

tCAM-IP Demo Instruction

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tCAM-IP Demo Instruction

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This document provides step-by-step instructions for running a tCAM-IP demo on the KCU116 development board. The tCAM-IP, or Ternary Content Addressable Memory, is based on FPGA technology that offers extremely low-latency matching functionality. The demo is divided into two parts. In the first part, the capability of the tCAM-IP to perform searches will be demonstrated. In the second part, a simple application will be demonstrated, showcasing how the tCAM-IP can assist in performing searches, such as text replacement.

All configurations required for this demo can be easily managed through the serial console interface. This instruction provides guidance on how to set up the test environment, execute the demo, and interpret the results.

1 Environment Setup

To operate tCAM-IP demo, please prepare following test environment.

- 1) FPGA development board (KCU116 development board).
- 2) Test PC.
- 3) Micro USB cable for JTAG connection between FPGA board and Test PC.
- 4) Micro USB cable for UART connection between FPGA board and Test PC.
- 5) Vivado tool for programming FPGA installed on Test PC.
- 6) Serial console software such as TeraTerm installed on PC. The setting on the console is Baudrate=115,200, Data=8-bit, Non-parity and Stop=1.
- 7) Demo configuration file (To download this file, please visit our web site at www.design-gateway.com).

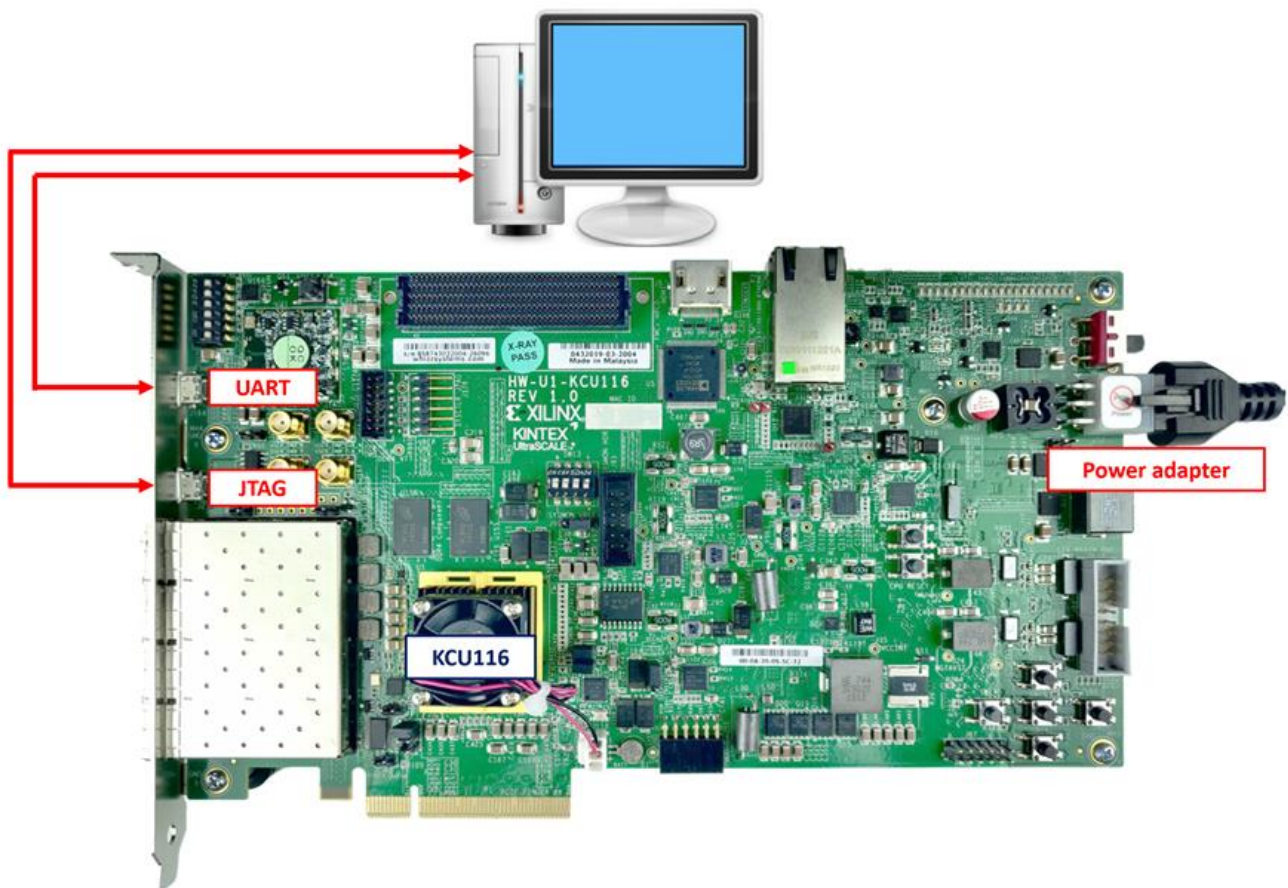


Figure 1 tCAM-IP demo environment on KCU116 board

2 FPGA development board setup

- 1) Make sure the power switch is off and connect the power supply to KCU116 development board.
- 2) Connect USB cable between PC to JTAG micro USB port.
- 3) Power on the system.
- 4) Open Vivado Hardware Manager to program FPGA by following steps.
 - i) Click open Hardware Manager.
 - ii) Open target -> Auto Connect.
 - iii) Select FPGA device to program bit file.
 - iv) Click Program device.
 - v) Click “...” to select program bit file.
 - vi) Click Program button to start FPGA Programming.

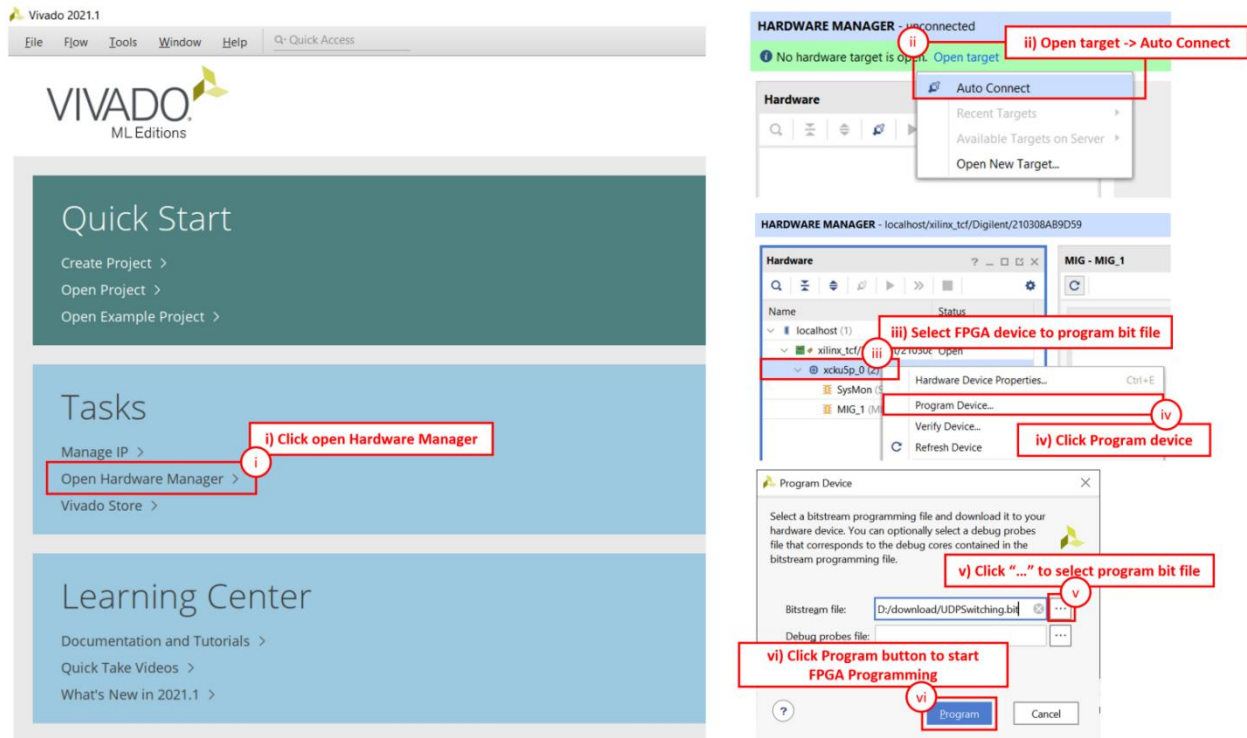


Figure 2 Program Device

3 Serial Console

The serial console allows users to configure parameters and manage the tCAM-IP demo. Through this interface, users can input rule data, perform key searches, and utilize the word replacement feature. The commands menu for the tCAM-IP demo are displayed as shown in Figure 3, with detailed descriptions provided in topic 4 and topic 5.

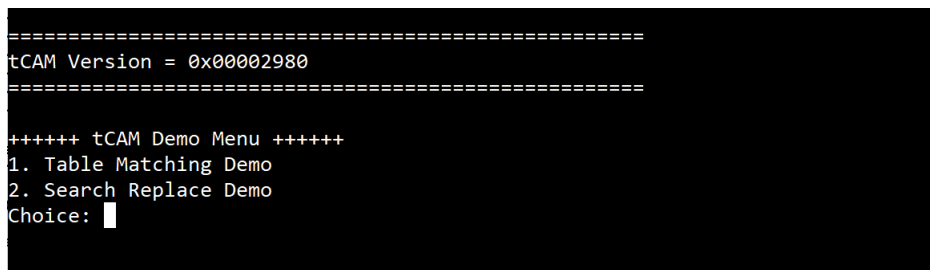


Figure 3 Serial Console

4 Table Matching Demo

This topic outlines the process of demonstrating the table matching functionality of the tCAM-IP. The demo showcases how the tCAM-IP matches input keys against predefined rules stored in its memory. The demonstration includes steps for initializing rules, performing key searches, and displaying the results.

```

+++++ Table Matching Demo +++++
1. Initial Rule Table
2. Display Rule Table
3. Key Search
4. Return to main menu
Choice: █
    
```

Figure 4 Table Matching Demo menu

4.1 File format for Rule data and Key data

User can prepare Rule data or Key data file for this demo. The file format is shown as Figure 5 and Figure 6 for rule width 32-bit and 64-bit respectively. The valid range of data is 0-256, where '256' is defined as a don't care value. To indicate the end of the data, the last rule must be followed by a blank line.

```

RuleTable4.txt
1 63 131 192 196
2 150 255 73 222
3 13 156 58 100
4 124 18 134 94
5 27 131 113 104
6 150 83 58 142
7 27 212 11 156
8 114 124 170 53
9 45 19 11 53
10 203 18 180 135
11 240 83 13 100
12 205 16 170 84
13 215 156 180 41
14 144 145 73 41
15 27 16 58 104
16 107 253 97 41
            
```

```

+++ Display Rule Table +++
Rule Width 4 byte
Rule Count 2048 rule
RULE  BYTE0  BYTE1  BYTE2  BYTE3
0001:  063   131   192   196
0002:  150   255   073   222
0003:  013   156   058   100
0004:  124   018   134   094
0005:  027   131   113   104
0006:  150   083   058   142
0007:  027   212   011   156
0008:  114   124   170   053
0009:  045   019   011   053
0010:  203   018   180   135
0011:  240   083   013   100
0012:  205   016   170   084
0013:  215   156   180   041
0014:  144   145   073   041
0015:  027   016   058   104
            
```

After "Initialize Rule Table" menu.

Figure 5 Example of 32-bit rule file

```

RuleTable.txt
1 20 244 146 217 142 6 36 135
2 67 189 146 162 193 118 30 59
3 67 256 246 256 193 256 30 135
4 28 129 146 217 142 49 36 164
5 67 129 246 162 193 49 36 135
6 67 189 146 217 193 49 36 135
7 28 129 246 49 224 118 30 59
8 28 189 89 217 224 49 30 59
9 67 244 146 217 193 49 30 59
10 20 189 146 217 224 49 118 135
11 67 129 246 217 224 118 118 135
12 20 244 89 162 142 6 118 135
13 67 189 89 217 224 49 30 164
14 67 189 246 162 142 6 30 59
15 67 189 146 162 193 118 118 135
16 20 189 246 49 193 49 36 164
            
```

```

+++ Display Rule Table +++
Rule Width 8 byte
Rule Count 64 rule
RULE  BYTE0  BYTE1  BYTE2  BYTE3  BYTE4  BYTE5  BYTE6  BYTE7
0001:  020   244   146   217   142   006   036   135
0002:  067   189   146   162   193   118   030   059
0003:  067   256   246   256   193   256   030   135
0004:  028   129   146   217   142   049   036   164
0005:  067   129   246   162   193   049   036   135
0006:  067   189   146   217   193   049   036   135
0007:  028   129   246   049   224   118   030   059
0008:  028   189   089   217   224   049   030   059
0009:  067   244   146   217   193   049   030   059
0010:  020   189   146   217   224   049   118   135
0011:  067   129   246   217   224   118   118   135
0012:  020   244   089   162   142   006   118   135
0013:  067   189   089   217   224   049   030   164
0014:  067   189   246   162   142   006   030   059
0015:  067   189   146   162   193   118   118   135
            
```

After "Initialize Rule Table" menu.

Figure 6 Example of 64-bit rule file

```

62 256 256 89 256 142 256 256 256
63 256 256 89 256 256 256 256 164
64 28 129 146 256 256 256 256 256 Last Rule
65 Blank Line
66 End of file
    
```

Figure 7 Example of including blank line to indicate the end of data

4.2 Initial Rule Table

This command is used to receive rules from the user and apply them to the initial rules of the tCAM-IP, as shown in Figure 8. Initially, the user must specify the size of the rule, ranging from 1 to 8. The system will then wait to receive data from the user. Once the data has been received complete, the rule size and the number of rules will be displayed. If the tCAM-IP can initialize the rule correctly, it will show the message: "Success: IP initialize completed." Users can send the rule data file via the serial console, as shown in Figure 9. In this demonstration, the maximum rule size is limited to 8 kB.

```
++++++ Table Matching Demo ++++++
1. Initial Rule Table
2. Display Rule Table
3. Key Search
4. Return to main menu
Choice: 1

+++ Initial Rule Table +++

Number of RuleWidth in byte : 8
Send Input rule file over serial console
....
Rule Byte 512 byte
Rule Width 8 byte
Rule Count 64 rule
Success: IP initialize completed.
```

Figure 8 Example of Initial rule file

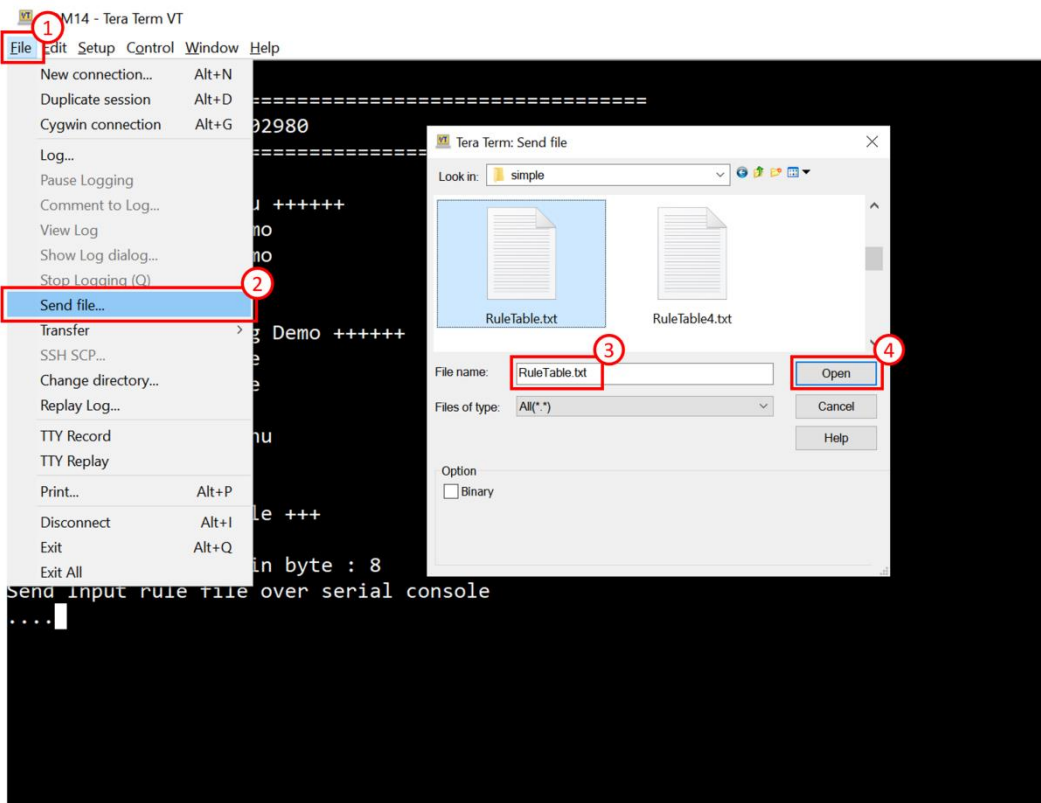


Figure 9 Example of transferring rule file

4.3 Display Rule Table

This command is used to displays the currently configured rules in the tCAM-IP. The displayed information will include details such as the rule index and the rule content. This functionality allows users to verify the correctness of the initialized rules and ensures that the tCAM-IP is set up as intended.

```

+++++ Table Matching Demo +++++
1. Initial Rule Table
2. Display Rule Table
3. Key Search
4. Return to main menu
Choice: 2

+++ Display Rule Table +++
Rule Width 8 byte
Rule Count 64 rule

RULE  BYTE0 BYTE1 BYTE2 BYTE3 BYTE4 BYTE5 BYTE6 BYTE7
0001:  020   244   146   217   142   006   036   135
0002:  067   189   146   162   193   118   030   059
0003:  067   256   246   256   193   256   030   135
0004:  028   129   146   217   142   049   036   164
0005:  067   129   246   162   193   049   036   135
0006:  067   189   146   217   193   049   036   135
0007:  028   129   246   049   224   118   030   059
0008:  028   189   089   217   224   049   030   059
0009:  067   244   146   217   193   049   030   059
0010:  020   189   146   217   224   049   118   135
0011:  067   129   246   217   224   118   118   135
0012:  020   244   089   162   142   006   118   135
0013:  067   189   089   217   224   049   030   164
0014:  067   189   246   162   142   006   030   059
0015:  067   189   146   162   193   118   118   135
0016:  020   189   246   049   193   049   036   164

```

Figure 10 Example console when displaying rule table

4.4 Key Search

This command is used to receive keys from the user and apply them to the tCAM-IP. It displays the incoming keys and the search results as rule numbers. Upon completion of the operation, the command will show the total number of searches conducted and the number of matches found, as show in Figure 11.

```

+++++ Table Matching Demo +++++
1. Initial Rule Table
2. Display Rule Table
3. Key Search
4. Return to main menu
Choice: 3

+++ Key Search +++

Send Input key file over serial console
...

KEY0 KEY1 KEY2 KEY3 KEY4 KEY5 KEY6 KEY7 MATCH
020  244  146  217  142  006  036  135  0001
028  129  146  217  142  049  036  164  0004
067  129  246  162  193  049  036  135  0005
028  129  146  162  193  118  118  164  0032
067  189  146  217  193  049  036  135  0006
028  129  246  049  224  118  030  059  0007
067  244  146  217  193  049  030  059  0009
020  189  246  049  193  049  036  164  0016
020  244  089  162  142  006  118  135  0012
067  189  089  217  224  049  030  164  0013
067  244  146  162  224  006  030  164  0033
067  189  246  162  142  006  030  059  0014
028  129  089  217  224  049  030  164  0029
067  189  146  162  193  118  118  135  0015
067  189  246  217  193  006  036  135  0019
020  244  246  217  193  049  036  059  0020

Key count : 16
Match count : 16

```

Figure 11 Example of Key Search

5 Search Replace Demo

This topic demonstrates the search and replace functionality using tCAM-IP. The demo allows users to input words, which are then compared against predefined rules with the help of tCAM-IP. If a match is found, the word is replaced according to the rule; otherwise, the original word is displayed.

```

+++++ Search Replace Demo +++++
1. Initial Word Rule
2. Display Word Rule
3. Search Replace
4. Return to main menu
Choice: █
    
```

Figure 12 Search Replace Demo menu

5.1 File format for word rule and word key

Users can prepare rule data in the specified file format shown in Figure 13. The valid range of data includes characters from 'A-Z', 'a-z', and '0-9'. To indicate the end of the data, the last rule must be followed by an empty line as shown in Figure 7.

RULE	Search	Replace
0001:	white	word001
0002:	White	word002
0003:	bhide	word003
0004:	worse	word004
0005:	horse	word005
0006:	Horse	word006
0007:	Worse	word007
0008:	noise	word008
0009:	three	word009
0010:	city	word010
0011:	duty	word011
0012:	City	word012
0013:	Duty	word013
0014:	busy	word014
0015:	easy	word015
0016:	Busy	word016

Figure 13 Example of word rule file

```

SampleTextA.txt
1 [Sample Text]
2 There was once a young Shepherd Boy who tended his sheep at the foot of a mountain near a dark forest. It was
rather lonely for him all day, so he thought upon a plan by which he could get a little company and some excitement.
3 He rushed down towards the village calling out Wolf, Wolf. And the villagers came out to meet him, and some of them
stopped with him for a consideration time. This pleased the boy so much that a few days afterwards he tried the
4 same trick, and again the villagers came to his help.
But shortly after this a wolf actually did come out from the forest and began to worry the sheep, and the boy of
5 course cried out wolf, wolf" still louder than before.
But the villagers, who had fooled twice before, thought the boy was again deceiving them, and nobody stirred to
6 come to his help. So the wolf made a good meal off the boy's flock.
7 Moral of the story
8
    
```

Figure 14 Example of word key file

5.2 Initial Word Rule

This command is used to receive rules from the user and apply them to the initial rules of the tCAM-IP, as shown in Figure 15. Initially, the user must specify the size of the rule, ranging from 1 to 8. The system will then wait to receive data from the user. Once the data has been received complete, the rule size and the number of rules will be displayed. If the tCAM-IP can initialize the rule correctly, it will show the message: "Success: IP initialize completed." Users can send the word rule file via the serial console, as show in Figure 9. In this demonstration, the maximum rule size is limited to 8 kB.

```

+++++ Search Replace Demo +++++
1. Initial word Rule
2. Display word Rule
3. Search Replace
4. Return to main menu
Choice: 1

+++ Initial word Rule +++

Number of RuleWidth in byte : 5
Send Input word file over serial console
...
Rule Byte 3580 byte
Rule Width 5 byte
Rule Count 716 rule
Success: IP initialize completed.

```

Figure 15 Example of Initial word rule file

5.3 Display Word Rule

This command retrieves and displays the currently configured word rules in the tCAM-IP. The displayed information will include details such as the rule index and the corresponding word content. This functionality allows users to verify the correctness of the initialized word rules and ensures that the tCAM-IP is set up as intended.

```

+++++ Search Replace Demo +++++
1. Initial Word Rule
2. Display Word Rule
3. Search Replace
4. Return to main menu
Choice: 2

+++ Display Word Rule +++
Rule Width 5 byte
Rule Count 716 rule

RULE Search Replace
0001: white word001
0002: White word002
0003: bhide word003
0004: worse word004
0005: horse word005
0006: Horse word006
0007: Worse word007
0008: noise word008
0009: three word009
0010: city word010
0011: duty word011
0012: City word012
0013: Duty word013
0014: busy word014
0015: easy word015
0016: Busy word016
0017: bury word017
0018: vary word018
0019: very word019
0020: Bury word020
0021: many word021
0022: tiny word022
0023: deny word023
0024: Deny word024
0025: Many word025
0026: lady word026

```

Figure 16 Example console when displaying word rule

5.4 Search Replace

This command is used to receive words from the user and apply them to the tCAM-IP. If the incoming word matches any of the predefined rules, it will be replaced according to the specified rules. Conversely, if the word does not match any rules, the original word will be displayed. Upon completion of the operation, the command will display the total number of searches and the number of words that were replaced, as show in Figure 17.

```
+++++ Search Replace Demo +++++
1. Initial Word Rule
2. Display Word Rule
3. Search Replace
4. Return to main menu
Choice: 3

+++ Search Replace +++

Send Input Search file over serial console
...
[Sample Text]
There was once a young Shepherd Boy who tended his sheep at the foot of a mountain near a forest. It was rather lonely
all day, thought upon a plan which could a little company and
excitement.
rushed down towards the village calling word317, word317. And the villagers meet word6
36, and of them stopped word282 word636 word579 a consideration word421. This pleased the boy word697 word305 word102 a
days afterwards tried the trick, and again the villagers his word142.
shortly after a word315 actually did word423 word544 from the forest and began worry the sheep, and th
e boy of course cried word544 word315, word315" still louder before.
word577 the villagers, who had fooled twice before, thought the boy was again deceiving them, and nobody stirred word699 word4
22 word699 his word142. word715 the word315 made a good meal off the boy's flock.
Moral of the story

Search 172 word
Replace 48 word
```

Figure 17 Example of Search Replace

6 Revision History

Revision	Date (D-M-Y)	Description
2.01	14-Oct-24	Update table of contents.
2.00	2-Oct-24	Improve reference design to be standalone version.
1.00	30-Jun-21	Initial version release.