
  ACCEPTORS IN SILICON
  III-V COMPOUNDS
  II-VI COMPOUNDS
  OPTICAL PROPERTIES
MAIN → STK PRINT VIEW FONT UP
  
```

Move the pointer to PROPERTIES OF SI and press **ENTER**. This topic contains 28 properties of silicon (in this case there is no subtopic level). Eight properties appear on the screen at a time:

```

▼ Properties of Si
→ATOMS: 5.0E22_1/CM^3
  AT WT: 28.08
  BR FLD: 3E5_V/CM
  XTAL: DIAMOND
  DEN: 2.328_G/CM^3
  ER: 11.8
  NC: 2.8E19_1/CM^3
  NV: 1.0E19_1/CM^3
MAIN → STK PRINT UNIT FONT UP
  
```





Use the  key to scroll down the list to BANDGAP (item number 14). The following screen shows that the bandgap of silicon is 1.12\_eV.

```

Properties of Si
NC: 2.8E19_1/CM^3
NV: 1.02E19_1/CM^3
MLE: 0.97
MTE: 0.19
MTH: 0.16
MHH: 0.5
EL AFFINITY: 4.05_V
→BAND GAP: 1.12_EV
MAIN ←STK PRINT UNIT FONT UP


```

To put the silicon bandgap on the calculator stack, press  (For a summary of the softkeys used throughout the Electrical Engineering Reference Pac, see the end of this chapter.) After you have exited the Electrical Engineering Reference Pac by pressing , the following stack view appears:





```

{ HOME }
4:
3:
2:
1: Band gap: 1.12_eV
EEREF ←STK OUT


```

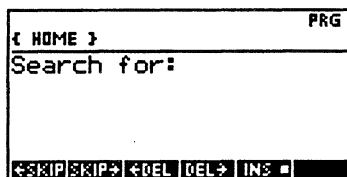
Use the “DTAG” or UVAL command of the HP 48SX to remove the “Band gap” label (See the *HP 48SX* manual for an explanation of units). You may proceed with your calculation or press  to re-enter the Electrical Engineering Reference Pac.


## Managing Units




You can choose whether you want the Electrical Engineering Reference Pac to display units on the screen or not by pressing the  softkey. This softkey toggles between the unit and non-unit modes.  indicates that units will be displayed with all entries. When units are displayed, pressing  places the entry onto the stack with units. When units are not displayed on the screen, units are not included when  is pressed. Note that values in the constants library will be displayed with units whether units are toggled on or off. The Pocket Professional uses standard international (SI) units, customarily used in electrical engineering. Be aware that using units usually increases the processing time for display.

## Using the Search Mode

When data lists are long, it may be faster to locate an item using the search mode. To initiate a search, press the  key. The following screen is displayed:



The calculator is now in *alpha* entry mode, as indicated by the alpha ( $\alpha$ ) annunciator at the very top of the screen. Alpha entry mode overrides the function of the standard keyboard. This means that each key that has a white capital letter printed to its lower right loses its original function and types that letter onto the command line when pressed. (See the *HP 48SX Owner's Manual*, "The Keyboard and Display", for a complete description of how the alpha mode operates). Type the first letter or letters of the name you want to search for, to create the *search string*, and press . The search function is case-sensitive.

The search mode softkeys (    ) along the bottom of the screen are command line editing keys which allow you to edit the search string. Their functions are summarized at the end of this chapter.

---

## Summary of Functions

- |             |  |
|-------------|--|
| <b>FONT</b> | Toggles the display font between condensed and large sizes.  |
| <b>QUIT</b> | Exits the Electrical Engineering Reference Pac.  |
| <b>UP</b>   | Moves up one level in the menus.   |
| <b>MAIN</b> | Moves to the main menu of the Electrical Engineering Reference Pac.  |
| <b>PICT</b> | In a few cases, a picture is available to help explain the data item. Pressing this softkey displays the figure on the screen. |

<b>PRINT</b>	Allows you to print a data field or the entire list of data to an IR printer.
<b>ALL</b>	Sends all the data in a list to an IR printer.
<b>ONE</b>	Sends the data in the field selected by the pointer to an IR printer.
<b>UNITS</b>	Toggles between unit and non-unit modes. The Pocket Professional uses standard international (SI) units customarily used in electrical engineering.
<b>←SKIP</b>	Moves the cursor from its current position to the beginning of the word (left).
<b>SKIP→</b>	Moves the cursor to the beginning of the next word (right).
<b>←DEL</b>	Deletes all the characters from the cursor's position to the beginning of the word (left).
<b>DEL→</b>	Deletes all the characters from the cursor's position to the first character of the next word (right).
<b>INS</b>	Toggles between insert and typeover modes.
<b>VIEW</b>	Displays the entire text of an item too wide to fit on the screen up to an entire screen size. If an item fits on the screen this key is non-functional.
<b>ENTER</b>	Moves to the category, topic, or sub-topic indicated by the pointer.
<b>ATN</b>	Exits the Electrical Engineering Reference Pac.
<b>α</b>	Initiates a case sensitive search for a specific entry.
<b>↵</b>	Moves to the bottom of the screen or pages down.
<b>⏮</b>	Moves to the top of the screen or pages up.
<b>⏮⏮</b>	Moves the pointer to the top of the list.
<b>⏮↵</b>	Moves the pointer to the bottom of the list.
<b>⏮VISIT</b>	Displays remaining data (a screen width at a time) on the screen for entries too wide for the screen. If the topic is too long to fit within the display, an ellipsis (...) is displayed on the right of the screen.

**Notes:**

## Chapter 2

# Electronic Properties

## In This Chapter

This section covers electronic reference data for the following categories:

- Digital Specifications
- Frequency Bands
- Piezoelectric Properties
- Laser Materials
- Electro-Acoustics
- $\mu$ -wave Materials
- Superconductors, Critical Temperature
- Thermionic Emission

## Digital Specifications

This topic contains general specifications of digital circuits. Specifications covered include operating range for logic inputs, switching parameters (such as gate delays), rise time for a typical load, operating and storage temperature ranges, and maximum clock rates. Data is presented for four technologies:

- ☐ NMOS Technology
- ☐ CMOS Technology
- ☐ TTL Technology
- ☐ ECL Technology

The following table lists the properties included for NMOS, CMOS and TTL technologies:

Vdd (typ),	Typical supply voltage
Vdd (max),	Maximum supply voltage
Vdd (min),	Minimum supply voltage
Top (min),	Minimum operating temperature
Top (max),	Maximum operating temperature
Storage T ,	Minimum storage temperature
Storage T ,	Maximum storage temperature
ViL (max),	Input low voltage
ViH (min),	Input high voltage
VoL (max),	Output low voltage

## Electronic Properties

VoH (min),	Output high voltage
IiLk (min),	Minimum input leakage current
IiLk (max),	Maximum input leakage current
IolK (min),	Minimum output leakage current
IolK (max),	Maximum output leakage current
Cin,	Capacitance for an input pin
Cin (I/O) ,	Capacitance of an I/O pin
prop delay,	Typical propagation delay
toggle f ,	Toggle frequency in MHz
Noise immunity,	Voltage
Fan out ,	Fanout

The following list of properties included for ECL Technology varies slightly from the data given in the table above:

VEE (typ),	Typical supply voltage
VEE (max),	Maximum supply voltage
VEE (min),	Minimum supply voltage
Top (min),	Minimum operating temperature
Top (max),	Maximum operating temperature
Storage T,	Minimum storage temperature
Storage T,	Maximum storage temperature
ViL (max),	Input low voltage
ViH (min),	Input high voltage
VoL (max),	Output low voltage
VoH (min),	Output high voltage
IiLk (max),	Maximum input leakage current
Cin,	Capacitance of an input pin
Cout,	Capacitance of an output pin
prop delay,	Typical propagation delay
toggle f,	Toggle frequency in MHz
Noise immunity,	Voltage
Fan out,	Fanout

## Frequency Bands

Microwave frequencies are generally grouped into different frequency bands. The bands and the corresponding frequency ranges are included under the two subtopics below:

- New Frequency Bands
- Millimeter and Submillimeter Bands

### New Frequency Bands

In 1970, a new band designation scheme was adopted. This new designation categorizes frequency bands as follows:

- Band A through M
- Millimeter bands
- Submillimeter bands
- Frequency ranges for each band are presented.

## Millimeter and Submillimeter Bands

Traditional definitions of microwave bands and waveguide sizes are included for the following bands:

Band L  
 Band S  
 Band G  
 Band C  
 Band J  
 Band H  
 Band X  
 Band M  
 Band P  
 Band N  
 Band Ku  
 Band K  
 Band R  
 Millimeter Band  
 Submillimeter Band

Data available for each band include waveguide size and frequency ranges.

## Piezoelectric Properties

This subtopic covers two aspects of piezoelectric materials:

Piezoelectric Constants  
 Piezoelectric, Pyroelectric and Ferroelectric Properties

### Piezoelectric Constants

In this subtopic, physical properties of piezoelectric materials, such as quartz, lithium sulfate, barium titanate, PZT-4, PZT-5 and lead niobate, are included. The properties and definitions listed for each material are shown below:

Density	Density
Acous	Acoustic impedance
$F^*t$	Frequency thickness constant
Max T	Maximum operating temperature
$\epsilon_r$	Dielectric constant
k33	Electromechanical coupling factor for thickness mode
kp	Electromechanical coupling for radial mode
Elastic Q	Elastic quality factor
d33	Piezoelectric modulus
q33	Piezoelectric pressure constant
$\rho$	Electrical resistivity
Curie T	Curie temperature
Young M	Young's modulus
Tensile str	Tensile strength

### Piezo/Pyro/Ferro Properties

Piezoelectric and pyroelectric materials are non-centrosymmetric. The properties of the following common materials are included in this subtopic:

$\text{NaK}_4\text{H}_4\text{O}_8 \cdot \text{H}_2\text{O}$   
Rochelle salt  
 $\text{KH}_2\text{PO}_4$   
 $\text{Pb}_2\text{KNb}_5\text{O}_{15}$   
 $\text{BaTiO}_3$   
 $\text{Bi}_4\text{Ti}_3\text{O}_{12}$   
 $\text{LiNbO}_3$   
DOBAMBC - Smectic liquid crystal  
PVDF - Polyvinylidene fluoride

For each material, the following properties are listed:

Tcrit	Critical temperature
Spont. Polar.	Spontaneous polarization
Temp	Spontaneous polarization temperature
Piezoelec $\eta$	Piezoelectric efficiency
Pyroelec coeff	Pyroelectric coefficient

### Laser Materials

In this topic, properties of semiconductor lasers, pulsed lasers, common continuous wave (CW) lasers and commercial CW lasers are included.

#### Semiconductor Laser

Key properties of various semiconductor lasers using III-V and II-VI compounds are listed by their active layer in this sub-topic. The lasers described in this subtopic included the following materials:

$\text{Ga}_{(1-x)}\text{Al}_{(x)}\text{As}/\text{Ga}_{(1-y)}\text{Al}_{(y)}\text{As}$   
(GaIn)P/-  
 $\text{Ga}(\text{AsP})/(\text{GaIn})\text{P}$   
(GaIn)(AsP)/InP  
 $\text{Ga}(\text{AsSb})/(\text{GaAl})(\text{AsSb})$   
 $(\text{GaAl})\text{Sb}/(\text{GaAl})(\text{AsSb})$   
 $(\text{GaIn})(\text{AsSb})/(\text{GaAl})(\text{AsSb})$   
(PbSn)Te/-  
(PbSn)Se/-  
(PbSn)Te/PbTe  
Pb(SSe)/PbSe  
(PbSn)Se/PbSe

For each laser type above, the following properties are included:

Passive layer  
Substrate  
Lattice match  
Laser type  
Wavelength (range),  $\lambda$   
Current density,  $J_{th}$



## Pulsed Lasers

Some common high-powered pulsed lasers in the wavelength range from 157 nm to 496  $\mu\text{m}$ , such as Fe, ArF and XeCl, are included in this subtopic.

Properties covered include:

- Active atomic or molecular species
- State of material
- Pulse width
- Energy/pulse
- Rate in pulses per second

## Common CW Lasers

Common CW lasers in the wavelength range from 325 nm to 496  $\mu\text{m}$  forms the basis of this subtopic. The properties covered include:

- Atom or molecule
- Material
- Power

## Commercial CW Lasers

Characteristics of commercial continuous wave lasers, such as Argon, Krypton, and Dye, are covered in this subtopic. Properties listed include the following:

- |            |   |
|------------|---|
| Type       | Type of laser                           |
| Wavelength | Wavelength                              |
| Pwr TEM    | Power in TEM <sub>00</sub> mode (range) |
| Pwr mult   | Power in multimode (range)              |
| Beam dia   | Beam diameter (range)                   |
| Beam div   | Beam divergence (range)                 |

## Electro-Acoustics

Electro-acoustics data defines the relationship between sound and its electrical analogs. The Electrical Engineering Reference Pac covers four subtopics in electro-acoustics:

- Sound Intensity Equations (simplified)
- Sound Velocity in Liquids
- Sound Velocity in Metals
- Sound Velocity in Miscellaneous Materials

## Sound Intensity Equations (simplified)

In this subtopic, the simplified equations for sound intensity for quartz, ammonium dihydrogen phosphate (ADP), Rochelle salt (0°C), and barium titanate (40°C) are tabulated. The properties listed for each material are:

- |           |                                 |
|-----------|---------------------------------|
| Mode      | Modes of vibration              |
| Xtal cut  | Crystal cut                     |
| Piezo mod | Effective piezoelectric modulus |

## Electronic Properties

velocity	Sound velocity
$\rho$	Density
Sound inten	Sound intensity equation in water (for an air backed transducer). In these equations, the following definitions apply: $f_0$ = frequency in MHz, $V$ = Voltage in kV, $E$ = Electric field in kV/cm. *

Note that  $E$  appears in some equations for Electric field. In some equations,  $1E4$  ( $= 10,000$ ) is used as a conversion factor.

## Sound Velocity in Liquids

In liquids, sound velocity is determined by the liquid's compressibility and density. In this subtopic, the sound velocities of water, mercury and many organic solvents at specified temperatures are tabulated.

## Sound Velocity in Metals

In this subtopic, electro-acoustic properties of common metals, such as aluminum, beryllium, zinc, and zirconium, are listed:

Vel bulk	Longitudinal bulk velocity (in m/s and in/s)
Vel bar	Longitudinal bar velocity (in m/s and in/s)
Vel shear	Shear velocity (in m/s and in/s)
Density	Density
Char imp	Characteristic impedance

## Sound Velocity in Miscellaneous Materials

In this subtopic electro-acoustic properties of many common materials, such as crown glass, granite, ice and nylon, are included. The properties are the same as those listed above for sound velocity in metals.

## $\mu$ -wave Materials

This subtopic lists key properties of commercially available microwave garnets and a variety of rare earth compounds. The properties covered include:

Comp	Composition
Sat magzn	Saturation magnetization
Curie temp	Curie temperature
Resn ln wid	Resonance line width
Lande g fac	Lande g factor
Coercive f	Coercive force
$\epsilon_r$	Dielectric constant
$\tan(\delta)$	Dielectric loss factor
Remanent ind	Remanent induction

## Superconductors, Critical Temperature

This subtopic lists the critical temperature for over 40 superconducting metals, alloys, and compounds.

## Thermionic Emission

This subtopic includes two thermionic properties, the work function and Richardson's constant of cathodes made of the following materials:

### Materials, Examples

Metals,	Tungsten,, zirconium,, cesium,, barium
Metallic films,	Tungsten-cesium,, tantalum-thorium
Oxide films,	BaO and thoria
Compounds,	TiC and ThO <sub>2</sub>

**Notes:**

## Chapter 3

# Thermocouples

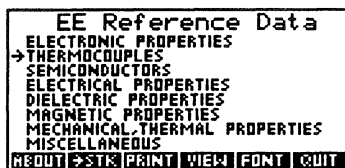
### In This Chapter

Thermocouple analysis is used to convert measured voltage to temperature and vice versa. This chapter covers:

- E Type
- J Type
- K Type
- S Type
- T Type

---

### Thermocouples



This analysis tool is designed to convert a temperature to a thermocouple output in millivolts and vice versa. The software has the ability to handle T, E, J, K and S type thermocouples. The implied assumption for a reference temperature is 0 °C. The thermocouple computations are based on the IPTS-68 standards.

### Using the Thermocouples Function

Select THERMOCOUPLES at the main menu. The first screen lists the five types of thermocouple values supported by the software.



As an example, suppose you want to find the corresponding temperature of an E type thermocouple showing a 22.13 millivolt reading. First, move the pointer to TYPE E and press **ENTER** to display the following screen:

```

Type E Thermocouple
→VOLTAGE(MV): 0
TEMP(°C): 0

HELP T→V V→T ⇄STK FONT QUIT

```

At the voltage prompt press **ENTER** and type 22.13 and press **ENTER** again.

```

Type E Thermocouple
VOLTAGE(MV): 22.13
→TEMP(°C): 0

HELP T→V V→T ⇄STK FONT QUIT

```

The screen displays this value as voltage in millivolts. Next, press the **V→T** softkey to initiate the voltage-to-temperature conversion calculation (314.059 °C):

```

Type E Thermocouple
VOLTAGE(MV): 22.13
→TEMP(°C): 314.059428565

HELP T→V V→T ⇄STK FONT QUIT

```

The Help screen contains limits on voltages and temperatures for each type of thermocouple. Simply press the **HELP** softkey to view the Help screen.

```

Help Screen
→T→V TEMP. RANGE(°C): -270/1000
V→T TEMP. RANGE(°C): 0/400
V→T MAX DEV(°C): 0.25

FONT UP

```

## Basis for Temperature/Voltage Conversions

The temperature-to-voltage conversion is based on a 12th to 14th order polynomial, ensuring very precise calculations. The voltage-to-temperature

conversion is based on a 5th or 6th order polynomial. A maximum deviation listing or applicable temperature ranges are displayed on each screen.

---

## Summary of Softkeys

<b>FONT</b>	Toggles between small and large display fonts.
<b>-STK</b>	Copies selected entry to calculator stack.
<b>QUIT</b>	Moves up one level in the menu structure.
<b>T-V</b>	Converts temperature specified in °C to voltage in mV.
<b>V-T</b>	Converts voltage specified in mV to temperature in °C.





# Chapter 4

## Semiconductors

### In This Chapter

In this topic, semiconductor properties are classified into seven subtopics:

- Properties of Silicon
- Properties of GaAs
- Donors in Silicon
- Acceptors in Silicon
- III-V Compounds
- II-VI Compounds
- Optical Properties

### Properties of Silicon

Selected electronic properties of silicon are listed in this subtopic:

Atoms	Atoms/cm <sup>3</sup>
At wt	Atomic weight
Br fld	Breakdown field
xtal	Crystal structure
Den	Density
$\epsilon_r$	Dielectric constant
N <sub>c</sub>	Effective density of states (Conduction band)
N <sub>v</sub>	Effective density of states (Valence band)
m <sub>le</sub>	Effective mass of electrons
m <sub>te</sub>	Transverse effective mass of electrons
m <sub>th</sub>	Effective mass of holes
m <sub>hh</sub>	Transverse effective mass of holes
El affinity	Electron affinity
Band gap	Bandgap
n <sub>i</sub>	Intrinsic carrier concentration
Lattice a	Lattice constant
$\alpha_{th}$	Coefficient of thermal expansion
M pt	Melting point
$\tau$	Minority-carrier lifetime
$\mu_n$	Mobility of electrons
$\mu_p$	Mobility of holes
Raman E	Raman phonon energy
Sp ht	Specific heat
Th cond	Thermal conductivity at 300 °C
Diff con	Thermal diffusivity
Vapor pr	Vapor pressure at 1600 °C
Vapor pr	Vapor pressure at 930 °C

## Properties of GaAs

The properties of GaAs are given in the same order as the properties of silicon, listed above.

## Donors in Silicon

In this subtopic, the activation energy levels of many known donors in silicon are listed. By convention, the energy levels given are referenced to the conduction band. For deep donors, such as silver, energy levels are referenced to the valence band (VB).

## Acceptors in Silicon

Most known acceptor levels in silicon are listed in this subtopic. By convention, the energy levels given are referenced to valence band. For deep acceptor levels, such as for magnesium, energy levels are referenced to the conduction band (CB).

## III-V Compounds

This subtopic includes the following III-V compounds:

GaP  
GaSb  
InAs  
InP  
InSb

For each of these compounds, the following properties are listed:

Eg	Energy gap
$\mu n$	Electron mobility
$\mu p$	Hole mobility
mn/mo	Effective energy mass
mp/mo	Effective hole mass
a	Lattice constant
MP	Melting point
$\epsilon r$	Dielectric constant
density	Density

## II-VI Compounds

This subtopic includes properties for the following II-VI compounds:

CdS  
CdSe

CdTe  
ZnS  
ZnSe  
ZnTe

The properties listed in this subtopic are the same as those listed for III-V compounds.

## Optical Properties

The Electrical Engineering Reference Pac covers two subtopics under this heading:

Refractive Index  
Light Guide System Sensitivity

### Refractive Index

This subtopic lists free space, refractive indices and material wavelengths for three types of glass, for GaAlAs, and for plastic commonly used by electrical engineers.

### Light Guide System Sensitivity

This subtopic lists sensitivities of state-of-the-art receivers in the wavelength range from 1300 and 1550 nm. Materials covered are:

InGaAs PINFET (-40.4)  
Ge APD (-33.1)  
Ge APD (-37.1)  
Ge APD (-20.5)  
InGaAs/InP APD (-46.5)  
InGaAs SAGM APD (-45.2)  
InGaAs SAGM APD (-44.5)  
InGaAs PINFET (-38.0)  
Ge APD (-35.5)  
InGaAs PINFET (-34.0)  
InGaAs SAGM APD (-36.6)  
InGaAs SAGM APD (-28.2)  
InGaAs SAGM APD (30.6)

Wavelength, sensitivity, BER and line rate are included for each receiver. Numbers in parenthesis are sensitivities in dBm.

**Notes:**

## Chapter 5

# Electrical Properties

## In This Chapter

In this broad category, eight subtopics are included:

- Resistor Color Chart
- Standard Component Values
- Wire Gauge
- VSWR Calculations
- Decibel Conversion
- Battery Characteristics
- Solders and Brazes
- Film Electrical Properties

---

## Resistor Color Chart

Upon choosing Resistor Color Chart from the Electrical Properties menu, the following screen appears:

--[       ]--					
BLACK		BROWN		RED	
ORANGE		YELLOW		GREEN	
BLUE		VIOLET		GREY	
WHITE		SILVER		GOLD	
NONE					
1ST	2ND	3RD	4TH	CALC	EXIT

The calculator computes the resistor value for a resistor that has 4 color bands specified. The input screen has three distinct areas; top row that is updated with color choices made; the middle area specifying colors; the softkey row with keys labelled **1ST**, **2ND**, **3RD**, **4TH**, **CALC** and **EXIT**. To select a color, use the cursor keys to match the desired color and press the softkeys **1ST**, **2ND**, **3RD** or **4TH**. Once the four color bands have been specified, press **CALC** to compute the resistance and display the result. Pressing **EXIT** key will return to the previous menu level.

Pressing **ENTER** will display the color band definitions as shown below:

I II III IV				I II III IV			
SILV	±E2	±10%		YEL	4	±E4	
GOL	±E1	±5%		GRN	5	±E5	±.5%
BLK	0	±E0		BLU	6	±E6	±.25%
BRN	1	±E1	±1%	VIOL	7	±E7	±.10%
RED	2	±E2	±2%	GRY	8	±E8	±.05%
ORA	3	±E3		WHI	9	±E9	
PRESS [ENTER] TO RETURN TO LIST...							

**Example:** Find the resistance of a 4 band resistor with the following colors: BROWN, BLACK, YELLOW, GOLD.

Move the cursor to BROWN and press **1ST**

Move the cursor to BLACK and press **2ND**

Move the cursor to YELLOW and press **3RD**

Move the cursor to GOLD and press **4TH**, the screen should look as follows:

--[BRN BLK YEL GOL]--		
BLACK	BROWN	RED
ORANGE	YELLOW	GREEN
BLUE	VIOLET	GREY
WHITE	SILVER	GOLD
NONE		
1ST	2ND	3RD 4TH CALC EXIT

Pressing **CALC** displays the following screen:

--[BRN BLK YEL GOL]--	
Value:	
100.00_kΩ	
Tolerance:	
± 5%	
PRESS [STO] TO SAVE TO STACK ...	
PRESS [ENTER] TO RETURN TO LIST ...	

Press **[STO]** to save the result to the stack, or **[ENTER]** or **[ATN]** to return to the Electrical properties menu without saving the result on the stack.

## Standard Component Values

The Electrical Engineering Reference Pac computes the closest standard component value available for a specified tolerance value. Upon selecting this function, the following screen appears:

{ HOME EEREF }	PRG
Enter component value: <value>	
↓	
PICO	NANO MICRO MILLI KILO MEGA

When entering a component value, a row of softkeys PICO, NANO, MICRO, MILLI, KILO, MEGA, FEMT, GIGA enhance data entry by adding appropriate multipliers.

This analysis section computes the closest standard resistance value to the one specified using the selected tolerance.

**Example:** Find the closest standard value for a 123  $\Omega$  resistor and 5% tolerance.

Type 123 and press ENTER. The program prompts for input of tolerance level as shown by the screen below:

Pick tolerance:		
± 20%	± 2%	± 0.25%
± 10%	± 1%	± 0.10%
± 5%	± 0.5%	± 0.05%
		EXIT

Use the cursor to pick the appropriate tolerance value of 5% and press ENTER. The result of the computation is displayed as follows:

--[BRN RED BRN GOL]--
Value: 120_?
Tolerance: ± 5%
PRESS [STO] TO SAVE TO STACK ...
PRESS [ENTER] TO RETURN TO LIST ...

The result is presented as a 120\_?, along with tolerance value, the color scheme for a standard resistor. The standard values work with capacitors and inductors in addition to resistors.

Press **[STO]** to save the result to the stack, or **[ENTER]** or **[ATN]** to return to the Electrical properties menu without saving the result on the stack.

# Wire Gauge

This topic provides gauge comparisons for a variety of conductors in the following areas:

- ☐ Solid Copper
- ☐ Annealed Copper
- ☐ Hard Drawn Copper
- ☐ Copper Wire Table
- ☐ Stranded Conductors
- ☐ Maximum Current Capacity
- ☐ Fusing Current

## Solid Copper

In this subtopic, properties of various wire gauges from numbers 0 through 21 are listed. Wire classifications by American (B&S), Birmingham (Stubs) and British standard (NBS) are included. The properties listed for each entry are diameter, area, and weight.

## Annealed Copper

In this subtopic, properties of annealed wire gauges from number AWG (B&S) 0000 through 40 are listed. The properties for each entry are:

Dia	Diameter
Area	Cross sectional area
Res/1kft	Resistance per 1000 ft at 20 °C
Wt/1kft	Weight per 1000 ft
Length/lb	Length per pound
Length/Ω	Length per Ω at 20 °C
Res/lb	Resistance per pound at 20 °C

## Hard Drawn Copper

In this subtopic, properties of hard drawn copper wire with AWG (B&S) gauges 4/0 to 18 are listed. The properties for each entry are:

Wire Dia	Wire diameter
Brk load	Breaking load
Tnsle St	Tensile strength
Wt/1kft	Weight per 1000 ft.
Wt/mile	Weight per mile
Res/1kft	Maximum resistance per 1000 ft at 20 °C
Area	Cross sectional area

## Copper Wire Table

The Electrical Engineering Reference Pac lists the following properties of stranded copper wire with AWG (B&S) gauges 4/0 to 20:



# wires	Number of wires
Ind wire dia	Individual wire diameter in inches
Cable dia	Cable diameter in inches
Area	Area in square inches
Wt/kft	Weight per 1000 ft.
Wt/mile	Weight per mile
R/kft	Resistance per 1000 ft at 20 °C

## Stranded Conductors

In this subtopic, physical properties of stranded copper conductors with AWG (B&S) gauges 0 to 30 are listed:

# strands	Number of strands
# msng strands	Allowable number of missing strands
dia strand	Nominal diameter of individual strands
Max dia strand	Maximum diameter of stranded conductor
Res (Sn coat)	Resistance per 1000 ft. at 20 °C (tin coated)
Res (Ag plate)	Resistance per 1000 ft at 20 °C (silver plated)
Res (Ni plate)	Resistance per 1000 ft. at 20 °C (nickel plated)
Res (hi str cu)	Resistance per 1000 ft at 20 °C (silver plated/copper alloy)

## Maximum Current Capacity

The Electrical Engineering Reference Pac lists the maximum current capacity of copper and aluminum conductors for sizes 30 through 0000. The data for each size include the following:

Sngl Cu wire	Single wire (copper)
Bndld Cu wire	Bundled wire (copper)
Sngl Al wire	Single wire (aluminum)
Bndld Al wire	Bundled wire (aluminum)
Natl Ele code	Maximum current - National Electric code
UL at 60 °C	Maximum current - Underwriters Laboratory (at 60 °C)
UL at 80 °C	Maximum current - Underwriters Laboratory (at 80 °C)
Am Insurance	Maximum current - American Insurance Association Standards
500 c mils	Current for 500 circular mils area

## Fusing Current

This subtopic covers the fusing currents for AWG wire sizes 40 through 6 for the following materials:

- Al - aluminum
- Cu - copper
- GS - German silver
- Fe - iron
- Sn - tin

The fusing current can be predicted using the empirical relationship:

$$I = K.d^{3/2}$$

where  $I$  is the fusing constant,  $K$  is a constant, and  $d$  is the wire diameter. The constant  $K$  is indicated for each material.

## Voltage Standing Wave Ratio Calculations

This section allow Ham and CB operators as well as communications engineers to compute the VSWR of their antenna feed lines. The VSWR is the ratio of maximum voltage to the minimum voltage along the line. It is the measure of the mismatch between the line and its load. When the line and the load are perfectly matched, the VSWR is equal to 1. For mismatch conditions the VSWR increases, limiting the amount of power radiated by the transmitter. In order to calculate the VSWR, the incident power and the reflected power of the line must be entered.

**Example:** Suppose the reflected wave power is 2.5 Watts, and the incident wave power is 180 Watts, compute the VSWR.

After selecting the VSWR calculations item from the Electrical Properties menu, the following screen is displayed:

PRG

{ HOME EEREF }

Enter reflected and  
 incident wave power:  
 <watts> <watts>

←SKIP SKIP→ ←DEL DEL→ INS →STX

Type 2.5 SPC 180 ENTER. The result is displayed in the following screen:

Result:  
 1.26719102463

PRESS [STO] TO SAVE TO STACK ...  
 PRESS [ENTER] TO RETURN TO LIST ...

Press STO to save the result to the stack, or ENTER or ATN to return to the Electrical properties menu without saving the result on the stack.

## Decibel Conversions

This section allows the conversion of Current, Voltage, and Power ratio's to decibels (dB).

- ☐ Voltage
- ☐ Current
- ☐ Power

**Example:** Convert the Output current of 3 milliamps to Input current of 10 milliamps to decibels.

After selecting the Current item from the Decibel Conversions menu, the following screen is displayed:

PRG
{ HOME EEREF }
Enter input and output currents: <in> <out>
←SKIP→ ←DEL DEL→ INS →STX

Type 10  3 . The result is displayed in the following screen:

Result: 10.4575749056
PRESS [STO] TO SAVE TO STACK ... PRESS [ENTER] TO RETURN TO LIST ...

Press  to save the result to the stack, or  or  to return to the Electrical properties menu without saving the result on the stack.

## Battery Characteristics

This subtopic lists characteristics of the following major battery systems:

- Leclanche
- Magnesium
- Alkaline-MnO<sub>2</sub>
- Mercury
- Mercad
- Silver oxide
- Zinc-air
- Li-SO<sub>2</sub>

**Electrical Properties**

- Li-MnO<sub>2</sub>
- Cuprous chloride
- Zinc-silver-oxide
- Lead-acid
- Edison
- Nickel-cadmium
- Silver-zinc
- Nickel-zinc
- Nickel-hydrogen
- Silver-cadmium
- Zinc-chlorine
- High temperature (Li/FeS)
- High temperature (Na/S)

The data presented for each battery include anode and cathode materials, theoretical voltages and capacity, and typical voltage and capacity.

---

**Solders and Brazes**

The Electrical Engineering Reference Pac lists solders and brazes from Dupont and ESL by melting point. The reference data include the following:

- |      |                          |
|------|--------------------------|
| No.  | Manufacturer's ID number |
| Comp | Composition              |
| MP   | Melting point            |

---

**Film Electrical Properties**

This subtopic covers the following properties for both thin and thick films.

- |                  |  |
|------------------|--|
| Film sheet res   | Film sheet resistivity                 |
| Res range        | Resistivity range                      |
| Init Tolerance % | Resistance tolerance, initial          |
| with trimming %  | Resistance tolerance with trimming     |
| Temp coeff       | Temperature coefficient of resistance  |
| Matching         | Matching temperature coefficient       |
| Power            | Power dissipation                      |
| Stability        | Stability per year                     |
| Sht resistance   | Metal sheet resistance                 |
| Line resolutin   | Line resolution                        |
| $\epsilon r$     | Dielectric constant                    |
| Capacitance      | Capacitance per area                   |
| Range (min)      | Minimum range of data                  |
| Range (max)      | Maximum range of data                  |
| Temp coeff       | Temperature coefficient of capacitance |
| Allowed stress   | Allowable stress                       |
| Operating V      | Operating voltage                      |

## Chapter 6

# Dielectric Properties

## In This Chapter

In this topic, various properties of dielectric materials are classified into five categories:

- Insulating Materials
- Dielectric Constants
- Insulator Resistance
- Insulating Films
- Insulating Liquids

## Insulating Materials

This subtopic lists characteristics of a wide range of insulating materials:

Types of Insulating Materials	Examples
Ceramics	$\text{Al}_2\text{O}_3$ , $\text{MgO}$ , Porcelain, $\text{TiO}_2$
Glass	Iron-sealing glass, soda-borosilicate
Plastic	Alkyd resin, cross linked polystyrene, polyvinyl
Organic liquids	Benzene, ethyl alcohol, Vaseline, jet fuel
Waxes	Beeswax, polybutene, dichloronaphthalene
Rubbers	Butyl rubber, neoprene rubber
Wood	Douglas fir, balsa, birch
Miscellaneous	Amber, paper, mica

For each material, properties include (if available):

Temp	Temperature °C
$\epsilon_r$ at 1kHz	Dielectric constant at 1_kHz
$\epsilon_r$ at 1MHz	Dielectric constant at 1_MHz
$\epsilon_r$ at .1GHz	Dielectric constant at .1_GHz
$\epsilon_r$ at 3 GHz	Dielectric constant at 3_GHz
$\tan(\delta)$ 1kHz	Dissipation factor at 1_kHz
$\tan(\delta)$ 1MHz	Dissipation factor at 1_MHz

## Dielectric Properties

$\tan(\delta)$ .1GHz	Dissipation factor at .1 GHz
$\tan(\delta)$ 3GHz	Dissipation factor at 3 GHz
Dielectric st	Dielectric strength (at 25 °C)
$\rho$ at 25 °C	Resistivity (at 25 °C)
Therm expn	Thermal expansion
Softening pt	Softening point
Moisture abs	Moisture absorption

## Dielectric Constants

Lists approximate dielectric constants at 20 °C and at a pressure of 1 atmosphere for 40 materials.

## Insulator Resistance

This subtopic lists dielectric constant and loss factors at 1 MHz for 21 insulating materials, such as:

- Cellulose acetate
- Polypropylene
- Polystyrene, foam
- Hard rubber
- Forsterite
- Alumina
- Fused quartz
- Boron nitride

## Insulating Films

This subtopic lists properties for 18 different insulating films, such as:

- Cellulose acetate
- Polyurethane elastomer
- Polyethylene
- Polyimide
- Fluorohalocarbon
- TFE-tetrafluoroethylene
- Cellulose triacetate
- FFP-fluorocarbon
- Polyvinyl chloride
- Polyimide

Properties include:

- Processing
- Forms
- Thickness
- Maximum width
- Area factor
- Specific gravity
- Tensile strength

Elongation	
Burst strength	
Tear strength	
Endurance	
H <sub>2</sub> O absorption	
$\epsilon_r$ , 1kHz	Dielectric constant at 1_kHz
$\epsilon_r$ , 1MHz	Dielectric constant at 1_MHz
$\epsilon_r$ , 1GHz	Dielectric constant at 1_GHz
$\delta$ , 1kHz	Dissipation factor $\delta$ at 1_kHz
$\delta$ , 1MHz	Dissipation factor $\delta$ at 1_MHz
$\delta$ , 1GHz	Dissipation factor $\delta$ at 1_GHz
Dielec st	Dielectric strength
Resistivity	Resistivity
Orientation	Orientation

## Insulating Liquids

This subtopic lists properties of transformer oil, cable and capacitor oil, solid cable oil, and transformer Askerel:

Sp gr	Specific gravity
Saybolt VICS	Saybolt viscosity
Flash pt	Flash point
Fire pt	Fire point
Pour pt	Pour point
Sp ht	Specific heat
Coef expan	Coefficient of expansion
Th cond	Thermal conductivity
dielec st	Dielectric strength
$\epsilon_r$	Dielectric constant
$\rho$	Resistivity

**Notes:**



## Chapter 7

# Magnetic Properties

## In This Chapter

The properties of magnetic materials listed in the Electrical Engineering Reference Pac are classified into six categories:

- High Permeability Materials
- High Remanance Materials
- Laminated Cores
- Soft Magnetic Materials
- Laminated/Wound Cores of Silicon Steel
- Ferrites

## High Permeability Materials

This subtopic lists magnetic properties for 15 different high permeability materials, such as iron, mumetal, supermalloy and ferroxcubes:

comp	Composition
Init $\mu$	Initial permeability
Max $\mu$	Maximum permeability
Coercivity	Coercivity
Retentivity	Retentivity
B max	B maximum
$\rho$	Resistivity

## High Remanance

This subtopic lists the following magnetic properties of 23 different high remanant materials, such as carbon steel, tungsten steel, and Alnico:

Comp	Composition
Hmax	H maximum
Bmax	B maximum
Br	Retentivity
Hc	Coercivity
BdHd	External energy
Form	Typical form
$\rho$	Resistivity

**Laminated Cores**

This subtopic covers properties for the following high permeability materials: silectron cores and laminations, mumetal, molybdenum permalloy, deltamax, and supermalloy. The properties are:

- Moly %
- Silicon %
- Nickel%
- $\mu_{max}$
- B at  $\mu_{max}$
- $\mu_{max}$  at 40B
- $\mu_{max}$  at 100B
- AC permeability
- $\mu$  at 200B
- $\mu$  at 2000B
- Saturation induction
- Specific gravity
- Resistivity

**Soft Magnetic Materials**

This subtopic lists properties of soft magnetic alloys for 21 materials such as purified iron, alfer, supermalloy, mumetal, hipernik, and permendur. The properties include:

- |             |                      |
|-------------|----------------------|
| Composition | Composition          |
| Crit tem    | Critical temperature |
| $\mu_a$     | Average permeability |
| Max $\mu_a$ | Maximum permeability |
| Hc          | Coercive force       |
| Is          | Flux density         |
| $\Theta$    | Curie temperature    |
| $\rho$      | Resisitivity         |
| $\sigma$    | Density              |

**Laminated/Wound Cores of Silicon Steel**

Laminated cores of steel are used in such applications as transformers, large rotating machines, and high efficiency motors and generators. The properties listed in this subtopic are for the grades M-6, M-7, M-19, M-22, M-27, M-36, and M-43 silicon steels:

- Nominal silicon content
- Saturation induction
- Specific gravity
- Resistivity
- Maximum core loss at 60 hz for a variety of thicknesses at 1 Tesla and 1.5 Tesla.

## Ferrites

In this subtopic, properties of ferrites are classified under four categories:

- Ferrite properties
- Ferro, piezo and pyroelectric properties
- Pressed powder materials
- Garnets

## Ferrite Properties

This subtopic lists the following properties for 17 common ferrites, such as  $\text{NiFe}_2\text{O}_4$  and  $\text{MnFe}_2\text{O}_4$ :

- Saturation moment (Tesla)
- Curie temperature
- X-ray density
- Lattice constant
- First order anisotropy constant
- Saturation magnetostriction
- Saturation Moment (Bohr Magnetons)

## Ferroelectric, Piezoelectric and Pyroelectric Properties

Ferroelectric, piezoelectric and pyroelectric materials are non-centrosymmetric. The following common materials are covered:

- $\text{NaK}_4\text{H}_4\text{O}_6 \cdot \text{H}_2\text{O}$
- Rochelle salt
- $\text{KH}_2\text{PO}_4$
- $\text{Pb}_2\text{KNb}_5\text{O}_{15}$
- $\text{BaTiO}_3$
- $\text{Bi}_4\text{Ti}_3\text{O}_{12}$
- $\text{LiNbO}_3$
- DOBAMBC - Smectic liquid crystal
- PVDF - Polyvinylidene fluoride

The properties listed for each material include:

- |                  |                                      |
|------------------|--------------------------------------|
| Tcrit.           | Critical temperature                 |
| Spont.           | Spontaneous polarization             |
| Temp             | Spontaneous polarization temperature |
| Piezoelec $\eta$ | Piezoelectric efficiency             |
| Pyroelec coeff   | Pyroelectric coefficient             |

## Pressed Powder Materials

This subtopic includes the following properties of nine pressed powder and ferrite core materials:

- |           |                      |
|-----------|----------------------|
| Comp      | Composition          |
| Treatment | Treatment            |
| $\mu_a$   | Average permeability |
| Hc        | Coercive force       |
| Is        | Flux density         |
| Curie tem | Curie temperature    |
| Res       | Resistivity          |

**Garnets**

Characteristics of 29 commercially available microwave garnets and ferrites are listed in this subtopic:

Comp	Composition
Sat magzn	Saturation magnetization
Curie temp	Curie temperature
Resn ln wid	Resonance line width
Lande g fac	Lande g factor
Coercive f	Coercive force
$\epsilon'$	Dielectric constant
$\tan(\delta) * 1000$	Dielectric loss factor
Remanent	Remanent induction

## Chapter 8

# Mechanical and Thermal Properties

### In This Chapter

Mechanical and thermal properties are classified into the following seven categories:

- Properties of Metals and Films
- Plastics, Thermosetting Materials
- Thermal Conductivity
- Critical Points of Gases
- Elastic Constants of Metals
- Planetary Data
- Phase Transition Data

### Properties of Metals and Films

Mechanical properties are listed in this subtopic for three types of materials:

- Copper alloys
- Aluminum alloys
- Thick films

### Copper Alloys

In this subtopic, electrical conductivity ( $\sigma$ ), electrical resistivity ( $\rho$ ) and the temperature coefficient of resistivity ( $\alpha$ ) are listed for the following materials:

- Pure copper
- Electrolytic copper
- Oxygen-free copper
- Free-machining copper
- Gilding metal
- Red brass
- Cartridge brass
- Yellow brass
- Phosphor bronze
- Cupro nickel
- Beryllium copper

**Aluminum Alloys**

This subtopic covers composition, electrical conductivity ( $\sigma$ ), and electrical resistivity ( $\rho$ ) for the following materials:

- Aluminum
- EC (O & H 19)
- 1100 (O)
- 2011 (T3)
- 3003 (O)
- 5056 (H38)
- 6061 (T4 & T6)
- 7075T6

**Thick Films**

The Electrical Engineering Reference Pac lists data for the following materials:

- Ag film
- Pd-Ag film
- Pt-Pd-Ag film
- Cu film
- Au film
- Pt-Pd-Au film
- Pt-Ag film
- Pt-Au film
- In203-SnO2 film

The data include:

- |               |                       |
|---------------|-----------------------|
| Mfr           | Manufacturer          |
| No.           | Number                |
| $\rho_s$      | Sheet resistivity     |
| Adhesion      | Adhesion              |
| Min thickness | Recommended thickness |

**Plastics, Thermosetting Materials**

This subtopic covers 14 thermosetting molding plastic products, such as epoxy and mellamine. The following properties are listed for each product:

- $\rho$ Volume resistivity
- Br fld(short )
- Dielectric strength, short-time
- Br fld(step)
- Dielectric strength, step-by-step
- $\epsilon_r$
- Dielectric constant
- Diss fact
- Dissipation factor
- Arc resistances
- Specific gravity
- Specific volume
- Tensile strength

Elongation  
Tensile modulus  
Compressive strength  
Flexural strength  
Impact strength  
Rockwell hardness  
Thermal conductivity  
Thermal expansion  
Maximum use temperature  
Heat distortion temperature  
Water absorption  
Effect of weak acids  
Effect of strong acids  
Effect of weak alkali  
Effect of strong alkali  
Effect of organic solvents

## **Thermal Conductivity**

In this subtopic thermal conductivity is listed for solids and high temperature insulators.

### **Solids**

Densities, temperatures and thermal conductivities are listed for 67 materials.

### **High Temperature Insulators**

Bulk densities, maximum operating temperatures, and thermal conductivities at different temperatures are listed for 15 different materials.

## **Critical Points of Gases**

In this subtopic, boiling point, critical pressure, critical temperature, and critical volume are listed for 44 gases.

## **Elastic Constants of Metals**

In this subtopic, the following properties are listed for 20 materials, such as steels, copper, brass, monel and molybdenum:

Young's modulus  
Rigidity modulus  
Bulk modulus  
Poisson's ratio

**Planetary Data**

This subtopic includes the following data for the nine planets in the solar system:

- Equatorial radius
- Polar radius
- Mass
- Mean density
- Visual albedo
- Rotational period
- Inclination

**Phase Transition Data**

In this subtopic, the following data are included for a variety of materials, such as acetic acid, chlorine, ethyl ether and hydrogen sulfide:

- |                  |                        |
|------------------|------------------------|
| Formula          | Formula                |
| M                | Mass                   |
| Tm               | Melting point          |
| $\Delta h_{fus}$ | Heat of fusion         |
| Tb               | Boiling point          |
| $\Delta h_{vap}$ | Heat of vaporization   |
| Pc               | Critical pressure      |
| vc               | Critical volume        |
| Tc               | Critical temperature   |
| Zc               | Compressibility factor |



## Chapter 9

# Miscellaneous

### In This Chapter

Miscellaneous contains commonly used mathematical reference data.





This chapter covers:

- ☐ Constants Library
- ☐ Common Prefixes
- ☐ Greek Alphabet
- ☐ ASCII Table

---

### Using Miscellaneous

To get to the Miscellaneous section, follow these steps:

1. Press  **LIBRARY** to display all libraries available to the HP 48SX.
2. Find and press  to enter the Electrical Engineering Reference Pac library directory.
3. Press the first softkey, **EE REF**, to start the application.
4. At the Main menu, move the arrow to Miscellaneous (by pressing  and ) and press **ENTER**.



### Items in the Miscellaneous Menu

Each entry in the Miscellaneous menu is briefly described below and is discussed in detail later in this chapter.

Item	Description
Constants Library	Commonly used mathematical constants. (Universal, Physical, Magnetic, and Mechanical)
Common Prefixes	Commonly used prefixes.
Greek Alphabet	Uppercase and lowercase Greek letters.
ASCII Table	A browser displaying all of HP 48SX characters.

## Summary of Operations (Miscellaneous)

Key	Action
<b>FONT</b>	Toggles between the small and large fonts.
<b>MAIN</b>	Returns to the Main menu.
<b>PRINT</b>	Prompts for <b>ONE</b> or <b>ALL</b> to select items, and then sends those items to an IR printer.
<b>STK</b>	Prompts for <b>ONE</b> or <b>ALL</b> to select items, and then copies those items to the stack. The items are placed in a list if <b>ALL</b> was chosen.
<b>UP</b>	Moves up one level in the menu structure.
<b>VIEW</b>	Displays the entire text of an item too wide to fit on the screen, up to one entire screen size. If the item fits on the screen, this key is non-functional.
<b>ATN</b>	Quits the EEREF Pac to the HP 48SX stack.
<b>ENTER</b>	Moves down one level in the menu structure.
<b>ON</b> - <b>WTH</b>	Dumps the current screen to an IR printer.

## Constants Library

The Constants Library offers you access to 39 constants commonly used in electrical engineering. All constants are listed in SI units and are classified under four categories:

### Universal Constants

R	Universal gas constant
NA	Avogadro's number
Vm	Molar volume
StdT	Standard temperature

StdP	Standard pressure
$\epsilon_0$	Permittivity
c	Velocity of light
h	Planck
hb	Dirac
k	Boltzmann

## Physical Constants

q	Electron charge
$m_e$	Electron mass
$r_e$	Classic electron radius
$m_p$	Proton mass
$\mu_N$	Neutron mass
$R_\infty$	Rydberg's
$\alpha$	Fine structure
$a_0$	Bohr radius
$\mu_B$	Bohr magneton
$\lambda$	Wavelength for 1 eV
$\lambda_c$	Compton's wavelength
$\sigma$	Stefan-Boltzmann
c1	1st radiation
c2	2nd radiation
c3	Wiens' displacement
Vt	Thermal voltage at 300 K

## Magnetic Constants

$\mu_0$	Permeability of free space
$\phi_0$	Magnetic flux quantum
F	Faraday constant
$\mu_e$	Electron magnetic moment
$\mu_p$	Proton magnetic moment

## Mechanical and Thermal Constants

G	Gravitational constant
g	Acceleration due to gravity

$\rho_{H_2O}$	Density of water at 20 °C
$\lambda_{H_2O}$	Refractive index of water at 20°C
$C_{pH_2O}$	Molar heat capacity of water
$H_{fH_2O}$	Heat of fusion of water
$H_{vH_2O}$	Heat of vaporization of water
$c_{H_2O}$	Velocity of sound in water

Upon choosing Universal Constants from the Miscellaneous menu, the following screen appears:

```

▼ Universal Constants
→R (GAS CONSTANT): 8.31441 J/(K·mol)
NA (AVOGADRO'S NUMBER): 6.022E23
VM (MOLAR VOLUME): 22.41383 L
STDP (STANDARD TEMPERATURE): 273.15
STDP (STANDARD PRESSURE): 101.325
EO (PERMITTIVITY): 8.8541878176E-12
C (VELOCITY OF LIGHT): 2.9979245E8
H (PLANCK): 6.626176E-34 J*s
MAIN → STR PRINT UNIT FONT UP

```

**NOTE:** The values are unjustified because the small font is proportionally spaced; switching to the large font will align the numerical data in the same column.

**Example:** Look up the value of Planck's constant. First, move the arrow down to H by pressing **↓**. Now, press **UNITS** to turn on units. Finally, although you can see most of the value of H on the display, press **ENTER** to view the full value of the constant:

```

Constants Library
h (Planck's)
6.626176E-34 J*s
PRESS [STO] TO SAVE TO STACK ...
PRESS [ENTER] TO RETURN TO LIST ...

```

Press **STO** to save the constant to the stack as a tagged object, or **ENTER** or **ATN** to return to the Universal Constants menu without saving the constant on the stack.

## Greek Alphabet

Upon choosing Greek Alphabet from the Miscellaneous menu, the following screen appears:

ALPHA	Αα	IOTA	Ιι	RHO	Ρρ
BETA	Ββ	KAPPA	Κκ	SIGMA	Σσ
GAMMA	Γγ	LAMBDA	Λλ	TAU	Ττ
DELTA	Δδ	MU	Μμ	UPSILON	Υυ
EPSILON	Εε	NU	Νν	PHI	Φφ
ZETA	Ζζ	XI	Ξξ	CHI	Χχ
ETA	Ηη	OMICRON	Οο	PSI	Ψψ
THETA	Θθ	PI	Ππ	OMEGA	Ωω
PRESS [ENTER] TO RETURN TO LIST ...					

This screen is a picture displaying representations of all of the uppercase and lowercase Greek letters. Many of these characters are available from the HP 48SX keyboard, but not all of them. To get a printed copy of this screen, press **[ON]-[MTH]** now. Press **[ENTER]** to return to the Miscellaneous menu.

**NOTE:** The uppercase and lowercase letters alternate columns, due to limitations of the pixel resolution of the HP 48SX screen.

## Standard Prefixes

Upon choosing Standard Prefixes from the Miscellaneous menu, the following screen appears:

Standard Prefixes	
→EXA (E):	10E18
PECA (P):	10E15
TERA (T):	10E12
GIGA (G):	10E9
MEGA (M):	10E6
KILO (K):	10E3
HECTO (H):	10E2
DECA (DA):	10
MAIN →STK PRINT VIEW FONT UP	

The only difference in behavior between Standard Prefixes and Constants Library is that units are not relevant to the prefixes, so **[UNITS]** has been replaced with **[VIEW]**.


## ASCII Table

Upon choosing ASCII Table from the Miscellaneous menu, the following screen appears:







	CHR	HEX	DEC	OCT	BIN	
→	A	41	065	101	01000001	A
	B	42	066	102	01000010	5X8
	C	43	067	103	01000011	A
	D	44	068	104	01000100	5X7
	E	45	069	105	01000101	A
	F	46	070	106	01000110	A
	G	47	071	107	01000111	5X7
	H	48	072	110	01001000	5X7
	-16	+16	-32	+32	-64	+64

This function displays hexadecimal, octal, binary and ASCII equivalents for the decimal numbers 0 through 255.

### Example:

Suppose you want to find the binary equivalent of the ASCII  $\alpha$  character. Enter the ASCII Table, The first screen displays characters at decimal number 065 (although ASCII characters beginning at decimal 0 are available). Use the  cursor key to scroll down the list until you find the  $\alpha$  character (decimal 140). Look under the BIN heading to find the binary equivalent of  $\alpha$ .

	CHR	HEX	DEC	OCT	BIN		
↑	89	137	211	10001001		$\alpha$	
	8A	138	212	10001010		5X8	
	8B	139	213	10001011		$\alpha$	
→	8C	140	214	10001100		5X7	
↓	8D	141	215	10001101		A	
↓	8E	142	216	10001110		5X7	
↓	8F	143	217	10001111		5X7	
↓	90	144	220	10010000		5X7	
		-16	+16	-32	+32	-64	+64

Since the search mode is not available in the ASCII table, you need to use the , , , , ,  softkeys to jump forward or backward 16, 32, or 64 characters at a time.

### The HP48SX Character Set

The top two boxes at the far right of the ASCII listing display the selected character in the HP 48SX small (5X7) and medium (5X9) fonts. The third box displays the I/O character and translate code setting required to download data from a personal computer to the HP 48SX. (See the *HP 48SX Owner's Manual* for complete instructions.)

## Summary of Operations (Miscellaneous Sections)

Key	Action
<b>FONT</b>	Toggles between the small and large fonts.
<b>MAIN</b>	Returns to the Main menu.
<b>PRINT</b>	Prompts for <b>ON</b> or <b>ALL</b> to select items, and then sends those items to an IR printer.
<b>SAVE</b>	Prompts for <b>ON</b> or <b>ALL</b> to select items, and then copies those items to the stack.
<b>ON</b>	Indicates that units are currently turned on. Pressing this key turns off units, automatically stripping units from all constants.
<b>OFF</b>	Indicates that units are currently turned off. Pressing this key turns on units, automatically appending units to all constants.
<b>UP</b>	Moves up one level in the menu structure.
<b>VIEW</b>	Displays the entire text of an item too wide to fit on the screen, up to one entire screen size. If the item fits on the screen, this key is non-functional.
<b>ATH</b>	Quits the EEREF Pac to the HP 48SX stack.
<b>ENTER</b>	For picture data, <b>ENTER</b> displays the picture. For text, <b>ENTER</b> displays the screen title, the item label, and the item, all expanded to one screen.
<b>ON</b> - <b>MTH</b>	Dumps the current screen to an IR printer.

**Notes:**



# Appendix A

## Warranty and Service

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### Pocket Professional Support

You can get answers to your questions about using your Pocket Professional card from Sparcom. If you don't find the information in this manual or in the *HP 48SX Owner's Manual*, contact us in writing, at :

**Sparcom Corporation**

Attn: Technical Support Dept.

897 NW Grant Avenue, Corvallis, OR 97330, U.S.A. (503) 757-8416

or send E-mail:

from **Internet:**

[support@sparcom.com](mailto:support@sparcom.com)

from **Compuserve:**

> [Internet:support@sparcom.com](mailto:Internet:support@sparcom.com)

from **FidoNet:**

To: [support@sparcom.com](mailto:support@sparcom.com)

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### Limited One-Year Warranty

#### What Is Covered

The Pocket Professional is warranted by Sparcom Corporation against defects in material and workmanship for one year from the date of original purchase. If you sell your card or give it as a gift, the warranty is automatically transferred to the new owner and remains in effect for the original one-year period. During the warranty period, we will repair or replace (at no charge) a product that proves to be defective, provided you return the product and proof of purchase, shipping prepaid, to Sparcom.

#### What Is Not Covered

This warranty does not apply if the product has been damaged by accident or misuse or as the result of service or modification by any entity other than Sparcom Corporation.

No other warranty is given. The repair or replacement of a product is your exclusive remedy. **ANY OTHER IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS IS LIMITED TO THE ONE-YEAR DURATION OF THIS WRITTEN WARRANTY. IN NO EVENT SHALL SPARCOM CORP. BE LIABLE FOR CONSEQUENTIAL DAMAGES.** Products are sold on the basis of specifications applicable at the time of manufacture. Sparcom shall have no obligation to modify or update products, once sold.

---

## **If the Card Requires Service**

Sparcom will repair a card, or replace it with the same model or one of equal or better functionality, whether it is under warranty or not.

### **Service Charge**

There is a fixed charge for standard out-of-warranty repairs. This charge is subject to the customer's local sales or value-added tax, wherever applicable. Cards damaged by accident or misuse are not covered by fixed charges. These charges are individually determined based on time and material.

### **Shipping Instructions**

If your card requires service, ship it to Sparcom Corporation, 897 NW Grant Avenue, Corvallis, OR 97330, U.S.A.

- Include your return address and a description of the problem.
- Include proof-of-purchase date if the warranty has not expired.
- Include a purchase order, along with a check, or credit card number and expiration date (VISA or MasterCard) to cover the standard repair charge.
- Ship your card, postage prepaid, in adequate protective packaging to prevent damage. Shipping damage is not covered by the warranty, so insuring the shipment is recommended.

Cards are usually serviced and reshipped within five working days.

---

## Environmental Limits

The reliability of the Pocket Professional depends upon the following temperature and humidity limits:

- Operating temperature: 0 to 45 °C (32 to 113 °F).
- Storage temperature: -20 to 60 °C (-4 to 140 °F).
- Operating and storage humidity: 90% relative humidity at 40 °C (104 °F) maximum.

**Notes:**

## **Appendix B**

# **References**

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### **Electronic Properties**

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**Donald G. Fink, Editor, "Standard Handbook for Electrical Engineers," McGraw-Hill, NY, 1978**

**C.A. Harper, Editor, "Handbook of Materials and Processes for Electronics," McGraw-Hill, NY, 1970**

**"Reference Data for Radio Engineers," Sixth Edition, Howard W. Sams & Co., Inc., NY, 1975**

**Notes:**



## Appendix C

# Menu Structure

This chapter presents the menu structure format of the Electrical Engr. ref. Pac. The main menu items are shown in bold typeface for clarity.

### **Electronic Properties**

- Digital Specifications
  - NMOS Technology
  - CMOS Technology
  - TTL Technology
  - ECL Technology
- Frequency Bands
  - New frequency bands
  - Mm & Sub Mm Bands
- Piezoelectric Properties
  - Piezoelectric Constants
  - Piezo/pyro/ferro properties
- Properties of Lasers
  - Semiconductor Laser
  - Pulsed Lasers
  - Common Lasers (nm)
  - Commercial CW Lasers
- Electro-Acoustics
  - Sound Intensity Eqns
  - Sound Vel in Liquids
  - Sound Velocity in Metals
  - Sound Vel in Misc. Matls.
- $\mu$ -Wave Materials
- Superconductors, Tcrit.
- Thermionic Emission

### **Thermocouples**

- E Type
- J Type
- K Type
- S Type
- T Type

## **Semiconductors**

- Properties of Si
- Properties of GaAs
- Donors in Silicon
- Acceptors in Silicon
- III-V Compounds
- II-VI Compounds
- Optical Properties
  - Refractive Index
  - Light Guide Sys. Sensitivity(\_dBm)

## **Electrical Properties**

- Resistor Color Code Interpretation
- Standard Comp Values
- Wire Gauge
  - Solid Copper
  - Annealed Copper
  - Hard Drawn Copper
  - Copper Wire Table
  - Stranded Conductors
  - Max Current Capacity
  - Fusing Current
- Voltage Standing Wave Ratio (VSWR) Calculations
- Decibel Conversions
  - Current
  - Voltage
  - Power
- Battery Characteristics
- Solders, Brazes
- Film Electrical Properties

## **Dielectric Properties**

- Insulating Materials
  - Ceramics
  - Glasses
  - Plastics
  - Organic Liquids
  - Waxes
  - Rubbers
  - Woods
  - Miscellaneous
- Dielectric Constants

Insulator Resistance  
Insulating Films  
Insulating Liquids

## **Magnetic Properties**

Hi Permeability matl  
Hi Remanence  
Laminated Cores  
Soft Magnetic Matl  
Laminated/Wound cores of Si Steel  
Ferrites  
    Ferrite Properties  
    Ferro, Piezo, Pyro Props  
    Pressed Powder  
    Garnets

## **Mechanical, Thermal Properties**

Properties of Metals/Films  
    Copper Alloys  
    Al alloys  
    Thick Films  
Plastics, Thermosetting Matls  
Thermal Conductivity  
    Solids  
    Hi Temp Insulators  
Critical Points-Gases  
Elastic Constants of Metals  
Phase Transition Data

## **Miscellaneous**

Universal Constants  
Physical Constants  
Magnetic Constants  
Mechanical, Thermal Constants  
Greek Alphabet  
Standard Prefixes  
ASCII Table

**Notes:**

## Appendix D


# Questions and Answers

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

### Commonly Asked Questions

**Q.** I'm not sure whether the Pocket Professional card is malfunctioning or I'm doing something improperly. How can I verify that the card and the calculator are functioning properly.

**A.** There are several possibilities for this condition to occur.

- check to make sure that the card is properly seated in the calculator port.
- turn the calculator ON and press  LIBRARY. The calculator checks the reference card when it turns on; if "Invalid Card Data or Port Not Available" message is displayed, then the card may require service. If the library menu does not include the reference name shown in Chapter 1, then the card may require service.
- a third possibility occurs when you remove a merged RAM card incorrectly and install the Pocket Professional card. In this case, the calculator display shows "Recovering Memory".

**Q.** What do three dots (...) mean at the end of a display line?

**A.** The three dots indicate that the object is displayed too long to show on one line. To view the complete object, select the object using the  or the  key by moving the pointing arrow to the object to be displayed, press  and . Pressing  or  will return to the browser.

**Q.** While searching a list of information, I used the alpha key to do the search, but the search did not work. Why?

**A.** Most likely, the search did not work because of case sensitivity of the alpha search.

**Notes:**

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