4051s Talk To Each Other

by Chuck Eng

Every 4051 equipped with Option 1 (the RS 232 data communications interface) has the ability to communicate with another 4051, which is also equipped with Option 1.

The RS 232 interface is generally used to connect the 4051 to a mainframe host computer or to a peripheral. Two 4051s can, however, talk to each other through this interface, either directly or over a telephone line.

This feature is a convenient method of exchanging data files, program files or for exchanging graphic information like charts or maps between installations. It is also finding applications in game simulation, where two people compete with each other through interconnected 4051s.

How It's Done

Data communciation over telephone lines or through Satellites is far from news in the computer world, but we're not talking in this case about communication between a terminal and a large host computer. We're talking about communication between two intelligent 4051s.

STAT 4 Expands Regression Techniques

Tektronix recently introduced a new addition to the 4051 Statistics Program Library. It is identified as **4050A10 STATISTICS VOL. 4 (STAT 4)** and is available now as a separate software volume or as part of the four volume statistics library.

STAT 4 is a modern, comprehensive nonlinear analysis package. The programs included in this package are: nonlinear least square fitting using the Marquardt-Levinburg method and Newton's method, functional minimization, data fits to nonlinear systems of equations, exponential least square curve fitting, exponential one knot spline curve fitting, cubic spline fitting, Fourier regressions, and linear regressions.

This package of nonlinear regression analysis programs should be of particular interest to those of you involved in forecasting through trend projections, in biology or sociology for construction of logistic growth curves, or in spectrophotometry for construction of Gaussian peak models or any other field that requires fitting nonlinear functions.

All the programs require a minimum of 16k memory to run, except the linear regression program, which requires 32k.

Nonlinear Regression Analysis Using Marquardt's Least Squares Method

by Gary P. Laroff

When seeking relationships between physically measured or observed variables, mathematical or statistical models are frequently proposed. The proposed model is often an equation or formula, which is assumed to explain the relationship between the variables. The proposed equation generally also involves unknown constants or parameters. The problem in statistical modeling is then to estimate these parameters so that the resulting model fits the experimental data. Regressive analysis, i.e. fitting equations to data, is the most popular technique used to estimate these parameters.

In This Issue

Have You Submitted A Program To The 4051 Applications Library Yet?

The 4051 Applications Library is now 5 months old and over this time we've heard from a great number of you. To date over 150 programs have been ordered from the library. We are also beginning to receive programs from you. Abstract number 51/00-8001/0 in this issue was submitted by Mr. T.F. Schatzki of the U.S.D.A.—Western Regional Research Lab in Berkeley, California.

As we stated in our first library newsletter, the library service is intended to save you the time and expense of developing software that may already be available. You can do this either by buying programs directly from the 4051 Applications Library, or by trading programs you have developed for programs from the library. In exchange for having one of your programs included in the library, you are eligible to receive any three programs from the library, plus a blank tape in return for the tape you submitted.

To submit a program you merely fill out one of our documentation forms and send it along with a tape of the program to the 4051 Applications Library. If the program is accepted, you receive credit for three programs from the library and a blank tape. A documentation package is sent to every member of the 4051 Applications Library. If you need additional forms contact your local Tektronix Field Office or write to Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005, c/o Applications Library 60-369. We are anxious to hear from you and learn the exciting as well as the workhorse uses you have been finding for your 4051.

Are You A Member Of The 4051 Applications Library?

If you are not already a member of the 4051 Applications Library, fill out the attached membership form and send it to us. Members of the 4051 Applications Library receive Tekniques, the applications library newsletter, which contains application notes, programming tips, new product information, and abstracts of new programs submitted and approved during the previous month.

Editors Note

Dear Reader,

With this issue of the 4051 Applications Library newsletter you will see some changes. Most notably we have a new name—Tekniques—thanks to your generous and most creative response to our name the newsletter contest. (See the article below about our contest winner.)

Along with this new name and format, we are adding a few new features, which we hope will be both helpful to you and help us further develop our dialogue with you.

Besides the 4051 Applications Library program abstracts, applications notes, and programming tips we've provided in the past, we will also be providing new product information. The lead story in this newsletter describes the new Statistics Volume 4 software now available. This software volume provides some much needed programs for nonlinear regression analysis.

We're also very interested in having you share with us and our other readers, some of the applications you are putting your 4051 to work on. We'd like to hear about your everyday routines as well as your most ambitious applications. You may submit articles or merely notes to us on what you are doing and how other 4051 users might benefit from your experience. If you have a problem and like some help solving, submit it to us. Maybe one of the other 4051 users has some ideas. Of course we're always interested in a program tip.

Finally keep up the good work with your submissions to the 4051 Applications Library. It is through this software exchange program that we feel we can best serve you.

Newsletter Has New Name

As you can see from the front page, the 4051 Applications Newsletter has a new name—Tekniques. It was one of over 125 names submitted by 4051 users. The names ranged from Tek Fourty News and 4051 Interface to Graph Bag and Graphic Traffic. Our thanks to all of you for putting your imagination to work for us.

The name Tekniques was the combined effort of the Cost and Economic Analysis Division of the Strategic Air Command, Offutt Air Force Base, Nebraska. The names offered by this group were submitted by Major Anthony D.H. Wilbur, USAF, Chief of the division.

Major Wilbur informed us that they use their 4051 to process statistical data, determine time value of money, and for econometrics. They use the graphic capability of the 4051 to prepare viewing graphs on the status of the command for executive management briefing. These briefs are presented quarterly to the Commander and Chief the Strategic Air Command.

The division will receive a complete set of all the programs in the 4051 Applications Library as of December 15, 1976 in return for their contribution.
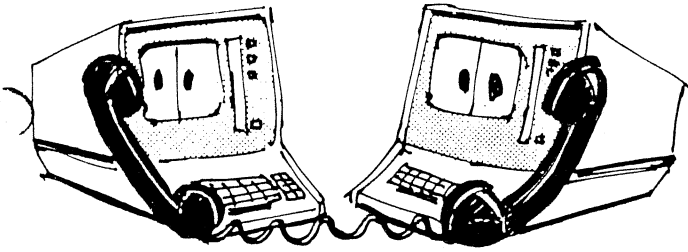
4051s Talk To Each Other Continued

Let's start by coupling two 4051s together directly—no phone line this time. If you only have one 4051 in your office, don't stop here. Next we will show you how you can talk with a friend's 4051 over the telephone.

1. Set two 4051s (each equipped with Option 1) together and power them both up.
2. Call 'TERMIN' on both units (note the I/O and Busy lights toggling in search of the proper return signal from the other 4051).
3. Plug the Option 1 cable of one 4051 into the other 4051. When the lights stop toggling, you are communicating.
4. Type anything on either 4051 and it appears on both screens.

Now let's put this feature to a more practical use. Let's transfer a tape file from one 4051 to the other. It does not matter which unit is the sender and which is the receiver, but for the following dialogue, we will call the 4051 used to transmit the tape file the SENDER and the receiver of the file the RECEIVER.

The following dialogue is not necessary, but it is a good example both of the sequence of events to communicate and the types of information to be exchanged. When RECEIVER presses DATA RECEIVE function key 3, his 4051 will transmit 'GO' to SENDER and wait for an input. Upon seeing 'GO' on the screen, SENDER presses key 4 to initiate the data send function. When the tape units stop and the cursor returns, tape file transfer has been completed.

Now let's apply this procedure to communication over a telephone line. There is essentially no difference except that telephone communication requires a few more preliminary hook up steps. Note that the ability to communicate with

the 4051 operator on the other end of the line by typing on the keyboard makes this system of communication both simple and convenient.

Either data phones or acoustic couplers can be used to link the telephones to the 4051s. Despite the fact that acoustic couplers are more mobile, there are no real differences between data phones and acoustic couplers. (One of the two acoustic couplers or dataphones must have an ANSWER capability and the other must have ORIGINATE capability. Two ORIGINATE modems cannot communicate with one another.) In this example, let's use acoustic couplers.
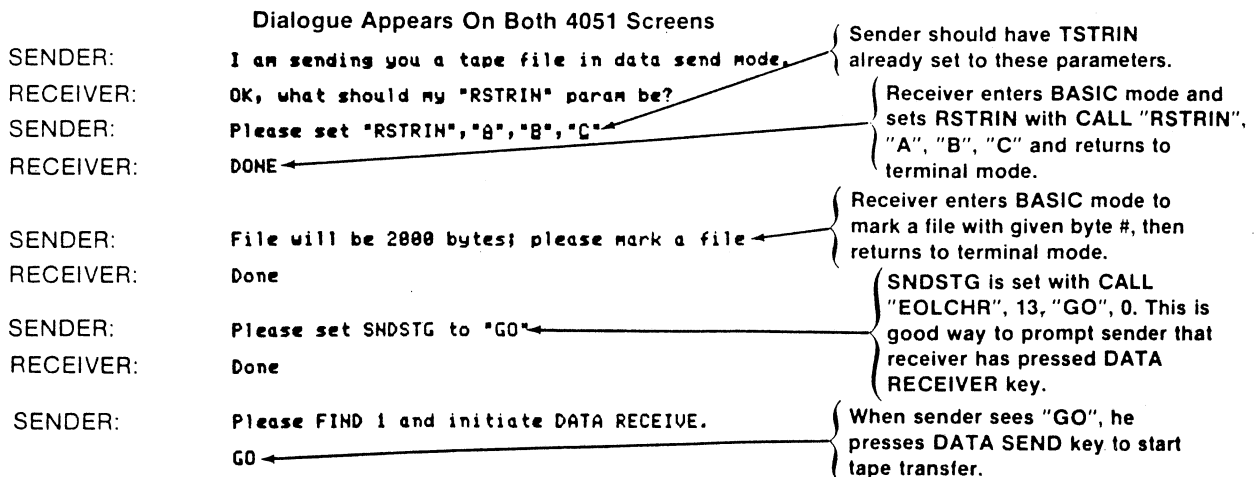
To establish a data communication line between the telephones, one of the couplers requires an answer mode. The answer mode is a sound frequency of approximately 1000 Hz. This tone informs the other modem that it has its attention. When the other modem receives this tone, it responds with the same frequency completing a hookup with each modem having the other's attention. The sequence in which hookup is made is not as critical when using modems as it is when the 4051s are coupled directly.

Let's assume you are in San Francisco and you want to communicate with a 4051 in New York. This is how you proceed:

San Francisco	New York
Originate mode	Answer mode
1. Connect 4051 to modem through Option 1 cable.	Same
2. Power up 4051 and modem.	Same
3. Dial the New York telephone number.	Answers the telephone call.
4. Place telephone receiver on modem. Observe 'carrier' light 'on' to indicate attention on both modems.	Same
5. Call 'TERMIN'. If there is no line searching (toggling of lights), communication is established.	Same

From here you proceed as in the example of the two 4051s connected together directly.

We invite you to use your imagination as to how you can use this feature to your best advantage.

Dialogue Appears On Both 4051 Screens

SENDER:	I am sending you a tape file in data send mode.	{ Sender should have TSTRIN already set to these parameters.
RECEIVER:	OK, what should my "RSTRIN" param be?	{ Receiver enters BASIC mode and sets RSTRIN with CALL "RSTRIN", "A", "B", "C" and returns to terminal mode.
SENDER:	Please set "RSTRIN","A","B","C"	
RECEIVER:	DONE	
SENDER:	File will be 2000 bytes; please mark a file	{ Receiver enters BASIC mode to mark a file with given byte #, then returns to terminal mode.
RECEIVER:	Done	
SENDER:	Please set SNDSTG to "GO"	{ SNDSTG is set with CALL "EOLCHR", 13, "GO", 0. This is good way to prompt sender that receiver has pressed DATA RECEIVER key.
RECEIVER:	Done	
SENDER:	Please FIND 1 and initiate DATA RECEIVE.	{ When sender sees "GO", he presses DATA SEND key to start tape transfer.
	GO	

Example of possible dialogue between two 4051s.

The topic of regression analysis can be conveniently split into two sub-headings: linear regression and nonlinear regression. Linear regressions have two general forms: multiple linear regression and polynomial regression. Volume 3 of the 4051 statistics library was designed to allow both forms of linear regression analysis.

While all linear regressions are essentially the same, nonlinear regressions are not. An important function in pharmacology, for example, is:

$$Y = \frac{C_1 * C_3}{C_1 - C_2} \left[e^{-C_2 X} - e^{-C_1 X} \right] \quad (1)$$

This equation has a double exponential that is nonlinear in both C_1 and C_2. Nonlinear equations are much more difficult to fit than linear equations. Usually a unique program must be written for each form of the nonlinear function to be fit. Now using Marquardt's method allows you to customize one nonlinear least squares curve fitting program by merely keying in the nonlinear equation to be analyzed in standard algebraic format. For most problems, the local and global convergence properties of this program method surpass those of the older Gauss-Newton iteration method.

When performing regression analysis, you typically begin with a set of data comprising X, Y pairs or another format such as X_1, X_2, X_3, Y quartets. The object is to solve the problem for the specific model and find the parameters C_1, C_2, C_3, etc. as in equation 1.

The function is written in BASIC with dependent variable Y1 and independent variables X(I,J) for J independent variables. C(N) denotes the N parameter values you are trying to determine. For example, if the model is $y = ax^2 + b \log(gx)$

C(1) = a
C(2) = b
C(3) = g
X(I,1) = x
Y1 = y

The model would be entered in BASIC as:

```
1100 Y1=C(1)*X(I,1)↑2+C(2)*LGT(C(3)*X(I,1))
```

Another example is the well known exponential decay equation, $y = a + be^{-cx}$. This equation would be entered as:

```
1100 Y1=C(1)+C(2)*EXP(-C(3)*X(I,1))
```

	DATA POINTS	
I:	X1	Y
1:	1	76.72
2:	2.71	88.93
3:	4.43	77.54
4:	6.14	65.6
5:	7.86	55.3
6:	9.57	46.59
7:	11.29	39.25
8:	13	33.07
9:	14.71	27.86
10:	16.43	23.47
11:	18.14	19.77
12:	19.86	16.66
13:	21.57	14.03
14:	23.29	11.02
15:	25	9.96

Fig. 1. Data points for Equation 1.

Fig. 1 shows the list of data for the pharmaceutical equation (Eq. 1) given earlier. Using the "PLOT DATA" key on the function overlay this data can be plotted as shown in Fig. 2. Fig. 3 shows equation 1 as it would be written and entered into the program in BASIC.
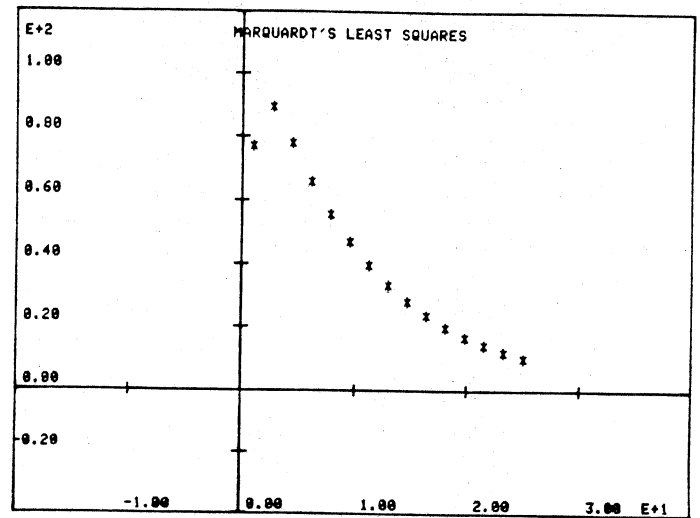

Fig. 2. Graph of data points for Equation 1.

```
MARQUARDT'S NONLINEAR LEAST SQUARES FIT

ENTER YOUR EQUATIONS AS A SUBROUTINE STARTING AT LINE 1100
A SAMPLE SET OF EQUATIONS IS PROVIDED:

1090 REM *------------------------------------*
1100 REM *---*SAMPLE USER WRITTEN SUBROUTINE*---*
1110 Y1=C(1)*C(3)/(C(1)-C(2))*(EXP(-C(2)*X(I,1))-EXP(-C(1)*X(I,1)))
1120 RETURN
1130 REM *---*END OF USER WRITTEN SUBROUTINE*---*
1140 REM *------------------------------------*

NOTE: YOUR EQUATIONS MUST BE WRITTEN SO THAT
      ALL THE PARAMETERS HAVE VALUES >= 0.


PRESS KEY #1 <INITIALIZE>  OR  KEY #11 <FROM TAPE>
```

Fig. 3. Equation 1 as is would be entered in BASIC using Marquardt's Least Squares program in STAT 4.

To solve the equation, you press the "SOLVE" function key and enter the desired accuracy and the initial estimates for the unknown parameters. Initial estimates of 1, 0.1, and 100 were entered in Fig. 4.

```
RELATIVE CHANGE IN EACH COEFFICIENT IS LESS THAN 1.0E-5

TERMINATION AFTER 4 ITERATIONS.
    FINAL SUM OF SQUARES = 0.00184817841074

                DF = 12

             SIGMA = 0.0124102726627


    J     PARAMETER            ERROR

    1   1.30012930993       5.388654431E-4
    2   0.0999879893919     1.84184745E-5
    3   111.989324319       0.0141051817905


DO YOU WANT TO SEE THE INVERSE MATRIX:
```

Fig. 4. Initial estimates of unknown parameters for Equation 1.

The data and resultant function are plotted as in Fig. 5 with the "PLOT FUNCTION" key. Complete data editing as well as estimates, lists of residuals and residual plots for the dependent and independent variables are available.

4

Fig. 5. Graph of curve fit calculated with Marquardt's Least Squares program.

Marquardt's method relies heavily on the use of matrix inversions. Program execution speed is optimized with the 4051R01 Matrix Functions ROM Pack.

Next Month: Optimization of initial parameter estimates with Nelder and Mead Function Minimization.
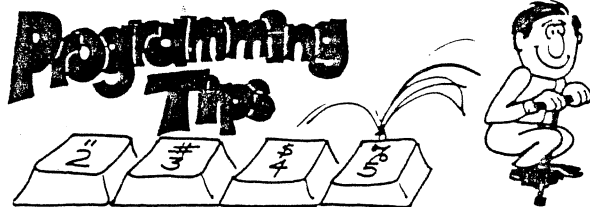
Circuit Simulation

by Will Gallant

4051 BASIC lends itself to simulation of logical circuit elements through the functions AND, OR and NOT. In the example G, H and K are "And Gates." I and L are "Or Gates." J is a logical inverter. The output of G will be true (1) if A and B are true. The output of I will be true if C or the output of G is true. J will change an input true (1) to a false (0) and vice versa.

Add graphics and you have a powerful teaching aid in the area of digital logic.


```
100 INPUT A,B,C,D,E,F,C1
110 G=A AND B
120 H=D AND E AND F
130 I=G OR C
140 J=NOT(I)
150 K=C1 AND H
160 L=J OR K
170 PRINT L
180 REM above circuit is to demonstrate
190 REM a coding application, not EE work
```

4051 Applications Library Program Abstracts

Documentation and program listings of these programs may be ordered for $15.00 each. Programs will be put on tape for an additional $2.00 handling charge per program and a $26.00 charge for the tape cartridge. (The program material contained herein is supplied without warranty or representation of any kind. Tektronix, Inc. assumes no responsiblity and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.)

Please use the Applications Library Order Form. Order forms are included in the Membership Packet and are available from your local Tektronix Field Office.
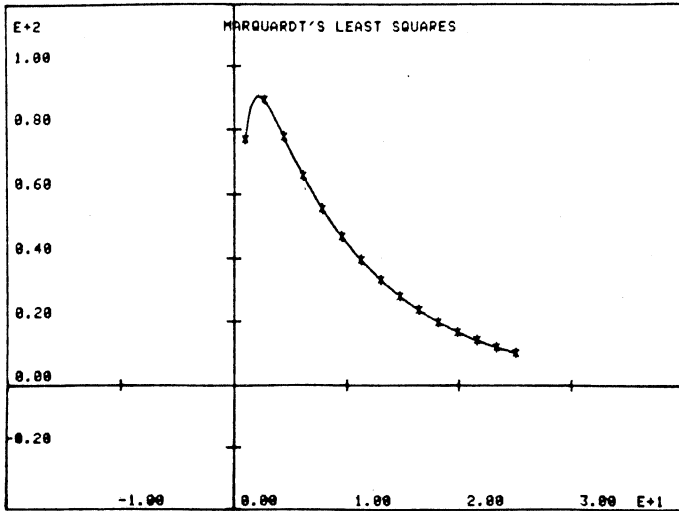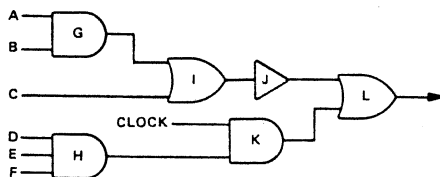
● BUSINESS ADMINISTRATION

GENERAL

ABSTRACT NUMBER: 51/00-0901/0
Title: **Calendar Plot**
Author: Aaron Eisenback
Memory Requirements: 32k bytes
Peripherals: 4662 Optional
Abstract:

CALENDAR PLOT is an interactive program which allows you to produce single or multiple plot graphs on a scale of Data vs. Months.

It is sometimes difficult to analyze comparison graphs of data from different periods of time, which are plotted on the same chart. With this program you can select the least confusing graph, form a set of three plot options, for the final copy. It is a very useful program for comparing sales, financial, or other business data.

The program includes two major categories.
1. Graph of data for months within a one year period.
   a. Graph of one period
   b. Comparison of two periods
   c. Comparison graph for three periods
2. Graph of data for months which start in one year and end in the following year.
   a. Graph for one period
   b. Comparison graph for two periods
   c. Comparison graph for three periods

The plots include one or more of the following plot formats:
1. Line
2. Dashed Line
3. Bar
4. Shaded Bar

CAPITAL EXPENDITURES - PLANT # 3

1975 TO 1976
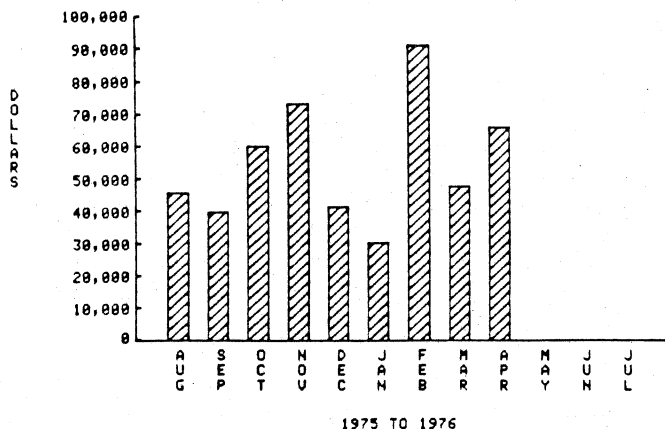
ABSTRACT NUMBER: 51/00-0902/0
Title: **Calendar Routines (7-Day Week)**
Author: Judy Peterman
Memory Requirements: 8k
Peripherals: None
Abstract:

This program contains five calendar utility routines based on a seven-day week, Sunday through Saturday. They have been designed specifically for use in programs that calculate and graph financial and other business data, but can be used in any program that involves the collection or display of time related data. The routines:

1. Gives the date a specific number of time segments before or after a specific date.
2. Gives day number, week number, and day of the week of a specific date based on January 1, 1900.
3. Gives the number of time segments between two specific dates.
4. Verifies a date entry.
5. Unpacks a date.

All routines accommodate five time frames: days, weeks, months, quarters, and years. For example, if you are using days as the time segment in routine #1, 11/17/74 +2 yields 11/19/74; in weeks 11/17/74 +2 yields 12/1/74. The routines will not produce results prior to January 1, 1901.

The routine package comes with examples. Routines and examples require 7.9k bytes to run; the routines alone require 5.3k bytes.

ABSTRACT NUMBER: 51/00-0903/0
Title: **Calendar Routines (5-Day Week)**
Author: Judy Peterman
Memory Requirements: 8k
Peripherals: None
Abstract:

This program contains five calendar utility routines based on the premise that a week is five days, Monday through Friday. The routines are the same as those found

in Abstract No. 51/100-0902/0, the calendar routines for a 7-day week:
1. Date in time segments,
2. Date #, week #, and day of the week,
3. Time segments between dates,
4. Date entry verify, and
5. Unpack date.

The routines with the examples take 8.3k bytes to run but the routines alone take only 5.6k bytes.

```
                    Calendar Routines
Enter time mesh (i.e. 1=daily, 2=weekly, 3=monthly,
                     4=quarterly, 5=yearly) 2

Enter packed date (i.e. 120577) (not Sat or Sun) 51277
Your date unpacked is 5/12/77


Permitted format for "dates":
    mm/dd/yy  (e.g. 11/7/74)

Enter another date (not Sat or Sun) 8/18/76

1st date is May 12, 1977
2nd date is Aug 18, 1976
Time (excluding Sat & Sun) between dates is -38 weeks

Enter a date (not Sat or Sun) 2/14/77
Enter # of weeks (+ or -) -10

Date plus -10 weeks (w/o Sat & Sun) is Dec 6, 1976


Enter date 2/14/77
It is a    Monday
It is day #28169
It is in week #4025
```

●SCIENTIFIC

MATHEMATICS

ABSTRACT NUMBER: 51/00-5503/0
Title: **Hexadecimal Program**
Author: Marv Abe
Memory Requirements:
Peripherals: None
Abstract:

This routine allows the user to perform some miscellaneous hexadecimal functions using the 4051. Each one of the routines provided are called by use of the function keys.

Conversion routines provided are:
1. Decimal Values — Hex Representation
2. Hexadecimal Values — Decimal Representation
3. RAD40 — ASCII*
4. ASCII — RAD40 Represntation*
5. Hexadecimal # — Bit Pattern
   *NOTE: For Tektronix 4081

Arithmetic functions provided are:
1. Hexadecimal Subtraction
2. Hexadecimal Addition

Both functions are provided in cumulative form and add and subtract from some constant value. The different routines prompt the user for the required input and most always terminate on a carriage return.

```
DECIMAL to HEXADECIMAL conversion a <cr> will terminate

Decimal value ?1
        HEX eqiv: 1
Decimal value ?16
        HEX eqiv: 10
Decimal value ?32
        HEX eqiv: 20
Decimal value ?256
        HEX eqiv: 100
Decimal value ?511
        HEX eqiv: 1FF
Decimal value ?512
        HEX eqiv: 200
Decimal value ?32767
        HEX eqiv: 7FFF
Decimal value ?65000
        HEX eqiv: FDE8
Decimal value ?
```

● RESOURCE MATERIAL

ABSTRACT NUMBER: 51/00-7001/0
Title: **WANG 2200 To 4051 Conversion Guide**
Author: Nick Fkiaras
Abstract:

This instruction manual provides all the information required to convert WANG 2200 programs into 4051 compatible programs. The guide consists of five sections:
1. A hardware description that quickly familiarizes a Wang user with program entering and execution on the 4051.
2. A software section that describes: (a) the programming features unique to WANG, (b) all the language elements identical in name, function, and syntax on both machines. (c) all language elements in WANG that are different than 4051 BASIC in name. function or syntax. In this part the equivalent 4051 functions or a description of a routine to emulate WANG language elements given.
3. A description of how a user can transfer programs from a Wang 2200 to a 4051 via the data communications interfaces available on each machine.
4. Examples.
5. A brief description of how to approach this conversion problem.

This conversion guide is not to be interpreted to be authorization by Tektronix for any user to convert proprietary programs supplied by Wang.

ABSTRACT NUMBER: 51/00-7002/0
Titles: **HP9830 to 4051 Conversion Guide**
Author: Nick Fkiaras
Abstract:

This instruction manual provides all the information required to convert HP9830 programs into 4051 compatible programs. The guide consists of seven sections:
1. A description of all the HP9830 systems covered by this guide.
2. Lists the differences from a 4051 system in features related to entering and running a program.
3. A software section that describes: (a) the programming features unique to HP9830, (b) all the language elements identical in name, function and syntax on both machines, (c) all language elements in PH9830 that are different than 4051 BASIC in name, function or syntax. In this part the equivalent 4051 functions or a description of a routine to emulate HP9830 language elements given.
4. Examples.
5. A description of how a user can transfer programs from an HP9830 to a 4051 via the data communications interfaces available on each machine.
6. Lists all the 4051 features that can be added to a HP9830 program to enhance it.
7. A brief outline of the steps to be taken when converting a program.

This conversion guide is not to be interpreted to be authorization by Tektronix for any user to convert proprietary programs supplied by Hewlett-Packard.

● UTILITY

GENERAL

ABSTRACT NUMBER: 51/00-8011/0
Title: **Tape Duplication**
Author: T.F. Schatzki Research Leader U.S.D.A.— Western Regional Research Lab Berkeley, CA
Memory Requirements: 8k
Peripherals: 4924 Tape Drive
Abstract:

This program allows you to copy any standard format tape onto another tape with minimum operator attention. starting with file X on source tape and file Y on target tape. (X and Y are INPUT from keyboard). The program preserves file order and all header information. No premarking is required on target tape.

● MISCELLANEOUS

GRAPHICS

ABSTRACT NUMBER: 51/00-9512/0
Title: **PIE Chart Routine for 4662**
Author: Will Gallant
Memory Requirements: 8k or less
Peripherals: 4662
Abstract:

This program accepts a value and text for a variable number of segments of a pie chart. The values entered are summed with each value compared to the sum to determine its percentage of the pie. Text is centered and drawn

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