MATLAB SIGNAL STATISTIC CAPABILITIES
AND MOTOROLA TPU HARDWARE TESTS

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Abstract

A Matlab application is used to analyze logic signals. The application is primarily designed to speed up and simplify the testing of functions on the Motorola Time Processor Unit (TPU).

The Motorola Time Processor Unit (TPU) is a semi-autonomous intelligent microcontroller designed for timing control. Operating simultaneously with the CPU, the TPU module performs timing functions on as many as 16 pins. Each pin can be set as an input or output, and the associated timing function processes the incoming logic signal or generates an output logic signals. Figure 1 shows an example of application that uses the TPU.
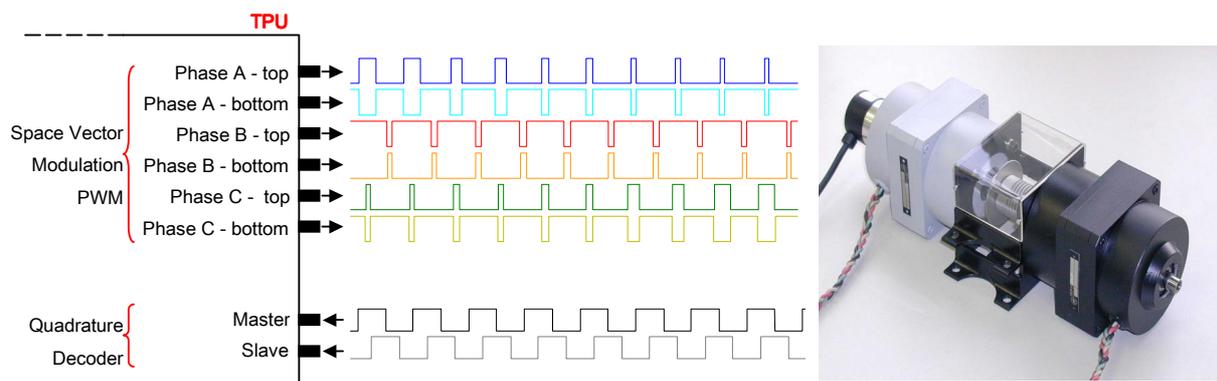

Figure 1. Example of application with TPU: TPU generates 6-channel 3-phase PWM signals to drive an AC-motor and simultaneously the TPU process a pair of out-of-phase quadrature encoder signals to measure the rotor position and velocity.

The TPU is used in real-time applications. The development of TPU functions poses a work on the edge between software and hardware. The testing of a developed TPU function can be a very complicated task. The debugging is often hard to achieve or even impossible. The function can be verified on the simulator, but only in some measure. Some trickiness doesn't appear until the hardware is run, and sometimes even after a long time of run.

The TPU output and input signals can be recorded using a logic analyzer. The logic analyzer can even wait till some special state of TPU signals arise and then it can record the surroundings of this state. Using Matlab to analyze the recorded signals is an advantage. The Matlab has very good abilities to
- visualize signals
- perform statistical processing of signals
- load the signal data very fast
- and is an open tool, that enables the user to perform any other special operations from Matlab command-window if needed.

The TPU Hardware Test Analysis is a Matlab application that was created to speed up the hardware-test process – see Figure 2. It is operated through a graphical user interface and is open to perform any other special operations from Matlab command-window if needed.
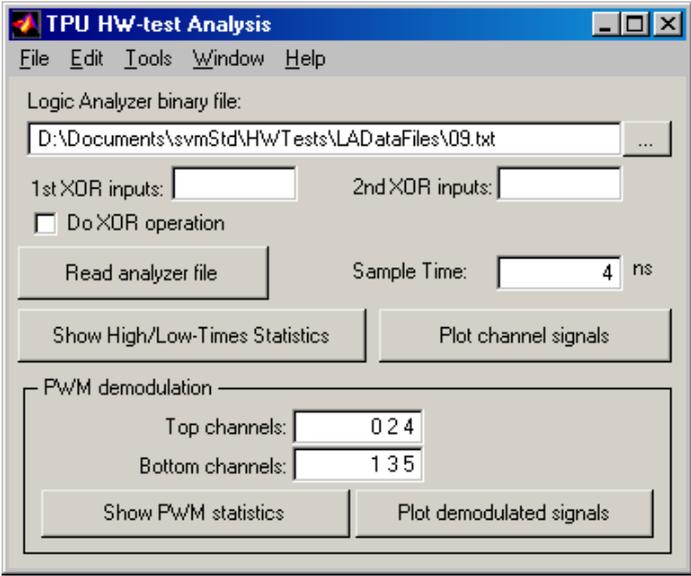
Figure 2. TPU Hardware Test Analysis application main window.

The input is a text file of ones and zeros generated by the logic analyzer. Matlab can very quickly read it as a matrix of samples. The number of columns is equal to the number of signals and the number of rows grows with the length of signals. The user has to enter the logical analyzer sample time.
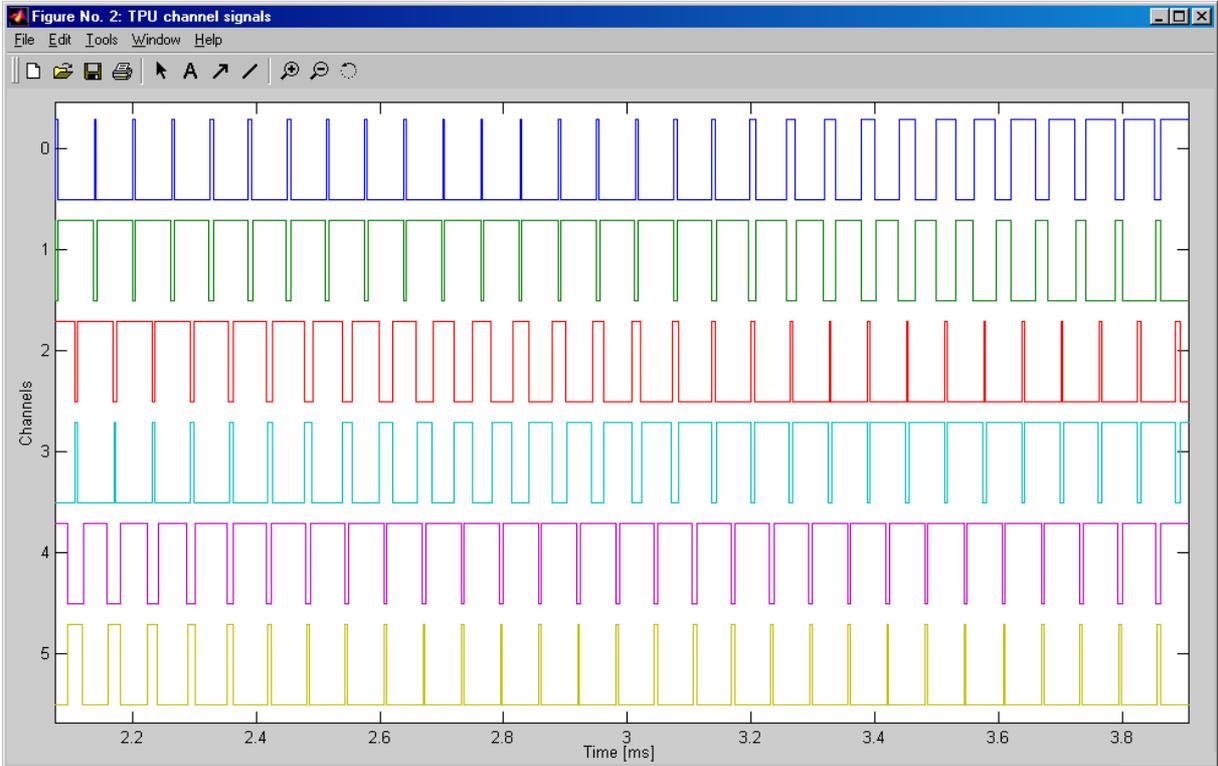

Figure 3. TPU signals.

The TPU signals can be viewed, and using the zoom tools inspected in detail – Figure 3.
The basic parameters of TPU signals are the high-times and low-times. The statistics of them are calculated in the High-Times/Low-Times Statistics window – Figure 4.

Channel	High Times [µs] < 100 µs				Low Times [µs] < 100 µs			
	min	avg	max	std	min	avg	max	std
0	54.95	54.95	54.96	0.00278	7.54	7.55	7.55	0.00191
1	5.85	5.86	5.86	0.00231	56.64	56.64	56.64	0.00196
2	22.77	22.77	22.78	0.00259	39.72	39.72	39.73	0.00199
3	37.90	37.90	37.91	0.00161	24.59	24.59	24.60	0.00204
4	5.70	5.70	5.70	0.00191	56.80	56.80	56.80	5.89e-014
5	54.99	54.99	54.99	0.00199	7.51	7.51	7.51	0.00182
6	10.15	10.16	10.16	0.00123	52.39	52.39	52.40	0.00229

Figure 4. High-Times/Low-Times Statistics.

The TPU functions often generate signals that are to be connected to XOR gate inputs and even the XOR gate output is the desired signal. In this case the parameters of the XOR gate output are to be analyzed, though the recorded signals are the TPU outputs. The TPU Hardware Analysis application enables to specify the XOR gate input pairs and performs the XOR operation before other processing.
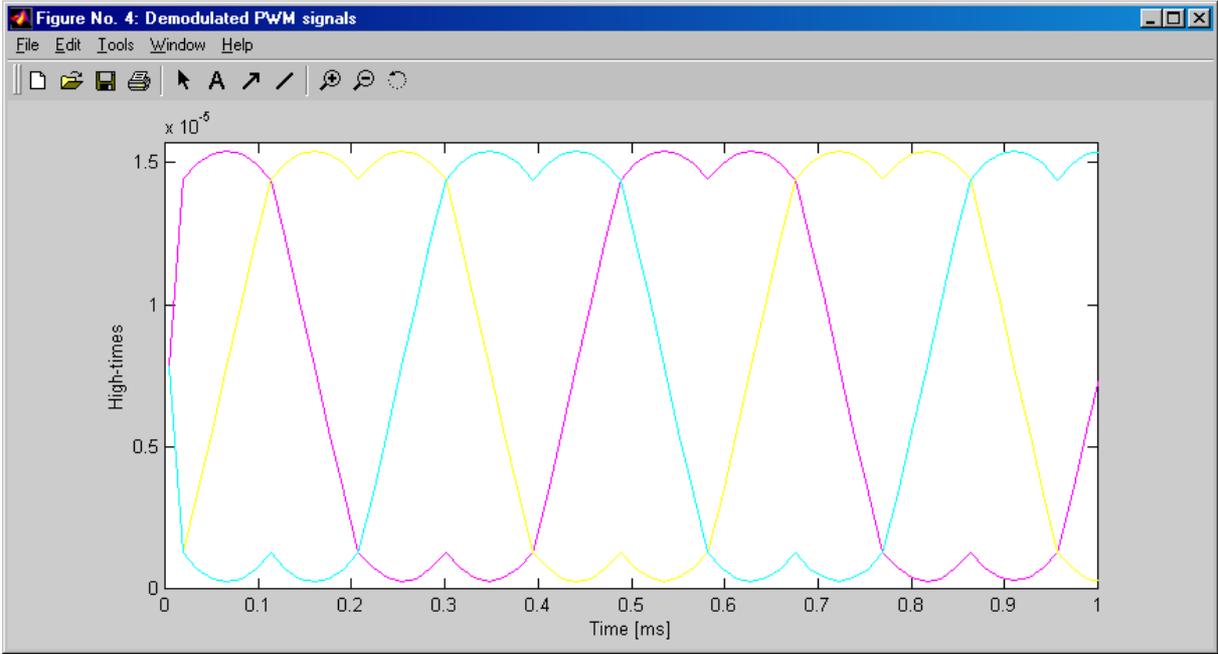

Figure 5. Demodulated PWM signals.

Many TPU functions generate pulse-width modulation (PWM) signals for a certain purpose. In his case the important signals parameters can be measured even after the demodulation of PWM signals. The application enables to demodulate selected TPU signals, calculate the demodulated signals statistics, and view the demodulated signals – Figure 5. If the user specifies the pairs of top and bottom PWM signal, the application calculates also the dead-time statistics – Figure 6. This is important to ensure that the dead-times are kept all the time.
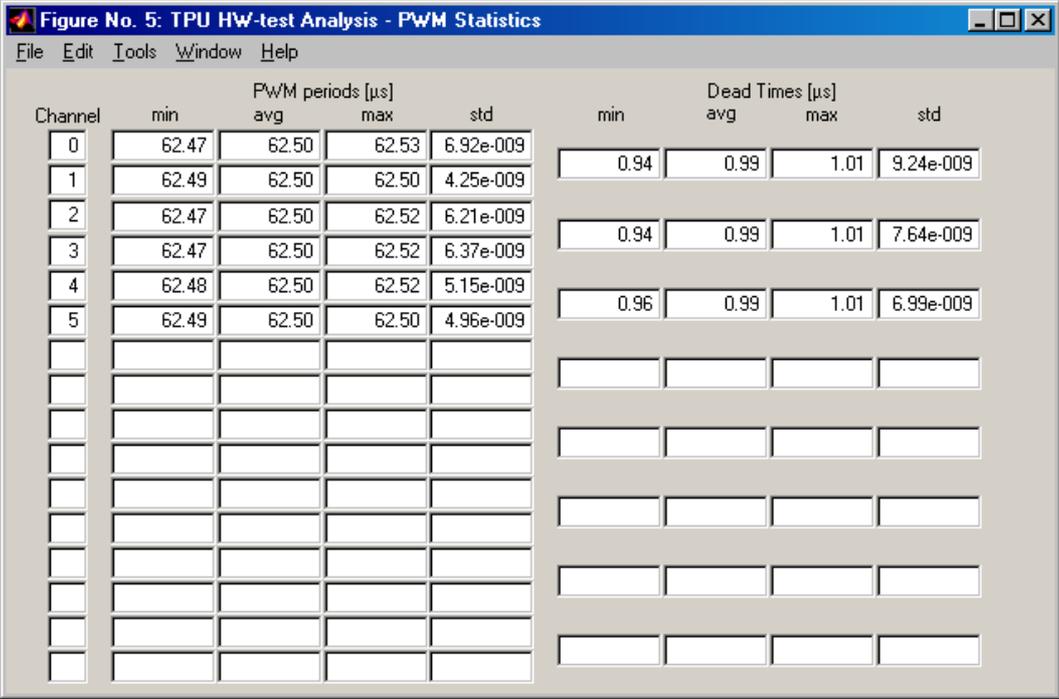
Figure 6. PWM Statistics.

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