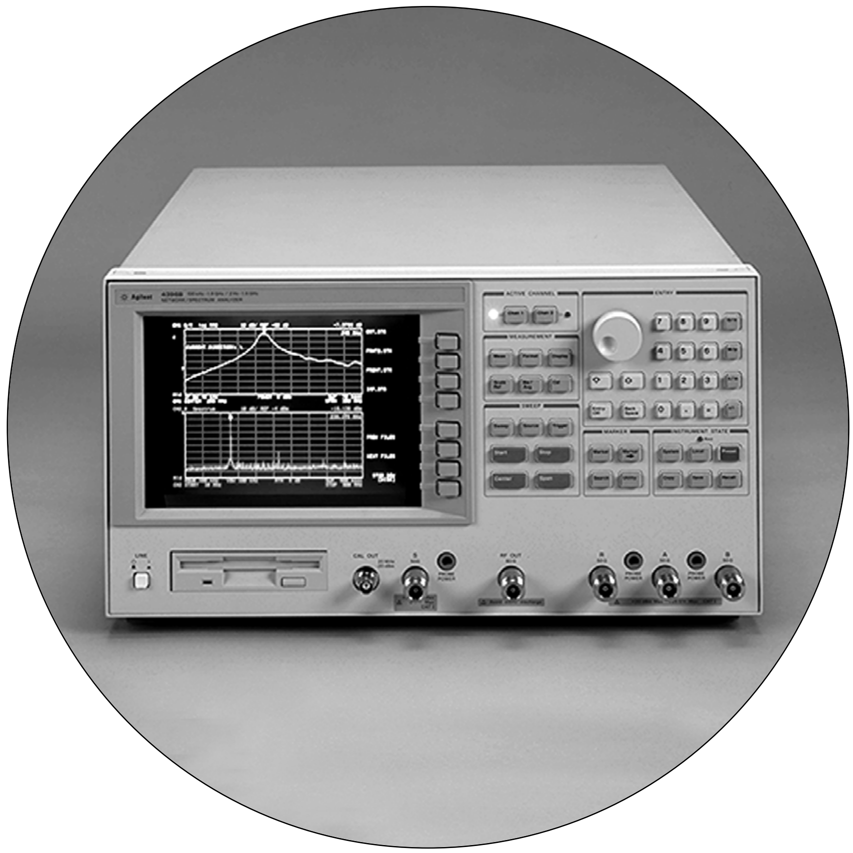
Agilent
Configuring the Agilent 4396B 1.8 GHz Network/Spectrum Impedance Analyzer for O/E Testing

Application Note 1288-2



Introduction

The recent trend in cable television (CATV) is the need for more selections, or channels, and the possibility of having interactive TV services such as On-Line-Banking and Movies-On-Demand. These requirements are pushing the limits of the copper cabling already laid out for today's CATV systems and these systems are not able to provide the "500 channels" of TV for the future. The industry is now changing from copper cable to fiber optic cable to carry the signals to the consumer.

The fiber optic cable carries the channel information as light signals, but all major TV equipment works upon electrical signals. Hence, tomorrow's CATV systems needs both Electrical-To-Optical converters (E/O) and Optical-To-Electrical (O/E) converters. An O/E converter changes light signals to electrical signals, and an E/O converter does the reverse. These converters need to be tested for conversion flatness and efficiency. A converter with too much ripple can cause distortions in the TV channels audio or video signals, which will show on the TV screen. A converter with low efficiency, or gain, can lead to low Signal-To-Noise ratio, which would cause "snow" on the TV. A converter without flat group delay will affect the quality of the audio and color of the channel.

There is a myriad of tests performed on these converters; this paper will concentrate solely on the test system setup for O/E converter test, using the 4396B 1.8 GHz Combination Analyzer.

The 4396B

The 4396B combines a network analyzer (NA), spectrum analyzer (SA), and impedance analyzer (ZA) into a single instrument. This combination allows for some major advantages:

1. **Reduced capital equipment cost**
   The 4396B costs less than a comparable network analyzer and spectrum analyzer if they were purchased separately.
2. **Simplicity**
   The 4396B is simpler to use. The front panel interface is always the same for every mode of the combination analyzer. Knowing how to operate the 4396B means you can operate 3 analyzers without constantly connecting and reconnecting the cables.
3. **Accuracy**
   The 4396B uses the latest digital signal processing (DSP) techniques to enhance its performance. The 4396B has digital bandwidth filters and a stepped FFT technique for speed and accuracy.
4. **Power**
   The 4396B has several powerful functions to enhance your testing capabilities, such as list sweep, a built-in floppy disk drive (FDD), and a controller capability with IBASIC to automate testing or test systems.

IBASIC allows for convenient control of the 4396B and automates testing. In this note, IBASIC is used to determine the offset factors for the E/O converter. In order to test an O/E converter, an optical system or an E/O converter must be characterized. These characteristics are placed into the 4396B memory array and subtracted from the actual E/O-O/E measurement to obtain the O/E parameters.

The 83400 series of lightwave sources are excellent E/O converters, with modulation bandwidths from 300 kHz to 3 GHz. They come provided with a disk of calibrated conversion parameters specific to each individual unit.

With an IBASIC program, the 4396B can read the E/O instrument disk and interpolate the conversion parameters for any bandwidth of interest. The IBASIC program will then put into the 4396B memory array the E/O conversion parameters. This IBASIC program is available from your local Agilent field sales representative upon request. (See Appendix for program listing.)

Conversely, the 83410 series of optical receivers can be used to characterize an E/O system. Instead of using a calibrated E/O for the test system, a calibrated O/E can be used to find the characteristics of the E/O system. This data can be factored into the measurements to obtain the corrected O/E device characteristics.

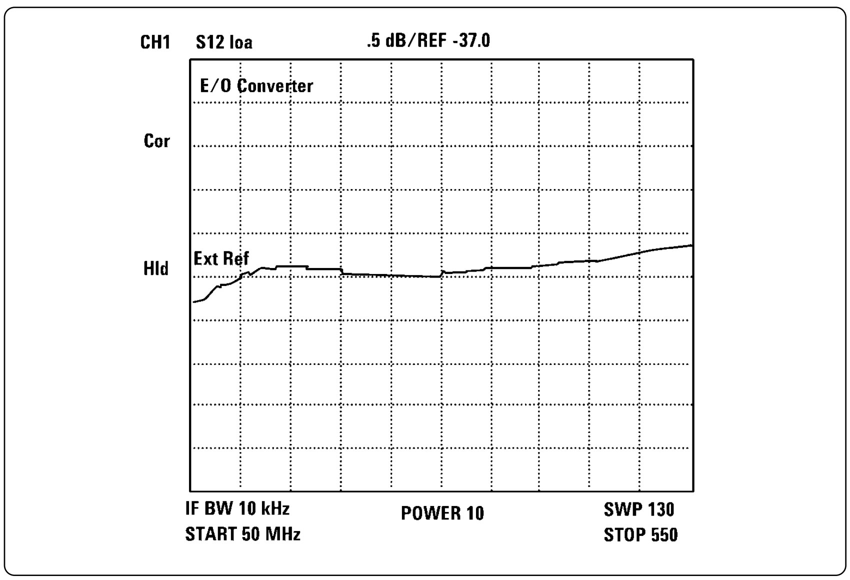


Figure 1. Conversion flatness for the 83400B

The 4396B for Testing O/E Conversion Flatness

One of the first tests of an O/E converter is magnitude and group delay flatness, also called conversion flatness. Conversion flatness indicates whether the device converts signals from light to electricity in a manner that is relatively flat over a given bandwidth. For TV signals, a channel bandwidth is 6 MHz.

The system layout is given in figure 2. The output from the network analyzer source is split; half the signal is returned to the analyzer's reference port, while the other half goes to the E/O converter. The optical output from the E/O is connected via fiber optic cable to the O/E converter (DUT). The electrical output of the O/E is the sent on to the analyzer's transmission port. An S-parameter test set can also be used to make full 2-port S-parameter measurements, although E/O converter will remain the same in every measurement.

After completing a THRU calibration by bypassing the E/O and O/E converters, the system is ready to make measurements. The calibrated data measured by the analyzer is the total conversion of both the E/O and the O/E converters. To get just the O/E converter conversion data, the analyzer will then subtract the conversion parameters of the E/O converter. The resultant trace, DATA - MEMORY, is the conversion flatness of the DUT. A sample conversion flatness result is given in figure 3.

The 4396B has a full vector network analyzer, which means it processes phase information in its measurements. The phase information combined with the frequency information results in group delay information.

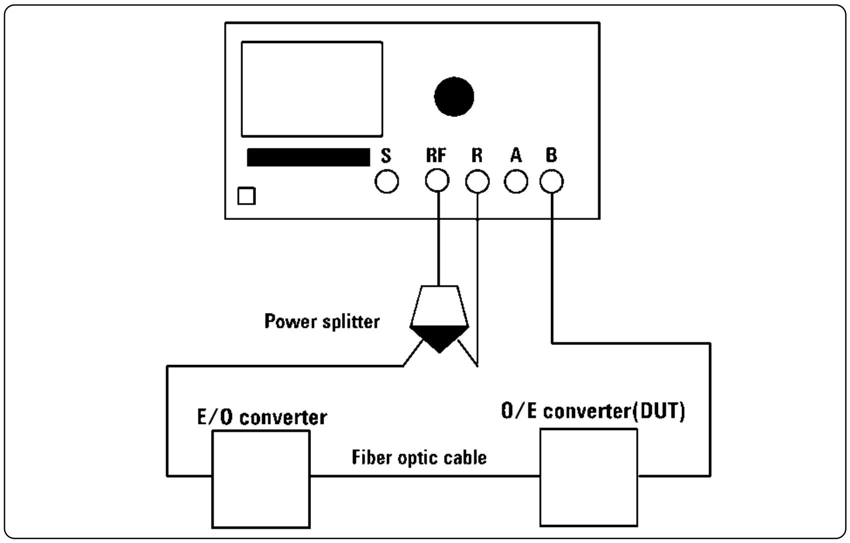


Figure 2. Network analysis system setup.

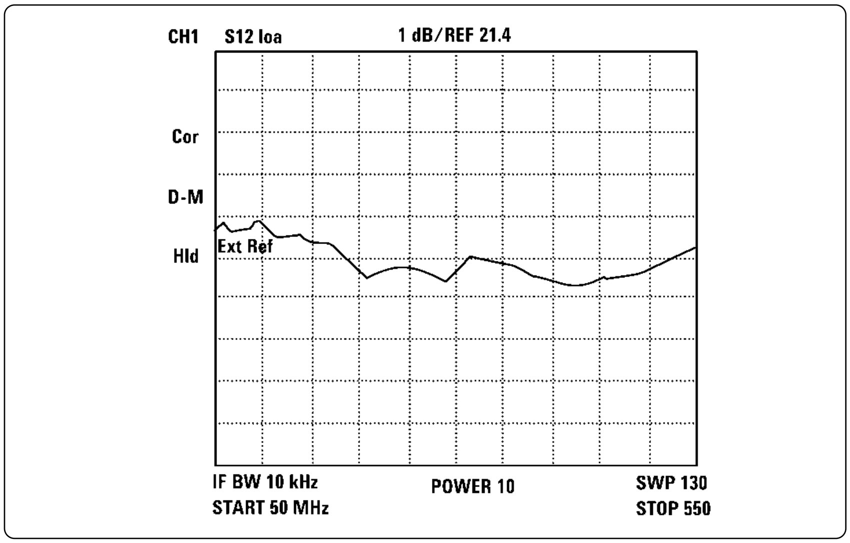


Figure 3. Corrected O/E converter amplitude flatness.

The 4396B Spectrum Analyzer

The 4396B has a powerful spectrum analyzer inside. It has a dedicated spectrum input port, and can also monitor the spectrum from the R, A, or B ports. A spectrum analyzer allows spectral testing of a component for Carrier-To-Noise (C/N), harmonics, hum, and composite triple beat (CTB). A system schematic for CTB testing is shown in figure 4. Separate signal generators are necessary to drive the E/O converter.

In figure 4, only one E/O converter is used with the two signal generators combined at the input to the E/O. Depending on the specifications of the E/O, two E/O converters can be used: one attached to the output of each signal generator, with an optical combiner to combine them before the input to the O/E under test. A screen from a CTB test is shown in figure 5.

C/N measures the amount of signal present compared to the amount of noise on the signal. Too little C/N means “snow” on the TV screen. CTB measures the amount of distortion from in-channel signals that “leaks” to other channels. This is called “crossmodulation” or “crossmod”, and typically is represented by jittery diagonal lines on the TV. Hum measures the AM modulation of the signal carrier due to the electrical power system. The TV picture will show overlaid horizontal if too much hum is present.

Conclusion

The 4396B fits in perfectly for testing CATV components, electrically and optically. The use of the calibrated optical transmitters and receivers allows for manufacturing test of O/E converters. The 4396B has a third analyzer in it, an impedance analyzer for measuring passive components. This triple functionality of the 4396B also makes it a very useful tool for R&D engineers making CATV components.

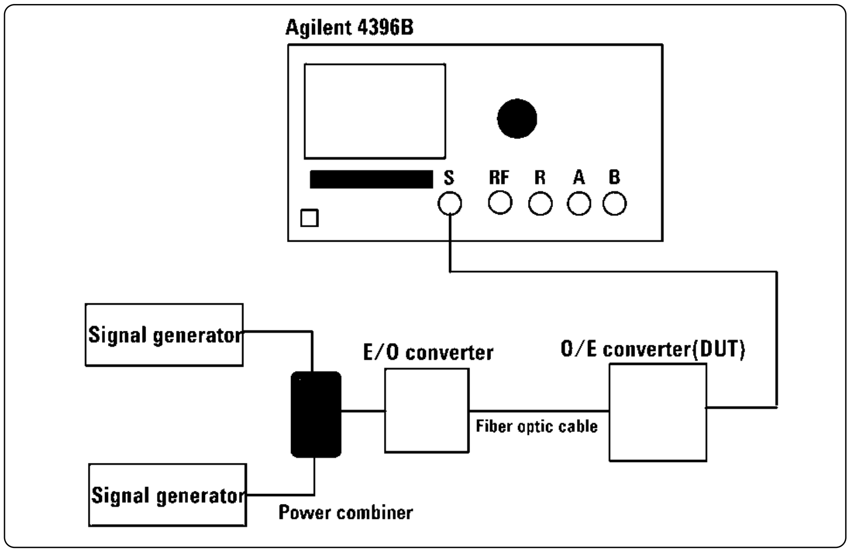


Figure 4. Spectrum analysis IMD test setup

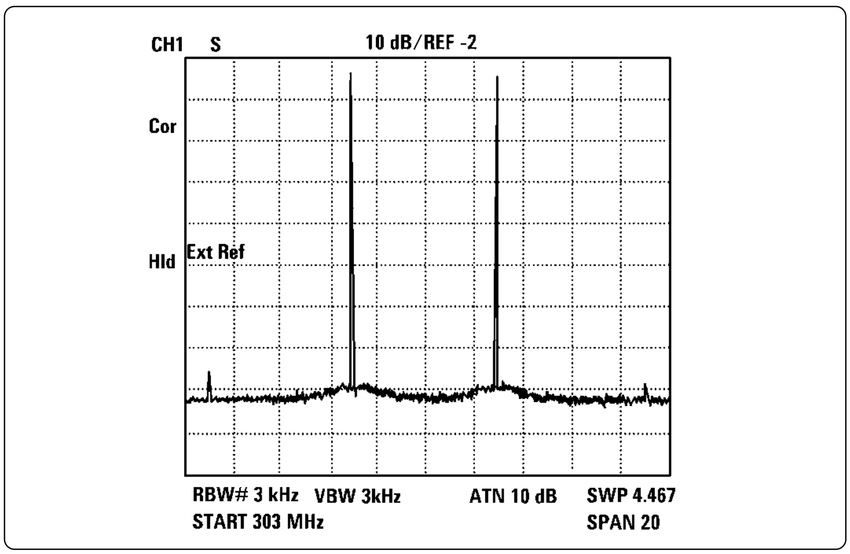


Figure 5. Spectrum analyzer CTB test results

Appendix

Program Listing

```
10000  ! Program to be run by Agt4396B internal IBASIC
10010  ! This program uses the correction factors for
10020  ! an Agt83411C lightwave receiver as found on
10030  ! the floppy disc shiped with the Agt83411C for
10040  ! use with an Agt8702.
10050  ! The name of the file to be used must be
10060  ! entered below.
10070  ! At startup and whenever the start frequency,
10080  ! the stop frequency or the number of points is
10090  ! changed this program will re-calculate the
10100  ! correction data for the Agt83411C and store
10110  ! this data in the so called memory array of
10120  ! the Agt4396B after which DATA+MEMORY is
10130  ! selected for display. This way all displayed
10140  ! data is corrected for the Agt83411C.
10150  REM
10151  COM /Ampl_phase/ Ampl(1:101,1:2),Phase(1:101,1:2),Delay
10160  INTEGER One_point,Err,Error
10170  REAL Points,Pnts
10180  REAL Strt,Stp,Sta,Sto
10190  REAL Dat(1:801,1:2)
10200  DIM Err$[256],Error$[256],Filename$[256]
10210  !
10220  !=======================================
10230  Filename$="" ! Enter filename here
10240    !=======================================
10250  !
10251  Delay=0
10252  !
10260  RAD
10270  !
10280  ASSIGN @Agt4396 TO 800
10290  ASSIGN @Bin TO 8;FORMAT OFF
10300  !
10310  ON KEY 1 LABEL "RETRY CAL" GOSUB Calkey
10320  !
10330  LOOP
10340    OUTPUT @Agt4396;";POIN?"    ! # of datapoints
10350    ENTER @Agt4396;Points
10360    OUTPUT @Agt4396;"STAR?"    ! Start frequency
10370   ENTER @Agt4396;Sta
10380   OUTPUT @Agt4396;"STOP?"    ! Stop frequency
10390   ENTER @Agt4396;Sto
10400   !
10410   IF Points<>Pnts OR Sta<>Strt OR Sto<>Stp THEN
10420    GOSUB Correction
10430   END IF
10440  END LOOP
10450 STOP
10460 !
10470 Correction:!
10480  BEEP
10490  !
10500  ! Save new Points, Sta and Sto values
10510  !
10520  Pnts=Points
10530  Strt=Sta
10540  Stp=Sto
10550  !
10560  OUTPUT @Agt4396;";MEAS S21"   ! Meas S21
10570  OUTPUT @Agt4396;";HOLD"     ! Stop sweep
10580  OUTPUT @Agt4396;";DISA ALLB"  ! Claim display
10590  !
10600  PRINT
10610  PRINT
10620  !
10630  GOSUB Err
10640  !
10650  IF Error=0 THEN
10660   !
10670   ! Get correction values from disc.
10680   !
10690   Read_floppy(Filename$,Error,Error$)
10700  END IF
10710  !
10720  IF Error=0 THEN
10730   PRINT
10740   PRINT
10750   PRINT
10760   PRINT "RE-CALCULATING Agt83411C CORRECTION CURVE"
10770   PRINT
10780   PRINT USING "K,10D";"Start frequency :";Sta
10790   PRINT USING "K,10D";"Stop frequency :";Sto
10800   PRINT "Number of points :";Points
10810   !
10820   ! Calculate new correction by interpolation
10830   !
10840   Mkd(Strt,Stp,Pnts,Dat(*))
10850   !
10860   ! Send data header information
10870   !
10880   OUTPUT @Agt4396 USING "#,K";";FORM3;INPUDATA "
10890   OUTPUT @Agt4396 USING "#,K,6Z";"#6",Points*16
10900   !
10910   ! Send data and manipulate.
10920   !
10930   GOSUB Send           ! To DATA arrays
```

```
10940  OUTPUT @Agt4396;";DATMEM"   ! To MEMORY arrays
10950  OUTPUT @Agt4396;";SAVC"   ! Re-calculate CAL
10960  OUTPUT @Agt4396;";MATH DPLM" ! Disp DataPLusMem
10970 END IF
10980 !
10990 IF Error THEN
11000  Error=0
11010  OUTPUT @Agt4396;";DISA HIHB"! Claim 50% display
11020  !
11030  PRINT Error$
11040  PRINT
11050  PRINT "Correction failed. Check :"
11060  PRINT
11070  PRINT "- START frequency"
11080  PRINT "- STOP frequency"
11090  PRINT "- NUMBER of POINTS"
11100  PRINT
11110  PRINT "and change to correct values."
11120  PRINT "OR press RETRY CAL to retry with current values."
11130  !
11140  OUTPUT @Agt4396;";KEY 47" ! System menu
11150  OUTPUT @Agt4396;";KEY 0" ! IBASIC
11160  OUTPUT @Agt4396;";KEY 6" ! ON KEY LABELS
11170 ELSE
11180  OUTPUT @Agt4396;";DISA ALLI" ! Release display
11190 END IF
11200 !
11210 OUTPUT @Agt4396;";CONT"
11220 RETURN
11230 !
11240 Send: !
11250 FOR One_point=1 TO Points-1
11260  OUTPUT @Bin;Dat(One_point,1),Dat(One_point,2)
11270 NEXT One_point
11280 OUTPUT @Bin;Dat(One_point,1),Dat(One_point,2) END
11290 GOSUB Err
11300 RETURN
11310 !
11320 Calkey: !
```

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