TE/TM Insertion Loss Application with SWS

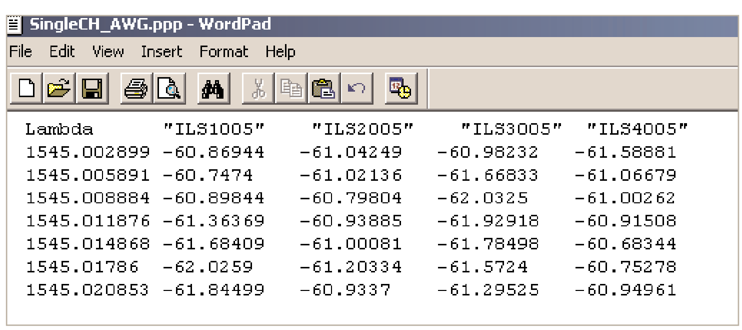
Introduction

The JDSU Swept Wavelength System (SWS) uses a four-state polarization controller to create four polarization states. In Polarization Dependant Loss (PDL) mode, the system measures a device as a function of wavelength for each polarization state. The SWS application software calculates the Mueller coefficients from the four-state insertion loss and determines the PDL and the average, minimum and maximum insertion loss over polarization.

With the latest SWS application software (version 4.2.2), the user has an extra option to save the raw four-state insertion loss data into a .ppp file, providing a stand-alone application program that allows the user to perform some post-data analysis including Transverse Electric/Transverse Magnetic (TE/TM) loss, polarization dependent (PD) wavelength shift (PD Lamda) and polarization dependent bandwidth (PD Bandwidth). This application note provides some examples of how to use .ppp files with SWS.

Formatting a .ppp file

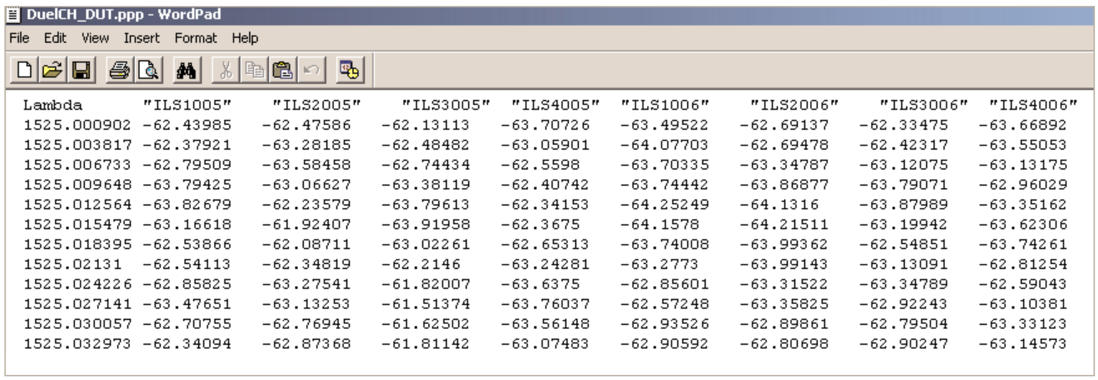
An example of a .ppp file with a single channel AWG is shown in figure 1. The columns of "ILS1, ILS2, ILS3 and ILS4" represent the insertion loss corresponding to four-state polarization. The "005" means the data saved as channel five with the SWS application software. In order to process the post data analysis, the insertion loss data is saved as 3 pm wavelength resolution. A smoothing index with SWS application software is not applied to this data file. In order to alleviate this problem, a section of cable is added at the OTDR launch location (front end) and at the receive location (far end) of the link under test.



Lambda	"ILS1005"	"ILS2005"	"ILS3005"	"ILS4005"
1545.002899	-60.86944	-61.04249	-60.98232	-61.58881
1545.005891	-60.7474	-61.02136	-61.66833	-61.06679
1545.008884	-60.89844	-60.79804	-62.0325	-61.00262
1545.011876	-61.36369	-60.93885	-61.92918	-60.91508
1545.014868	-61.68409	-61.00081	-61.78498	-60.68344
1545.01786	-62.0259	-61.20334	-61.5724	-60.75278
1545.020853	-61.84499	-60.9337	-61.29525	-60.94961

Figure 1. An example of single detector channel ppp file.

An example of two-channel Device Under Test (DUT) .ppp file is shown in figure 2. These are saved as channels five and six with the SWS application software.



DuelCH_DUT.ppp - WordPad

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Lambda	"ILS1005"	"ILS2005"	"ILS3005"	"ILS4005"	"ILS1006"	"ILS2006"	"ILS3006"	"ILS4006"
1525.000902	-62.43985	-62.47586	-62.13113	-63.70726	-63.49522	-62.69137	-62.33475	-63.66892
1525.003817	-62.37921	-63.28185	-62.48482	-63.05901	-64.07703	-62.69478	-62.42317	-63.55053
1525.006733	-62.79509	-63.58458	-62.74434	-62.5598	-63.70335	-63.34787	-63.12075	-63.13175
1525.009648	-63.79425	-63.06627	-63.38119	-62.40742	-63.74442	-63.86877	-63.79071	-62.96029
1525.012564	-63.82679	-62.23579	-63.79613	-62.34153	-64.25249	-64.1316	-63.87989	-63.35162
1525.015479	-63.16618	-61.92407	-63.91958	-62.3675	-64.1578	-64.21511	-63.19942	-63.62306
1525.018395	-62.53866	-62.08711	-63.02261	-62.65313	-63.74008	-63.99362	-62.54851	-63.74261
1525.02131	-62.54113	-62.34819	-62.2146	-63.24281	-63.2773	-63.99143	-63.13091	-62.81254
1525.024226	-62.85825	-63.27541	-61.82007	-63.6375	-62.85601	-63.31522	-63.34789	-62.59043
1525.027141	-63.47651	-63.13253	-61.51374	-63.76037	-62.57248	-63.35825	-62.92243	-63.10381
1525.030057	-62.70755	-62.76945	-61.62502	-63.56148	-62.93526	-62.89861	-62.79504	-63.33123
1525.032973	-62.34094	-62.87368	-61.81142	-63.07483	-62.90592	-62.80698	-62.90247	-63.14573

Figure 2. An example of two detector channels ppp file.

TE/TM Loss of Single Channel AWG

From the TE/TM Loss application directory, click the file TETMapplication_Multiple.exe. The GUI in figure 3 will appear. Type the total number of channels saved in the .ppp file and the channel to be analyzed. Click the "Data_Load" button. Load the data file SingleCH_AWG.ppp.

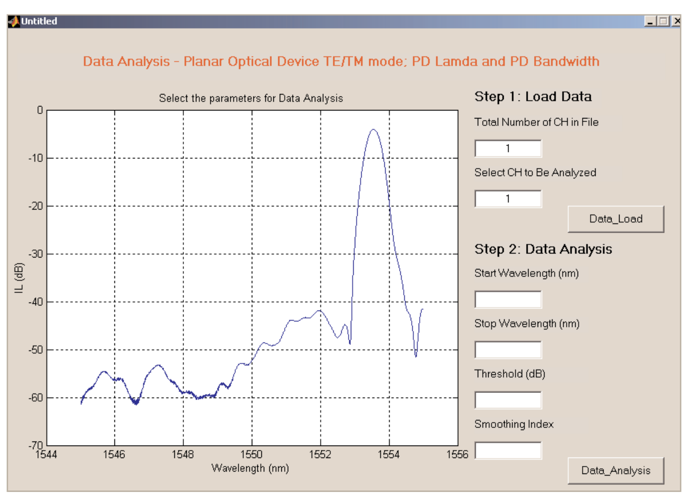


Figure 3. GUI for TE/TM loss application

After the data is loaded, use the left mouse button to zoom the area to be analyzed as shown in figure 4. Type the start and stop wavelengths for analysis. Select the insertion loss (IL) threshold used for calculating the central wavelength (CW) and bandwidth (BW). Select the smoothing index used for noise reduction. The definition of smoothing index is the same as the SWS application software. Click the "Data_Analysis" button. It takes a few second to complete the calculation, depending on the amount of data saved in the .ppp file.

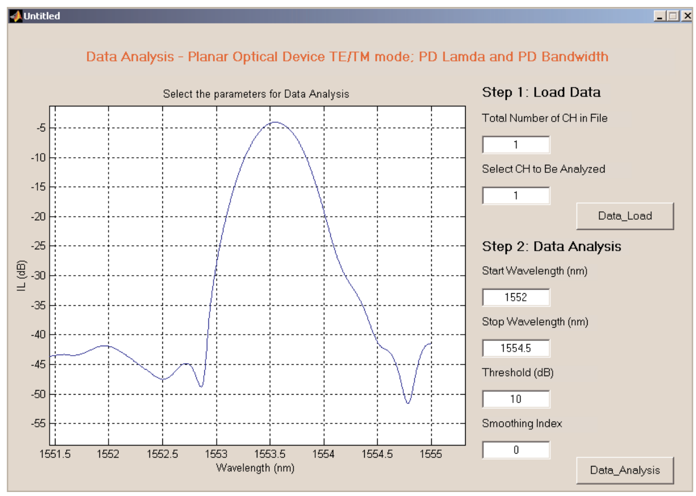


Figure 4. Zoom the analyzed area and input the data analysis parameters

When the data analysis is completed, a file named SingleCH_AWG_1stCH_results.dat is saved. The file contains the following information:

PDLamda = 10.29(pm)

PDBW = 3.333(pm)

Start Wavelength = 1552(nm)

Stop Wavelength = 1554.5(nm)

Threshold = 10(dB)

Smoothing Index = 0

Minimum insertion loss over polarization versus wavelength (Tmin)

Maximum insertion loss over polarization versus wavelength (Tmax)

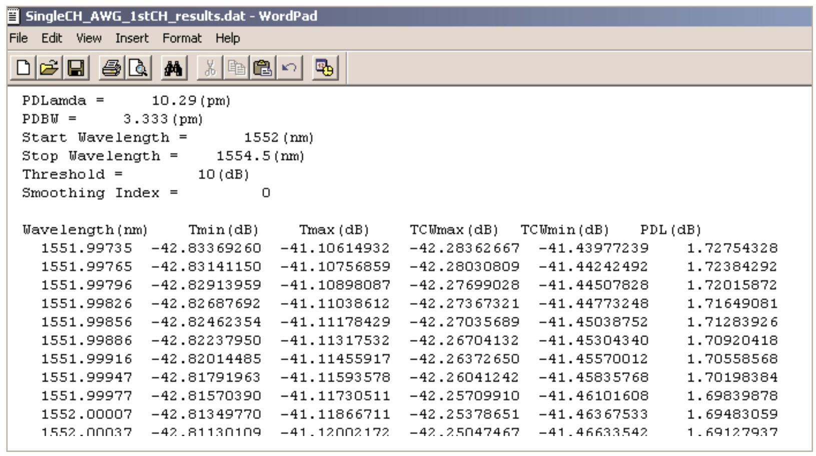
PDL

TE/TM loss, which are:

Insertion loss versus wavelength corresponding to highest value of CW (TCWmax)

Insertion loss versus wavelength corresponding to lowest value of CW (TCWmin)

The wavelength resolution shown in the file is 0.3pm due to the interpolation of the 3pm data in the original .ppp file.



SingleCH_AWG_1stCH_results.dat - WordPad

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PDLamda = 10.29(pm)
PDBW = 3.333(pm)
Start Wavelength = 1552(nm)
Stop Wavelength = 1554.5(nm)
Threshold = 10(dB)
Smoothing Index = 0

Wavelength(nm)	Tmin(dB)	Tmax(dB)	TCWmax(dB)	TCWmin(dB)	PDL(dB)
1551.99735	-42.83369260	-41.10614932	-42.28362667	-41.43977239	1.72754328
1551.99765	-42.83141150	-41.10756859	-42.28030809	-41.44242492	1.72384292
1551.99796	-42.82913959	-41.10898087	-42.27699028	-41.44507828	1.72015872
1551.99826	-42.82687692	-41.11038612	-42.27367321	-41.44773248	1.71649081
1551.99856	-42.82462354	-41.11178429	-42.27035689	-41.45038752	1.71283926
1551.99886	-42.82237950	-41.11317532	-42.26704132	-41.45304340	1.70920418
1551.99916	-42.82014485	-41.11455917	-42.26372650	-41.45570012	1.70558568
1551.99947	-42.81791963	-41.11593578	-42.26041242	-41.45835768	1.70198384
1551.99977	-42.81570390	-41.11730511	-42.25709910	-41.46101608	1.69839878
1552.00007	-42.81349770	-41.11866711	-42.25378651	-41.46367533	1.69483059
1552.00037	-42.81130109	-41.12002172	-42.25047467	-41.46633542	1.69127937

Figure 5. Output file of the analyzed TE/TM Loss

In addition, the results are shown in three graphs. Figure 6 shows the analyzed insertion loss traces of Tmin, Tmax, TCWmax and TCWmin. The traces can be zoomed by using the left mouse button.

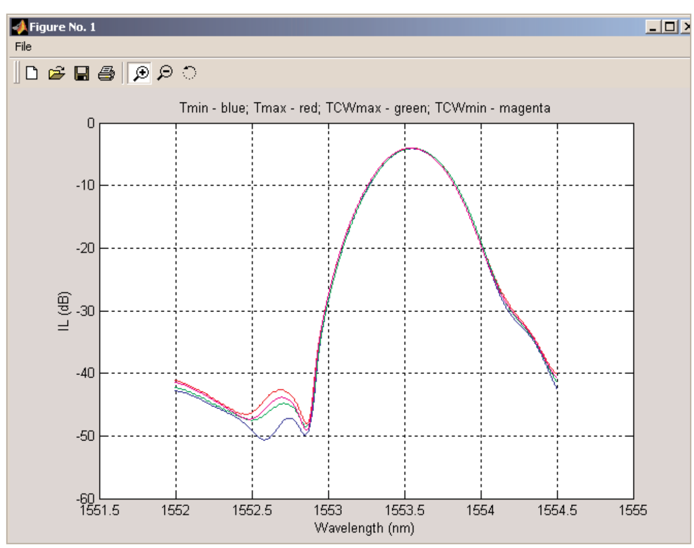


Figure 6. TCWmax and TCWmin correspond to TE/TM Loss

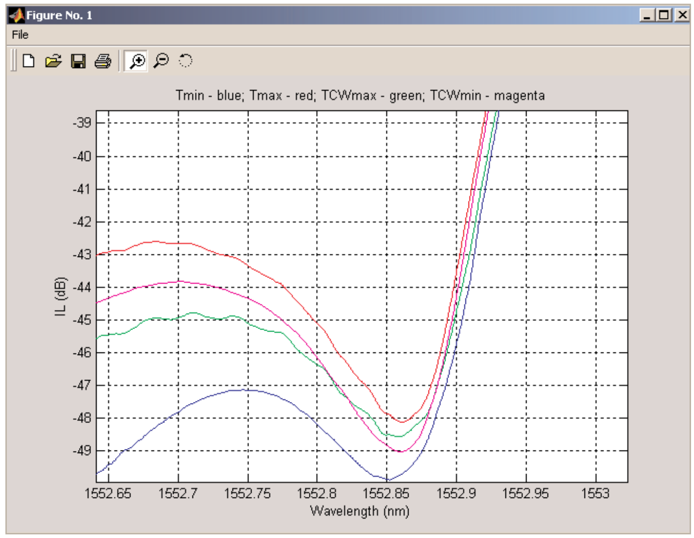


Figure 7. The zoomed TCWmax and TCWmin traces

Figure 7 shows the zoomed TE/TM loss TCWmax (green) and TCWmin (magenta). We can see how the two traces fall within the limits set by the Tmin (blue) and Tmax (red). It should be noted that the two polarization states that generated the TCWmax and TCWmin are 180° apart on the Poincare sphere, which is to be expected since waveguide device usually has the largest central wavelength differences for the TE/TM modes.

Figures 8 and 9 show the polarization-dependent CW and BW across the Poincare sphere. By clicking the  button, you can view the three dimensional plotting from any direction.

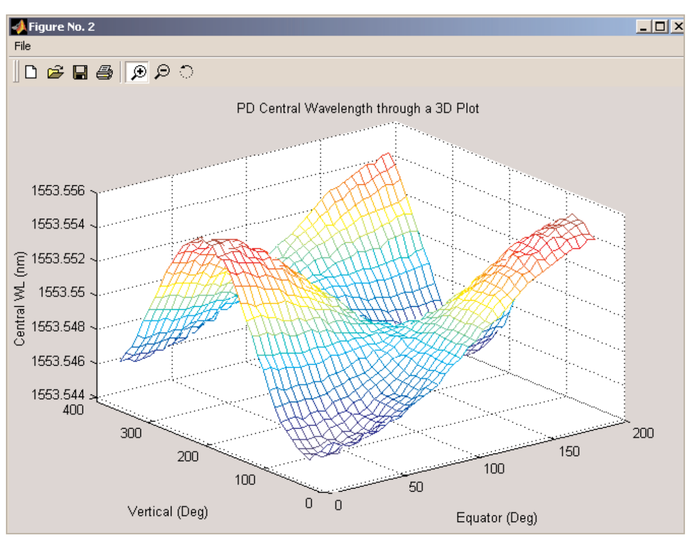


Figure 8. The polarization dependent CW across the Poincare sphere

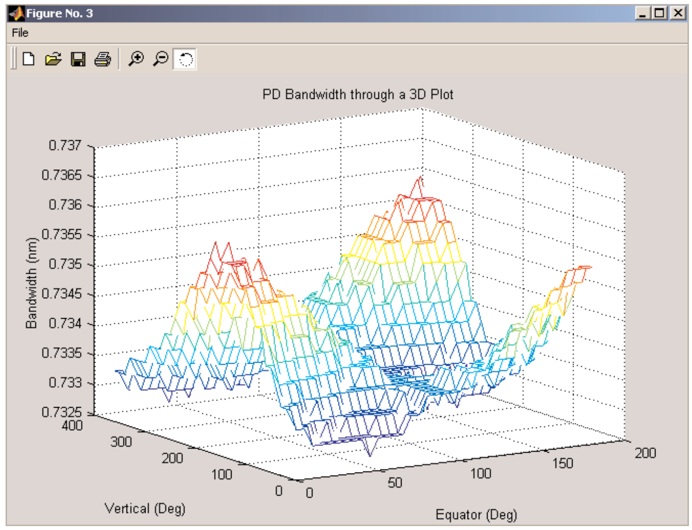


Figure 9. The polarization dependent BW across the Poincare sphere

TE/TM Loss of Dual Channel DUT

From the TE/TM Loss application directory, click the file TETMapplication_Multiple.exe. The GUI in figure 10 will appear. Type the total number of channels saved in the .ppp file and the channel to be analyzed. Click the "Data_Load" button. Load the data file as "DualCH_DUT.ppp."

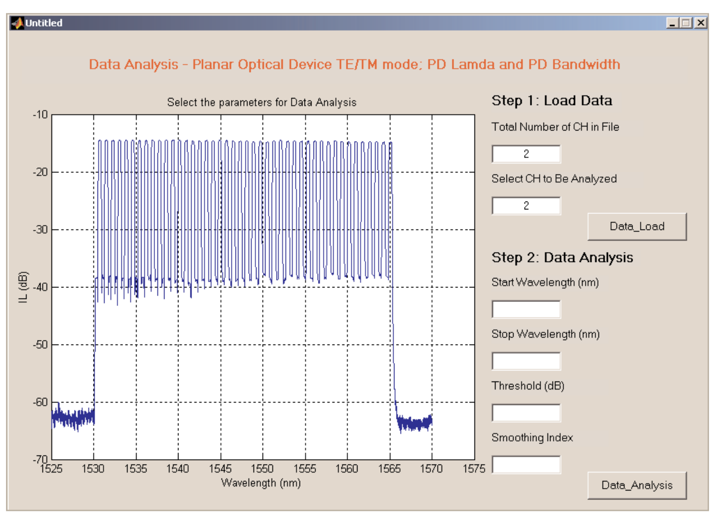


Figure 10. GUI for TE/TM loss application

After the data is loaded, use the left mouse button to zoom the area to be analyzed as shown in figure 11. Type the start and stop wavelengths for analysis. Select the IL threshold used for calculating the central wavelength (CW) and bandwidth (BW). Select the smoothing index used for noise reduction. As previously described, the definition of smoothing index is the same as the SWS application software. Click the "Data_Analysis" button. Again, it takes a few seconds to complete the calculation, depending on the amount of data saved in the .ppp file.

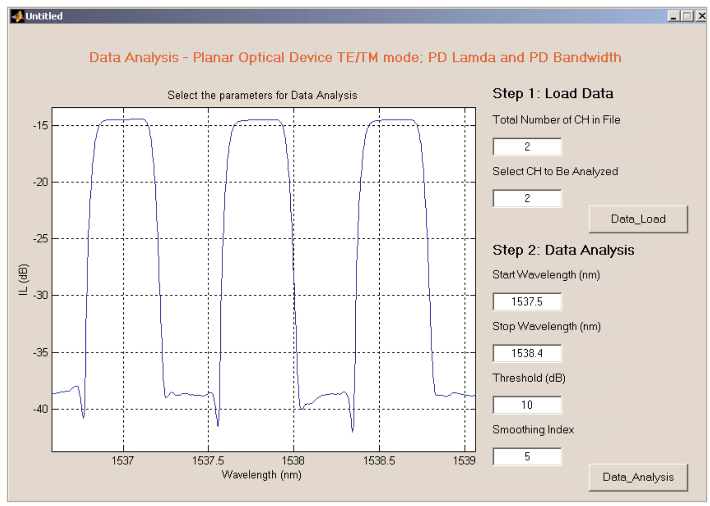


Figure 11. Zoom the analyzed area and input the data analysis parameters

When the data analysis is completed, a file named DualCH_DUT_2ndCH_results.dat is saved. The file contains the following information:

PDLamda = 1.779(pm)

PDBW = 3.558(pm)

Start Wavelength = 1537.5(nm)

Stop Wavelength = 1538.4(nm)

Threshold = 10(dB)

Smoothing Index = 5

Minimum insertion loss over polarization versus wavelength (Tmin)

Maximum insertion loss over polarization versus wavelength (Tmax)

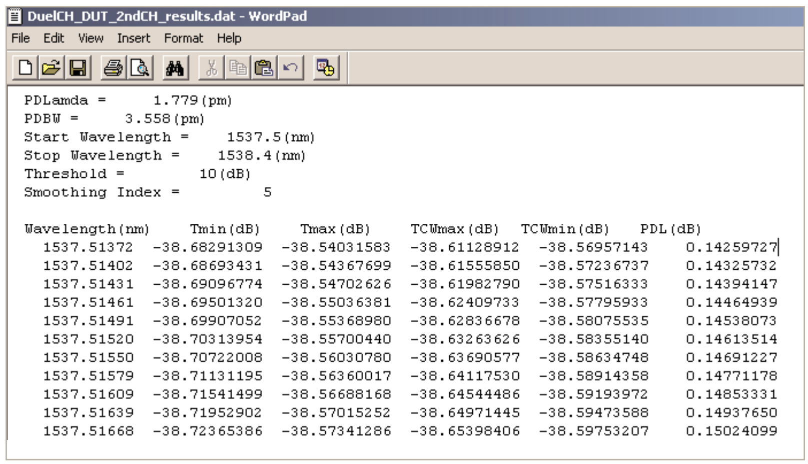
PDL

TE/TM loss, which are:

Insertion loss versus wavelength corresponding to highest value of CW (TCWmax)

Insertion loss versus wavelength corresponding to lowest value of CW (TCWmin)

Once again the wavelength resolution shown in the file is 0.3pm due to the interpolation of the 3pm data in the original .ppp file.



DuelCH_DUT_2ndCH_results.dat - WordPad

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PDLamda = 1.779(pm)
PDBW = 3.558(pm)
Start Wavelength = 1537.5(nm)
Stop Wavelength = 1538.4(nm)
Threshold = 10(dB)
Smoothing Index = 5

Wavelength(nm)	Tmin(dB)	Tmax(dB)	TCWmax(dB)	TCWmin(dB)	PDL(dB)
1537.51372	-38.68291309	-38.54031583	-38.61128912	-38.56957143	0.14259727
1537.51402	-38.68693431	-38.54367699	-38.61555850	-38.57236737	0.14325732
1537.51431	-38.69096774	-38.54702626	-38.61982790	-38.57516333	0.14394147
1537.51461	-38.69501320	-38.55036381	-38.62409733	-38.57795933	0.14464939
1537.51491	-38.69907052	-38.55368980	-38.62836678	-38.58075535	0.14538073
1537.51520	-38.70313954	-38.55700440	-38.63263626	-38.58355140	0.14613514
1537.51550	-38.70722008	-38.56030780	-38.63690577	-38.58634748	0.14691227
1537.51579	-38.71131195	-38.56360017	-38.64117530	-38.58914358	0.14771178
1537.51609	-38.71541499	-38.56688168	-38.64544486	-38.59193972	0.14853331
1537.51639	-38.71952902	-38.57015252	-38.64971445	-38.59473588	0.14937650
1537.51668	-38.72365386	-38.57341286	-38.65398406	-38.59753207	0.15024099

Figure 12. Output file of the analyzed TE/TM Loss

In addition, the results are shown in three graphs. Figure 13 shows the analyzed insertion loss traces of Tmin, Tmax, TCWmax and TCWmin. The traces can be zoomed by using the left mouse button.

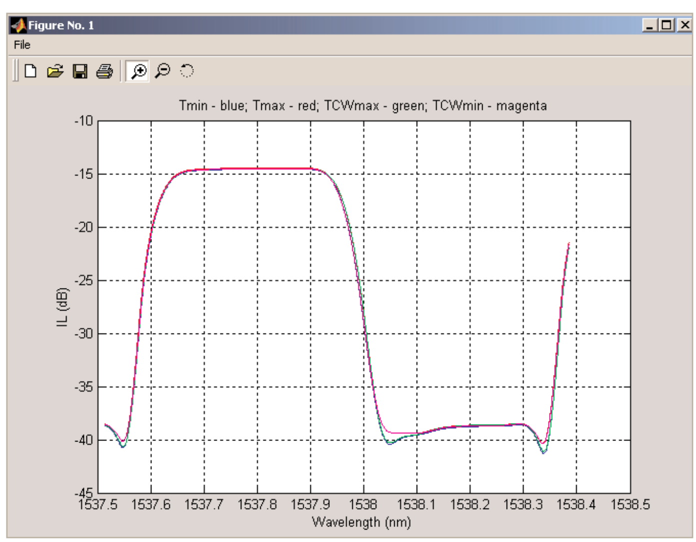

Figure 13. TCWmax and TCWmin correspond to TE/TM Loss

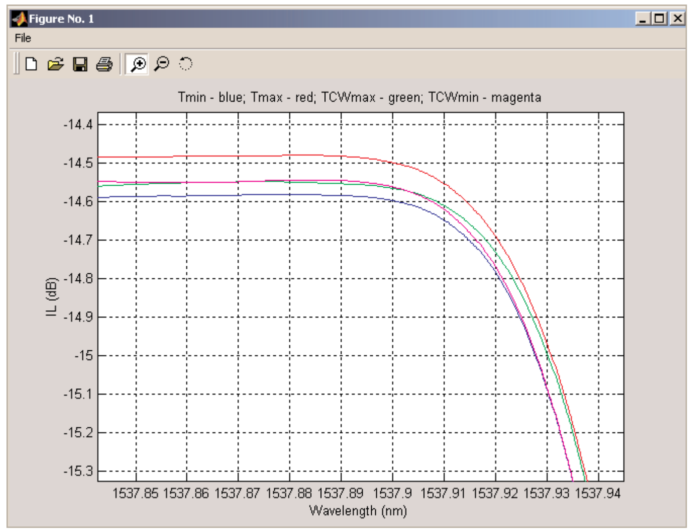

Figure 14. The zoomed TCWmax and TCWmin traces

Figure 14 shows the zoomed TE/TM loss TCWmax (green) and TCWmin (magenta). We can see how the two traces fall within the limits set by the Tmin (blue) and Tmax (red). It should be noted that the two polarization states that generated the TCWmax and TCWmin are 180° apart on the Poincare sphere, which is to be expected since waveguide device usually has the largest central wavelength differences for the TE/TM modes.

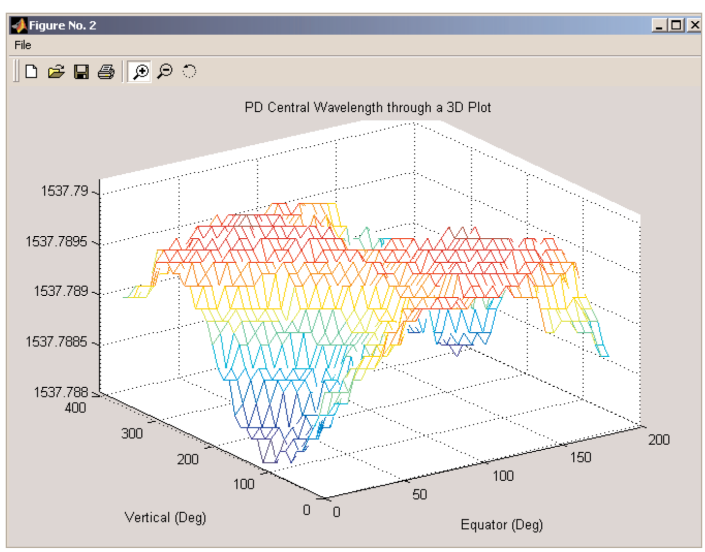

Figure 15. The polarization dependent CW across the Poincare sphere

Figures 15 and 16 show the polarization-dependent CW and BW across the Poincare sphere. By clicking the button, you can view the three dimensional plotting from any direction.

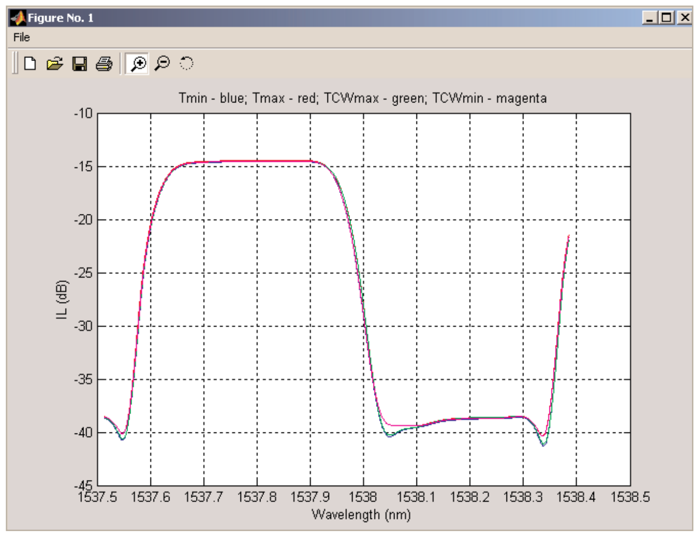

Figure 16. The polarization dependent BW across the Poincare sphere

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