### 72.7.1.10 Transmitter output waveform

The 10GBASE-KR transmitter includes programmable equalization to compensate for frequency-dependent loss in the backplane channel and facilitate data recovery at the receiver. This equalization may be accomplished with a three-tap finite impulse response (FIR) structure as shown in Figure 72–11. The actual implementation of the transmit equalizer, including the incorporation of additional taps, is beyond the scope of this standard.

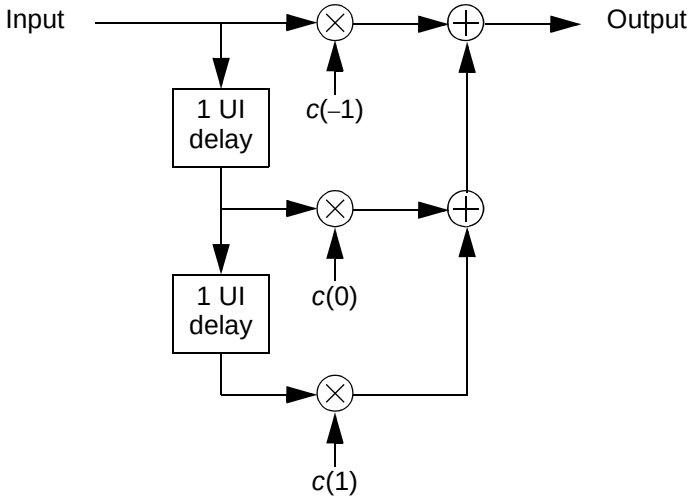


**Figure 72–11—Transmit equalizer example**

Transmit equalizer performance is specified in terms of ~~$V_{pre}$, $V_{pst}$, $V_{ss}$, $R_{pre}$, and $R_{pst}$, as~~ the voltages defined in 72.7.1.11. It should be noted that the valid ranges of the $c(1)$ and $c(-1)$ coefficients may ~~have~~ include positive ~~or~~ and negative values. A value of zero is used to turn off equalization for the tap.

The state of the transmitter equalizer and hence the transmitter output waveform is manipulated via the protocol defined in 72.6.10 or via management. The changes in the transmitter output waveform resulting from coefficient update requests shall meet the requirements stated in Table 72–7. The coefficient update requests

in Table 72–7 are to be followed by a coefficient update equal to hold for all taps. The results are to be verified after the coefficient status for all taps is reported as not_updated.

**Table 72–7—Transmitter output waveform requirements related to coefficient update**

| Coefficient update | | | Requirements | | |
|---|---|---|---|---|---|
| ***c*(1)** | ***c*(0)** | ***c*(–1)** | ~~$V_{pre}$~~ $v_1(k) - $ ~~$V_{pre}$~~ $v_1(k–1)$ (mV) | ~~$V_{pst}$~~ $v_2(k) - $ ~~$V_{pst}$~~ $v_2(k–1)$ (mV) | ~~$V_{ss}$~~ $v_3(k) - $ ~~$V_{ss}$~~ $v_3(k–1)$ (mV) |
| increment | hold[1] | hold | –20 to –5 | ~~–20~~ 5 to ~~–5~~20[2] | 5 to 20 |
| decrement | hold | hold | 5 to 20 | ~~5 to 20~~ –20 to –5 | –20 to –5 |
| hold | increment | hold | ~~–20~~ 5 to ~~–5~~20 | 5 to 20 | 5 to 20 |
| hold | decrement | hold | ~~5 to 20~~ –20 to –5 | –20 to –5 | –20 to –5 |
| hold | hold | increment | 5 to 20 | 5 to 20 | ~~5 to 20~~ –20 to –5 |
| hold | hold | decrement | –20 to –5 | –20 to –5 | ~~–20~~ 5 to ~~–5~~20 |

[1]Step size requirements for the tap under test apply regardless of the current value of the other taps.
[2]This difference is measured relative to the ~~value of the coefficient~~ voltage prior to the assertion coefficient update *k* equal to hold.

When sufficient increment or decrement updates have been applied to a given tap, it will reach a maximum or minimum limit governed by the coefficient range or by restrictions placed on minimum ~~$V_{ss}$~~ steady state or maximum ~~$V_{pk}$~~ peak voltage and the coefficient status is reported accordingly. The transmitter output waveform shall meet the requirements of Table 72–8 for all of the limiting cases represented in the table. Implementation of *c*(–1) or *c*(1) coefficient values greater than zero or less than the minimum defined by $R_{pre}$ (min) and $R_{pst}$ (min) is optional.

**Table 72–8—[1]Transmitter output waveform requirements related to coefficient status**

| Coefficient status | | | Requirements | | |
|---|---|---|---|---|---|
| ***c*(1)** | ***c*(0)** | ***c*(–1)** | $R_{pre}$ | $R_{pst}$ | ~~$V_{ss}$~~ $v_2$ (mV) |
| disabled | minimum | disabled | 0.90 to 1.10 | 0.90 to 1.10 | 220 to 330 |
| disabled | maximum | disabled | 0.95 to 1.05 | 0.95 to 1.05 | 400 to 600 |
| minimum | minimum | disabled | – | 4.00 (min) | – |
| disabled | minimum | minimum | 1.54 (min) | – | – |

[1]A coefficient may be disabled by first asserting the preset control defined in Table 45-56 and 45.2.1.78, then manipulating the other coefficients as required by the test.

In addition, for all transmit equalizer configurations:

a) The quantitizes $\Delta v_2$ and $\Delta v_5$ shall not exceed 40 $mV_{pk\text{-}pk}$.

b) The positive and negative voltages shall match such that each of the quantities $(v_1+v_4)/v_1$, $(v_2+v_5)/v_2$, and $(v_3+v_6)/v_3$ does not exceed 0.05.

c) ~~For all transmit equalizer configurations, $V_{ss}$~~ The quantity $v_2$ shall be greater than or equal to 40 mV.

d) Any coefficient update equal to decrement applied to any tap that would result in ~~Vss~~ $v_2$ less than ~~40~~ 40 mV shall return a coefficient status value minimum.

e) Any coefficient update equal to decrement ~~applied to c(−1) or c(1)~~ that would result in a violation of 72.7.1.4 shall return a coefficient status value ~~maximum~~minimum for that coefficient.

f) Any coefficient update equal to increment ~~applied to c(0)~~ that would result in ~~$V_{pk}$ greater than 600 mV~~ a violation of 72.7.1.4 shall return a coefficient status value ~~maximum~~maximum for that coefficient.

### 72.7.1.11 Transmitter output waveform measurement requirements

The transmitter output waveform shall be verified with the square wave test pattern defined in 49.2.8 with *n* greater than or equal to 8.

~~The transmitter output waveform test is based on eight voltages, $V_{rpre}$, $V_{rpst}$, $V_{rss}$, $V_{rripple}$ $V_{fpre}$, $V_{fpst}$, $V_{fss}$, and $V_{fripple}$ which shall be measured as shown in Figure 72–12 and described below. The absolute value of $V_{rpre}$ and $V_{fpre}$ must be within 5%. The absolute value of $V_{rpst}$ and $V_{fpst}$ must be within 5% and the absolute value of $V_{rss}$ and $V_{fss}$ must be within 5%. The maximum value of $V_{rripple}$ and $V_{fripple}$ shall be +/-20mv.~~

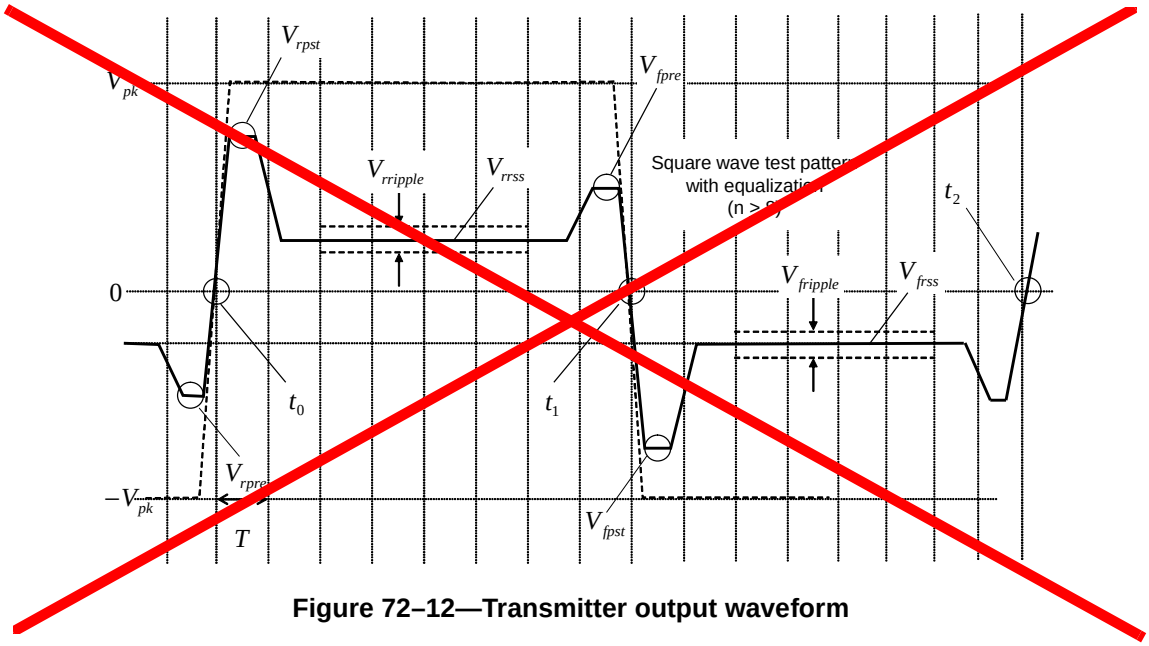


**Figure 72–12—Transmitter output waveform**

The transmitter output waveform test is based on the voltages $v_1$ through $v_6$, $\Delta v_2$, and $\Delta v_5$ which shall be measured as shown in Figure 72–13 and described below.

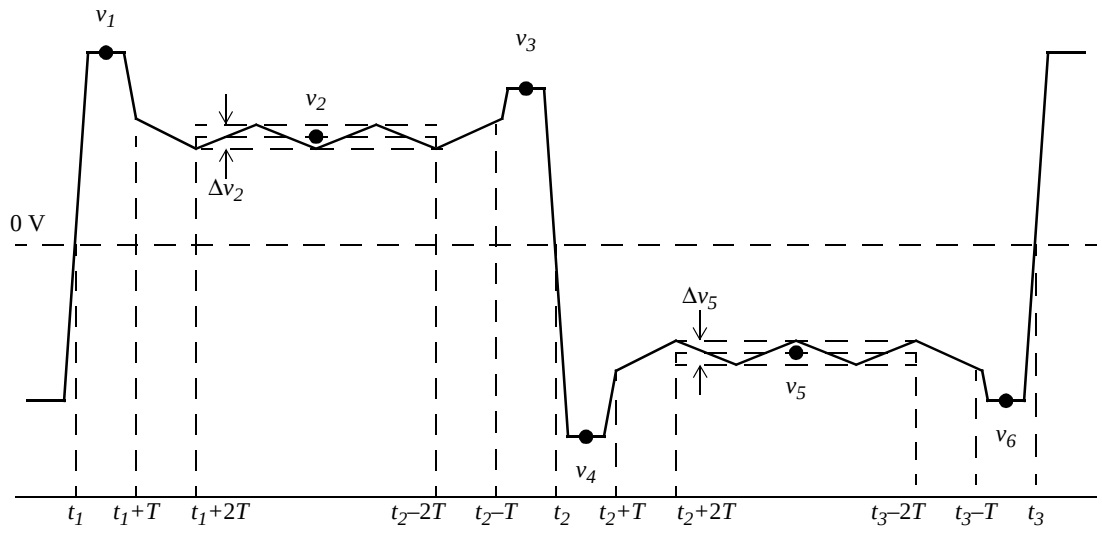


**Figure 72–13—Transmitter output waveform**

~~$V_{pk}$ = peak differential transmit output amplitude~~
$T$ = symbol period
~~$t_0$~~ $t_1$ = zero-crossing point of the first rising edge of the AC-coupled signal
~~$t_1$~~ $t_2$ = zero-crossing point of the falling edge of the AC-coupled signal
~~$t_2$~~ $t_3$ = zero-crossing point of the second rising edge of the AC-coupled signal
~~$V_{rpre}$~~ $v_1$ = ~~minimum~~ maximum voltage measured in the interval ~~$t_0$~~ $t_1$ to $t_1+T$
$v_2$ = positive steady-state voltage measured as the average voltage in the interval $t_1+2T$ to $t_2$ ~~$T$ to $t_0$~~ $2T$
~~$V_{rpst}$~~ $v_3$ = maximum voltage measured in the interval ~~$t_0$~~ $t_2$ ~~$T$~~ to ~~$t_0$~~ ~~$+ T$~~ $t_2$
~~$V_{rripple}$~~ $v_4$ = ~~maximum ripple~~ minimum voltage measured in the interval ~~$t_0$~~ $t_2$ to $t_2$ ~~$+ 2T$ to $t_1$ $- 2T$~~ $T$
~~$V_{rss}$~~ $v_5$ = negative steady-state voltage measured as the average voltage in the interval ~~$t_0$~~ ~~$+ 2T$~~ $t_2+2T$ to ~~$t_1$~~ $t_3$ ~~$-$~~ $2T$
~~$V_{fpre}$~~ $v_6$ = minimum voltage measured in the interval ~~$t_1$~~ $t_3$ ~~$-$~~ $T$ to ~~$t_1$~~ $t_3$
~~$V_{fpst}$~~ $\Delta v_2$ = ~~maximum~~ positive voltage ripple measured ~~in~~ as the peak-to-peak value of the ~~interval $t_1$ to $t_1$ $+ T$~~ difference
~~$V_{fripple}$~~ = ~~maximum ripple~~ between the voltage in the ~~interval~~ range $t_1$ ~~+~~ $2T$ to $t_2$ ~~$- 2T$~~ $2T$ and $v_2$
~~$V_{fss}$~~ $\Delta v_5$ = ~~steady-state~~ negative voltage ripple measured as the ~~average voltage in~~ peak-to-peak value of the ~~interval $t_1$ $+ 2T$~~ difference between the voltage in the range $t_2+2T$ to ~~$t_2$~~ $t_3$ ~~$- 2T$~~ $2T$ and $v_5$

From these voltages, the pre- and post-cursor equalization ratios $R_{pre}$ and $R_{pst}$ are ~~derived~~derived Equations (72–10) and (72–11).

$$R_{pre} = -\frac{V_{rpre}}{V_{rss}} \quad (72–8)$$

$$R_{pst} = \frac{V_{rpst}}{V_{rss}} \quad (72–9)$$

$$R_{pre} = \frac{v_3}{v_2} \quad (72–10)$$

$$R_{pst} = \frac{v_1}{v_2} \quad (72–11)$$

### 72.7.2 Receiver characteristics

The 10GBASE-KR receiver characteristics are summarized in Table 72–9 and detailed in the following sub-clauses.

**Table 72–9—Receiver characteristics for 10GBASE-KR**

| Parameter | Subclause reference | Value | Units |
|---|---|---|---|
| Bit error ratio | 72.7.2.1 | $10^{-12}$ | |
| Signaling speed | 72.7.2.2 | 10.3125 ± 100 ppm | GBd |
| Receiver coupling | 72.7.2.3 | AC | |
| Differential input peak-to-peak amplitude (maximum) | 72.7.2.4 | 1200[1] | mV |
| Differential input return loss (minimum)[2] | 72.7.2.5 | [See Equation (72–4) and Equation (72–5)] | dB |

[1]The receiver shall tolerate amplitudes up to 1600 mV without permanent damage
[2]Relative to 100 Ω differential.