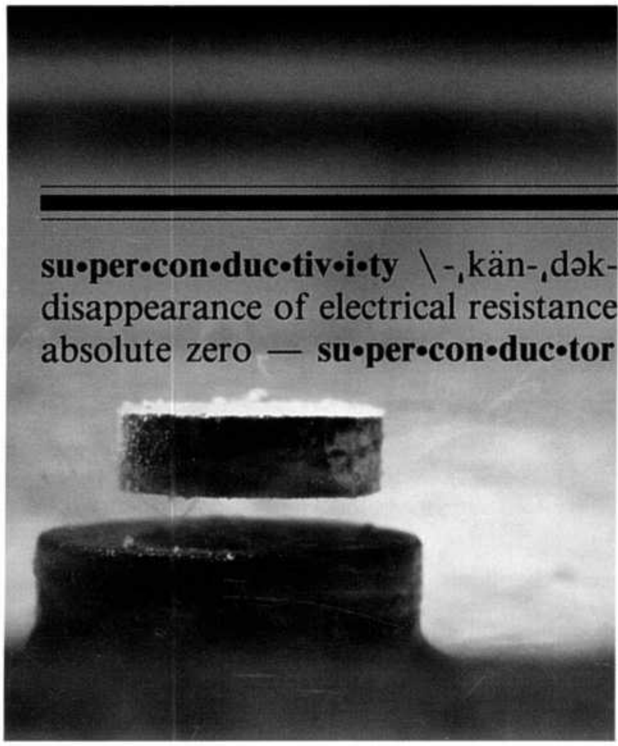
QEX 73

$1.75

MARCH 1988

ARRL Experimenters' Exchange and AMSAT Satellite Journal



su•per•con•duc•tiv•i•ty \-ˌkän-ˌdək-ˈtiv-ət-ē,-kən-\ *n* (1916): a complete disappearance of electrical resistance in a substance at temperatures near absolute zero — **su•per•con•duc•tor** \-kən-ˈdək-tər\ *n*

$YBa_2Cu_3O_7$

QEX: The ARRL
Experimenters' Exchange
American Radio Relay League
225 Main Street
Newington, CT USA 06111

Bulk Rate
U.S. Postage
PAID
Hartford, Conn
Permit No. 2929

TABLE OF CONTENTS

COLUMNS

QEX (ISSN: 0886-8093) is published monthly by the American Radio Relay League, Newington, CT USA.

Offices

225 Main St, Newington, CT 06111 USA
Telephone: 203-666-1541
Telex: 650215-5052 MCI
Electronic Mail: MCI MAIL ID:215-5052 (user name ARRL)

Subscription rate for 12 issues:
In the US by Third Class Mail:
ARRL/AMSAT Member $8, nonmember $16;
US by First Class Mail:
ARRL/AMSAT Member $13, nonmember $21;
Elsewhere by Airmail:
ARRL/AMSAT Member $23, nonmember $31.

QEX subscription orders, changes of address, and reports of missing or damaged copies may be marked: *QEX* Circulation.

Members are asked to include their membership control number or a label from their *QST* wrapper when applying.

ABOUT THE COVER

One demonstration of superconductivity involves the use of a magnet centered over a superconductor immersed in liquid nitrogren. Because of the Meissner Effect, flux fields are expelled from the super-conductor, allowing the magnet to "float" above it. *(Courtesy of the Perkin-Elmer Corporation. Photo by Gabe Palmer. Definition from Webster's Ninth New Collegiate Dictionary.)*

Purposes of *QEX*:

1) provide a medium for the exchange of ideas and information between Amateur Radio experimenters

2) document advanced technical work in the Amateur Radio Field

3) support efforts to advance the state of the Amateur Radio art.

All correspondence concerning *QEX* should be addressed to the American Radio Relay League, 225 Main Street, Newington, CT USA 06111. Envelopes containing manuscripts and correspondence for publication in *QEX* should be marked: Editor, *QEX*.

Both theoretical and practical technical articles are welcomed. Manuscripts should be typed and double spaced. Please use the standard ARRL abbreviations found in recent editions of *The ARRL Handbook*. Photos should be glossy, black-and-white positive prints of good definition and contrast, and should be the same size or larger than the size that is to appear in *QEX*.

Any opinions expressed in *QEX* are those of the authors, not necessarily those of the editor or the League. While we attempt to ensure that all articles are technically valid, authors are expected to defend their own material. Products mentioned in the text are included for your information; no endorsement is implied. The information is believed to be correct, but readers are cautioned to verify availability of the product before sending money to the vendor.

Empirically Speaking. . .

The ARRL Laboratory: A New Look

Some new walls, some fresh paint, more modern benches, a new supervisor—not more of your old status quo in the ARRL Lab. But there's more: a new approach to getting things done.

First, the new Lab Supervisor is Henry Grilk, WA2CCN, who just came on board on February 9. Hank came to us from Ketcham & McDougall Aqua Meter Instrument Corp, Roseland, NJ, where he was Director of Electronics Engineering. He earned his BS in EE, ME, Math and Physics at Fairleigh Dickenson University and Management/Finance at George Washington University. He brings with him 28 years of electronics experience, the last 18 of it in marine electronics. We're looking to Hank to keep projects moving.

The rest of the Lab team is:

- Senior Engineer Jon Bloom, KE3Z, who handles advanced hardware and software design, and technical liaison with AMSAT and others concerning space programs.
- Engineers Zack Lau, KH6CP, who has concentrated on RF design
- Engineer Ed Hare, KA1CV, who handles testing, and
- Technician Tom Miller, NK1P, who supports engineering.

The old lab was one big room with rows of benches and metal-working machinery, but no desk space for the staff. Now the machine room is walled off to cut down on the noise, and each engineer has a small office in which to do paperwork.

Basic functions of the Lab are:

- advertising acceptance (approval of ads for technical claims, meeting FCC requirements, and safety)
- testing of Amateur Radio equipment in support of Product Reviews published in *QST*
- evaluation of construction projects submitted for publication to ensure their reproducibility and that they meet author/designer's claims
- design of Amateur Radio equipment, nearly all of which ends up in the *Handbook, QST* or one of our publications
- engineering studies, the most current example of which is an engineering report for the League's comments to the FCC's proposed changes to Part 15 rules
- supporting Field Services Department's Technical Coordinators and Assistant Technical Coordinators who provide direct technical information service to our membership in the field

The Lab's R&D charter has been revised considerably to underscore that design in the League and Amateur Radio is primarily a volunteer activity. It stands to reason that for every staffer who is a qualified designer, there are at least a hundred out there in "Radioland" with equal or better qualifications. But, of course, volunteers usually have other careers that take up much of their waking hours. If a volunteer does something without any support from our lab, that's the best outcome because of both productivity through numbers and good designs resulting from the high-quality work done by some hams. Nevertheless, there is also the synergy of having the Lab work with a group of volunteers such as we do presently with AMSAT engineers and have done writing dual-port-digipeater software. So, what we're looking for is a continuous range of Amateur Radio design activities all the way from complete volunteer projects at one extreme to purely ARRL lab projects at the other extreme with *all* the possibilities in between.

Hank is interested in talking to you if you are a volunteer hardware or software designer (possibly working in a team)—particularly if you are able to take on a serious state-of-the-art design project in cooperation with the ARRL Lab.—W4RI

ASAT: An Apple-based Satellite Imaging System

By Grant Zehr, WA9TFB
2003 Woodfield Rd
Bloomington, IL 61701

It's Tuesday night and you chase the dog off the sofa so you can relax and watch television. As you get in a comfortable position, you hear scientists at the Jet Propulsion Laboratory in California tell about the most recent Voyager[1] encounter on TV. The spacecraft is on its way past Uranus and has sent back hundreds of "pictures." Instead of glossy prints, however, most of the pictures are stored in a computer with the investigators accessing the images on their CRT screens. The images are then enhanced to bring out features of interest. Wouldn't it be great to look at pictures from outer space at home with equipment like that? Well, if you *are* willing to settle for pictures of good old planet earth, you *can* do the same thing in your shack.

I'm talking about receiving weather satellite images, of course, specifically automatic picture transmission (APT) and weather facsimile (WEFAX) as transmitted by earth-orbiting weather satellites. Since the launch of the first weather satellite carrying APT transmitting equipment in 1963, amateurs have been active in tracking weather satellites. Presently, amateurs worldwide can receive images from polar-orbiting weather satellites launched by the US and the Soviet Union. Depending on your geographic location, you can also receive microwave signals in the S-band from the US' GOES spacecraft, or the European Space Agency's Meteosat. Each spacecraft transmits pictures on a daily basis. A lot of interesting imagery is available, and it is all free!

Various methods are used for reception and display of APT satellite images. If you are a newcomer to weather satellite facsimile, I suggest you refer to *The 1988 ARRL Handbook*[2] and *The Weather Satellite Handbook*.[3] To receive satellite pictures, your setup should include a VHF or S-band receiver, a stereo tape recorder, and a video display (see Fig 1). Until recently, most amateurs have used facsimile equipment to produce "hard copy" from the weather satellite APT signals.[4] Others have used analog CRT systems.[5] As the price of digital memory continues to plummet, new options are available.[6] Techniques that were once the preserve of a few privileged scientists can be used in your own satellite station.

[1]Notes appear on page 9.

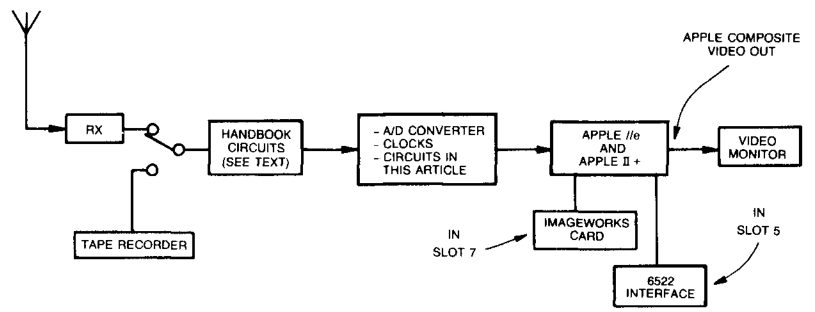


Fig 1—Block diagram of the author's Apple-based satellite imaging system.

Digital Frame Storage

Pictures produced with a digital frame-storage unit can be displayed on a conventional television screen. A computer monitor is a popular choice. The received image appears on the screen as a still picture or test pattern. Weather satellite images are drawn on the screen line by line (similar to amateur SSTV reception). Photographic techniques or special papers are unnecessary for viewing these pictures.

If you examine the screen of the video monitor closely, you will see that the image is made up of a large number of "dots" or *pixels* (picture elements). Each pixel is defined by three values. The first two values indicate its horizontal and vertical position on the screen. The third value is the brightness or gray-scale value. In a digital frame-storage unit this information is stored in random access memory (RAM). Typically, a specific memory location holds the gray value for a single specific pixel. The system hardware scans all these values quickly (60 times each second!), redrawing the picture on the screen each time. Your eye, however, interprets the picture as a still image.

The system hardware is assigned two major tasks: The first is to write the image data; the second is to read it. To write the image information into memory, the system must first load pixel values into memory locations. This is a rather slow process. At almost the same time, the system must also allow for the rapid, repetitive reading of the digital memory that holds the image data. This data is used to refresh the image on the monitor screen. The difficult part of designing a digital frame-storage unit is knowing how to interleave these two operations without losing data. Unless you are familiar with the addressing modes, timing and refresh instructions needed in using digital memory, the project can be overwhelming.

The Apple Satellite (ASAT) Project

After I gained experience with a dedicated digital frame-storage unit (the Matjaz Vidmar, YU3UMV, design[7]), I decided to develop a more flexible system. The goals for my project were: (1) to store and display an image at least 256 × 256 pixels, with at least 64 gray levels; (2) to access memory with a microprocessor so that real-time image enhancement could be done on the stored image; and (3) to use conventional digital storage (floppy or hard disk) so the images could be stored and retrieved quickly without the need to reload an image from the tape recorded satellite signal.

Since I was already familiar with the Apple II® series microcomputer, I looked for hardware that would allow me to build my system around the Apple. Until recently, however, there have been few graphic enhancement hardware utilities for the Apple II computers. (Most programmers are apparently willing to live with the limited high-resolution graphics built into the Apple II.)

I was ready to dismiss the idea when I heard about a small company in California that produces a graphics card for the Apple II series at a reasonable cost. I rushed off an order to Redshift Ltd[8], and soon their Imageworks™ card was in hand. Back to the work bench I went to build circuits for interfacing my old analog system to the Apple computer. I am satisfied with the end product, although I plan further software and hardware modifications.

The Graphics Card

The graphics card used in this project is manufactured by Redshift Ltd and costs around $300. This price includes software and documentation, and 64 kbytes of RAM that allows for an image of 256 × 256 pixels with 256 levels of gray.[9] Study the owner's manual for the Imageworks card first! Familiarize yourself with how the card normally operates. An important feature of this card is its ability to use both Apple and Imageworks graphics simultaneously. This means that you can use software to produce text that overlies the graphics image, or you can use the high-resolution graphics pages for drawing "on top of" the satellite picture.

The software supplied with the card includes a number of machine-language

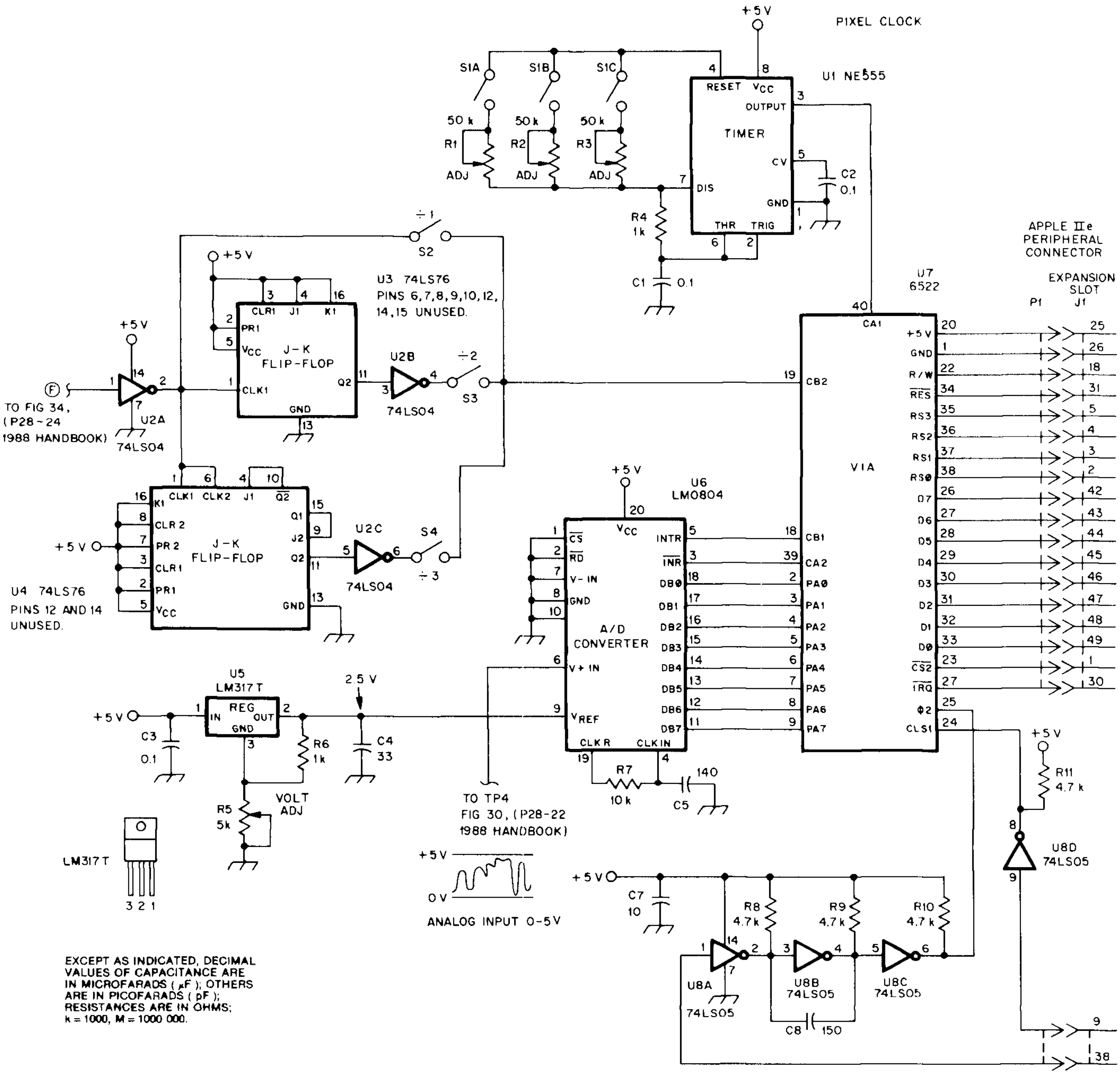


Fig 2—The 6522 VIA chip interfaces the input circuits with the Apple II expansion bus. Digital values that determine a pixel's brightness are generated by the LM0804. The low-current 2.5-V regulated supply acts as a voltage reference for the LM0804. The NE555 timer generates the pixel-clock signal. R1 through R3 are adjustable potentiometers used to get the pixel clock operating at the right frequency. Additional potentiometers may be added if needed.

S1—DIP switch.
S2,S3,S4—SPST switch.
U1—NE555 timer.
U2—74LS04 inverter.
U3,U4—74LS76 dual J-K flip flop.
U5—LM317T voltage regulator.
U6—LM0804 8-bit microprocessor A/D converter.
U7—6522 versatile interface adapter.
U8—74LS05 inverter.

routines, and the source code to list and modify those routines, if desired. This greatly simplifies the software development for the project. Schematic diagrams are included, allowing for a better understanding and repair of the card if disaster should strike.

The Interface

The interface shown here is designed to work with circuits (Figs 30, 33 and 34) described in chapter 28 of *The 1988 ARRL Handbook*. The local oscillator, the analog processing circuit (Fig 30), the phase-locked loop synchronization circuit (Fig 33), and the digital countdown circuit (Fig 34) are necessary parts of this system. The other circuits are not needed and power supplies can be simplified to ±15 V and +5 V dc.

A 6522 VIA (versatile interface adapter) chip is used to allow access to the Apple II expansion bus (Fig 2).[10, 11, 12] The 6522 is ideal for interacting with the 6502 microprocessor in the Apple II. I used an interface card with a layout similar to the one described by Marvin DeJong.[13] If a similar card can be located, it can be used. The circuit, however, is simple; it may be easier to build the circuit shown here on an Apple II prototype board. The interface chip needs to be programmed or configured to work in the desired mode. In this unit, the machine-language program (shown in Table 1) sends the instructions for configuring the 6522 VIA. The interface card is installed in slot no. 5.

The 6522 needs to be supplied with a digital pixel value, and not the analog signal as transmitted on APT. It also needs various clock signals to tell it when to save a value, when to wait, and when to stop. These signals are generated by the interface circuits.

To get a digital value for the brightness of a pixel, the output of the analog circuits described in the *Handbook* is sent to an analog-to-digital (A/D) converter chip. The National LM0804 is readily available and works well in this application.[14] The output from the analog processing circuit (TP4 in Fig 30) must be adjusted so the dc signal varies between 0 and 5 V. An oscilloscope is needed to make this adjustment. The output from TP4 is then connected to the input of the LM0804 A/D converter. A low-current 2.5-V regulated supply is needed as a voltage reference for this IC.

The line clock is derived from the countdown circuit shown in Fig 34. Two clocks (2 and 4 Hz) are locked to the tape speed. They are needed to get the desired "sweep-reset frequency" signal at pin 13 of U21A. U22 to U27 in Fig 34 are not needed, but U24C is used. Switches for horizontal phasing (both right and left) are also used. The remaining circuitry in Fig 34 need not be assembled.

An NE555 timer generates the pixel-clock signal. The resistance values

Table 1

Source Code For The Machine-Language Program

```
SOURCE   FILE #01 =>/DST/ASAT.SOURCE
-----NE I OBJECT FILE NAME IS ASAT.OBJ
0300:        0300           ORG   $0300         PUT MODULE AT $300 (768 DECIMAL)
0300:                  *
0300:                  ********************************************
0300:                  *                                          *
0300:                  *       ASAT--APPLE SATELLITE SYSTEM       *
0300:                  *                                          *
0300:                  *     FOR DISPLAY OF APT WEATHER SATELLITE *
0300:                  *                 IMAGERY                  *
0300:                  *                                          *
0300:                  *               26 MAY 87                  *
0300:                  *                                          *
0300:                  *          GRANT ZEHR   WA9TFB             *
0300:                  *                                          *
0300:                  ********************************************
0300:                  *
0300:                  *
0300:                  *   ***  DEFINE VIA CHIP ADDRESSES  ***
0300:                  *
0300:        C500      PBD      EQU   $C500         I/O PORT B
0300:        C501      PAD      EQU   $C501         I/O PORT A
0300:        C503      DDRA     EQU   $C503         DATA DIRECTION REG. A -- 0=IN
0300:        C502      DDRB     EQU   $C502         DATA DIRECTION REG. B -- 1=OUT
0300:                  *                            $00 GIVES 8 BIT INPUT PORT
0300:                  *                            $FF GIVES 8 BIT OUTPUT PORT
0300:        C50C      PCR      EQU   $C50C         PERIPHERAL CONTROL REGISTER
0300:        C50D      IFR      EQU   $C50D         INTERUPT FLAG REGISTER
0300:                  *
0300:                  *   ***  APPLE HOOKS  ***
0300:                  *
0300:        C000      KBD      EQU   $C000         KEYBOARD DATA & STROBE
0300:        C010      KBDSTRB  EQU   $C010         CLEAR KEYBOARD STROBE
0300:                  *
0300:                  *   ***  SETUP VIA INPUT, OUTPUT, AND CONTROL LINES  ***
0300:                  *
0300:A9 00                      LDA   #$00          SET PORT A FOR 8 BIT INPUT
0302:8D 03 C5                   STA   DDRA
0305:                  *
0305:A9 0A                      LDA   #$0A          CA1 AND CB1 TO READ NEG EDGE
0307:8D 0C C5                   STA   PCR           CA2 MODE 101 : CB2 MODE 000
030A:                  *                            CA1 - INPUT - PIXEL CLOCK
030A:                  *                            CA2 - OUTPUT - START A/D CONV.
030A:                  *                            CB1 - INPUT - A/D CONV. COMPLETE
030A:                  *                            CB2 - INPUT - ROW CLOCK
030A:                  *
030A:                  *   ***  'INITIALIZE' THE IMAGEWORKS CARD  ***
030A:                  *
030A:A9 01                      LDA   #$01          SETUP MODE
030C:8D FB C0                   STA   $C0FB
030F:AD 00 C7                   LDA   $C700         INIT RAM
0312:A9 01                      LDA   #$01          NORMAL MODE
0314:8D FA C0                   STA   $C0FA
0317:8D FD C0                   STA   $C0FD         TURN ON VIDEO CARD
031A:                  *
031A:                  *   ***  THE MAIN LOOP STARTS HERE WITH THE TOP LINE  ***
031A:                  *
031A:A9 0B             TLIN     LDA   #$0B          START NEW FRAME
031C:                  *                            SET ROW TO $0B (DECIMAL 11).
031C:                  *                            LEAVES THE TOP TEN LINES BLANK
031C:                  *                            AS RECCOMENDED IN IMAGEWORKS
031C:                  *                            DOCUMENTATION
031C:                  *
031C:A8                         TAY                  SAVE ROW NO. IN Y REG.
031D:8D F0 C0                   STA   $C0F0         SET ROW ON IMAGEWORKS CARD
0320:                  *
0320:A9 00                      LDA   #$00          SET COLUMN TO ZERO
0322:AA                         TAX                  SAVE COLUMN NO. IN X REG.
0323:                  *
0323:8D 10 C0                   STA   KBDSTRB       CLEAR THE KEYBOARD STROBE
0326:                  *
0326:A9 02             START    LDA   #$02          MASK FOR BIT 1
0328:2C 0D C5          PIX      BIT   IFR           CHECK BIT 1 IFR FOR TRAN ON CA1
032B:F0 FB    0328              BEQ   PIX           (WAIT FOR PIXEL CLOCK -- EXTERNAL)
032D:                  *
032D:AD 01 C5                   LDA   PAD           GET A PIXEL
0330:9D 00 C7                   STA   $C700,X       STORE IT AT NEXT ADDRESS
0333:                  *                            --CA2 GOES LOW FOR ONE CYCLE ON
0333:                  *                              LDA PAD INSTRUCTION
0333:                  *                            ----CA2 PULSE STARTS D/A CONVERS.
0333:                  *                                SIGNAL GOES TO WR PIN OF ADC 0804
0333:                  *                                CHIP.
0333:                  *                            --CA1 RESET ON LDA PAD.
0333:                  *
0333:A9 10                      LDA   #$10          MASK FOR BIT 4 (CB1)
0335:2C 0D C5          READY    BIT   IFR           WAIT FOR "READY" FROM A/D
0338:F0 FB    0335              BEQ   READY
```

Table 1 continued on next page.

Table 1 (continued)

```
033A:               *
033A:E8                     INX                   INCREMENT PIXEL --NEXT COLUMN
033B:8A                     TXA
033C:C9 00                  CMP    #$00          LAST COLUMN FULL?
033E:F0 03   0343           BEQ    ROW             YES--INCREMENT ROW
0340:4C 26 03               JMP    START           NO --GET NEXT PIXEL
0343:               *
0343:98             ROW     TYA                   CHECK ROW NUMBER
0344:C9 FF                  CMP    #$FF          LAST ROW?
0346:F0 22   036A           BEQ    END               YES -- END
0348:               *                                NO  -- CONTINUE
0348:C8                     INY                   INCREMENT ROW
0349:98                     TYA
034A:8D F0 C0               STA    $C0F0         SET ROW ON IMAGEWORKS CARD
034D:               *
034D:A9 08                  LDA    #$08          CHECK BIT 3 IFR FOR TRANS ON CB2
034F:               *
034F:2C 0D C5       WAIT    BIT    IFR           WAIT FOR THE ROW CLOCK (EXTERNAL)
0352:F0 FB   034F           BEQ    WAIT
0354:               *
0354:AD 00 C5               LDA    PBD           RESET CB2
0357:               *
0357:               *   *** AT THE END OF EACH ROW CHECK FOR A KEYPRESS  ***
0357:               *       AND BRANCH IF EITHER THE RETURN OR ESCAPE
0357:               *       KEYS HAVE BEEN PRESSED.  RETURN KEY STARTS
0357:               *       A NEW FRAME, ESC KEY RETURNS TO BASIC PROGRAM
0357:               *
0357:AD 00 C0               LDA    KBD           WAS ANY KEY PRESSED?
035A:10 CA   0326           BPL    START         NO, GO BACK FOR ANOTHER PIXEL
035C:8D 10 C0               STA    KBDSTRB       YES, CLEAR THE STROBE
035F:C9 9B                  CMP    #$9B          WAS IT THE ESC KEY?
0361:F0 07   036A           BEQ    END           IF SO END
0363:C9 8D                  CMP    #$8D          WAS IT THE RETURN KEY?
0365:F0 B3   031A           BEQ    TLIN          IF SO START A NEW FRAME
0367:4C 26 03               JMP    START         ANY OTHER KEY -- GET NEXT PIXEL
036A:               *
036A:60             END     RTS


 C503 DDRA         ?C502 DDRB          036A END          C50D IFR
 C000 KBD           C010 KBDSTRB       C501 PAD          C500 PBD
 C50C PCR           0328 PIX           0335 READY        0343 ROW
 0326 START         031A TLIN          034F WAIT
** SUCCESSFUL ASSEMBLY := NO ERRORS
** ASSEMBLER CREATED ON 30-APR-85 22:46
** TOTAL LINES ASSEMBLED   122
** FREE SPACE PAGE COUNT   89
```

Table 2
Approximate Pixel Clock Rates And Suggested Switch Arrangements

Type of Image	*Pixel Rate (Hz)*	*Line Select*	*Resistance (in kΩ*)*
Tiros full frame	1000	÷ 3	12
Tiros expanded	3400	÷ 1	2.4
Meteor full frame	550	÷ 2	25
GOES WEFAX full frame	1000	÷ 3	12
GOES WEFAX expanded	1800	÷ 2	6

*The resistor values listed allow you to receive a satellite picture on these frequencies. The values may be changed to acquire better resolution.

shown in Table 2 give the approximate pixel rates. A more elegant scheme would be to synthesize the pixel clock from the 2400-Hz satellite subcarrier, but the clock shown here works well and is easy to construct. Several multiturn potentiometers are used, one for each standard satellite mode. These are switched with a small DIP switch mounted on the circuit board.

The sweep-reset frequency switch in Fig 34 selects line rates of either 120 or 240 lines per minute. The interface card uses two 74LS76 J-K flip-flops: One is used as a divide-by-two counter, the other as a divide by three. This arrangement allows for selection of every line, alternate lines, or every third line, and is useful in adjusting the image to get the proper image-aspect ratio. By displaying alternate lines, or every third line, you can get more territory on one image, but at the expense of resolution (Table 2 suggests switch settings for the various satellites).

Software

The software featured in this article is available from me on diskette.[15] The programs perform a number of important tasks, such as loading an image into the Imageworks card. The BASIC program in Table 3 sets the screen for receipt of an image, and calls a machine-language routine to do most of the work. The machine-language program instructs the Apple's microprocessor to watch for clock signals on the two clock lines, grab a digital sample of the analog signal at the right moment, and load it into the correct address on the Imageworks card to provide the next pixel.

The machine-language program is fairly compact, and fits between \$0300 and \$03CF in the Apple's random access memory (RAM). In this location, it does not interfere with the BASIC program or the Imageworks machine-language utilities. The machine-language program can be entered with any of the Pro-DOS-based assemblers, or with the Apple Mini-assembler, if desired. The binary (object code) file should be saved under the name ASAT.OBJ so it can be located and loaded by the BASIC program.

It is helpful to trace the machine-language program for a better understanding of how the ASAT unit operates. First, the 6522 VIA chip is initialized. Port A is designated as the data input port. CA1, CA2, CB1 and CB2 lines are defined next, and are used to carry clock and ready signals between the computer and the interface circuits. More information on configuring the 6522 chip is available in the references provided at the end of this article, and a good discussion can be found in DeJong's book.

Next, the first pixel address is set for the upper left-hand corner of the screen (column set to zero, and line set to eleven). The microprocessor then waits for a clock signal from the pixel clock. When a clock signal is received, the analog signal is sampled and the value is stored in the first pixel address. The program advances the pixel count by one and checks to see if the count has advanced past 256. If not, the program loops back, waits for the next pixel clock signal, and repeats the process. If the pixel count has passed 256, the program pauses to wait for a signal from the line clock. After a line-clock signal is received, the program checks to see whether the last line of the image has been used. If not, the next line is filled with pixels. If the last line has been reached, the machine-language subroutine exits to the BASIC program.

Once in BASIC, you should see a satellite image on the screen. You can now exit the BASIC program and load the Imageworks utility program to save, invert, or rotate the image, look at the "negative" (inverse video) version of the image, perform a histogram equalization, or use any of the other options on the Imageworks menu. Since the software supplied with the Imageworks card is not protected (unlocked) and written in con-

Table 3
Basic Program That Loads The Machine-Language Program

```
100   REM   ******  ASAT: APPLE SATELLITE IMAGING SYSTEM
110   REM   ******  GRANT ZEHR  WA9TFB
120   REM   ******  THE IMAGEWORKS CARD MUST BE INSTALLED IN SLOT 7
130   REM   ******  THE ASAT INTERFACE MUST BE INSTALLED IN SLOT 5
150   PRINT CHR$ (4);"BLOAD ASAT.OBJ"
155   VTAB 1
    : HOME
160   PRINT "              ASAT:
170   PRINT
180   PRINT "   APPLE SAT IMAGING SYSTEM"
190   PRINT
    : PRINT
    : PRINT
200   PRINT "<RETURN> TO RESET THE SCAN LINE TO"
205   PRINT "          THE TOP OF THE SCREEN"
    : PRINT
210   PRINT "<ESC>    TO EXIT THE IMAGING MODE"
220   VTAB 14
    : GET A$
230   IF A$ = CHR$ (13) THEN HOME
    : CALL 768
    : GOTO 155
240   IF A$ = CHR$ (27) THEN END
250   GOTO 220
```

ventional Applesoft BASIC, it is a simple matter to rewrite the program to include the Imageworks features in a control program for the ASAT system.

Construction

Construction of the interface unit is straightforward. First, the circuits from the *Handbook* are built and aligned as described there. I built the circuit in Fig 2 on a Radio Shack experimenters PC board. The input to the A/D converter must be in the range of 0 to +5 V, as noted previously. When the A/D converter chip is working properly, a digital logic probe detects switching on each of the eight digital output lines (pins 11-18) with signal input. The reference voltage on pin 9 should be set to +2.5 V dc.

An oscilloscope can be connected to pin 3 of U1 to confirm the operation of the pixel clock. A frequency counter is helpful in getting the pixel clock operating at the right frequency. These rates can be adjusted by turning potentiometers R1 through R3 to obtain the proper image-aspect ratio on the monitor in use at your station. The oscilloscope is also helpful in determining that the divide-by-two and divide-by-three circuits are working properly.

The most difficult aspect of construction is to be sure that the control lines are going where they should be (the CA1, CA2, CB1 and CB2 pins). Review the assembly-language listing to understand how these lines work.

Power for the interface circuits can be obtained from the Apple II bus. I do not recommend powering the entire circuit from the bus: I use a separate power supply for the circuits from the *Handbook* to avoid overloading the Apple's power supply.

All of the parts used in construction of this project can be purchased from Digi-Key Corp.[16] The prototype board was bought at Radio Shack. The project has not yet been built into a separate chassis; my goal is to get all the circuits onto a plug-in card that fits inside the Apple //e cabinet.

Operation

When the circuits are operating normally, load the programs listed in Tables 1 and 3. Power up the interface circuits, and play the tape-recorded satellite signal into the tape input.

From the BASIC starter program, press the RETURN key to start loading the image into the graphics card. You should see the image develop on the screen. After the image begins to load, you can use the horizontal-phasing switches to center it on the screen. The RETURN key on the Apple keyboard restarts the frame. Once this key is pressed, the next video line loads into the top line on the screen. Pressing the ESC key causes a jump back to the BASIC program. Hitting the ESC key a second time lets you exit the program and provides you with the Applesoft blinking cursor. Your computer is now ready for the next program or application.

You may begin to load the Imageworks routines at this point. The image will stay on the screen unless your startup program asks for an "erase." This can be changed by modifying a single line in the Imageworks startup program, and is discussed in the owner's manual. Under normal conditions, a reset or even rebooting the disk will not destroy the image in the Imageworks card. The power to the computer should be left on, however, since an off/on cycle will erase the image from the Imageworks card.

If the image on the screen has an unusually large number of black areas or streaks, it may be necessary to reduce (not increase) the signal level. At times, a high input level can result in signal peaks beyond the +5-V input recommended. When this happens, the 8-bit digital output from the A/D converter may read zero or a low number, and the image will have unwanted dark areas.

Results

Some of the images I have received with my ASAT station are shown to demonstrate the possibilities of this system. The first set of images (Figs 3-6) were taken during a pass by NOAA 9 during August of 1986. Fig 3 shows a full-width image over the eastern part of North America. The NOAA gray scale and white timing bars are marked along the vertical edges of the image. Although the image clearly shows the "pixel effect," it also shows land detail and larger cloud patterns. Fig 4 is from the same pass. The tape recording of the satellite signal was rewound to the area over the Carolina coast, and the pixel and line rates were increased to show every line, but cover a much smaller geographic area. Smaller clouds and land details are now visible. Similar techniques were used in Figs 5 and 6. Fig 5 shows the area around Lake Huron in the visible mode. Fig 6 shows the matching infrared image. Notice that the high-altitude clouds over central Michigan, which are prominent in the infrared image, are hardly visible in the visible-mode image.

Figs 7-10 were taken during NOAA 9's pass over the east coast of North America. Fig 7 shows Cape Cod, Nantucket Island, and Martha's Vineyard. Note the small cloud over the ocean off the east coast. This feature helps orient the next two images. Fig 8 is the infrared image corresponding to the previous visible-mode image. While this image is of rather low contrast, patterns are clearly visible in the water offshore. These patterns correspond to temperature variations on the water surface. The darker areas are warm-water areas moving north along the Gulf Stream. The whiter areas indicate colder water from the North Atlantic. To see these patterns better, I used a simple contrast-stretching program. In Fig 9, the patterns stand out more clearly. The differences between the two images are the result of digital-image processing (photo techniques were the same in each case). One of the enhancement curves described with the VIC-image processor[17] could just as easily be used in place of the contrast-stretching curve.

The final image (Fig 10) is a visible-mode image from NOAA 9 made during a pass over the Gaspe peninsula in Quebec. This simply illustrates the land detail that the ASAT system is capable of producing.

Some Software Experiments

Because the Imageworks card allows for the display of both Apple and Image-

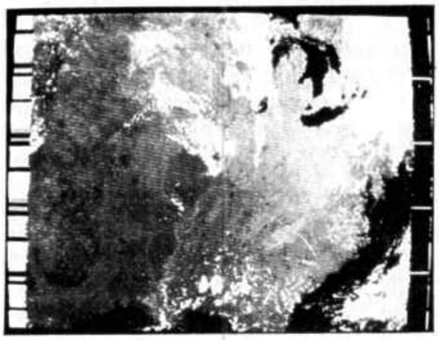


Fig 3—A full-width image of the eastern part of North America. NOAA 9's gray scale and white timing bars are shown along the vertical axis.

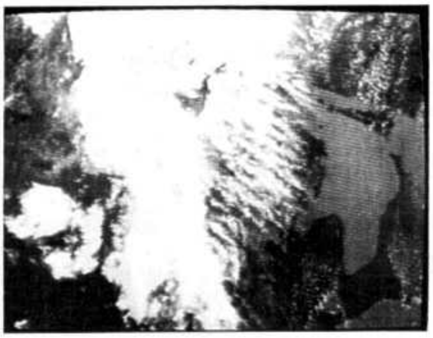


Fig 6—The Lake Huron area (from the map in Fig 3) in the infrared mode.

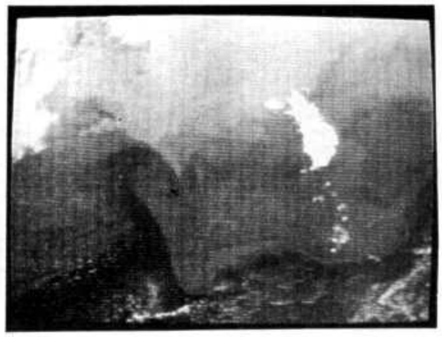


Fig 8—An infrared image of the Massachusetts coastal area showing water temperatures.

Fig 4—Same image shown in Fig 3, after pixel and line rates were increased to detail the Carolina coast. This picture covers a much smaller geographic area than Fig 3.

works graphics simultaneously, you can do some interesting experiments with the pictures. In Fig 7, for example, a cursor can be seen off the coast of Cape Cod. The software allows cursor movement with a standard Apple mouse, and the numeric brightness value of the pixel can be displayed on the screen. In this image, Z (the brightness value) is 44. (The blackest value is 0, and the brightest is 255, with 44 being very dark, but far from zero.) X and Y in the figures refer to the pixel's location on the Apple's high-resolution screen. XG and YG are the corresponding coordinates on the Image-works graphics card.

Another exercise to "doctor up" the image is to remove obviously incorrect pixels, and substitute them with a value that looks right. Single-pixel defects can be removed by replacing the bad pixel with a new one calculated by averaging the values of pixels located above and

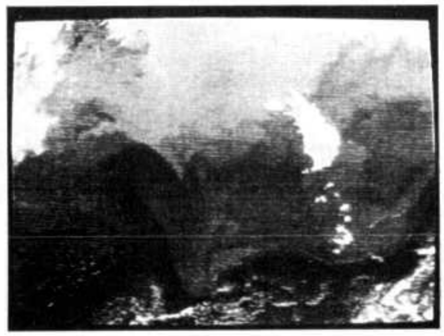


Fig 9—By using digital-image processing techniques, the water surface temperature patterns of Fig 8 stand out more clearly.

Fig 5—The Lake Huron area (from the map in Fig 3) in the visible mode.

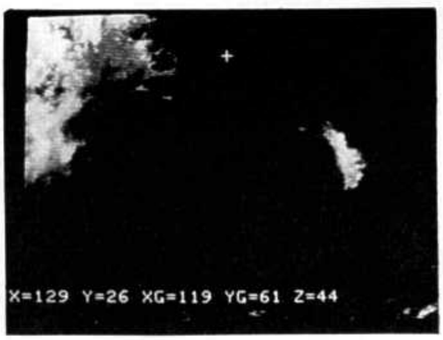


Fig 7—Cape Cod, Nantucket Island, and Martha's Vineyard.

Fig 10—The Gaspe Peninsula in Quebec. This image shows the land detail the ASAT is capable of producing.

below the bad one. Streaks in the image, caused by noise in the signal or faulty recording media, can sometimes be removed. This technique improves the overall "look" of the image, but must be used with care: This technique destroys the collected data and replaces it with something created by you and your computer.

The display can be used for many other applications. I am currently scanning NOAA publications to learn how to calibrate my system from the gray scale in the satellite-image border. In this way, it should be possible to calculate cloud-top temperatures and water-surface temperatures from data in the infrared images.

Problems

The most fundamental problem with this type of display concerns image resolution. As with any digital-imaging technique, the image resolution depends on the number of pixels that the system can display. In this system, the image is limited to about 256 × 256 pixels. This is the practical maximum for an 8-bit microprocessor-based microcomputer (such as the Apple *//e*) and a standard video monitor. Unfortunately, this is well below the full resolution of an APT analog image. Your choices are to either display a small part of the image at full resolution, or the full image at reduced resolution. Compared to a 256 × 256 digital image, a well-adjusted analog APT system will usually produce a sharper image, because it can display all the lines and is not limited by the number of pixels available.

A second problem arises when trying to obtain hard-copy images. It is not easy to get hard copy from this type of display. The screen can be photographed using standard close-up techniques (as was done for the images shown here). The alternative is to print out the display on a laser printer. The people at Redshift Ltd may have developed software to allow for an interface to be connected from the Apple *//e* to a laser printer. The limiting factor then becomes cost; a laser printer now costs around $2000.

A third consideration is cost. Since a microcomputer and a commercially-produced graphics card are required for this display, the display unit will cost more than a typical, homebuilt analog system.

Summary

In spite of the problems noted earlier, the system described here provides an excellent "advanced beginner" system. My goals for the project were met when I was able to store and manipulate an image of the desired resolution using standard Apple II programming techniques. The wide variety of Apple II peripheral devices available can be used to good advantage. The addition of larger disk storage devices, such as the 3.5-inch Unidisk or a hard disk, provides substantial upgrade to the station. Other useful additions are the Apple mouse, a light pen or graphics tablet. Accelerator cards (that speed up microprocessor operations) can be used to good advantage. Commercial software, including drawing programs, utility programs, and BASIC compilers, are available, speeding up the development of applications software.

At my station, I use an enhanced[18] Apple *//e* with one Unidisk 3.5- and one standard 5.25-inch floppy disk drive (generic). The monitor is a Zenith ZVM-121, a popular, older model 12-inch green screen monitor. An Apple mouse locates and measures brightness on individual pixels as described earlier. The hardware and software work equally well with unenhanced Apple *//e* computers and older Apple II+ computers equipped with the 16-kbyte language card (needed to operate the Pro-DOS operating system required by the Imageworks software).

With a little work, some inexpensive chips, and the purchase of a single commercial plug-in card, you can convert your "plain vanilla" Apple *//e* into a flexible digital-imaging station. Then you, too, can have the power of a true image-processing workstation just like the big boys.

Notes

[1]The Voyager I and Voyager II scientific spacecrafts were launched in 1977. Engineered by the Jet Propulsion Laboratory in California, their mission is to explore the universe.

[2]M. Wilson, ed., *The 1988 ARRL Handbook*, (Newington: ARRL, 1987), pp 28-20 to 28-29.

[3]R. Taggert, *The Weather Satellite Handbook*, 3rd edition.

[4]G. Emiliani and M. Righini, "Printing Pictures From "Your" Weather Geostationary Satellite," *QST*, Apr 1981, p 20.

[5]See note 2.

[6]C. Abrams, "In Search of the Perfect Picture, Part II," *QST*, Jan 1986, p 18.

[7]M. Vidmar, "A Digital Storage and Scan Converter for Weather Satellite Images, Part 1," *VHF Communications Magazine*, Apr 1982; Part 2, Jan 1983.

[8]Redshift Ltd, 847 Starlight Lane, Los Altos, CA 94022, tel 415-322-7373.

[9]Note: While the Imageworks card can store a full 256 × 256 pixels, most users will not be able to use all 256 rows. Because of the way composite video is generated, most monitors need about 10 blank lines to sync properly. In practice, 246 rows × 256 columns can be used with most standard composite video monitors (such as Zenith or Apple monitors).

[10]K. J. Ciszewski, "Add A Peripheral Interface Adapter to Your Apple II," *BYTE*, Jan 1982, pp 324-330.

[11]D. Paul and J. Wisman, "Interfacing the Apple to 6500 Family Peripherals," *COMPUTE*, Aug 1981, pp 74-5.

[12]VIA part no. R6522, Rockwell International Product Description, Rockwell International, 1977.

[13]M. L. DeJong, *Apple II Assembly Language Programming*, Howard W. Sams & Co, 1982.

[14]*ADC/DAC Data Book*, National Semiconductor, available from Digi-Key Corp, PO Box 667, Thief River Falls, MN 56701, tel 1-800-344-4539.

[15]The programs featured in this article are available on a diskette supplied by the author to users in the US for $15. Programs include the BASIC listing, the source code in EDASM format and the object code for ASAT. The ARRL and *QEX* in no way warrant this offer.

[16]See note 14.

[17]G. Zehr, "The VIP: A VIC Image Processor," *QST*, Aug 1985, p 25.

[18]Enhanced Apple *//es* use 65C02 microprocessors and BIOS and video ROMs that are updated versions of the original 1983 issue. If in doubt as to whether or not you have an enhanced *//e*, consult your Apple dealer.

Bits

New Edition of Popular Circuits Handbook Available

A thoroughly revised and updated third edition of the *Printed Circuits Handbook* is now available. More than 25 specialists have contributed material on how to design a cost-effective PC board without compromising the material, hardware or process. Explanations of how to make up, maintain and correct chemical solutions for printed circuitry are given and information on surface mount technology is included.

This 931-page book is an essential reference for electronics engineers, designers, manufacturers and technicians. Clyde F. Coombs, Jr, Editor in Chief, is the marketing manager for the Printed Circuit Board Division of Hewlett-Packard Company and has written articles on PC boards for different publications. Cost: $59.50. Contact McGraw-Hill Book Co, 11 W 19th St, NY, NY 10011, 212-337-5945 or 337-5951.—*Maureen Thompson, KA1DYZ*

First On-line Electronic Catalog

Schweber Electronics has introduced the first on-line electronic reference, pricing and order entry service. SchweberNET allows engineers to place orders for small quantities of components directly from their workstations.

SchweberNET is in an agreement with Videolog Communications of Norwalk, CT to have coupled access between Videolog's semiconductor reference library with Schweber's on-line inventory. Videolog users can search for commercial and military semiconductors by specific or generic part type, or by a key word. There is an additional menu-driven search feature that guides the viewer through databases containing over 750,000 part numbers from 700 manufacturers.

For a free look at the SchweberNET service, call 1-800-VIDPEEK on your modem-equipped terminal or PC. For more information, write or call David Klippert-Rowe, Corporate Business Manager, Schweber Electronics, CS 1032, Westbury, NY 11590, tel 516-334-7555.—*FYI, TI, Inc, PO Box 655012, MS 478, Dallas, TX*

Superconductivity—More Than Just Levitation

By Maureen Thompson, KA1DYZ
Assistant Editor, QEX

What's all this talk about superconductivity? New terms like semiconductor-superconductor hybrids, high-speed computer interconnects and Josephson junctions are popping up in technical conversations everywhere. How will this developing technology affect the electronics industry? Will Amateur Radio benefit?

Seeing an object levitate over another is mind boggling to those observing this manifestation of superconductivity for the first time. The researchers' brew calls for the immersion of a compound, fired as ceramic consisting of barium, lanthanum, copper and oxygen in liquid helium. A magnet is then centered over the alloy for a visual effect of superconductivity. The formula sounds easy, but there is more to this technology than meets the eye.

The roots of superconductivity date back to experiments performed as early as 1908, when helium was first liquified. In 1911, characteristics of superconductivity were observed in the laboratory for the first time by Heike Kamerlingh Onnes. In 1933, the Meissner theory was published. This theory states that when a superconductor is cooled, the material exhibits perfect *diamagnetism*. In other words, magnetic flux only penetrates the outer 10^{-6} cm of the molecules of the superconductor. The flux is almost completely excluded from the superconductive material. The flux field passes around the molecules as shown in Fig 1. This theory explains why a piece of superconductive material expels a magnetic field from itself; the repulsion generated is able to levitate a small object.

During the 1940s and 1950s, electron-only theories surfaced. Research by Heisenberg-Koppe showed that by using available alloys, a transition to the superconductive state could be observed at 10° K. Further contributions were made by Froblich and Bardeen in 1950.

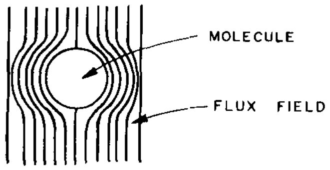


Fig 1—When a superconductor is cooled, magnetic-field lines of force are pushed out at the transition, allowing perfect diamagnetism in the superconductive material. The flux field (approximately 10^{-6} cm thick) engulfs the molecule. This theory is known as the Meissner Effect, and helps explain the behavior of superconductors.

In 1955, the Cooper Pair theory was introduced. Also known as the Bardeen-Cooper-Schrieffer (BCS) theory, it is the theory by which we understand superconductivity today. It predicts most of the properties that occur when electron-phonon interaction takes place. (The Cooper Pair is discussed in more detail later in this article.)

In 1957, papers documenting superconductivity applications in Russia were translated from an Eastern-European scientific journal. During this time, superconductive materials could carry current without great loss, but the behavior of Type I superconductors remained limited, and technically uninteresting.

Type I Superconductors

The niobium and germanium alloys used in superconductive experiments during early research exhibited ideal behavior, and were categorized as Type I materials. Type I materials are classified as having limited performance; they do not possess the ability to carry high current. They have a positive surface area—the energy created does not form a surface area that easily supports superconductivity.

Type I materials are strong diamagnets; they repel flux when a magnetic field is applied. The magnetic field in the superconductive material increases, then disappears. The performance of these materials can be represented by the intrinsic magnetism curve in Fig 2, for which a phase boundary exists.

Type II Superconductors—Nonideal Behavior

The superconductive relationship at the microscopic level can be considered almost a form of magnetism. A combination of yttrium, barium, and iron is used to create the ceramic material. Liquid nitrogen, which is inexpensive to purchase, is used to cool the ceramic to about 92 K.

Many elements other than those stated can be combined to form superconductive ceramic materials. The superconductive effect, however, is limited by the elements used: Not all will support superconductive activity. The current-carrying capability of the alloys depends on how the materials are processed. Type II materials have a negative surface area —the electrons create more surface area to support superconductivity, and thus are able to carry large currents without resistance.

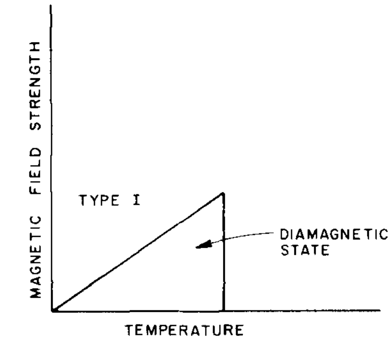


Fig 2—The intrinsic magnetism curve for Type I superconductors.

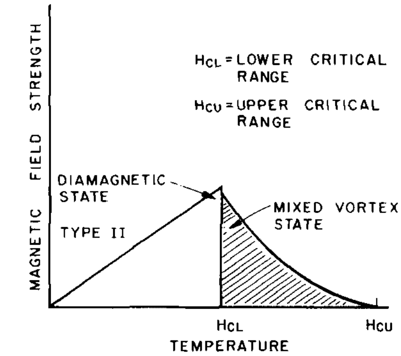


Fig 3—The intrinsic magnetism curve for Type II superconductors. On this curve, there is a lower critical range and an upper critical range, between which (in the shaded area) a mixed vortex state exists, supporting Type II superconductive activity.

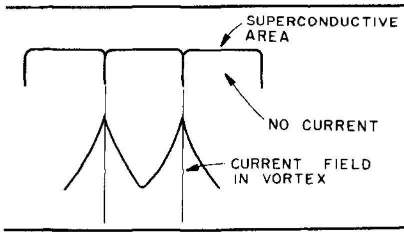


Fig 4—At A, a closeup of the superconducting region of a compound is shown. The top flat surfaces are where superconductivity occurs. Current fields exist between the flat surfaces in an area known as a vortex. The vortex regions are shown at B.

The intrinsic magnetism curve for Type II materials is shown in Fig 3. The shaded area represents that in which electrons are in a *mixed-vortex* state. Small circulating currents that create the magnetic fields are present in this mixed state.

The flat surfaces in Fig 4A bound the

superconducting region. In between these regions lie the vortex, where large current fields can exist. To stabilize the lattice elements and reduce electrical resistivity, it is necessary to process the material so that these vortices are "pinned," or locked in place, unable to shift. Fig 4B shows the vortex regions. They actually appear as a triangular distribution.

Rules of Superconductivity

Certain criteria must be met before a material is considered to be superconductive: (1) There must be a total lack of resistance to direct current, (2) the Meissner effect must be measured (it varies in different materials), (3) high reproducibility, and (4) high stability. Fig 5 is a phase diagram summarizing the types of superconductive states. The top region is the normal state, and the middle region is the mixed state that supports superconductive activity. The lower field experiences no flux penetration, so current is carried without resistance.

The Cooper Pair

Until very recently, the Cooper Pair (BCS theory) explained electron behavior in conventional superconductive materials. The process involves electron-phonon interaction. Ions vibrate with frequency. We know that a positive and negative electron are attracted to each other; they travel in different directions. In the Cooper Pair, the electrons travel in pairs: one electron spins upward, while the other spins downward, about a common axis. A *phonon* acts as a mediator to bring the two electrons together. This attraction overcomes normal repulsion to create an attractive interaction, giving rise to a superconductive ground state.

Another way to explain the Cooper Pair is to think of two marbles set apart from each other on a piece of paper. When each side of the paper is lifted, the marbles are set in motion, moving toward each other at a high rate of speed. The marbles eventually collide with great force, (an attractive interaction). The colliding force may be greater than what naturally occurs, resulting in ionic combinations that support superconductive activity.

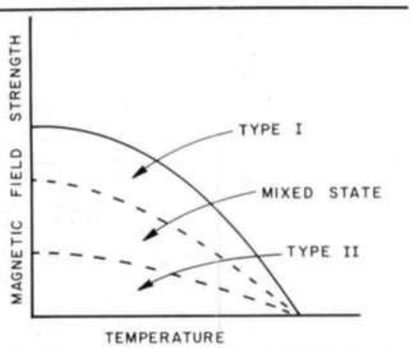


Fig 5—Phase diagram showing all three superconductive states.

Ablation—removal of part of a substance or object by melting or vaporization.

Diamagnet—a substance that can be slightly magnetized in the opposite direction of the magnetizing field.

Electron—an elementary particle of mass that consists of a negative or positive charge of electricity.

Electron-Phonon Interaction—when a phonon acts as a mediator to bring two electrons together to give rise to a superconductive ground state.

Flux—the rate of transfer of fluid, particles or energy across a given surface.

Ideal Behavior—a material that maintains constant properties and does not vary from the model is said to have this.

Ionic Combination—two atoms that are held together by electrostatic forces resulting from the transfer of one or more electrons from the outer shell of one atom to that of the other.

Meissner Effect—when a superconductor is cooled in a magnetic field the lines of induction (electric charge or magnetic field) are pushed out at the transition, allowing the superconductor to exhibit perfect diamagnetism.

Mixed-vortex State—see phase boundary.

Perovskites—class of ceramic materials named for the Russian village where they were first discovered in their natural state.

Phase Boundary—transitional region where a nonsuperconductive material changes to a superconducting material.

Phonon—a quantum of vibrational energy (as in a crystal). (A quantum is one of the very small increments or parcels into which many forms of energy are subdivided.)

Superconductor—a metal, alloy or compound that loses electrical resistance completely under a specific set of conditions (material dependent).

Vortex—a mass of fluid, especially a liquid, with a whirling or circular motion that is confined to a small area.

Many scientists question the validity of the Cooper Pair theory. Other theories that explain electron behavior in superconductive materials exist. At a 1987 Boston conference sponsored by the British journal *NATURE*, scientists gathered to review existing explanations. The *resonating valence bond* (RVB) theory, developed by Philip W. Anderson of Princeton University, states that superconductive activity relies on the magnetic spinning of copper atoms to cause, under special circumstances, the attraction of electron pairs. It may be at least five years, however, before a mechanism is identified and a microscopic theory for the crystal structure of the new materials is developed.

Oxygen Breathes Life Into Superconductive Elements

Two different copper-oxide materials have been successfully used in superconductivity research. The first element combination includes barium, lanthanum, copper and oxygen ($BaLa_2CuO_4$), and was researched by Bednorz and Müller in a Zurich laboratory in January 1986. They measured superconductivity at 30 to 40 K. It was their work with superconductivity that changed the thinking of many scientists.

Bednorz and Müller's report introduced *Perovskites* to the technical world. Perovskites are an obscure class of ceramic materials named for the Russian village where they were first discovered in their natural state. The properties of Perovskites are difficult to classify, however. Their crystal lattices are not identical in every direction, and electronic properties depend on the direction of current flow. Although it is difficult to classify them as electrical conductors or insulators, Perovskites are good conductors of ions; ionized oxygen and fluorine flows effortlessly through Perovskite compounds.

In January 1987, Dr Paul Chu of the University of Houston, and his colleagues at the Univeristy of Alabama, substituted yttrium in place of lanthanum ($YBa_2Cu_3O_{7-\delta}$). They raised the temperature to 50 K, and added pressure to achieve a transition temperature of about 98 K. Only part of their material is known to be superconductive, however.

The key to superconductive activity is controlling the oxygen. Manufacturers must learn how to process materials to keep the oxygen arranged properly. Through neutron scattering methods, researchers have found that the oxygen comes from one of four sites in the Perovskite structure of superconducting materials. When oxygen in superconductive elements is reduced to about 6.5 atoms, the lattice structure distorts and the material is no longer superconductive.

Uses For Superconductive Elements

Other than controlling the oxygen content in the material and the way it is arranged, other problems plague researchers. Critical current density is the amount of current per unit area that can be sent through a superconductor before resistance reappears. Some new superconductors that carry critical currents acceptable for power transmission purposes are only marginal for magnetic uses. Thin

Continued on page 15.

By Bill Olson, W3HQT
Box 2310, RR 1
Troy, ME 04987

Using Surplus 75-ohm Hardline at VHF

Unless you live way out in the sticks (like in Troy, Maine), you've probably got access to surplus 75-ohm cable-television (CATV) Hardline. Cable installers are usually left with "cable ends" of up to a couple hundred feet, and often these ends find their way into ham stations for the asking or for a token fee. The loss characteristics of ¾-inch CATV Hardline are excellent—about 0.8 dB per 100 feet at 2 meters and about 1.6 dB per 100 feet at 432 MHz. This is much better than RG-8! Many cable companies have switched to 1-inch Hardline, which is even better.

There are some tradeoffs, of course (there usually are with free stuff). CATV Hardline has a solid aluminum jacket and copper-plated solid-aluminum center conductor, so it is not flexible. Connectors can be difficult to come by, and then there's the concern about using 75-ohm Hardline in a 50-ohm system. You can't do much about the flexibility except be careful when handling the cable. You can, however, do something about connectors and impedance transformation.

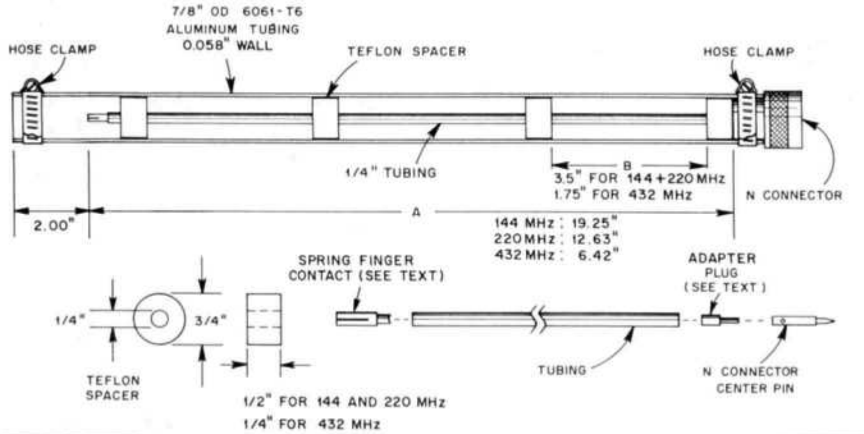


Fig 1—Dimensions of the 75-ohm CATV Hardline matching section and connector.

A Combination Matching Section and Connector

The devices described here solve two problems: making a suitable connector for CATV Hardline and matching 75-ohm cable to 50 ohms. They are designed for ¾-inch CATV Hardline; if you have ½- or 1-inch cable, you'll have to work out the details yourself. Developed by Clarke Greene, K1JX, and Jay Rusgrove, W1VD, connectors such as these have been in use at several Connecticut VHF stations for the past four years. Properly weather sealed, they offer reliable connections over the long term.

Each matching section is essentially a ¼-wavelength piece of 61.2-ohm coaxial cable that slips over ¾-inch CATV Hardline at one end and has an N connector on the other end. Fig 1 gives construction information and dimensions for matching sections for 144, 220 and 432 MHz. The matching section is mostly air dielectric, but there are Teflon® spacers to align the center conductor inside the outer conductor. The size and spacing of Teflon spacers were chosen to make the impedance 61.2 ohms when standard size tubing is used for the inner and outer conductors. (If no Teflon spacers are used, the impedance is higher than 61.2 ohms with the materials chosen.)

These matching sections work over a wide bandwidth (20 to 30 MHz), so construction tolerances are not critical. The match is excellent. When a pair of these connectors are attached to a section of 75-ohm Hardline and terminated in 50 ohms, return loss is greater than 30 dB (SWR = 1.06:1).

Materials

To build a pair of 144-MHz matching sections, you'll need about 4 feet of 7/8-inch-OD, 0.058-inch wall aluminum tubing, 4 feet of ¼-inch OD brass or copper tubing, 8 inches of ¾-inch OD Teflon rod, 2 inches of ¼-inch OD copper or brass rod, four 1-inch hose clamps, two UG-21D N connectors, and a UHF T connector. If you don't have 7/8-inch tubing left over from your last antenna project, try Metal and Cable Corp, PO Box 117, Twinsburg, OH 44087, tel 216-425-8455. The brass or copper tubing and rod and the Teflon rod may be available at hobby stores, or try Small Parts, PO Box 381736, Miami, FL 33238, tel 305-751-0856.

In addition to normal hand tools (hacksaw, file, large soldering iron, etc), you need access to a small lathe or a drill press to build these connectors. The job is easier with a lathe, but a drill press and file work fine, too, if you're patient.

Making the Pieces

Outer conductor. The outer conductor is made from 7/8-inch OD aluminum tubing with a 0.058-inch-thick wall. The wall thickness is important: This size tubing fits snugly over the aluminum outer jacket of 75-ohm CATV Hardline, and it fits well over the body of a UG-21D N connector. Cut the aluminum tubing to the right length for the frequency of interest. The exact length is not critical; start with dimension A in Fig 1, and add about 2 inches for a good mechanical connection to the Hardline. Cut four 5/8-inch-long slits in each end of the tubing (for tightening down the hose clamps), and deburr everything. If your tubing has been laying around for a while, make sure that the inside is clean and smooth.

Fig 2—Disassembled UHF T connector.

Adapter plug. An N-connector center pin is too small to fit inside ¼-inch center-conductor tubing, so you'll need to make an adapter plug from ¼-inch OD copper or brass rod. (This is where the lathe or drill press comes in.) One end of the adapter fits inside the ¼-inch tubing; the other fits inside the N-connector center pin. The exact dimensions of the adapter depend on the wall thickness of your ¼-inch tubing and on the N-connector center pin—turn the rod down a little at a time, until both ends just fit. If the fit is sloppy, you'll have a hard time making the pieces line up in the final assembly.

Fig 3—Completed matching sections for 432 (top) and 144 MHz.

Adapter length is not critical; ½ inch overall gives a good mechanical connection.

Contact fingers. The other end of the center conductor must make good mechanical and electrical connection to the Hardline center conductor. The commercial boys do this with silver-plated spring contact fingers that slip over the center conductor and grip it tightly. We can do that too.

Find a good-quality UHF T connector—the kind with two female ports and one male port. Grip the center pin of the male port with a pair of pliers and turn it counterclockwise. After overcoming some initial resistance, you'll be able to unscrew the male center pin and remove it completely. Now push on either of the female ends, and the insulator and female center pin will slip right out. The center pin is a single piece of silver-plated brass with contact fingers on each end. You'll end up with a pile of parts like those shown in Fig 2. We only need the female center pin. (If you come up with a good use for the rest of the parts, drop me a note.)

Cut the center pin in half (cut right through the threaded part), and you'll have a pair of contact fingers the right size to fit over the center conductor of ¾-inch CATV cable. You'll need the lathe or drill press again to turn down the cut end of each center-pin half to fit inside the matching-section center conductor.

Center conductor. The center conductor is made from ¼-inch-OD brass or copper tubing. The overall length of the center conductor, from the base of the N-connector center pin to the tip of the contact fingers, is shown as dimension A in Fig 1. The contact finger is about 5/8-inch long, so cut the center-conductor tubing 5/8 inch shorter than dimension A. Deburr both ends of the center-conductor tubing (inside and out) and clean the material with emery cloth or a scouring pad until it shines. Remove as much oxidation from the inside of the tubing as you can for ¼-inch or so from each end.

Teflon spacers. The spacers are cut from ¾-inch OD Teflon rod. They have a ¼-inch OD hole drilled in the center to pass the center-conductor tubing. For 144 and 220 MHz, make the spacers ½-inch wide; make them ¼-inch wide for 432 MHz. The number of spacers you'll need per matching section depends on the band. You'll need six for 144 MHz, four for 220 MHz and four for 432 MHz.

Prepare the CATV Hardline. If your cable has a plastic outer jacket, remove it for about 4 inches from the end. Use a hacksaw or tubing cutter to cut through and remove the aluminum outer conductor about 1 inch from the end. Deburr the end if necessary and make sure the aluminum jacket is smooth. Use a sharp knife to cut away the foam dielectric; be careful not to nick the center conductor. Use a sharp knife, fine file or sandpaper to remove any foam that sticks to the center conductor. Be careful not to file or cut away the copper plating. Cut the center conductor so that it protrudes ½ inch from the dielectric and round the end with a file.

Assembling the Parts

Place the spring finger contact in one end of the center-conductor tubing, make sure it's straight, and solder it in place. Try to keep the solder on the inside of the tubing. Soldering flux and a heavy iron make this job easier. Next, solder the adapter plug into the other end. Finally, solder the N-connector center pin to the adapter plug. Use a file to remove any solder from the outside of the center-conductor tubing.

Next, slip the Teflon insulators over the center conductor. Space them about 3.5 inches apart for 144 and 220 MHz, and 1.75 inches apart for 432 MHz. The spacing between the end insulators is a little closer to allow room for the N-connector body and contact fingers. Fig 3 shows the completed matching section.

Place the matching-section center-conductor assembly inside the outer conductor, slip the finger contacts over the Hardline center conductor, and slide the matching-section outer conductor over the Hardline outer conductor. Push the matching section onto the Hardline until the N-connector center pin sticks out the far end. Put the N-connector body on the center pin and push it until it seats against the end of the matching section center conductor. Adjust the position of the matching-section outer conductor so that the connector works properly, slide on and tighten down the hose clamps, and you're done.

Bits

FAR Scholarships

The Foundation for Amateur Radio (FAR), Inc, a non-profit organization with headquarters in Washington, DC, plans to award 28 scholarships for the academic year 1988-89 to assist licensed radio amateurs. The Foundation, composed of 50 area Amateur Radio clubs, fully funds six of these scholarships with the income from grants and annual hamfests. FAR administers, without cost to donors, seven scholarships for the Quarter Century Wireless Assn, two each for the Dade (FL) Radio Club, the Baltimore (MD) Amateur Radio Club, the Department of State Amateur Radio Club, the Amateur Radio News Service, the 10-10 International Net, the Radio Club of America and one each for the Richard G. Chichester Memorial, the Young Ladies' Radio League, the Columbia (MD) Amateur Radio Assn, the Frederick (MD) Amateur Radio Club and the Vienna (VA) Wireless Society.

Licensed radio amateurs may compete for these scholarships if they plan to pursue a full-time course of study beyond high school and are enrolled or have been accepted for enrollment at an accredited university, college or technical school. Some of the scholarships require the holding of at least an FCC *General* Class license or equivalent. The awards range from $500 to $2000 with preference given (in some cases) to residents of specific geographical areas or those planning to pursue certain study programs.

Additional information and application forms can be requested by letter or QSL card, postmarked prior to May 31, 1988 from FAR Scholarships, 6903 Rhode Island Ave, College Park, MD 20740.

The Foundation for Amateur Radio, incorporated in the District of Columbia, qualifies as a non-profit organization under Section 501(c)(3) of the Internal Revenue Code of 1954. It is devoted exclusively to promoting the interests of Amateur Radio and those scientific, literary and educational pursuits that advance the purposes of the Amateur Radio Service.—*Hugh A. Turnbull, W3ABC, Chairman, Scholarship Committee, Atlantic Division Director*

13 Centimeters

By Bill Olson, W3HQT
Box 2310, RR1
Troy, ME 04987

2160-MHz Local Oscillator

Good morning 13 cm fans. As promised, this month we start on the design for a 2160- or 2256-MHz local oscillator—the "heart" of our 13-cm transverter or receiving converter. Again, the design goals are:

1) Two 5-mW outputs for transmit and receive mixers.

2) A clean, stable output.

3) Easy to get running without a lot of microwave test equipment and easy to build without a lot of machine work.

The design philosophy is similar to others in the recent literature.[1] An oscillator-multiplier chain generates approximately 50 mW of clean energy at 360 MHz. This signal drives an X6 diode multiplier to the final frequency. The 2-GHz signal is filtered by a high-Q filter and amplified by a series of silicon MMIC amplifiers to the desired output level. A 3-dB hybrid power divider provides two outputs for the transverter mixers. See Fig 1.

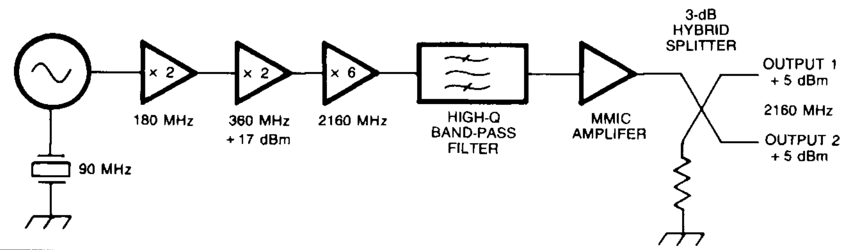


Fig 1—Block diagram of the 2-GHz local oscillator.

The advantages of using this LO scheme are many. For one, the 360-MHz signal is easy to generate. A number of proven designs in the literature use a 90- to 100-MHz crystal oscillator followed by two doublers. The doublers drive a single amplifier stage to the desired output level of 50-100 mW.[2] Doubler stages are relatively easy to get working at this frequency, and all transistors are inexpensive, garden variety types.

The biggest problem with many high-frequency oscillator/multiplier designs is instability of the high-frequency active multiplier and amplifier stages. This is because transistors that work well at these frequencies (1-2 GHz) have *very* high gain at lower frequencies. Without a spectrum analyzer, you're never quite sure what frequency your output is on!

Diode multipliers do not exhibit these problems because a diode has no gain and can't oscillate (at least not the types of diodes we'll use here!). A diode multiplier has a great deal of loss, though, especially as the multiplication order increases. Some diodes are manufactured specifically for frequency multiplication. Called step-recovery diodes (SRDs, or "snap" diodes), they operate quite efficiently. However, most SRDs are very expensive and not readily available on the surplus market.

A run-of-the-mill Schottky diode, or even a 1N914, multiplies with a great deal less efficiency, but since gain (with MMIC amplifiers) is cheap and easy to come by, we don't care. The MMIC stages are unconditionally stable and have 50 ohms input and output.

The output of the diode multiplier can be cleaned up with a high-Q filter that can be cut to frequency by carefully measuring the mechanical dimensions. There are a number of novel filter designs in the literature, both microstripline and air-transmission-line types. Often, sharp filters have a good deal of loss—but our MMIC amplifiers can make up for this as well.

The next 13 Centimeters column will be dedicated to the specific LO construction details.

MORE 13-CM PRODUCTS

Thanks to those who wrote in advising of commercially manufactured products for 13 cm. I recently received a catalog sheet from Ott, W4WSR, of HI-SPEC. In addition to the two-tube 1296-MHz cavity he has made for years, he offers two 13-cm designs. Model 13G1 is a one-tube cavity using a 7289; it has 10 to 13 dB gain with 25 to 50 W out, depending on the tube used. Model 13G2 is a two-tube version that puts out up to 100 W. Write HI-SPEC, PO Box 387, Jupiter, FL 33468 for more information. John Kitchens, NS6X, writes to inform that Antennes Tonna also offers a 2304-MHz Yagi. He didn't say anything about the claimed gain, number of elements, or availability, but Tonna antennas work very well. Anyone interested should contact Kitchens' Communications, PO Box 939, Camarillo, CA 93010 or The PX Shack, 52 Stonewyck Dr, Belle Mead, NJ 08502. Anyone else?

OPERATING NEWS

The January VHF Sweepstakes has just come and gone. While January is not normally known for extended UHF and microwave propagation, there are some very interesting "dead band" reports which can give us an idea of what minimum communications distances are on these frequencies. From "Pack Rat Land," Dave Hackford, N3CX, reports working 18 QSOs in 5 grids on 2304 MHz from his station in Green Lane, Pennsylvania (grid FN20). N3CX is running a home-brew solid-state transverter to a TRC29 2C39 amplifier at around 30 W out. His antenna is four 45-element loop Yagis at 70 feet fed with 1-5/8-inch Heliax®. Dave managed to work stations in grids FM29, FN20, FN10, FN21 and FN13. This last QSO was with Dave, KD5RO/2 in Pittsford, New York (near Rochester). KD5RO is running an SSB Electronics transverter (I think) to a 150-W TWTA and a 4-foot dish. This is a 220+ mile QSO over mountainous terrain in the middle of the winter! Signals were Q5 both ways.

Lauren Libby, KXØO, sends a report from the Salina, Kansas, contest operation —this time out using the call WAØTKJ. They worked 8 QSOs in 8 grids on 2304 MHz using 30 W to a single 45-element loop Yagi. The antenna is only 12 feet off the ground! Best DX was with rover station WBØVYV in northern Oklahoma (grids EM16 and EM06) at a distance of around 200 miles. WBØVYV was using a barefoot SSB Electronics transverter at ½ W out and a single 45-element loop Yagi. Lauren also reports some older news of significance. On Sep 7, 1987, KXØO with help from WØMXY, set up on Pike's Peak (14,000 feet high) in DM78. They worked WB5AFY in Vernon, Texas (EM04) at a distance of more than 450 miles—on a dead band! KXØO was using 30 W and a 60-element loop Yagi, while WB5AFY was running 400 W and a 4-foot dish. WB5AFY copied KXØO 53; signals in the other direction were 58!

On the West Coast, Allan, W6CPL, in Los Angeles reports making 5 QSOs in 5 grids during the January contest. While I don't have all the info here, Allan claims his best DX was 100 miles to San Diego, but he did have a one-way QSO with a station near Las Vegas, Nevada over a hilly 180-mile path. W6CPL uses an LMW transverter and a 45-element loop Yagi.

[1]Notes appear on page 15.

One of the grid hoppers out there was Barry, NØKV/6, who also runs an LMW rig.

After moving, I have just started to get my station back on the air. By the time you read this, I should be back up on 13 cm and will send in a report from Maine. Anyone else?

Notes

[1]The following references are useful:

R. Fisher, "Interdigital Converters for 1296 or 2304 MHz," *QST*, Jan 1974, pp 11-15, or see Chapter 32 of recent editions of *The ARRL Handbook*.

B. Atkins, "The New Frontier," *QST*, Feb 1988, p 65.

R. Campbell, "A No Tune Crystal Controlled Microwave Local Oscillator," *Proceedings of the 21st Conference of the Central States VHF Society*, available from ARRL.

[2]Suitable oscillator designs are:

J. Reisert, "VHF/UHF Receivers," *Ham Radio*, Mar 1984, pp 42-46.

P. Drexler, "A 404 MHz Local Oscillator," *Proceedings of the 1987 Mid Atlantic States VHF Conference*, available from the ARRL.

Superconductivity—More Than Just Levitation

Continued from page 11.

films manufactured by IBM can carry critical currents of 100,000 amperes per square centimeter—enough current to make microcircuitry applications feasible. Another question involves the stability of the materials: How will the new compound react to air and water, for instance?

The civilian and military sectors will benefit from discoveries made with superconductors. At the November 1987 RF Expo East in Boston, sponsored by *RF Design Magazine*, engineers and scientists lectured on practical and theoretical applications for the use of superconductive materials in filters, low-noise amplifiers, oscillators and delay-line applications. They concluded that superconductivity will indeed have an impact on future RF components and design techniques. Superconductor-aided computer communications would provide for high-speed signal transfer, and decrease power dissipation. Josephson junctions (superconducting transistor devices that act as a switch by amplifying small voltage signals in "on" and "off" states) are already being manufactured for use in high-speed oscilloscopes. The semiconductor industry could develop a host of semiconductor-superconductor hybrids. Superconductivity in underground transmission cables could reduce the lifetime cost of power-generating equipment. Present-day transmission networks are efficient, but some loss is incurred by the alternating current used in power transmission. Using cables made from superconductive materials would allow generators to run more efficiently.

Other areas that will benefit from developments in high-temperature superconductivity are in biomagnetics (the study of magnetic fields in the human body). The large magnets used in medical magnetic resonance imaging of humans must be made strong to carry large current fields. Magnetically levitated trains, electric cars, magnetic separation in film processing, energy storage, and magnetic weapons launchers are other possibilities. The Superconducting Super Collider project, developed around 1930, accelerates two beams of protons to energies of 20 trillion electron-volts each and force them to collide with each other to help scientists penetrate and reveal the smallest structures of matter. United Technologies is currently experimenting with *laser ablation*. In this operation, a laser deposits molecular units of superconductive material onto a substrate. The substrate collects the superconductive elements.

Conclusion

Knowledge continues to grow rapidly in the field of superconductivity, but many applications are yet to be developed. Advertisements in electronic trade journals are already making superconductors available for sale to the public. As of this writing, techniques for achieving superconductivity at temperatures as high as 500 K are being developed.

During the early part of this decade, NATO sponsored several symposiums on superconductivity research in the area of machines. All of this material is available for reference. As research laboratories at distinguished facilities such as IBM, Bell Laboratories, Perkin-Elmer, and universities around the world continue to research superconductivity, new opportunities for its use will surface. If you are involved in such research, you are invited to comment on how superconductivity will affect the electronics industry and how it may be applied to future Amateur Radio applications. Surely, if the electronics industry benefits from these developments, so will the Amateur Radio community.

References

C. Brown, "Perovskite Puzzle Deepens," *Electronic Engineering Times*, Oct 19, 1987, p 49.

J. Budnick, Techbreak lecture, Nov 10, 1987.

K. Hartley, "High-powered discussions on high-temperature superconductivity," *Science News*, Vol 132, Dec 5, 1987, p 359.

K. Hartley, "High-Temperature Superconductivity: What's Here, What's Near and What's Unclear," *Science News*, Vol 132, Aug 15, 1987, p 106.

W. C. Michels, et al, *The International Dictionary of Physics and Electronics*, NY, NY: D. Van Nostrand Co, Inc.

I. Peterson, "Signs of a New High in Ceramic Superconductivity," *Science News*, Vol 132, Dec 5, 1987, p 356.

A. Ramirez, "Superconductors Get Into Business," *Fortune*, June 22, 1987, p 114.

D. E. Thomsen, "Experimenting With 40 Trillion Electron-Volts," *Science News*, Vol 132, Nov 14, 1987, p 314.

D. E. Thomsen, "Super Collider: Steps to reality," *Science News*, Vol 132, Aug 5, 1987, p 103.

Bits

Call For DSP Sources

A lot of research is being done with digital signal processing (DSP), yet its presence in Amateur Radio seems scarce. If you work with DSP devices and are familiar with articles, textbooks and other literature, drop me a line. I'm interested in preparing a DSP bibliography. If you're ambitious, you can help me put one together. I'll need the name of the author(s), article (or book) title, the name of the magazine in which the article appears, publishing company, date and page number.—*Maureen Thompson, KA1DYZ, Asst Editor, QEX*

Celwave Offers Free Seminar Program

For the second year, Celwave of Marlboro, NJ is offering a series of free technical seminars to Land Mobile and Marine Communications professionals. The four-hour seminars are application oriented, hands-on workshops that address the latest technologies and products in the Land Mobile industry. Base station antennas and complete system components, mobile antennas, cable and marine products are a few of the product groups covered.

The seminars are open to dealers, installers, technicians and government personnel and will be held at various locations nationwide. For more information, contact Peter Devilliers, Field Sales Manager, Celwave, Route 79, Marlboro, NJ 07746.—*Maureen Thompson, KA1DYZ*

Coaxial Products

Looking for coaxial cable, cutting tools, crimping tools, stripping tools, coaxial adapters, coaxial detectors, or other coaxial interconnection products? Pasternack Enterprises has a complete 33-page catalog available to help you choose the right connector or tool to help you make that connection. For a free copy of their catalog, write Pasternack Enterprises, PO Box 16759, Irvine, CA 92713-6759, tel 714-261-1920.—*Maureen Thompson, KA1DYZ*

QEX MARCH AD INDEX