

# Using the High Voltage Physical Layer

## In the S12ZVM family

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## 1. Introduction

This application note provides an introduction to the High Voltage (HV) physical layer of the S12ZVM32 and S12ZVM16 MCUs. The HV layer is a physical interface that provides single-wire communication. This application note illustrates how to use the HV physical layer for PWM communication. For more information refer to the HV Physical Layer chapter of the S12ZVM reference manual at [freescale.com](http://freescale.com).

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## 2. The HV Physical Layer

The HV transmitter is a low-side MOSFET with current limitation and overcurrent transmitter shutdown. A selectable internal pull-up resistor with a serial diode structure is integrated, so no external pull-up components are required for the application in a slave node. The HV physical layer routes the receiver's pin to the channel 3 of the timer 0 in order to capture the rising and falling edges of the PWM signal.

The following is a summary of the most notable HV physical layer features:

- Compliant with the ISO9141 (K-line) standard.
- Standby mode with glitch-filtered wake-up.
- Slew rate selection optimized for: 5.2 kHz, 10 kHz and Fast Mode (up to 125 kHz).
- Switchable 34 k Ohms /330 k Ohms pull-up resistors
- Overcurrent protection.

The following figure illustrates how the HVPHY is internally connected in the S12ZVM32 and S12ZVM16 devices. The HVPHY connects to a TIM IC to capture the PWM. At the same time it can be controlled by software to pull the bus to ground and communicate to the master that there has been an error in the transmission.

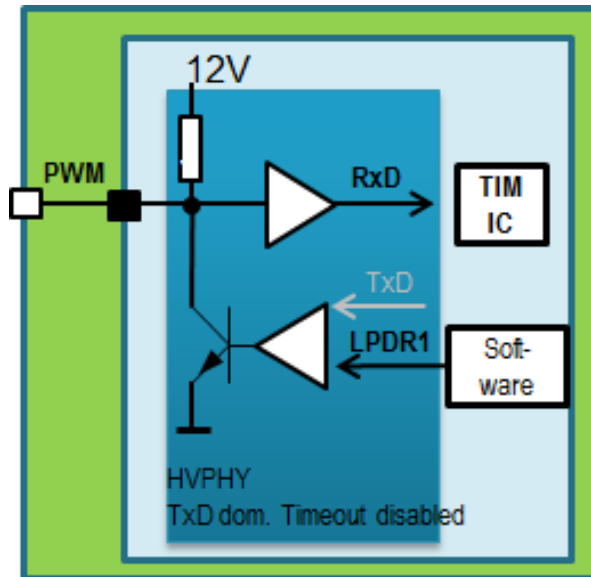


Figure 1. HVPHY hardware diagram

### 3. PWM Communication

The PWM or Pulse Width Modulation consist in changing the ON and OFF time of a signal in order to allow the control of the power supplied to electrical devices. Although this technique is mainly used for power control and can also be used to transmit certain information.

The message is transmitted using the duty cycle of the signal. Depending on the application the duty cycle read by the receiver could mean different commands, also the bus could be pulled down to ground by the slave in order to indicates that an error has occurred. In the example provided by this application note the S12ZVM microcontroller receives a PWM signal from master device and use its duty cycle to set the speed of a BLDC motor.

The HV physical layer is routed to the input capture channel 3 of timer TIM0. The timer counter is used to measure the elapsed time of the signal in ON and OFF states. The duty cycle can be obtained by comparing the duration of the ON state to the total period of the signal.

The following image illustrates how the communication is established.

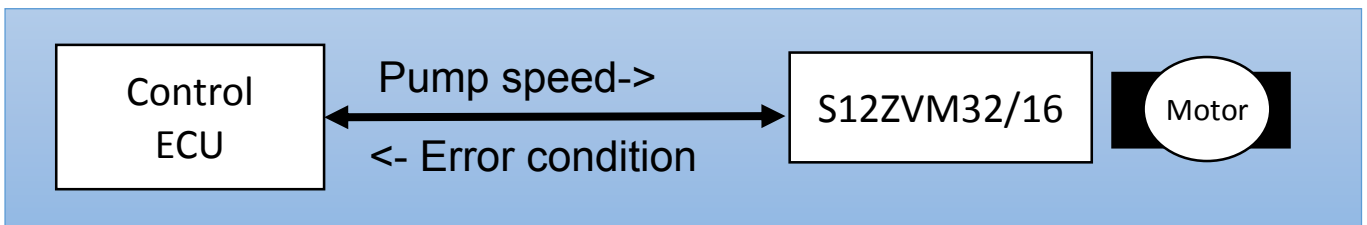


Figure 2. HVPHY communication diagram

**NOTE**

In the example provided by this application no error condition has been established.

#### 3.1. Initialization

To use the HV physical layer follow the steps shown below:

- Disable dominant timeout feature (LPDTPDIS=1) in the LPSLRM register, if needed
- Enable pull-up resistor in LPCR register (LPPUE=1)
- Route LPRXD0 to internal timer with T0IC3RR[1:0] = 01 to route the LPRXD0 to TIM0 IC channel 3.
- LPRXD0 must be linked to the SCI0 RXD (S0L0RR1=1)
- Enable HV physical layer in the LPCR register (LPE=1)

## 4. Application Example

In the example attached to this application note the S12ZVM32EVB is driving a Brushless DC Motor (BLDC) and using the HV physical layer reads a PWM signal of 200 Hz and set the motor's speed proportionally to the duty cycle of the PWM signal. No error signal has been implemented in this example.

A FreeMaster project was created in order to read out the RPM settings calculated from the PWM input duty cycle. In this example the motor speed is limited by software to a minimum of 1390 RPM and a maximum of 8000 RPM. A 16-bit value variable named *requiredSpeed* is used to set the motor speed and then transformed to RPM in the FreeMaster for better interpretation. The 1390 RPM value is equivalent to a 1990 value in the *requiredSpeed* variable. The 8000 RPM value is equivalent to an 11450 value in the *requiredSpeed* variable. The equation used in order to set the motor's speed according to the PWM duty cycle was the following one:

$$requiredSpeed = \frac{11450 - 1990}{100} DutyCycle + 1990$$

Where the *DutyCycle* represents the duty cycle captured by the timer routed to HVPHY. Its value goes from 0 to 100.

The formula used to approximate the RPM using the *requiredSpeed* variable is:

$$RPM = \frac{12500}{17895} requiredSpeed$$

This formula is an approximation and may present some variation of +/- 10 RPM on the FreeMaster scope.

The 200 Hz PWM signal was generated by a waveform generator and the receiver was an S12ZVM32EVB. The results of the example attached to this application note are showed in the next figures:

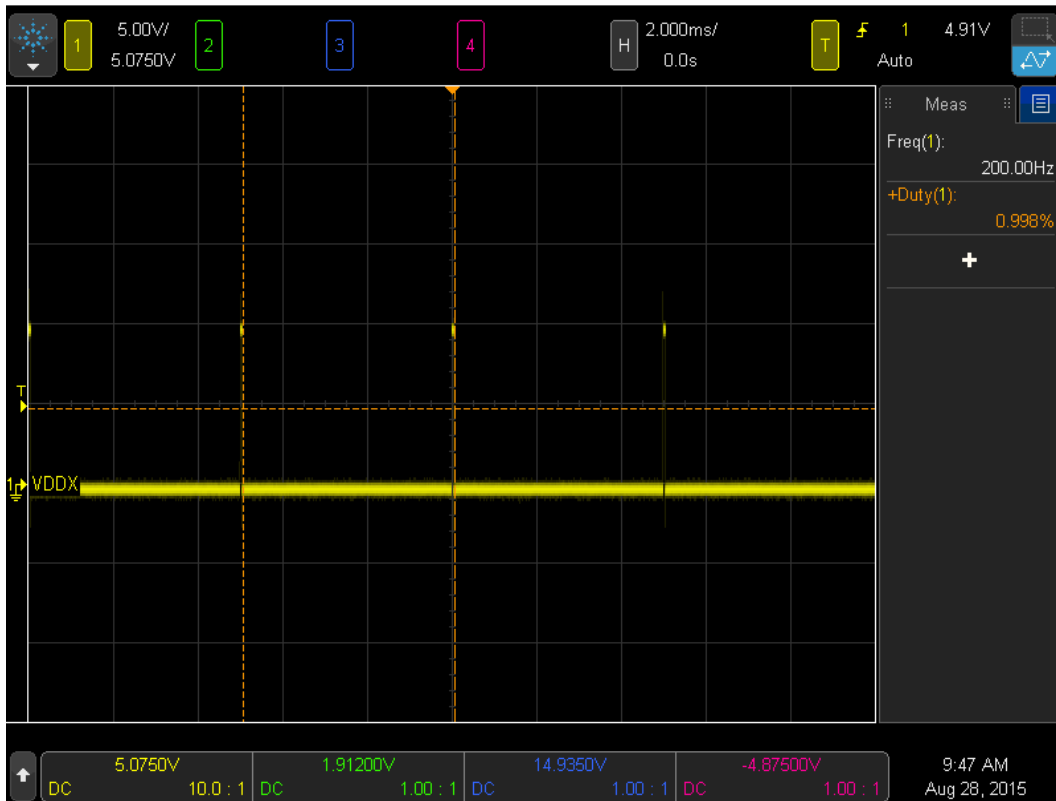


Figure 3. Oscilloscope 1% duty cycle signal

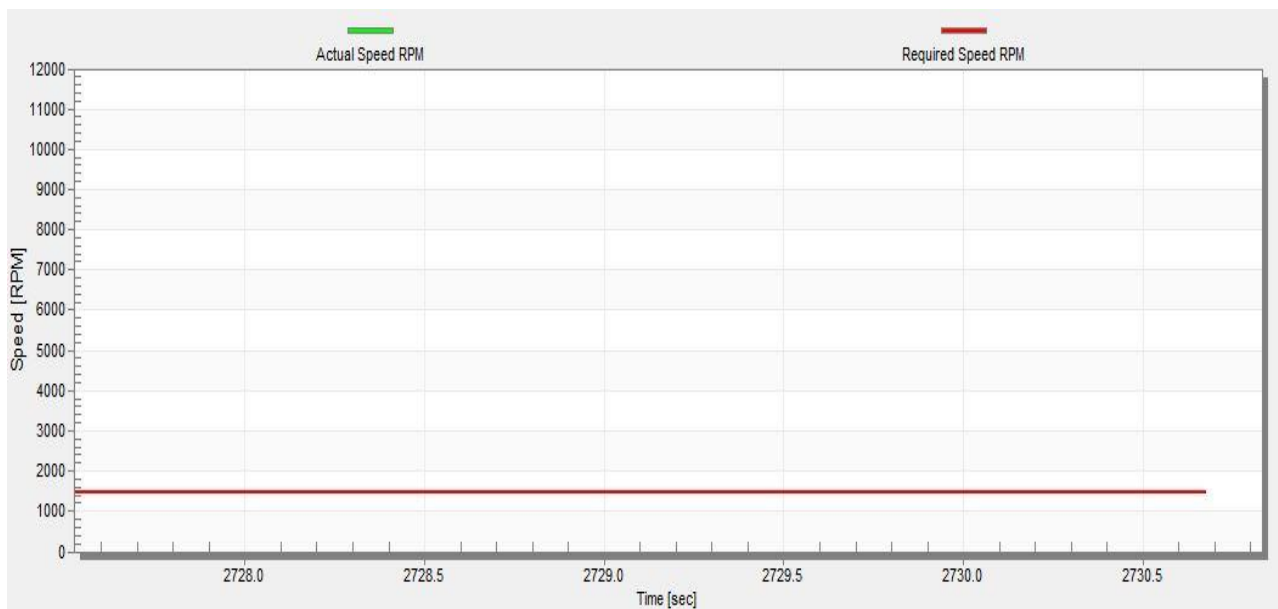


Figure 4. FreeMASTER Speed Scope at 1% duty cycle

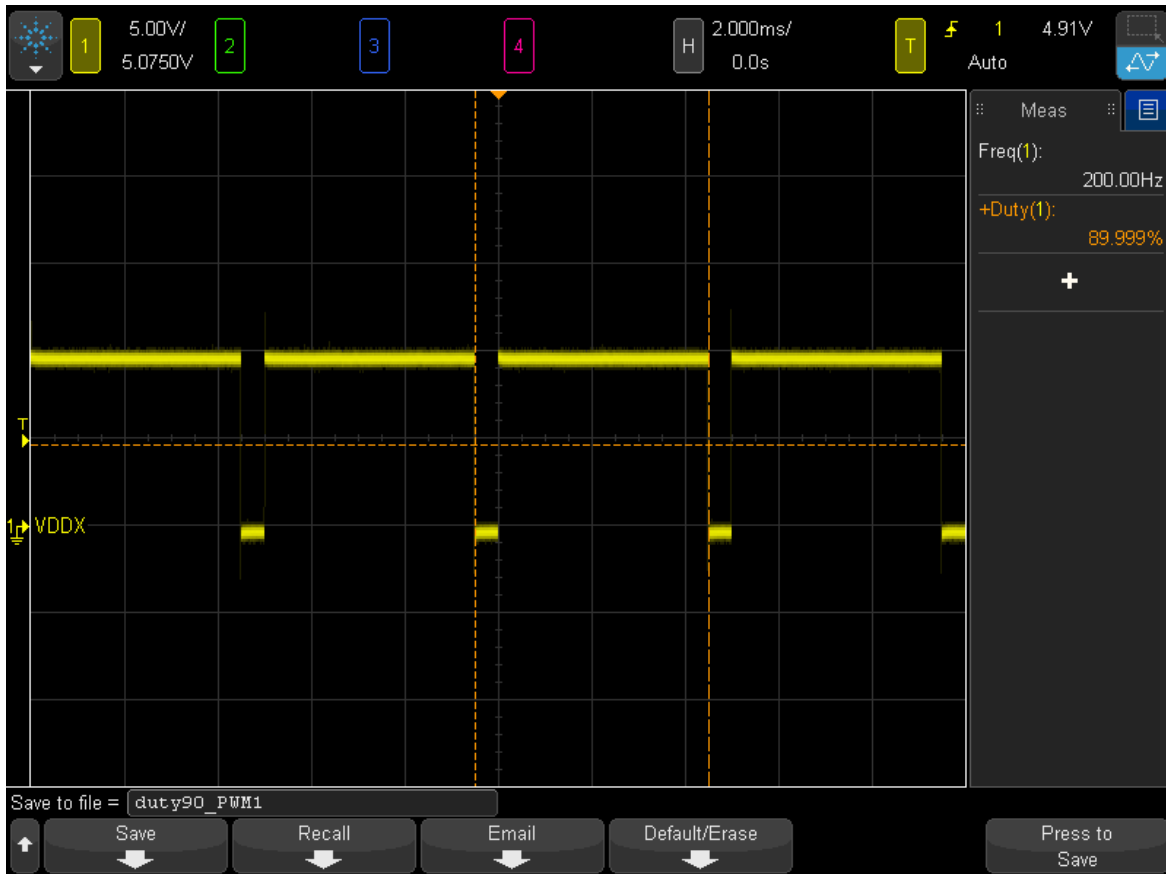


Figure 5. Oscilloscope 90 % duty cycle signal

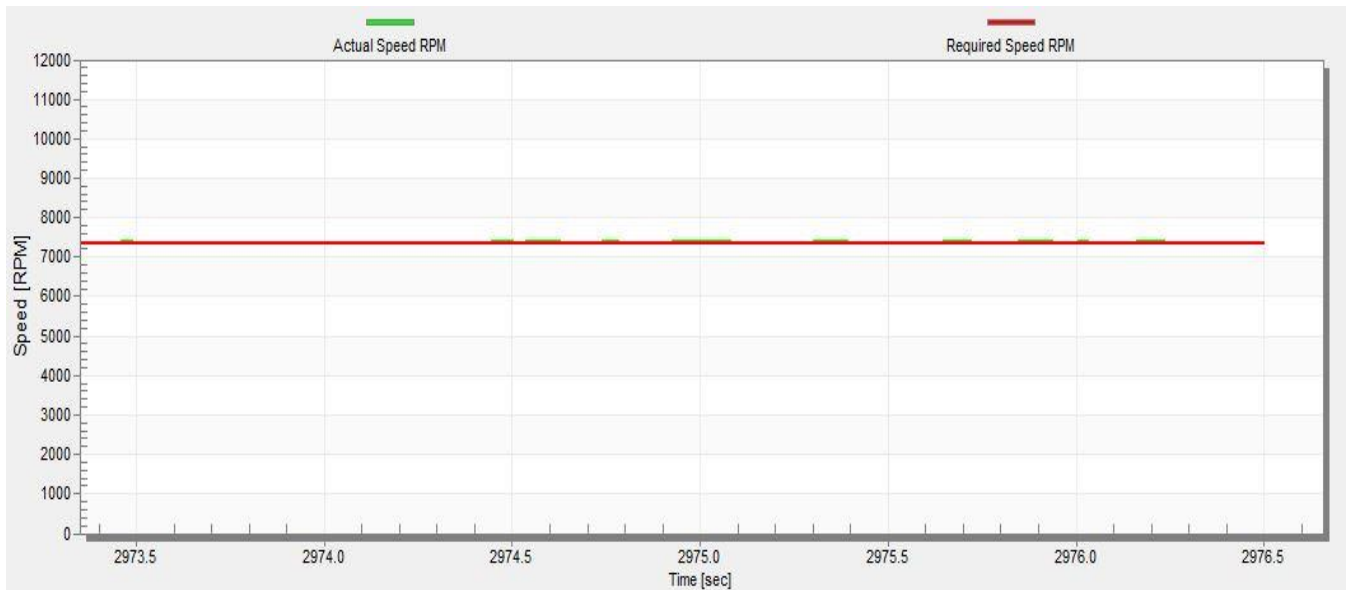


Figure 6. FreeMASTER Speed Scope at 90% duty cycle

## 5. Attachments

This application note includes the software that carries out the initialization described in initialization. It includes two examples, one with the configuration and obtaining of the duty cycle of the received signal, and the other one with a BLDC motor controlled by a PWM input signal.

- S12ZVM32\_PWM\_Speed (No control)
- S12ZVML31\_PWM\_BLDC\_Sensorless (Speed Control)

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