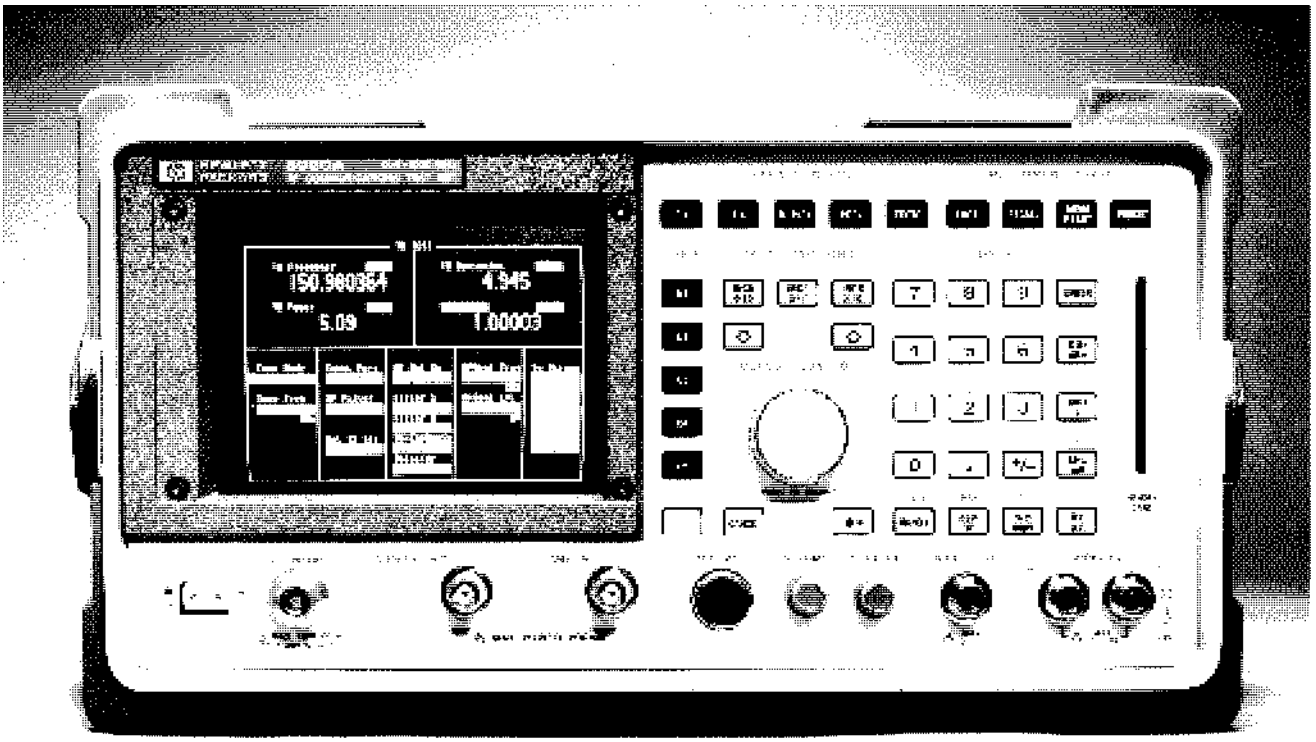
HEWLETT® PACKARD

Cellular call processing

Application Note

Programming techniques for the HP 8920A



Cellular Call Processing

Table Of Contents

Introduction

Call processing refers to the signalling protocol necessary to perform registrations, pages, originations, and channel handoffs for cellular phones. The purpose of this application note is to describe in detail the algorithms, messages and timing required to perform these call processing functions using the encoder and decoder capability of the HP 8920. This application note specifically describes the format for AMPS cellular, however the techniques are similar for systems like NAMPS and TACS.

Early HP 8920's did not have firmware with built-in cellular call processing functions. To test cellular phones with these early units, it was necessary to use software to control the encoder and decoder of the HP 8920. For this application, most HP 8920 users relied on the HP 11807 IBASIC software that was sold as an accessory to the HP 8920. For most applications the standard HP 11807 software was sufficient, however, some users wanted to modify the IBASIC program or port the IBASIC algorithms to run on an external computer. Because the HP 11807 was never designed to be modified by users, many found this task to be extremely difficult and required a broad range of training, experience, and documentation.

To address this concern, HP began shipments of the HP 8920 with built in AMPS call processing functions. This made it possible to test AMPS cellular phones without software, or for users that required automation, it was much easier to develop application software that simply accesses the built in AMPS call processing functions.

This document describes programming techniques for AMPS analog call processing functions. These techniques are used in HP 11807A option 004, 008, and 009 software. Also, these algorithms are very similar to the firmware algorithms being used in the new HP 8920's with built-in call processing. This information is useful for anyone writing call processing software for the older instruments, or for users that need to understand the algorithms being used in the latest HP 8920's. The programming techniques described here are valid for all versions of the HP 8920, however, users with newer HP 8920's would most likely want to use the built-in functionality instead of writing their own algorithms. The techniques for using the built-in call processing functions are described in the Users Guide and Programmers Guide provided with the new HP 8920's.

How each topic is discussed

This application note is organized into five sections, one for each of the major call processing functions. The five functions described are registration, page, origination, handoff (to change channel), and level change (to cause the mobile to change its output power). Each section contains a brief example of a typical 'real world' situation where a landstation and mobile would be communicating. Following each example, a flowchart is used to describe the recommended software algorithm that will cause the HP 8920 to simulate the land station and control the mobile begin tested. To support the flowchart, a detailed bit-level discussion of each control message is included. To summarize each section, a simpl BASIC program is provided that will simulate each call processing function.

For many users, using the simple program and expanding it to meet a particular need may be the easiest and fastest technique to developing custom software.

Many of the call processing messages are commom among registration, paging, and origination. Because the messages that are common are only explained in detail once, you should study this application note from start to finish.

Things you should already know

Before attempting to write your own AMPS call processing software, you should already be knowledgeable on AMPS cellular call processing

functions, you should be familar with overall HP 8920 operation including the encoder and decoder, and you should have a firm grasp on programming - preferrably in HP BASIC. As supplemental information, you should have access to EIA/TIA 553 standards, IS-88 standards, HP BASIC documentation, and the Users Guide and Programmers Guide for the HP 8920. If you are modifying an 11807 software package, you can review the actual code as you are reading this document and compare the 11807 messages and algorithms to the simplified programs supplied in this document.

References

This document relies heavily on the EIA/TIA 553 and IS-88 standards. Because the standards are primarily written to describe the behavior of the mobile, there is quite a bit of flexibilty required for interpretation about how the land station should perform many of the functions.

The algorithms used in the HP 8920 and 11807 software have been designed and evolved with many years of experience. It is recommended that when writing your own software, you follow these guidelines as closely as possible.

The EIA/TIA 553 and IS-88 standards can be ordered from:

EIA Engineering Publications
2001 Pennsylvania Ave., N.W.
Washington, D.C. 20006
(202) 457-4963

Overview of the bit level programming task

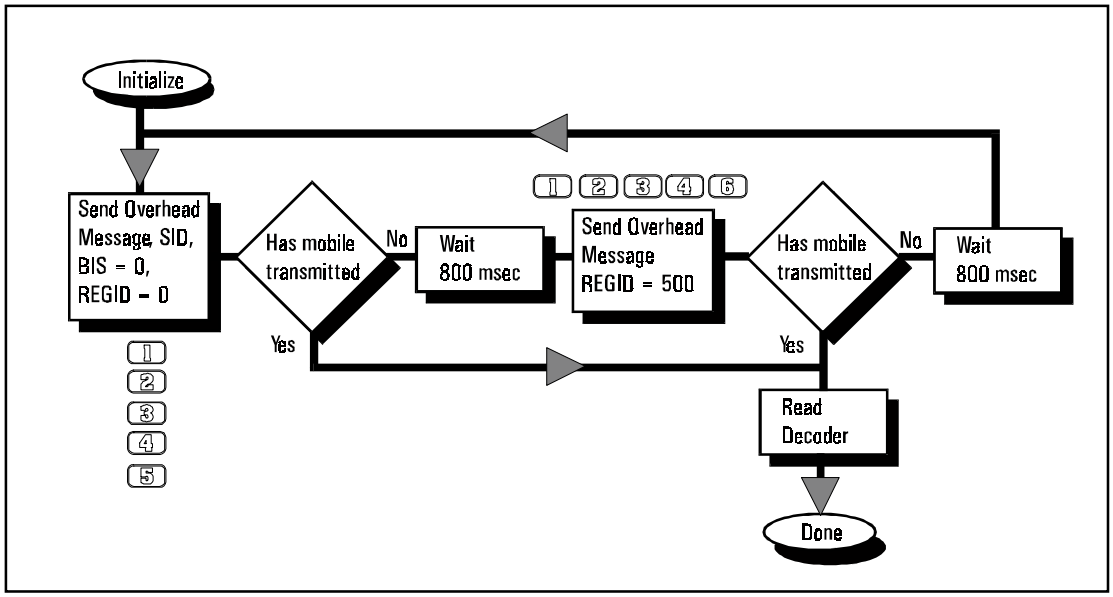
Each sample program shows a call processing function using predetermined messages. For writing your own programs, a significant portion of your task will be to understand and create the messages bit-by-bit that will control the mobile. For each sample program, the most important bits in each message is explained. To change any of the messages, you will need the EIA/TIA 553 or IS-88 standards.

For some functions you will want to decode the information returned back from the mobile. The sample programs show how to arm and capture data into the decoder. To better understand the meaning of the data in the decoder, refer to the HP 8920 users guide and appropriate standards.

Registration

Registration is where a mobile phone will contact the closest landstation and 'register' on the system. When someone trys to call the mobile, the system can quickly locate the mobile and connect the call. There are typically two situations which causes the mobile to initiate a registration. The first situation is when the mobile is first powered on, the second situation is when the mobile moves from one cell to another and needs to register with the new cell. Each of these two basic methods are described in EIA/TIA 553 standards and will reliably cause a mobile phone to register with a land station. In the first method the mobile receives a SID (Station ID) number that is different from a SID previously received. The algorithm in the mobile will conclude that the mobile has moved into a new area and will begin registration with the new land station. The second method, and the one chosen for the 11807A software, is where a REGID (Registration ID) message is transmitted such that the mobile determines it should register with the current station. This method to cause the phone to register is described in detail in EIA/TIA 553 (2.6.2.1 step 4). The testset uses a control channel to repeatedly broadcast messages with an alternating REGID. First REGID = 0 then REGID = 500. This will cause the phone to quickly go into a state where the phone sends its registration information back to the testset. The testset monitors the reverse control channel to receive the registration information from the mobile.

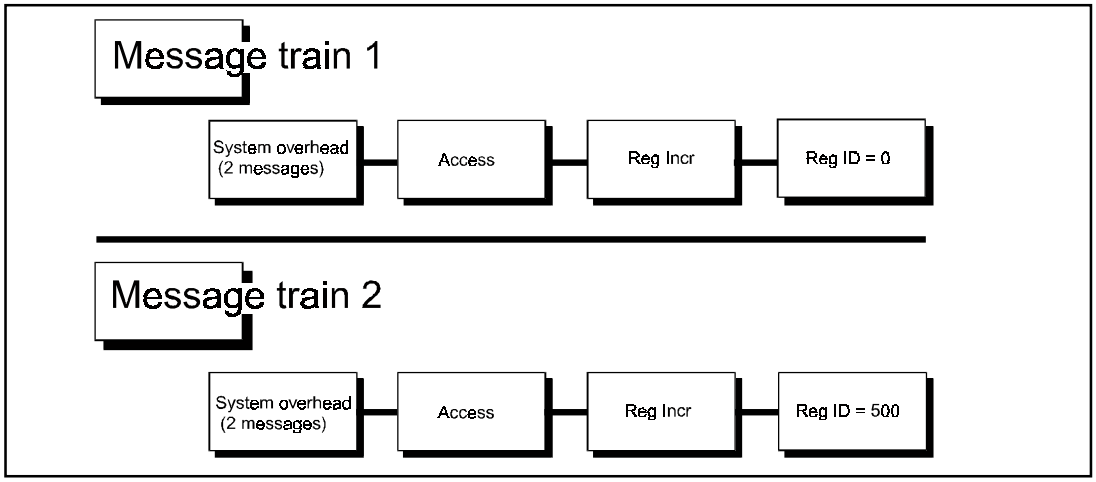
As shown in the flowchart, the HP 11807 Software begins by initializing the testset. This sets the RF frequency to a control channel, sets the output power and filters, and sets up the decoder to receive data back from the mobile. See the sample program for recommended settings. After the initialization, the testset transmits the overhead message train number 1 (explained later). The software then checks the decoder to determine if it has received a reply back from the mobile. If no data has been received from the mobile, the software will wait 800 milliseconds and transmit overhead message train number 2. Again, if no data has been received from the mobile, the software waits 800 milliseconds and starts the process over. Typically this will cause the phone to register within a few seconds. Because some mobiles are programmed to favor System A and others are programmed to favor System B, if possible, you should select the control channel that simulates the primary system for the mobile. Typically a mobile will scan its primary system first, then check the secondary system if no primary is found.



AMPS registration

Details of the REGID method:

The 11807A software begins the registration function by creating two message trains, with each train containing 5 messages. Each message is 28 bits, therefore each message train is a total of 140 bits. The message trains are exactly alike, except for the registration ID value contained in the last message of each train. The message trains look like:



Explanation of messages in each train

A complete description of each bit in each message is described in EIA/TIA 553 section 3.7. In addition to describing the message, the standard describes dotting sequences, word syncs, busy/idle bits and parity bits. When using the 8920A, it is not necessary for the software or users to determine these additional bits since these are automatically added in by the testset hardware.

The following explanation of System Overhead Messages, Access Messages, and Control Filler Message applies to Registration, Paging, and Origination. The messages described here are exactly the messages used in the HP 8920 and 11807. Most of the parameters (bits) in these messages should be used exactly as they are described.

System Overhead Message

This is actually 2 messages. The first message contains the 14 most significant bits of the System ID number (SID). The SID number is entered as a parameter by the user of the 11807A software. The first message also contains a 2 bit Digital Color Code (fixed at DCC=1 in software), and (NAWC = 4) meaning the Number of Additional Words Coming is 4 (This is required for a message train with 5 messages). The second message of the system overhead message contains nine bits, or combination of bits, with various system information. The bits and their meanings are detailed later in the Bit Level Message Discussion. The newer version of HP 8920 with built-in call processing allows the user to select a DCC other than 1, however the 11807 software does not allow this flexibility and there is very little reason you should need to change these bits. For many applications, setting the SID is important because this determines if the phone will be in a 'ROAM' or 'HOME' condition. When writing your own software, you would probably want to change the bits associated with SID and possibly DCC.

Access Message

This is called a global action message. One of the important bits in this message is BIS which indicates to the mobile how it should interpret the busy/idle bit stream from the land station. The software sets the value of BIS bit to 0, which indicates to the mobile that the mobile does not need to monitor the busy/idle bit stream transition from the testset. In 'standard' land stations, the mobile monitors the busy/idle bits from the land station and will only begin transmissions when the bit indicates 'idle'. When the mobile starts to transmit, it monitors the busy/idle bit stream from the land station and expects to see this bit stream toggle from idle to busy after a certain number of bits of transmission from the mobile. By setting the BIS=0, this instructs the mobile that monitoring the transition from idle to busy is not necessary. Although it is possible for the testset to monitor the decoder 'real time' and toggle the busy/idle during transmissions, this feature is not implemented as an option in the 11807 software and it is not necessary to sucessfully test a mobile.

Reg Incr (Registration Increment) Message

This is a global action message that sets REGINCR bits to decimal 100. This is a 12 bit value used in a calculation by the mobile to determine if it should send its registration information to the base station. The algorithm used by the mobile is explained later in this section.

Reg ID (Registration Identification) Message

This message contains a 20 bit REGID value used by the mobile to determine if it should send its registration information to the base station. Message train 1 sends a value of REGID = 0, where message train 2 sends a value of REGID = 500. By alternating these two messages to the mobile, the algorithm used by the mobile will quickly converge to a state where the mobile will begin transmission of the registration information. The algorithm is explained next.

Registration algorithm

Each mobile maintains a variable in memory called NXTREG (Next Registration). The base station transmits two values called REGID and REGINCR. If NXTREG is less than the REGID received, the mobile will wait a short time and send its registration information back to the base station. If NXTREG is greater than or equal to (REGID + REGINCR + 5), the mobile does not transmit anything, it merely decrements the NXTREG value and continues to monitor the base station. With enough decrements, the NXTREG will eventually be less than the REGID received and the mobile will respond to the base station with the registration information. To speed this process along, the testset software uses two separate REGID values to perform two distinct steps. Step 1 - The REGID value (transmitted) is set to zero, which causes the mobile to quickly decrement its NXTREG value. Step 2 - The REGID value (transmitted) is set to 500, and if NXTREG is less than 500, it will cause the mobile to perform a registration. Because the actual value of NXTREG is unknown, it may be necessary to repeat these steps a few times before the mobile will register. The complete algorithm used by the mobile is documented in EIA/TIA 553 Section 2.6.2.1 but is basically this:

Start:

IF NXTREG >= (REGID + REGINCR + 5) THEN
Set NXTREG = 0 or NXTREG = NXTREG - 2^20 whichever is greater
END IF

IF NXTREG < REGID THEN
Goto Registration Routine
END IF
End:

This algorithm is run by the mobile whenever a REG ID message is received from the basestation. By sending REGID = 0, the value of NXTREG quickly decrements to a value less than (REGINCR + 5) which is equal to 105 in the software. When REGID = 500 is sent, the comparison in the mobile will show REGID >= NXTREG and cause the phone to register. Because the value of NXTREG changes in the phone over time, and this value is saved whenever the phone is turned off, it is not possible to determine an algorithm which will always register the mobile on the first message. The values used in the software for both REGINCR and REGID have been chosen based on experience that they are a reliable and robust method to quickly register any mobile.

The primary advantage of the REGID method of phone registration is that the SID number can be set such that the phone will register as either HOME or ROAM depending on the preference of the user. In the method where SID numbers are changed, it is difficult to insure that the mobile will register as a HOME station.

Bit level message discussion

The actual messages used in the 11807A registration routine are explained here. The messages shown are the default values used by the software. Certain parameters can be set by the user (like System ID Number) which will change some of the bits in the following messages. This section is useful to compare the messages being sent by the testset with the mobile operation that is specified in the EIA/TIA standards. Each message is programmed in hex, and you will see hex used in the software and on the encoder screen. The Hex messages are described here in a binary format so they can easily be compared with the EIA/TIA 553 standards section 3.7.

System Overhead Message 1

D01CE26 HEX = 11 01 00000001110011 1 00 0100 110 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
SID = 00000001110011 is 14 most significant digits of SID = 231
EP = 1 indicates Extended Protocol Enabled (See IS-88 standard)
NAWC = 0100 indicates Number Additional Words Coming is 4
OHD = 110 indicates this is first word of a system parameter overhead message

System Overhead Message 2

DF2D967 HEX = 11 01 1 1 1 1 00 10110 1 1 0010110 0 111 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
S = 1 indicates Serial Number should be sent by mobile
E = 1 indicates Extended address should be sent by
REGH = 1 indicates Register Home Enabled. Signifies that mobiles in home system are required to register.
REGR = 1 indicates Register ROAM Enabled. Causes roaming mobiles to register.
DTX = 0 indicates DTX Disabled. Mobiles not allowed to use discontinuous transmission.
N - 1 = 10110 indicates 23 possible paging channels in the system.
RCF = 1 indicates Read Control Filler enabled. Causes mobile to read filler messages.

CPA = 1 indicates Combined Paging / Access True. Indicates Pages and Access use same control channel.
CMAX-1 = 0010110 indicates 23 possible access channel in the system.
END = 0 indicates this is not the end message
OHD = 111 indicates this is the second word of a system parameter overhead message

3 Access Message

D900004 HEX = 11 01 1101 0 000000000000000 0 100 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
ACT = 1101 indicates Access Type Parameters Global Action Message
BIS = 0 indicates mobile is not required to monitor busy/idle bit transition
END = 0 indicates this is not the end message
OHD = 100 indicates a global action message

4 Registration Increment Message

D206404 HEX = 11 01 0010 000001100100 0000 0 100 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
ACT = 0010 indicates Registration Increment Global Action Message
REGINCR = 000001100100 indicates Registration Increment of 100
END = 0 indicates this is not the end message of the message train
OHD = 100 indicates the Registration Increment Message

5 Registration ID Message with REGID = 0

D000008 HEX = 11 01 00000000000000000000 1 000 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
REGID = 20 zeros which indicates Registration ID of zero
END = 1 indicates this is the end message of the message train
OHD = 000 indicates the Registration ID Message

6 Registration ID Message with REGID = 500

D001F48 HEX = 11 01 00000000000111110100 1 000 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
REGID = 00000000000111110100 indicates Registration ID of 500

END = 1 indicates this is the end message of the message train
OHD = 000 indicates the Registration ID Message

7 Control-Filler Message

As soon as the testset completes the transmission of the first overhead message, the testset will automatically begin transmitting a control-filler message. The testset continues to transmit this message unless it is specifically turned off. If the testset is programmed to send another overhead control message, the control-filler will pause until the overhead message is sent, then the control filler will resume. In general, the testset will usually be transmitting control filler message unless an action is being performed like registration, page, handoff, or origination. The control filler message used by the testset expressed in Hex format is: D5C19F9.

D5C19F9 HEX = 11 01 010111 000 00 11 00 1 1 1111 001 (Binary)

The information contained in this message is.

T1T2 = 11 indicating it is an overhead message.
DCC = 01 indicating digital color code of 1.
CMAC = 000 indicating Control Mobile Attenuation Code of 0 (highest power available)
WFOM = 1 indicating Wait For Overhead Message is true.
OHD = 001 indicates this is a control filler message.

For most applications, the only bits you would need to modify are the SID bits which are the 14 most significant bits of the System ID number. By setting the correct SID, the mobile will indicate service as a HOME system, any other SID will cause the mobile to indicate service as a ROAM system. Other bits such as REGID, REGINCR, DCC, and CMAC could also be modified so long as the effects are fully understood as described in the standards.

The following program is designed to be a starter program for someone trying to write their own registration routine. This code was tested on a few different phones and would normally register the phone in < 5 seconds for a HOME system, slightly longer for ROAMing phones. Timing in the loop is important. The overhead message should be sent approximately every 800 milliseconds. Also, when reading the hardware status register (to determine if the decoder has received data) it is quite easy to accidentally cause the testset to lock up. Be certain that the program doesn't use the HP-IB bus for a few milliseconds after reading the status byte. The messages used in this sample program are exactly the messages as described above.

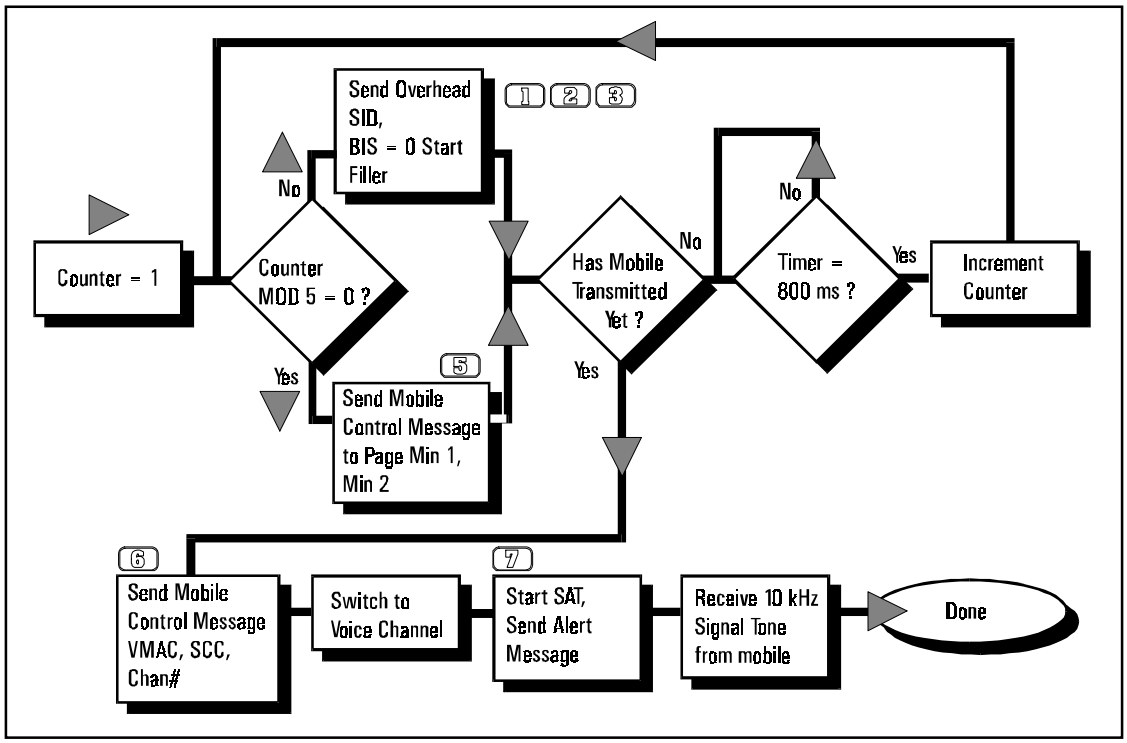
```
30 ! Sample program to register an AMPS cellular phone
40 COM Uut_addr
50 DIM M$(6)[7],Temp$[4000]
60 DIM Mess_0$[50],Mess_500$[50]
70   !
80 CLEAR 7
90 Uut_addr=714
100  ! Build messages, see the standard for exact bits used
110 Filler$="D5C19F9"! Filler with DCC=1, CMAC = 1, WFOM = 1
120 M$(1)="D01CE26"  ! Overhead DCC=1, SID=231, EP=1, NAWC=4
130 M$(2)="DF2D967"  ! Overhead DCC=1, S=E=REGH=REGR=CPA=1
140 M$(3)="D900004"  ! BIS = 0
```

```
150 M$(4)="D206404"  !  REGINCR = 100
160 M$(5)="D000008"   ! REGID = 0
170 M$(6)="D001F48"   ! REGID = 500
180! Initialize testset
190 ON TIMEOUT 7,10 GOTO End_program
200 OUTPUT Uut_addr;"*RST" ! Reset to a known state
210 WAIT 5 ! Give it time to reset
220 OUTPUT Uut_addr;"RFAN:TMODE 'MANUAL';IFBW '230 KHZ';SQUELCH
  'FIXED';FREQ 834.63 MHZ;ATT:MODE 'HOLD';:RFAN:ATT '20 DB'"
230 OUTPUT Uut_addr;"RFG:FREQ 879.63 MHZ;AMPL -50
  DBM;:AFG1:FM:STATE OFF"
240 OUTPUT Uut_addr;"DISP AFAN"
250 OUTPUT Uut_addr;"AFAN:INP 'FM DEMOD';FILT1 '300HZ HPF'"
260 OUTPUT Uut_addr;"TRIG:MODE:RETRIGGER SINGLE"
270 OUTPUT Uut_addr;"DISP DEC"
280 OUTPUT Uut_addr;"DEC:MODE 'AMPS-TACS';LEV:FM 14
  KHZ;:DEC:AMPS:GATE 250 MS"
290! Set up filler (this is sent whenever no data is available)
300 OUTPUT Uut_addr;"ENC:AMPS:FILL:DATA1 '"&Filler$&"';DATA2
  '"&Filler$&""
310 OUTPUT Uut_addr;"ENC:STOP;SEND" ! Stop it, then restart
320! These are the two messages that cause the mobile to register
330 Mess_0$=M$(1)&M$(2)&M$(3)&M$(4)&M$(5)  ! Message train 1
340 Mess_500$=M$(1)&M$(2)&M$(3)&M$(4)&M$(6)! Message train 2
360 OUTPUT Uut_addr;"DEC:ARM"  ! Arm the decoder for a measurement
370 Junk=FNCheck_decoder! First reading may not be valid
380 Loop_count=0
390 LOOP ! Continue looping until the mobile responds or count = 100
400    ! Send the message with REGID = 0 in both stream A and B
410    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_0$&"';DATA2
  '"&Mess_0$&""
420    OUTPUT Uut_addr;"ENC:SEND"
430 EXIT IF FNCheck_decoder! This checks the decoder to see if data available
440    WAIT .8 ! 800 millisecond wait between overhead messages
450    ! Send the message with REGID = 500 in both stream A and B
460    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_500$&"';DATA2
  '"&Mess_500$&""
470    OUTPUT Uut_addr;"ENC:SEND"
480 EXIT IF FNCheck_decoder
490    WAIT .8
500    Loop_count=Loop_count+1! Simple loop counter to stop program
510    PRINT "Loop Count = ";Loop_count
520    IF Loop_count>100 THEN STOP
530 END LOOP ! Loops until Loop count > 100 or decoder receives data !!
540!
```

```
550! The program reaches here when we have data in the decoder
560 OUTPUT Uut_addr;"MEAS:DEC:AMPS:DATA?" ! Read decoder data
570 ENTER Uut_addr;Temp$
580! Now decode the data from the decoder and print the phone number.
590 Print_number(Temp$)
600 End_program: END
610!
620!
630 Check_decoder: DEF FNCheck_decoder
640! This monitors the Hardware1 condition register to see if
  decoder is still armed
650! or has received data. Make certain program has a short wait
  after calling this routine.
660    COM Uut_addr
670    OUTPUT Uut_addr;"STATUS:HARDWARE1:CONDITION?"
680    ENTER Uut_addr;B
690    IF B=9.E+99 THEN RETURN 0
700    IF BIT(B,9) OR BIT(B,10) THEN RETURN 0
710    WAIT 2
720    RETURN 1
730 FNEND
750!
760 SUB Print_number(Temp$)
770    ! Compact method to decode the phone number
780    ! Hex bytes 7,8,9 contain the phone prefix data. (Byte 1 is a quote mark)
790    Prefix=111+INT(DVAL(Temp$[7;3],16)/4)
800    ! Hex bytes 10,11,12 contain data for last three digits of phone #
810    Suffix=111+INT(DVAL(Temp$[10;3],16) MOD 1024)
820    Convert_zeros(Prefix,P$) ! This resolves zeros encoded as '10'
830    Convert_zeros(Suffix,S$)
840    ! Hex bytes 9 and 10 contain data for the middle digit of phone #
850    S1$=VAL$((INT((DVAL(Temp$[9;2],16) MOD 64)/4)) MOD 10)
860    PRINT "Phone number is ";P$;"-";S1$;S$
880 SUBEND
900 SUB Convert_zeros(In_val,Out_val$)
910! This routine gives zeros their proper weighting
920! Example: IF In_val = 609 THEN Out_val$ = "509"
930    DIM Results(3)
940    FOR I=3 TO 1 STEP -1
950       Results(I)=In_val MOD 10
960       In_val=(In_val-Results(I)-10*(Results(I)=0))/10
970    NEXT I
980    Out_val$=VAL$(Results(1))&VAL$(Results(2))&VAL$(Results(3))
990  SUBEND
```

Paging

The protocol for paging a mobile phone on the AMPS system has a specific series of steps that must happen with the correct timing and in the correct sequence. Before starting the page sequence, the landstation is in an idle state transmitting filler messages and overhead messages on a control channel. The overhead messages are transmitted every 800 milliseconds and contain the same overhead information described previously in the registration algorithm. When the landstation receives an order to page a mobile, the landstation transmits a page command which is attached to one of the overhead messages. This page command contains the MIN number of the mobile being paged. If the mobile is in the area, the mobile receives the page and sends an acknowledgement back to the landstation. When the landstation receives the acknowledgement from the mobile, the landstation transmits a mobile control message which directs the mobile to change to a voice channel. In addition to the voice channel assignment, the mobile control message notifies the mobile which SAT tone will be used on the new voice channel, and what output power the mobile should use on the new channel. The landstation will then assign one of its tranceivers to tune to the new voice channel and begin transmitting the correct SAT frequency. The landstation then uses the newly assigned voice channel to transmit a Mobile Control Alert message which causes the mobile phone to ring. When the mobile user answers, the mobile transmits a 10 kHz signaling tone back to the landstation. By receiving the signaling tone from the mobile, this confirms that the voice channel is now open for conversation between the landstation and mobile.



AMPS paging

The HP 8920 and 11807 software follows the previous example almost exactly (see the flowchart). The 11807 software begins by creating an overhead message which identifies the System ID (SID) and access parameters that describe how the mobile should use the reverse control channel. This access message is the same message used in the AMPS registration algorithm described earlier. This message is transmitted each 800 milliseconds, with control-filler messages transmitted during the dead time.

As the software tries to page the mobile, every fifth overhead message is replaced with a mobile control message which contains the page order as well as the MIN1 and MIN2 numbers of the mobile. For a page to work, it is necessary for the software to know the MIN numbers either by an earlier registration or by the user entering the MIN number or mobile telephone number directly. The software will repeat the process of sending overhead access messages and mobile control message until the mobile responds.

Once the mobile responds, the software sends a single mobile control message that includes MIN Number, Voice Mobile Attenuation Code (power level), SCC (indicating the SAT frequency), and Channel Number. This is the last message sent on the Control Channel and the software tunes the testset to the correct voice channel and begins sending the SAT frequency.

After tuning to the voice channel, the software transmits a Mobile Station Alert Message which will cause the mobile phone to ring. The software then uses the testset audio analyzer to monitor the voice channel for a 10 kHz tone indicating that the mobile phone was answered. At this point the software is finished and the voice channel is open between the testset and the mobile.

Message Sequencing Details

The AMPS Paging Flowchart contained in the document provides an efficient algorithm that will reliably page a mobile phone. The Flowchart is intended to help you understand a working algorithm, although it isn't the exact algorithm used by 11807. The algorithm used in the 11807 software is slightly more complicated, although the effect is the same. For complete details of the 11807 algorithm, view the software subroutines, T02, Obtain_v_ch, and Acq_fcc. For writing your own software (or understanding the algorithm conceptually) use the flowchart and the sample program at the end of this section.

The following describes the messages in detail.

Overhead meassage train
The overhead message train is actually 3 messages that correspond to:

D01CE16 DF2D967 D90000C

1 System Overhead Message 1

D01CE16 HEX = 11 01 00000001110011 1 00 0010 110 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
SID = 00000001110011 is 14 most significant digits of SID = 231
EP = 1 indicates Extended Protocol Enabled (See IS-88 standard)
NAWC = 0010 indicates Number Additional Words Coming is 2
OHD = 110 indicates this is first word of a system parameter overhead message

2 System Overhead Message 2

DF2D967 HEX = 11 01 1 1 1 1 00 10110 1 1 0010110 0 111 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
S = 1 indicates Serial Number should be sent by mobile
E = 1 indicates Extended address should be sent by mobile

REGH = 1 indicates Register Home Enabled. Signifies that mobiles in home system are required to register.
REGR = 1 indicates Register ROAM Enabled. Causes roaming mobiles to register.
DTX = 0 indicates DTX Disabled. Mobiles not allowed to use discontinuous transmission.
N - 1 = 10110 indicates 23 possible paging channels in the system.
RCF = 1 indicates Read Control Filler enabled. Causes mobile to read filler messages.
CPA = 1 indicates Combined Paging / Access True. Indicates Pages and Access use same control channel.
CMAX-1 = 0010110 indicates 23 possible access channel in the system.
END = 0 indicates this is not the end message
OHD = 111 indicates this is the second word of a system parameter overhead message

3 Access Message

D90000C HEX = 11 01 1101 0 000000000000000 1 100 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
ACT = 1101 indicates Access Type Parameters Global Action Message
BIS = 0 indicates mobile is not required to monitor busy/idle bit transition
END = 1 indicates this is the end message
OHD = 100 indicates a global action message

4 Control-Filler Message

Whenever the testset is transmitting on the forward control channel, it either transmits overhead messages, mobile station control messages or control filler messages. In general, the testset will usually be transmitting control filler message unless an action is being performed like registration, page, handoff, or origination. The control filler message used by the testset expressed in Hex format is: D5C19F9.

D5C19F9 HEX = 11 01 010111 000 00 11 00 1 1 1111 001 (Binary)

The information contained in this message is.

T1T2 = 11 indicating it is an overhead message.
DCC = 01 indicating digital color code of 1.
CMAC = 000 indicating Control Mobile Attenuation Code of 0 (highest power available)
WFOM = 1 indicating Wait For Overhead Message is true.
OHD = 001 indicates this is a control filler message.

5 Mobile Station Control Message Train 1

This is actually two messages sent to page the mobile. This message train does not assign the mobile to a voice channel. The actual assignment happens only after the mobile responds to this page.

Note: These messages include a MIN number and are only valid for paging the telephone with phone number (509) 994-4707.

5DCD2B8 HEX = 01 01 110111001101001010111000 (Binary)

The information contained in this message is.

T1T2 = 01 indicating this is the first word of a multiple-word mobile station control message.
DCC = 01 indicating digital color code of 1.
MIN1= Mobile Identification One, 24 bits representing prefix+suffix

B7C8000 HEX = 10 11 0111110010 0 00000 000 00000 (Binary)

The information contained in this message is.

T1T2 = 10 indicating an additional word in the mobile station control message.
SCC = 11 invalid SCC indicates a mobile order message.
MIN2= Mobile Identification Two, 10 bits representing area code
ORDQ = 000 indicating a page.
ORDER = 00000 indicating a page.

6 Mobile Station Control Message Train 2

Once the mobile has responded to the page, the following two messages are sent to instruct the mobile to change to a valid voice channel. These messages contain the mobile MIN number and also contain information about power level and SAT frequency.

5DCD2B8 HEX = 01 01 110111001101001010111000 (Binary)

The information contained in this message is.

T1T2 = 01 indicating this is the first word of a multiple-word mobile station control message.
DCC = 01 indicating digital color code of 1.
MIN1= Mobile Identification One, 24 bits representing prefix+suffix

87C8070 HEX = 10 00 0111110010 000 00001110000 (Binary)

The information contained in this message is.

T1T2 = 10 indicating an additional word in the mobile station control message.
SCC = 00 indicates SAT Color Code (5970 Hz).
MIN2= Mobile Identification Two, 10 bits representing area code
VMAC = 000 Voice Mobile Attenuation Code 0 (highest power).
CHAN = 00001110000 indicating voice channel 112.

7 Mobile Control Alert Message

Once the testset has been tuned to the voice channel, the following Alert Message is sent to cause the mobile phone to ring.

B000001 HEX = 10 11 00 0 0000000 000 000 00001 Binary

The information contained in this message is.

T1T2 = 10 indicating first word of mobile station control message.
SCC = 11 invalid SCC indicates mobile control message.
PSCC = 00 indicating present SAT color code is 0 (5970 Hz)
ORDQ = 000 indicating a page.
ORDER = 00001 indicating an alert (rings the phone).

```
10 ! re-store "page.prg"
30 ! Sample program to page an AMPS cellular phone
40 ! This program pages the phone on control channel 321 and
50 ! assigns the phone to voice channel 112
60 COM Uut_addr
70 DIM M$(6)[7],Temp$[4000]
80 DIM Mess_0$[50],Mess_1$[50],Mess_2$[50]
90   !
100 CLEAR 7
110 Uut_addr=714
120  ! Build messages
130 Filler$="D5C19F9"! Filler with DCC=1, CMAC = 1, WFOM = 1
140 M$(1)="D01CE16"  ! Overhead DCC=1, SID=231, EP=1, NAWC=2
150 M$(2)="DF2D967"  ! Overhead DCC=1, S=E=REGH=REGR=CPA=1
160 M$(3)="D90000C"  ! BIS = 0, END = 1
170 Ms1$="5DCD2B8"   ! Min1 for 994-4707
180 Ms2$="B7C8000"   ! Min2 = 509, ORDQ & ORDER = 0 = page
190 Ms3$="87C8070"   ! Min2 = 509, SCC=0, VMAC = 0, CHAN = 112
200 Ms4$="B000001"   ! PSCC=0, ORDQ=0, ORDER = 1 (Alert to ring phone)
210 Mess_0$=M$(1)&M$(2)&M$(3) ! Overhead message
220 Mess_1$=Ms1$&Ms2$        ! Initial page of phone to see if it's alive
230 Mess_2$=Ms1$&Ms3$        ! Assigns voice channel if mobile responded
240 Mess_3$=Ms4$             ! Alert to ring the phone on the voice channel
250! Initialize testset
260 ON TIMEOUT 7,10 GOTO End_program
270 OUTPUT Uut_addr;"*RST" ! Reset to a known state
280 WAIT 5 ! Give it time to reset
290 OUTPUT Uut_addr;"RFAN:TMODE 'MANUAL';IFBW '230 KHZ';SQUELCH
  'FIXED';FREQ 834.63 MHZ;ATT:MODE 'HOLD';:RFAN:ATT '20 DB'"
300 OUTPUT Uut_addr;"RFG:FREQ 879.63 MHZ;AMPL -50
  DBM;:AFG1:FM:STATE OFF"
310 OUTPUT Uut_addr;"DISP AFAN"
```

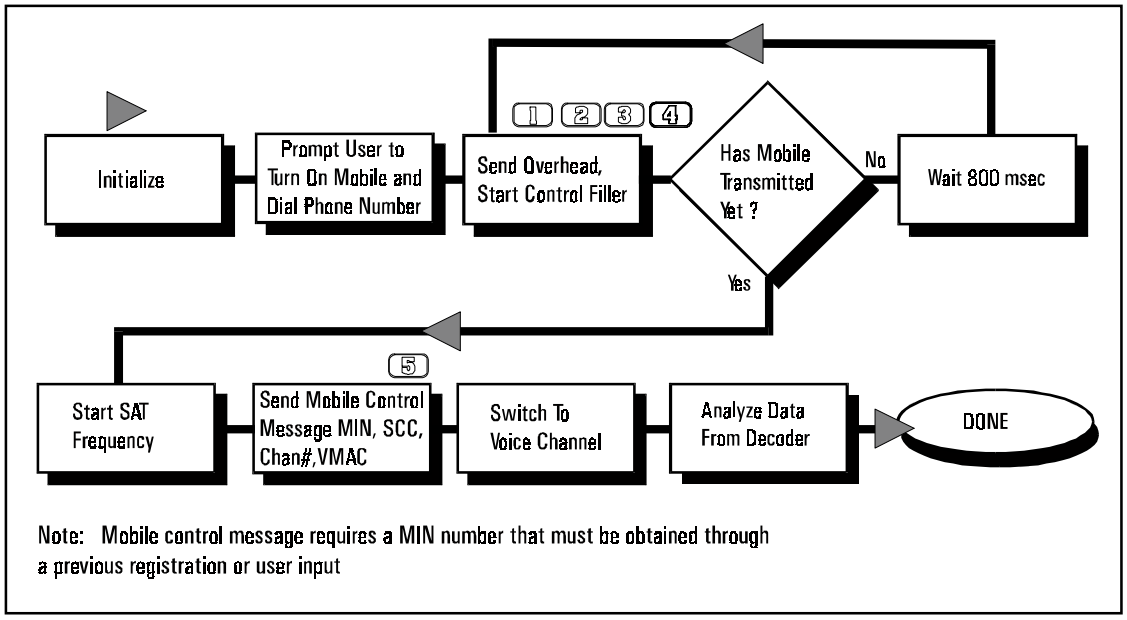
```
320 OUTPUT Uut_addr;"AFAN:INP 'FM DEMOD';FILT1 '300HZ HPF'"
330 OUTPUT Uut_addr;"TRIG:MODE:RETRIGGER SINGLE"
340 OUTPUT Uut_addr;"DISP DEC"
350 OUTPUT Uut_addr;"DEC:MODE 'AMPS-TACS';LEV:FM 14
  KHZ;:DEC:AMPS:GATE
250 MS"
360! Set up filler (this is sent whenever no data is available)
370 OUTPUT Uut_addr;"ENC:AMPS:FILL:DATA1 '"&Filler$&"';DATA2
  '"&Filler$&""
380 OUTPUT Uut_addr;"ENC:STOP;SEND" ! Stop it, then restart
400!
410 OUTPUT Uut_addr;"DEC:ARM"  ! Arm the decoder for a measurement
420 Junk=FNCheck_decoder! First reading may not be valid
430 Loop_count=1
440 LOOP ! Continue looping until the mobile responds or count = 100
450  IF Loop_count MOD 5=0 THEN
460    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_1$&"';DATA2
470 ELSE
  '"&Mess_1$&""
480    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_0$&"';DATA2
  '"&Mess_0$&""
490  END IF
500  OUTPUT Uut_addr;"ENC:SEND"
510 EXIT IF FNCheck_decoder! This checks the decoder to see if data
  available
520  WAIT .8   ! 800 millisecond wait between overhead messages
530  Loop_count=Loop_count+1  ! Simple loop counter to stop program
540  PRINT "Loop Count = ";Loop_count
550  IF Loop_count>100 THEN STOP
560 END LOOP ! Loops until Loop count > 100 or decoder receives data !!
570!
580    ! The program reaches here when the mobile has responded
590    ! Send message to mobile to assign it to a voice channel
600 OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_2$&"';DATA2
'"&Mess_2$&""
610 OUTPUT Uut_addr;"ENC:SEND"
620 WAIT .3    ! Give the mobile a little time to get to the voice channel
630    !
640    ! Now set up the SAT tone and tune the testset to the voice channel
650 OUTPUT Uut_addr;"ENC:AMPS:SAT:FREQ 5970 HZ"
660 OUTPUT Uut_addr;"ENC:AMPS:FILL:STOP"
670 OUTPUT Uut_addr;"RFAN:FREQ 828.36 MHZ;:RFG:FREQ 873.36 MHZ"
680    ! Now send the alert message on the voice channel to ring the phone
690 OUTPUT Uut_addr;"ENC:AMPS:CHAN
700 OUTPUT Uut_addr;"ENC:AMPS:FVCM '"&Mess_3$&""
```

```
710 OUTPUT Uut_addr;"ENC:
720    !
730 End_program: END
740 Check_decoder: DEF FNCheck_decoder
750! This monitors the Hardware1 condition register to see if decoder
760! is still armed or has received data.
770    COM Uut_addr
780    OUTPUT Uut_addr;"STATUS:HARDWARE1:CONDITION?"
790    ENTER Uut_addr;B
800    IF B=9.E+99 THEN RETURN 0
810    IF BIT(B,9) OR BIT(B,10) THEN RETURN 0
820    WAIT 2
830    RETURN 1
840 FNEND
```

AMPS Phone Origination

When a mobile needs to originate a call on the AMPS system, it monitors the forward control channel for system access information. Part of the information transmitted on the forward control channel is a busy/idle bit stream that indicates the status of the corresponding reverse control channel. When this busy/idle bit stream indicates to the mobile that the reverse channel is free, the mobile sends a message to signal the landstation that it needs to place a call. Included in the message from the mobile is the mobile MIN number, plus the phone number digits that were dialed. The landstation uses the MIN number to respond to the request by sending a voice channel assignment message back to the mobile. Both the landstation and mobile will immediately switch to the new voice channel, and the landstation will begin transmiting a SAT frequency which is transponded (received and retransmitted) by the mobile. At this point, the voice channel is open and the landstation will continue to place the call through the local telephone network. Both the mobile and landstation will maintain this link until one of the users disconnects or the mobile is handed to a new channel.

The 8920A and 11807A/E software uses an algorithm similar to the real landstation station example. The 11807A/E software begins by creating overhead messages which identify the System ID (SID) and access parameters that describe how the mobile should use the reverse control channel. This access message is the same message used in the AMPS registration and paging algorithms described earlier.



Amps Origination

As shown in the flowchart, the software begins an origination by initializing the testset and prompting the user to turn on the mobile and dial a phone number. Simultaneously, the software begins transmitting control messages and overhead access messages which are required for the phone to obtain service. Every 800 milliseconds the software sends the overhead messages and continues to monitor the reverse control channel for a transmission from the mobile. When the decoder receives data, the software assumes the message was an origination request and it sends a mobile control message to assign the mobile to a voice channel. The testset switches to the new voice channel and transmits the correct SAT frequency. At this point the origination is complete and the voice channel is open between the testset and the mobile.

One minor difference between a real landstation and the HP 8920/11807 algorithm is how the data for the mobile channel assignment message is determined. In a real landstation, the

mobile transmits its MIN number in the origination request, and the landstation uses the MIN number it received to send a message back to the mobile and assign the voice channel. The landstation analyzes the data real-time to determine the correct mobile MIN number. Early versions of the 11807 software does not analyze the data received to get the MIN number used in the voice channel assignment. The early software requires the user to enter the mobile phone number or requires that a phone registration be completed before running the origination test. Some software users required an improvement that would allow an origination without any previous knowledge of the mobile MIN number. This improvement will be included in new releases (approximately June 1995) of 11807A/E Option 004, 008 and 009. The sample program at the end of this discussion uses a technique that simulates a real land station by analyzing the received data and creating the mobile control message from the bits received.

Message Sequencing Details

The AMPS Origination Flowchart shows the algorithm for the 11807A/E software. The sample program is the same, except the data is analyzed before sending the Mobile Control Message. The flowchart is intended to help you understand a working algorithm that will reliably receive and process an origination request from a mobile phone.

The following messages are the exact messages being sent by the testset for an origination. Use the sample program and flowchart to understand the program flow and timing required for an origination. The program timing and flow should not be changed, however parameters such as SID, SAT, voice channel number, and control channel number can be adjusted as needed. As stated before, understanding the messages as described in the correct standards is critical to making any significant changes. Note that the overhead, access, and control filler messages are the same messages used in the AMPS registration and paging routines.

Overhead message train
The overhead message train is actually 3 messages that correspond to:

D01CE16 DF2D967 D90000C

System Overhead Message 1

D01CE16 HEX = 11 01 00000001110011 1 00 0010 110 Binary

The information in this message is:

T1T2 = 11 indicates overhead messag
DCC = 01 indicates Digital Color Code of 1
SID = 00000001110011 is 14 most significant digits of SID = 231
EP = 1 indicates Extended Protocol Enabled (See IS-88 standard)
NAWC = 0010 indicates Number Additional Words Coming is 2
OHD = 110 indicates this is first word of a system
parameter overhead message

System Overhead Message 2

DF2D967 HEX = 11 01 1 1 1 1 00 10110 1 1 0010110 0 111 (Binary)

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
S = 1 indicates Serial Number should be sent by mobile
E = 1 indicates Extended address should be sent by mobile
REGH = 1 indicates Register Home Enabled. Signifies that mobiles in home system are required to register.

REGR = 1 indicates Register ROAM Enabled. Causes roaming mobiles to register.
DTX = 0 indicates DTX Disabled. Mobiles not allowed to use discontinuous transmission
N - 1 = 10110 indicates 23 possible paging channels in the system.
RCF = 1 indicates Read Control Filler enabled. Causes mobile to read filler messages.
CPA = 1 indicates Combined Paging / Access True. Indicates Pages and Access use same control channel.
CMAX-1 = 0010110 indicates 23 possible access channel in the system.
END = 0 indicates this is not the end message
OHD = 111 indicates this is the second word of a system parameter overhead message

3 Access Message

D90000C HEX = 11 01 1101 0 000000000000000 1 100 Binary

The information in this message is:

T1T2 = 11 indicates overhead message
DCC = 01 indicates Digital Color Code of 1
ACT = 1101 indicates Access Type Parameters Global Action Message
BIS = 0 indicates mobile is not required to monitor busy/idle bit transition
END = 1 indicates this is the end message
OHD = 100 indicates a global action message

4 Control-Filler Message

Whenever the testset is transmitting on the forward control channel, it either transmits overhead messages, mobile station control messages or control filler messages. In general, the testset will usually be transmitting control filler message unless an action is being performed like registration, page, handoff, or origination. The

control filler message used by the testset expressed in Hex format is: D5C19F9.

D5C19F9 HEX = 11 01 010111 000 00 11 00 1 1 1111 001 (Binary)

The information contained in this message is.

T1T2 = 11 indicating it is an overhead message.
DCC = 01 indicating digital color code of 1.
CMAC = 000 indicating Control Mobile Attenuation Code of 0 (highest power available)
WFOM = 1 indicating Wait For Overhead Message is true.
OHD = 001 indicates this is a control filler message.

5 Mobile Station Control Message

When the mobile transmits an origination message to the testset, the testset responds with the following two messages. These messages instruct the mobile to change to a valid voice channel. These messages contain the mobile MIN number and also contain information about power level and SAT frequency.

NOTE: The following messages contain MIN number information for phone number (509) 994-4707. Testing a different phone would have slightly different messages.

5DCD2B8 HEX = 01 01 11011100110100101011100 0 (Binary)

The information contained in this message is.

T1T2 = 01 indicating this is the first word of a multiple-word mobile station control message.
DCC = 01 indicating digital color code of 1.
MIN1= Mobile Identification One, 24 bits representing prefix+suffix

87C8070 HEX = 10 00 0111110010 000 00001110000 (Binary)

The information contained in this message is.

T1T2 = 10 indicating an additional word in the mobile station control message.
SCC = 00 indicates SAT Color Code (5970 Hz)
MIN2= Mobile Identification Two, 10 bits representing area co
VMAC = 000 Voice Mobile Attenuation Code 0 (highest power).
CHAN = 00001110000 indicating voice channel 112.

```
10   ! re-store "/hpspk7bl/disk1/users/henley/rmb/TRAINING/originat.prg"
30 ! Sample program to originate a call from an AMPS cellular phone
60 COM Uut_addr
70 DIM M$(6)[7]
80 DIM Mess_0$[50]
100 CLEAR 7
110 Uut_addr=714
120  ! Build messages
130 Filler$="D5C19F9"! Filler with DCC=1, CMAC = 1, WFOM = 1
140 M$(1)="D01CE16"  ! Overhead DCC=1, SID=231, EP=1, NAWC=2
150 M$(2)="DF2D967"  ! Overhead DCC=1, S=E=REGH=REGR=CPA=1
160 M$(3)="D90000C"  ! BIS = 0, END = 1
170 Mess_0$=M$(1)&M$(2)&M$(3) ! Overhead message
180! Initialize testset
190 ON TIMEOUT 7,10 GOTO End_program
200 OUTPUT Uut_addr;"*RST" ! Reset to a known state
210 WAIT 5 ! Give it time to reset
220 OUTPUT Uut_addr;"RFAN:TMODE 'MANUAL';IFBW '230 KHZ';SQUELCH
  'FIXED';FREQ 834.63 MHZ;ATT:MODE 'HOLD';:RFAN:ATT '20 DB'"
230 OUTPUT Uut_addr;"RFG:FREQ 879.63 MHZ;AMPL -50
  DBM;:AFG1:FM:STATE OFF"
240 OUTPUT Uut_addr;"DISP AFAN"
250 OUTPUT Uut_addr;"AFAN:INP 'FM DEMOD';FILT1 '300HZ HPF'"
260 OUTPUT Uut_addr;"TRIG:MODE:RETRIGGER SINGLE"
270 OUTPUT Uut_addr;"DISP DEC"
280 OUTPUT Uut_addr;"DEC:MODE 'AMPS-TACS';LEV:FM 14
  KHZ;:DEC:AMPS:GATE 250 MS"
```

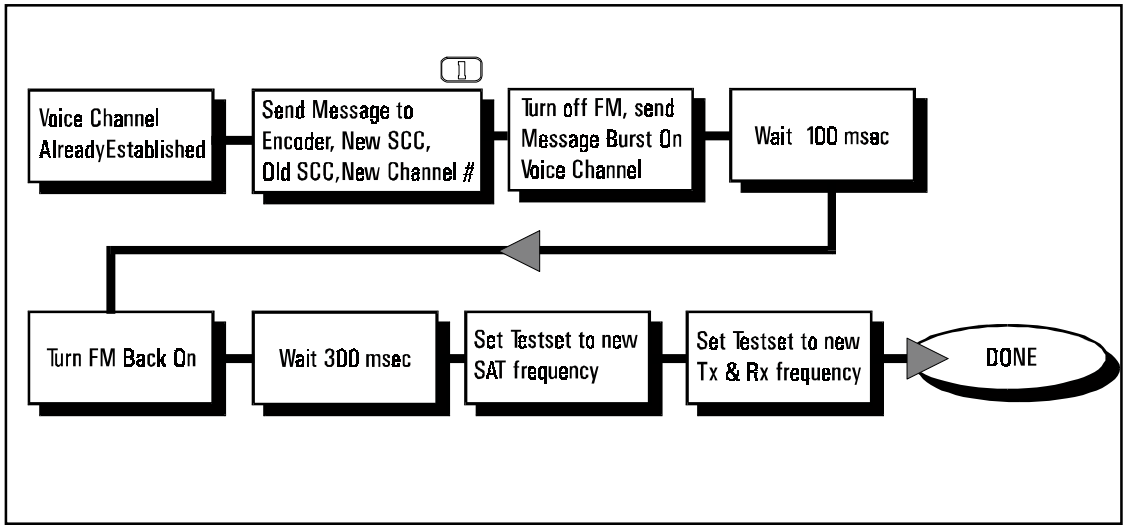
```
290! Set up filler (this is sent whenever no data is available)
300 OUTPUT Uut_addr;"ENC:AMPS:FILL:DATA1 '"&Filler$&"';DATA2
  '"&Filler$&"'"
310 OUTPUT Uut_addr;"ENC:STOP;SEND" ! Stop it, then restart
320!
330 OUTPUT Uut_addr;"DEC:ARM"  ! Arm the decoder for a measurement
340 Junk=FNCheck_decoder! First reading may not be valid
350 PRINT "Power up the phone. When the phone shows service, dial"
360 PRINT "a number and press send."
370 Loop_count=1
380 LOOP ! Continue looping until the mobile responds or count = 100
390    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_0$&"';DATA
  '"&Mess_0$&"'"
400    OUTPUT Uut_addr;"ENC:SEND"
410 EXIT IF FNCheck_decoder! This checks the decoder to see if data available
420    WAIT .8 ! 800 millisecond wait between overhead messages
430    Loop_count=Loop_count+1  ! Simple loop counter to stop program
440    DISP "Loop Count = ";Loop_count
450    IF Loop_count>100 THEN STOP
460 END LOOP ! Loops until Loop count > 100 or decoder receives data
480! The program reaches here when the mobile has responded
490 CALL Get_min(Min1$,Min2$)
500 ! Build the mobile control messages using the MIN numbers
510 Mob_cont1$="5"&Min1$
520 Temp$=DVAL$(DVAL(Min2$,16)*4,16)
530 Mob_cont2$="8"&Temp$[LEN(Temp$)-2]&"070"
540 Mcont$=Mob_cont1$&Mob_cont2$
550    !
560    ! Now set up the SAT tone, send the mobile control message and tune
570    ! to the voice channel
580 OUTPUT Uut_addr;"ENC:AMPS:SAT:FREQ 5970 HZ"
590 OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mcont$&"';DATA2
  '"&Mcont$&"'"
600 OUTPUT Uut_addr;"ENC:SEND"
610 WAIT .3 ! This is included in 11807 SUB Send_fcc
620 OUTPUT Uut_addr;"ENC:AMPS:FILL:STOP"
630 OUTPUT Uut_addr;"RFAN:FREQ 828.36 MHZ;:RFG:FREQ 873.36 MHZ"
640 OUTPUT Uut_addr;"ENC:AMPS:CHAN 'Voice'"
650    !
660 End_program:END
670 Check_decoder:DEF FNCheck_decoder
680! This monitors the Hardware1 condition register to see if decoder
690! is still armed or has received data.
700    COM Uut_add
710    OUTPUT Uut_addr;"STATUS:HARDWARE1:CONDITION?"
```

```
720    ENTER Uut_addr;B
730    IF B=9.E+99 THEN RETURN 0
740    IF BIT(B,9) OR BIT(B,10) THEN RETURN 0
750    WAIT 2
760    RETURN 1
780 Get_min:SUB Get_min(Min1$,Min2$)
790    COM Uut_addr
800    DIM I_o$[2000]
810    OUTPUT Uut_addr;"MEAS:DEC:AMPS:DATA?"
820    ENTER Uut_addr;I_o$
830    I_o$=I_o$[4] ! Strip off quote and 7 bit
840    Min1$=I_o$[4;6]
850    Min2$=I_o$[67;3] ! Includes 2 extra bits - should be OK
860 SUBEND
```

AMPS Phone Handoff

A handoff is used in the AMPS system to force a mobile to a new voice channel or to notify the mobile to expect a different SAT frequency. After the initial voice channel is set up (either from an origination or page), the landstation sends a simple message to a mobile that includes the new channel number and the new SAT tone the mobile should expect from the landstation. The landstation will then immediately assign a tranceiver to the new frequency and begin sending the new SAT tone. The mobile will tune to the new channel, and transpond the SAT tone back to the landstation. At this point the handoff is complete.

Because the voice channel is only used by a single mobile station and landstation pair, the communication between the two is much more straightforward than communications on a control channel. There are no overhead messages, no MIN number and no control-filler messages. This is one of the easiest call processing tasks to perform with the 8920A and 11807A/E software. The mobile control message has the flexibility to change either the SAT tone, channel number, or both. For example, if only the SAT frequency will change, simply transmit the current channel number in place of the new channel number.



AMPS Channel Handoff

The flowchart shows the process for programming the handoff.

The basic steps are:

1) Create the message (28 bits).
2) Download the message into the testset encoder.
3) Turn off any other FM modulation and send the encoder data.
4) Turn the FM back on.
5) Tune the testset to the new SAT tone, Rx Frequency, and Tx Frequency.
6) The voice channel should now be set up with the new parameters.

The following describes the mobile control handoff message in detail. This message contains information about current color code, new color code, new voice mobile attenuation code and new channel number.

Mobile Station Control Message

A following message would be transmitted if the present SAT color code was zero and the new SAT color code will be one and the new channel will be 121.

9000079 HEX = 10 01 00 0 0000000 000 00001111001 (Binary)

The information in this message is:

T1T2 = 10 indicates mobile control message
SCC = 01 indicates New SAT Color Code of 1 (6000 Hz)
PSCC = 00 indicates Present SAT Color Code of 0 (5970 Hz)
VMAC = 000 indicating the new Voice Mobile Attenuator Code is 0
CHAN = 00001111001 indicating a new channel of 121

This program pages a phone (509) 994-4707 and assigns it to voice channel 112 using SAT frequency 5970. The program pauses and waits for the user to press continue. The program then sends a message to the mobile to handoff to voice channel 121 and use SAT frequency 6000 Hz. The testset then switches to this new frequency and generates the correct SAT tone.

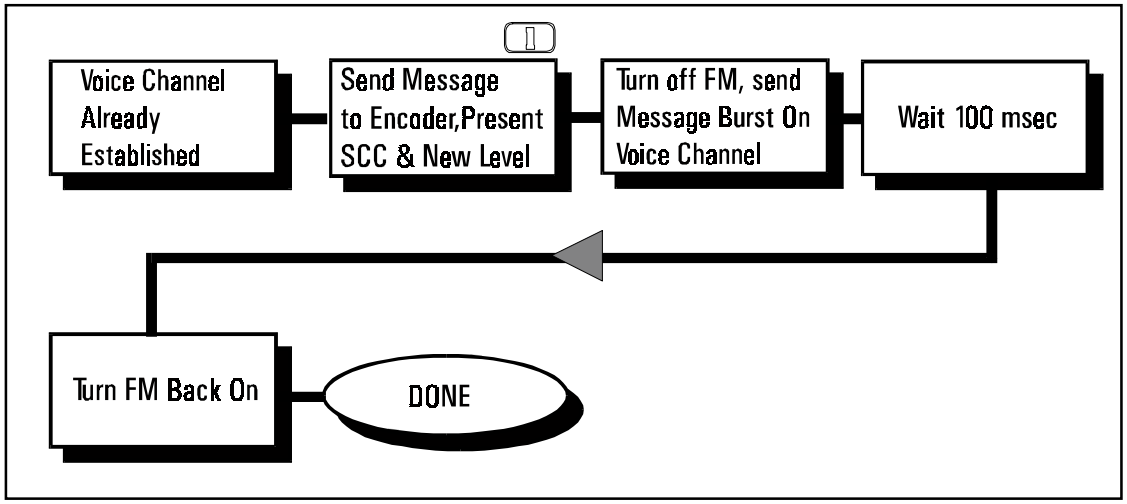
```
10    ! re-store "/hpspk7bl/disk1/users/henley/rmb/TRAINING/handoff.prg"
30 ! Sample program to page an AMPS cellular phone and then change channel
31 ! This example is exactly the same as the page.prg except for the
32 ! last 14 lines of the code. Lines 710 to 830
50 !
60 COM Uut_addr
70 DIM M$(6)[7],Temp$[4000]
80 DIM Mess_0$[50],Mess_1$[50],Mess_2$[50]
90    !
100 CLEAR 7110 Uut_addr=714
120   ! Build messages
130 Filler$="D5C19F9"! Filler with DCC=1, CMAC = 1, WFOM = 1
140 M$(1)="D01CE16"  ! Overhead DCC=1, SID=231, EP=1, NAWC=2
150 M$(2)="DF2D967"  ! Overhead DCC=1, S=E=REGH=REGR=CPA=1
160 M$(3)="D90000C"  ! BIS = 0, END = 1
170 Ms1$="5DCD2B8"   ! Min1 for 994-4707
180 Ms2$="B7C8000"   ! Min2 = 509, ORDQ & ORDER = 0 = page
190 Ms3$="87C8070"   ! Min2 = 509, SCC=0, VMAC = 0, CHAN = 112
200 Ms4$="B000001"   ! PSCC=0, ORDQ=0, ORDER = 1 (Alert to ring phone)
210 Mess_0$=M$(1)&M$(2)&M$(3) ! Overhead message
220 Mess_1$=Ms1$&Ms2$        ! Initial page of phone to see if it's alive
230 Mess_2$=Ms1$&Ms3$        ! Assigns voice channel if mobile responded
240 Mess_3$=Ms4$             ! Alert to ring the phone on the voice channel
250! Initialize testset
260 ON TIMEOUT 7,10 GOTO End_program
270 OUTPUT Uut_addr;"*RST" ! Reset to a known state
280 WAIT 5 ! Give it time to reset
290 OUTPUT Uut_addr;"RFAN:TMODE 'MANUAL';IFBW '230 KHZ';SQUELCH
'FIXED';FREQ 834.63 MHZ;ATT:MODE 'HOLD';:RFAN:ATT '20 DB'"
300 OUTPUT Uut_addr;"RFG:FREQ 879.63 MHZ;AMPL -50 DBM;:AFG1:FM:STATE
OFF"
```

```
310 OUTPUT Uut_addr;"DISP AFAN"
320 OUTPUT Uut_addr;"AFAN:INP 'FM DEMOD';FILT1 '300HZ HPF'"
330 OUTPUT Uut_addr;"TRIG:MODE:RETRIGGER SINGLE"
340 OUTPUT Uut_addr;"DISP DEC"
350 OUTPUT Uut_addr;"DEC:MODE 'AMPS-TACS';LEV:FM 14
KHZ;:DEC:AMPS:GATE 250 MS"
360! Set up filler (this is sent whenever no data is available)
370 OUTPUT Uut_addr;"ENC:AMPS:FILL:DATA1 '"&Filler$&"';DATA2 '"&Filler$&"'"
380 OUTPUT Uut_addr;"ENC:STOP;SEND" ! Stop it, then restart
390!
400 OUTPUT Uut_addr;"DEC:ARM"  ! Arm the decoder for a measurement
410 Junk=FNCheck_decoder! First reading may not be valid
420 Loop_count=1
430 LOOP ! Continue looping until the mobile responds or count = 100
440  IF Loop_count MOD 5=0 THEN
450    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_1$&"';DATA2
'"&Mess_1$&"'"
460  ELSE
470    OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_0$&"';DATA2
'"&Mess_0$&"'"
480  END IF
490  OUTPUT Uut_addr;"ENC:SEND"
500 EXIT IF FNCheck_decoder! This checks the decoder to see if data available
510  WAIT .8   ! 800 millisecond wait between overhead messages
520  Loop_count=Loop_count+1  ! Simple loop counter to stop program
530  PRINT "Loop Count = ";Loop_count
540  IF Loop_count>100 THEN STOP
550 END LOOP ! Loops until Loop count > 100 or decoder receives data !!
560!
570! The program reaches here when the mobile has responded
580    ! Send message to mobile to for it to a voice channel
590 OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_2$&"';DATA2
'"&Mess_2$&"'"
600 OUTPUT Uut_addr;"ENC:SEND"
610 WAIT .3    ! Give the mobile a little time to get to the voice channel
620    !
630    ! Now set up the SAT tone and tune the testset to the voice channel
640 OUTPUT Uut_addr;"ENC:AMPS:SAT:FREQ 5970 HZ"
650 OUTPUT Uut_addr;"ENC:AMPS:FILL:STOP"
660 OUTPUT Uut_addr;"RFAN:FREQ 828.36 MHZ;:RFG:FREQ 873.36 MHZ"
670    ! Now send the alert message on the voice channel to ring the phone
680 OUTPUT Uut_addr;"ENC:AMPS:CHAN 'Voice'"
690 OUTPUT Uut_addr;"ENC:AMPS:FVCM '"&Mess_3$&"'"
700 OUTPUT Uut_addr;"ENC:SEND"
710 ! VOICE CHANNEL IS NOW ACTIVE - New code starts here
720 PRINT "Press continue to have the mobile change channel."
730 PAUSE
740 ! Send Forward Voice Channel Message
750 ! From SAT = 0 to SAT = 1  (5970 Hz to 6000 Hz)
760 ! New channel = 121 = (.03 * 121) + 825  MHz
770 OUTPUT Uut_addr;"ENC:AMPS:FVCM '9000079'"
780 OUTPUT Uut_addr;"ENC:SEND"
790 WAIT .4
800 OUTPUT Uut_addr;"ENC:AMPS:SAT:FREQ 6000 HZ"
810 OUTPUT Uut_addr;"RFAN:FREQ 828.63 MHZ;:RFG:FREQ 873.63 MHZ"
820    !
```

```
830 PRINT "Program ended" ! End of the new code for handoff
840 End_program: END
850 Check_decoder: DEF FNCheck_decoder
860! This monitors the Hardware1 condition register to see if decoder
870! is still armed or has received data.
880    COM Uut_addr
890    OUTPUT Uut_addr;"STATUS:HARDWARE1:CONDITION?"
900    ENTER Uut_addr;B
910    IF B=9.E+99 THEN RETURN 0
920    IF BIT(B,9) OR BIT(B,10) THEN RETURN 0
930    WAIT 2
940    RETURN 1
950 FNEND
```

AMPS Phone Change Level

A level change message is used in the AMPS system to force a mobile to change its output power. After the initial voice channel is set up (either from an origination or page), the landstation sends a simple message to a mobile that includes the SAT frequency and new power level. There are 8 power levels referred to as levels 0 to 7, with level 0 corresponding to the highest power. Typically, many portables do not support level 0 or 1, they respond to these orders by changing to their highest level (equivalent to level 2).



AMPS level change

The process for programming the level change is similar to the channel handoff. The steps are:

1 Create the message
2 Download the message into the testset encoder
3 Turn off any other FM modulation and send the encoder data
4 Wait a little while, turn the FM back on.
5 The mobile is now transmitting at the new power level.

The following describes the mobile control level change message in detail. This message contains information about current color code and new power level.

A following message would be transmitted if the present SAT color code was zero and the new power level desired was level 4.

Mobile Station Control Message - Change Power

B00008B HEX = 10 11 00 00000000000000 100 01011 Binary

The information in this message is:

T1T2 = 10 indicates mobile control message
SCC = 11 indicates this is an order message
PSCC = 00 indicates Present SAT Color Code of 0 (5970 Hz)
ORDQ = 100 indicates power level 4
ORDER = 01011 indicates change level order

```
10 ! re-store "level.prg"
30 ! Sample program to page an AMPS cellular phone and then force the
40 ! mobile to change level.
50 ! This example is exactly the same as the page.prg except for the
60 ! last 15 lines of the code. (Lines 740 to 880)
80 !
90 COM Uut_addr100 DIM M$(6)[7],Temp$[4000]
110 DIM Mess_0$[50],Mess_1$[50],Mess_2$[50]
120   !
130 CLEAR 7
140 Uut_addr=714
150   ! Build messages
160 Filler$="D5C19F9"! Filler with DCC=1, CMAC = 1, WFOM = 1
170 M$(1)="D01CE16"  ! Overhead DCC=1, SID=231, EP=1, NAWC=2
180 M$(2)="DF2D967"  ! Overhead DCC=1, S=E=REGH=REGR=CPA=1
190 M$(3)="D90000C"  ! BIS = 0, END = 1
200 Ms1$="5DCD2B8"   ! Min1 for 994-4707
210 Ms2$="B7C8000"   ! Min2 = 509, ORDQ & ORDER = 0 = page
220 Ms3$="87C8070"   ! Min2 = 509, SCC=0, VMAC = 0, CHAN = 112
230 Ms4$="B000001"   ! PSCC=0, ORDQ=0, ORDER = 1 (Alert to ring phone)
240 Mess_0$=M$(1)&M$(2)&M$(3) ! Overhead message
250 Mess_1$=Ms1$&Ms2$        ! Initial page of phone to see if it's alive
260 Mess_2$=Ms1$&Ms3$        ! Assigns voice channel if mobile responded
270 Mess_3$=Ms4$             ! Alert to ring the phone on the voice channel
280! Initialize testset
290 ON TIMEOUT 7,10 GOTO End_program
300 OUTPUT Uut_addr;"*RST" ! Reset to a known state
310 WAIT 5 ! Give it time to reset
320 OUTPUT Uut_addr;"RFAN:TMODE 'MANUAL';IFBW '230 KHZ';SQUELCH
'FIXED';FREQ 834.63 MHZ;ATT:MODE 'HOLD';:RFAN:ATT '20 DB'"
330 OUTPUT Uut_addr;"RFG:FREQ 879.63 MHZ;AMPL -50 DBM;:AFG1:FM:STATE
OFF"
340 OUTPUT Uut_addr;"DISP AFAN"
350 OUTPUT Uut_addr;"AFAN:INP 'FM DEMOD';FILT1 '300HZ HPF'"
360 OUTPUT Uut_addr;"TRIG:MODE:RETRIGGER SINGLE"
370 OUTPUT Uut_addr;"DISP DEC"
380 OUTPUT Uut_addr;"DEC:MODE 'AMPS-TACS';LEV:FM 14
KHZ;:DEC:AMPS:GATE 250 MS"
390! Set up filler (this is sent whenever no data is available)
400 OUTPUT Uut_addr;"ENC:AMPS:FILL:DATA1 '"&Filler$&"';DATA2 '"&Filler$&"'"
410 OUTPUT Uut_addr;"ENC:STOP;SEND" ! Stop it, then restart
420!
430 OUTPUT Uut_addr;"DEC:ARM"  ! Arm the decoder for a measurement
440 Junk=FNCheck_decoder! First reading may not be valid
450 Loop_count=1
460 LOOP ! Continue looping until the mobile responds or count = 100
470    IF Loop_count MOD 5=0 THEN
480       OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_1$&"';DATA2
'"&Mess_1$&"'"
490    ELSE
500       OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_0$&"';DATA2
'"&Mess_0$&"'"
510    END IF
520    OUTPUT Uut_addr;"ENC:SEND"
530 EXIT IF FNCheck_decoder! This checks the decoder to see if data available
540    WAIT .8 ! 800 millisecond wait between overhead messages
```

```
550    Loop_count=Loop_count+1! Simple loop counter to stop program
560    PRINT "Loop Count = ";Loop_count
570    IF Loop_count>100 THEN STOP
580 END LOOP ! Loops until Loop count > 100 or decoder receives data !!
590!
600! The program reaches here when we the mobile has responded
610    ! Send message to mobile to for it to a voice channel
620 OUTPUT Uut_addr;"ENC:AMPS:MESS:DATA1 '"&Mess_2$&"';DATA2
'"&Mess_2$&"'"
630 OUTPUT Uut_addr;"ENC:SEND"
640 WAIT .3    ! Give the mobile a little time to get to the voice channel
650    !
660    ! Now set up the SAT tone and tune the testset to the voice channel
670 OUTPUT Uut_addr;"ENC:AMPS:SAT:FREQ 5970 HZ"
680 OUTPUT Uut_addr;"ENC:AMPS:FILL:STOP"
690 OUTPUT Uut_addr;"RFAN:FREQ 828.36 MHZ;:RFG:FREQ 873.36 MHZ"
700    ! Now send the alert message on the voice channel to ring the phone
710 OUTPUT Uut_addr;"ENC:AMPS:CHAN 'Voice'"
720 OUTPUT Uut_addr;"ENC:AMPS:FVCM '"&Mess_3$&"'"
730 OUTPUT Uut_addr;"ENC:SEND"
740 ! VOICE CHANNEL IS NOW ACTIVE - New code starts here
750 PRINT "Press continue to have the mobile change level."
760 PAUSE
770 ! Send Forward Voice Channel Message
780 ! Sweep the level from 0 to 7
790 FOR I=0 TO 7 ! Causes phone to switch to all 8 levels.
800    PRINT "Sending the mobile to level";I
810    Temp$=DVAL$(SHIFT(I,-1),16)
820    Fvc_mess$="B0000"&Temp$[LEN(Temp$)]&"B"
830    OUTPUT Uut_addr;"ENC:AMPS:FVCM '"&Fvc_mess$&"'"
840    OUTPUT Uut_addr;"ENC:SEND"
850    WAIT 2
860 NEXT I
870    !
880 PRINT "Program ended" ! End of the new code for handoff
890 End_program:END
900 Check_decoder:DEF FNCheck_decoder
910! This monitors the Hardware1 condition register to see if decoder
920! is still armed or has received data.
930    COM Uut_addr
940    OUTPUT Uut_addr;"STATUS:HARDWARE1:CONDITION?"
950    ENTER Uut_addr;B
960    IF B=9.E+99 THEN RETURN 0
970    IF BIT(B,9) OR BIT(B,10) THEN RETURN 0
980    WAIT 2
990    RETURN 1
1000 FNEND
```


Data subject to change
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