Pattern Creator/Converter Software
User Manual

MAXIM High-Frequency/Fiber Communications Group

/VI/IXI/VI

Maxim Integrated Products

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1 Introduction

The Pattern Creator/Converter software (available for download at: http://www.maxim-ic.com/tools/other/) was written to facilitate the creation and use of complicated and non-standard test patterns for evaluation of ICs, modules, and systems used in fiber-optic, video, backplane and other applications. This application note will step through the features and use of the Pattern Creator / Converter software and show examples on how to use the program. The software has three main sections: a Pattern Creator, a Pattern Converter and Additional Resources / Information.

Note: This software is intended to run on a windows-based desktop computer (Windows 98 or newer) with a screen resolution of 800x600 or larger. The operating system that is included with test equipment (pattern generators, oscilloscopes, etc.) will often lack the necessary installed window components to allow correct operation of the program directly on that equipment.

2 Pattern Creator

The Pattern Creator (Figure 1) allows the user to create long binary test patterns in a text file format. To start a new pattern, click the **Output File Name** button and choose a filename and location. Once the file location and name are selected, the file is created. Patterns can then be added sequentially by pressing the buttons of the various built-in pattern sequences.

The sequence of the pattern created will appear in the **Pattern Sequence** box and the statistics of the pattern will be displayed in the **Pattern Statistics** text box. Pressing the **Done** button closes the text file that was created. More details and an example of how to use the buttons and features of the Pattern Creator section will be demonstrated in the following paragraphs.
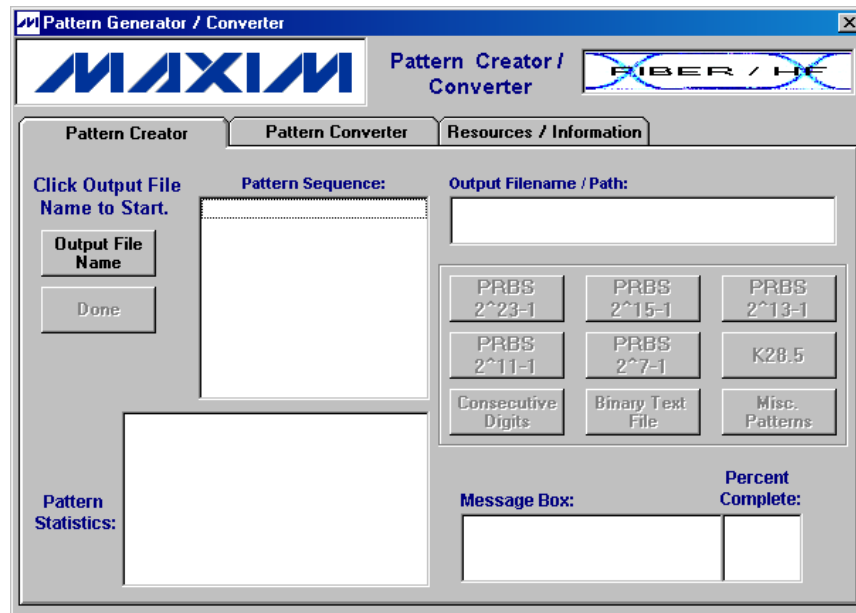

Figure 1.   Pattern Creator Tab Menu

2.1 PRBS Patterns

The Pseudo Random Bit Sequences (PRBS) are generated using a software version of the conventional hardware shift register with the taps of minimum shift algorithms generated from Galois-field arithmetic (Figure 2, Table 1, see References 1 & 2). The shift register length is determined by the pattern title. For example, a PRBS 2^7-1 pattern would be generated using a shift register 7 bits long. Where n is the register length, the PRBS pattern contains every possible combination of n bits (except one).
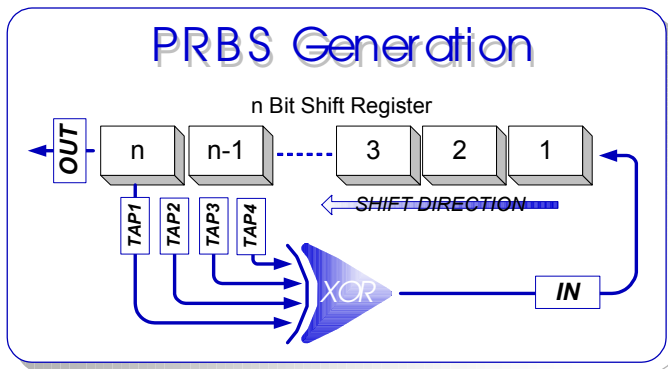

Figure 2.   PRBS Generation

The mark density (100%*(number of ones / total bits)) and the transition density (100%*(number of bit transitions / total number of bits)) of PRBS patterns are approximately 50%. This approximation improves as the pattern length (shift register length) increases. Also, the maximum number of consecutive identical digits (CIDs) is equal to the register length (n) (e.g. a 2^{23}-1 PRBS has a maximum of 23 CIDs).

Pressing any of the PRBS buttons opens the option list shown in Figure 3. Using this option list, the PRBS sequence can be repeated an integer number of times or the total number of bits to write of the given PRBS can be selected. The PRBS can also be written to the file inverted or non-inverted. It is important to note that the mark density and the transition density of the pattern sequence can deviate from the 50% approximations if only part of the PRBS is written to the file.

Table 1: PRBS Pattern Length / Tap Positions

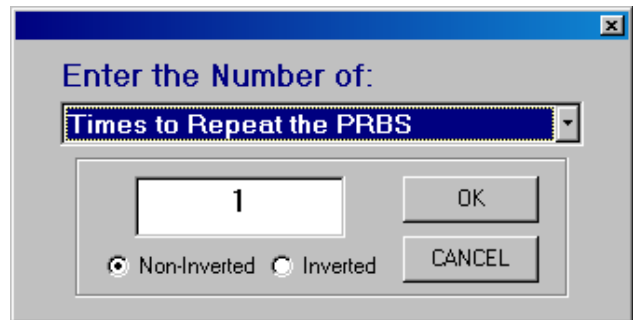| Register Length (n)	Pattern Length (2^n-1)	Register Number (1 to n)			
		Tap1	Tap2	Tap3	Tap4
3	7	3	2		
4	15	4	3		
5	31	5	3		
6	63	6	5		
7	127	7	6		
8	255	8	7	3	2
9	511	9	5		
10	1023	10	7		
11	2047	11	9		
12	2095	12	9	8	5
13	8191	13	12	10	9
14	16383	14	13	3	2
15	32767	15	14		
16	65535	16	14	13	11
17	131071	17	14		
18	262143	18	11		
19	524287	19	18	14	13
20	1048575	20	17		
21	2097151	21	19		
22	4194303	22	21		
23	8388607	23	18		

Figure 3.   PRBS Options

In this software program, each PRBS register is initialized with all 1's. Therefore, each PRBS sequence will start with the maximum CID length (e.g. the first seven bits generated from the non-inverted PRBS 2^7-1 will be all ones).

2.2 K28.5 Pattern

By pressing the K28.5 button, the user can add one or multiple K28.5 sequences with the choice of being inverted or non-inverted (Figure 4). The data bits added for each K28.5 sequence is the entire K28.5± pattern, where the non-inverted bits are: 1100 0001 0100 1111 1010.
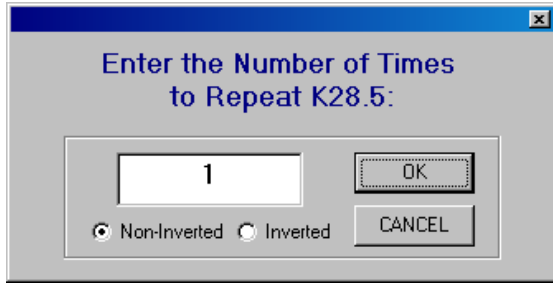

Figure 4.   K28.5 Options

2.3 Adding Consecutive Identical Digits

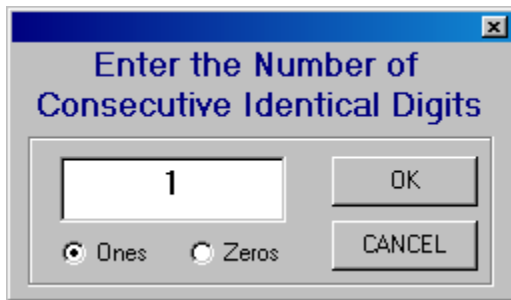The consecutive digits button lets the user add 1 to 99999 consecutive ones or zeros to the pattern sequence (Figure 5).

Figure 5.   CID Options

2.4 Binary Text File

The pattern creator/converter software includes the option of inserting an existing text file. The software will read any text file and extract the "1" and "0" text characters from the file and insert them into the pattern being created. The file can be written inverted or non-inverted and then be repeated up to 999 times (Figure 6)
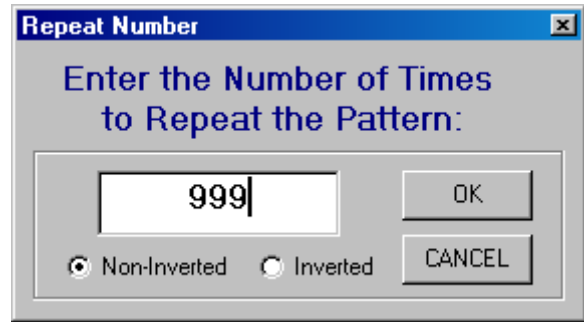

Figure 6.   Binary File Options

This feature can also be used to read in an existing pattern/text file and determine its statistics. This can be a useful tool in evaluating test files or actual data in the system.

2.5 Miscellaneous Test Patterns

By pressing the **Misc. Patterns** button, the user can add sections of various length repeating one/zero patterns (10, 1100, 111000, etc.), non-standard PRBS patterns or variable bit lengths of internally generated random bits (Figure 7).
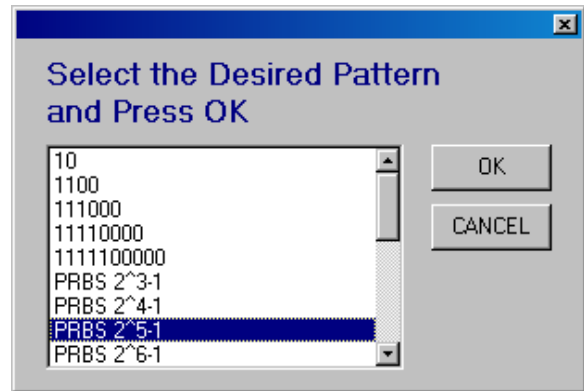

Figure 7.   Miscellaneous Test Patterns

2.6 Pattern Creator Considerations

The following items should be considered when creating test patterns with this software:

- The software writes the pattern to the selected file sequentially. It is not possible to go back and edit the file after a pattern has been added.

- Pattern Granularity (see section 3.2)

- Pattern files greater than 2 million bits can take a couple of minutes to write.

- The software does not allow the pattern length to exceed 34 million bits.

- Many pattern generators can only use pattern files up to 8 million bits in length and may have limitations to the number of CIDs that they can tolerate.

- Once the **Done** button is pressed the pattern sequence and statistics are erased. The information should be written down before pressing the **Done** button if it will be needed at a later time.

2.7   Example

A common use of this software is to add sections of CIDs to existing PRBS patterns in order to test the response of a device with data that has low frequency content. For example, to create a 2^7-1 PRBS + 100CID test pattern, the following steps are used.

1. Click the **Output File Name** button and enter the name and location of the file that will be created (Figure 8)
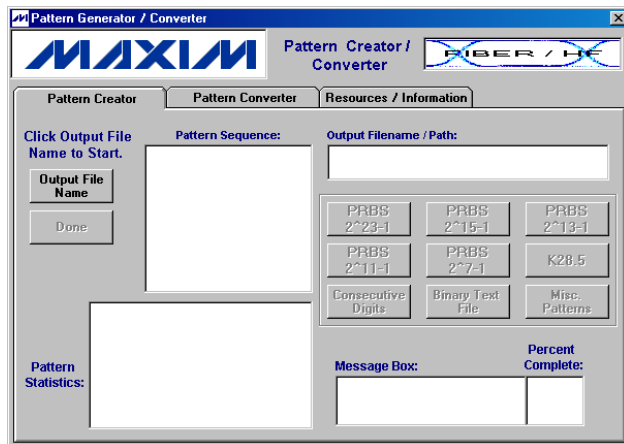

Figure 8.   Creator Example Step #1

2. Click the **PRBS 2^7-1** button.

3. Click on the pull down menu (Figure 9) and verify that **Times to Repeat the PRBS** is selected, enter 1 in the text box, verify that the **Non-Inverted** option is selected and then click the **OK** button.
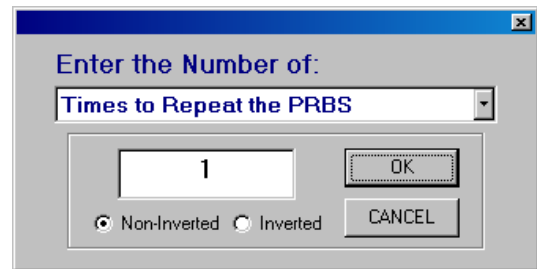

Figure 9.   Creator Example Step #3

4. The first sequence of the pattern is now shown in the **Pattern Sequence** box and the corresponding statistics of the pattern to this point are shown in the **Pattern Statistics** textbox (Figure 10).
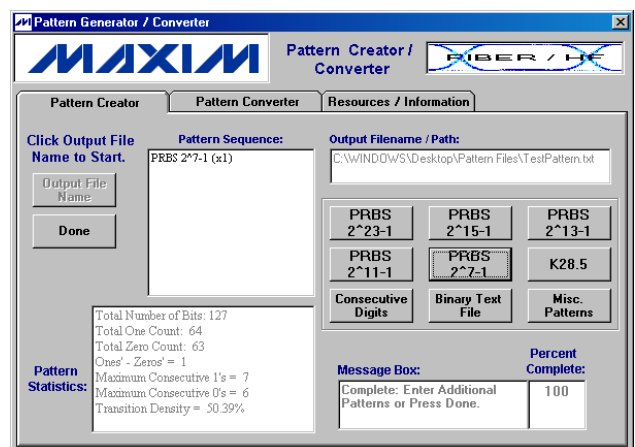

Figure 10. Creator Example Step #4

5. Add 100 1's to the end of the pattern by clicking the **Consecutive Digits** button, entering 100 in the box, selecting the **Ones** option and then by clicking on the **OK** button (Figure 11).
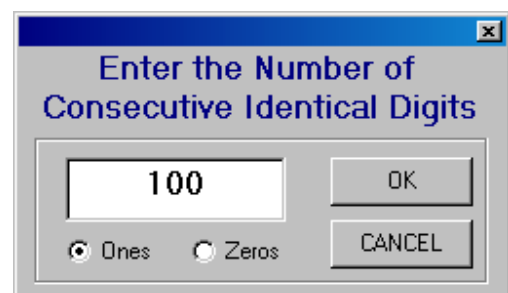

Figure 11. Creator Example Step #5

6. To balance the pattern, two additional sequences need to be added. Namely, the inverse of the first two sequences. To add the next sequence, repeat step #3, except with the **Inverted** option selected (Figure 12). Note that after **OK** button is clicked, the

sequence list adds the letters **INV** to the end of the PRBS sequence to indicate it was inverted (Figure 14).
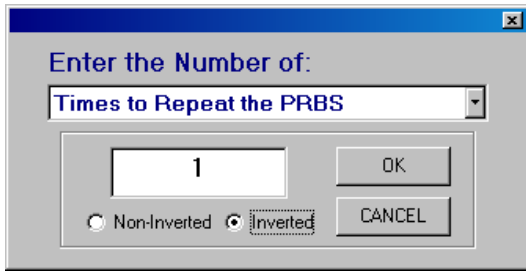

Figure 12. Creator Example Step #6

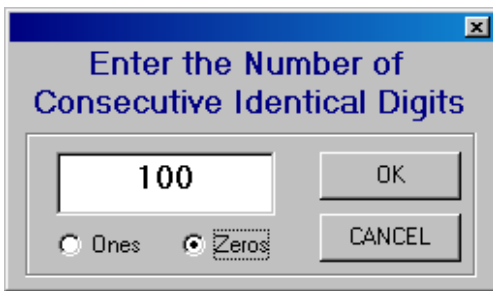7. Repeat Step 5 except with the **Zeros** option selected (Figure 13).

Figure 13. Creator Example Step #7

8. The pattern is now created. As seen in the pattern statistics, the pattern is balanced (same number of ones and zeros). Given the long CID sequences that were added, the transition density is much less than 50% (Figure 14).

9. Click the **Done** button to complete the procedure. The pattern is now ready to be used as a text file or converted to a pattern generator test file.
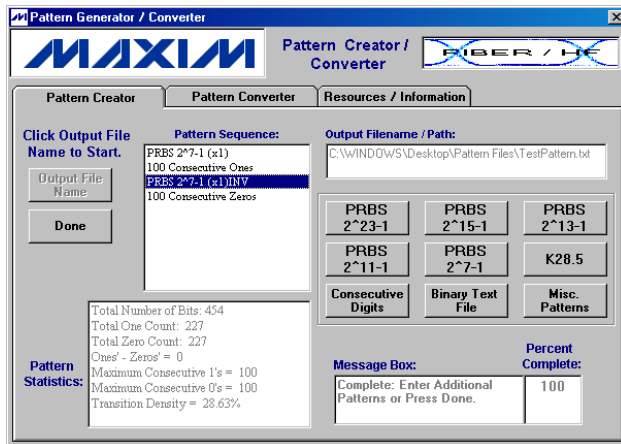

Figure 14. Creator Example Step #8

3   Pattern Converter

The pattern Converter section of the software reads-in existing patterns and converts them to one of three formats for use with common pattern generators.

3.1   Pattern Types

3.1.1   Hex Pattern Files

HEX pattern files can be used with Agilent N4901/2 and 86130 pattern generators. The HEX files can be opened and viewed in any text editor.

3.1.2   PTRN Pattern Files

PTRN file types can be used with Agilent N4901/2 and 86130 pattern generators. The files are binary files so they can not be read in text editors. PTRN files should be used for longer pattern files because they require less disk space.

3.1.3   DAT Pattern Files

DAT file types can be used with Agilent 70843 and 70841 pattern generators. These files are also binary files but they include different file header information than the PTRN file type. Pattern generators that use DAT file types have pattern store locations 5-12 available. The pattern file name is included in the header information of the file. If the name is changed, the pattern generator will not recognize the file.

3.2   Pattern Granularity

When using the Agilent 86130A, 70843 or 70841 pattern generators, the length of a user input pattern must be a predefined multiple for a given range of pattern lengths. As the pattern length increases, the multiple increases as well.

Tables 2 and 3 list the pattern granularity of each generator. This information can also be accessed with the software by clicking the **Pattern Granularity** button.

Table 2: Granularity Table (70841 / 70843)

Pattern Length (L) (Bits)	Step Size (Bits)
L < 32000	1
32000 ≤ L < 64000	2
64000 ≤ L < 128000	4
128000 ≤ L < 256000	8
256000 ≤ L < 512000	16
512000 ≤ L < 1024000	32
1024000 ≤ L < 2048000	64
2048000 ≤ L < 4096000	128
4096000 ≤ L ≤ 8000000*	256

*The Maxim pattern length for the 70841 is 4194304 bits

Table 3: Granularity Table (86130A)

Pattern Length (L) (Bits)	Step Size (Bits)
L < 128000	1
128000 ≤ L < 256000	2
256000 ≤ L < 512000	4
512000 ≤ L < 1024000	8
1024000 ≤ L < 2048000	16
2048000 ≤ L < 4096000	32
4096000 ≤ L ≤ 8000000	64

If the pattern does not meet these requirements, the pattern generator may not recognize the file. The software will verify the pattern length when doing a conversion. If an error is found in the pattern length a message box will appear (Figure 15) with the two pattern lengths that meet the requirements that are closest to the original pattern length. The pattern will then need to be adjusted before the conversion can take place.
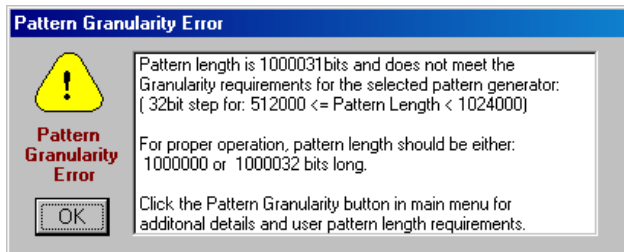
Figure 15. Pattern Granularity Error

3.3 Additional Pattern Converter Considerations

In addition to the items in sections 2.6 and 3.2, the following items should also be noted when using the pattern converter section of the software.

- It can take several minutes to convert a pattern file that is over 2 million bits in length.
- The software must first count the number of bits in the file to verify that the pattern is the correct type, and that it does not exceed the maximum pattern length.
- PTRN and DAT file types should be used when possible as they take up less disk space.
- DAT files require specific filenames. The number of the filename should be selected before clicking the **DAT** button.

3.4 Example

To convert the pattern that was created in section 2.7:

1. Select the pattern generator that will be used. For this example, we will assume the generator is the Agilent 70843 series (Figure 16).
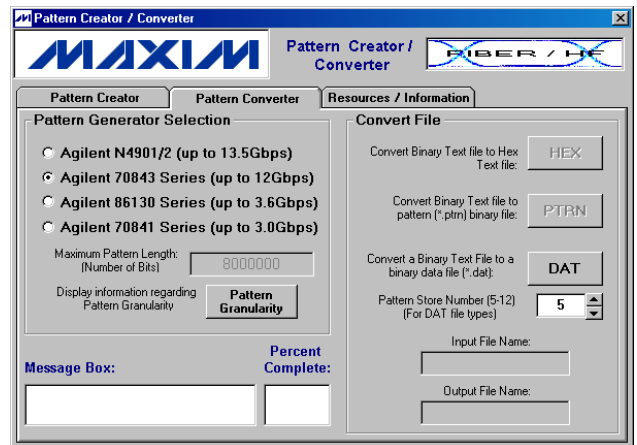
Figure 16. Converter Example Step #1

2. Set the pattern store number for the DAT file type to any number between 5 and 12 by clicking on the up/down buttons (Figure 16).

3. Click on the **DAT** button and find the binary text file that needs to be converted and then click on **Open** (Figure 17). After the **Open** button is clicked, the program will count the number of data bits in the file.
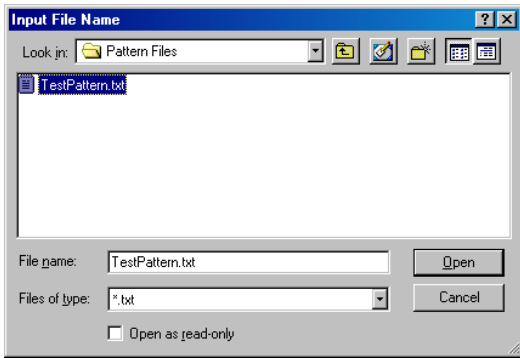
Figure 17. Converter Example Step #3

4. Select the location where the new pattern file should be stored and click the **Save** button (Figure 18). Note: Do not change the filename when using DAT-type pattern files. If the name is changed, the pattern generator will not recognize the test file.
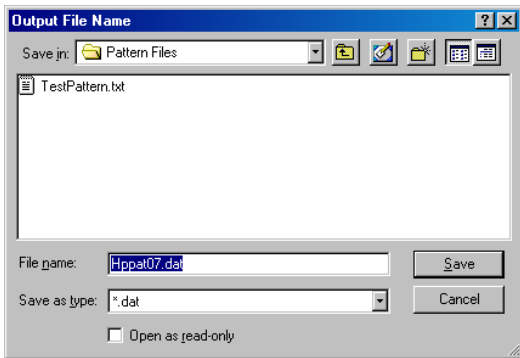

Figure 18. Converter Example Step #4

5. After clicking the **Save** button, the program will then convert the file and display a message when it has completed (Figure 19). The pattern can now be read and used by the pattern generator.
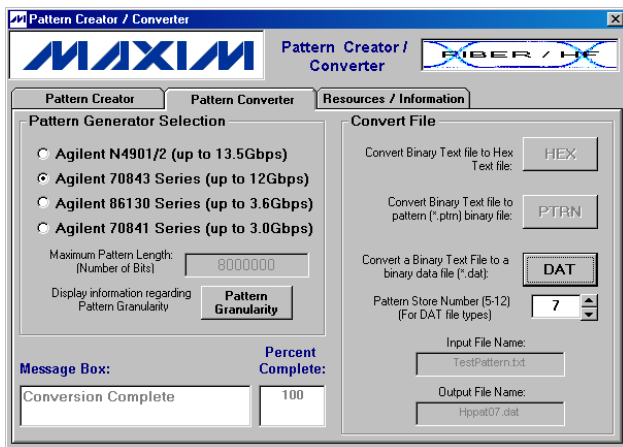

Figure 19. Converter Example Step #5

4 Resources/Information

The Resources/Information tab (Figure 20) includes links to helpful Maxim Integrated Products websites, the software license agreement and information about the software version number.

Technical support is not available for this software. However, if errors (bugs) are found in the evaluation of the software or additional features are requested, please email maximfibersupport@maximhq.com with **PRBSsoft** in the subject line. Any comments submitted will be considered in future revisions of the program.
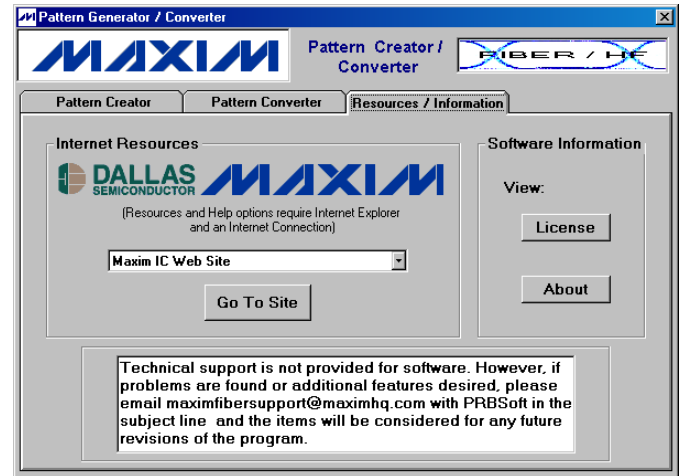

Figure 20. Resources/Information Section

References:

1. The Art of Electronics: Horowitz & Hill, Cambridge University Press – 1995

2. "Primitive Binary Polynomials", Wayne Stahnk, Mathematics of Computation, Vol 27, No. 124, pages 977-980 - Oct 1973