Using the TLK2711-SP With Minimal Protocol

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ABSTRACT

The TLK2711-SP can be implemented using a minimal protocol with various levels of additional complexity for added features. This can run the range of streaming raw data with occasional comma character for transmission to packetizing data with checksum transmission and link level commands.

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1 Introduction

The TLK2711-SP is a 1.6-Gbps to 2.5-Gbps Class V SERDES transceiver capable of approximately 1.28-Gbps to 2-Gbps of data payload. It has a 16-bit parallel interface with built in 8B/10B encoding.

In order to successfully implement a TLK2711 transceiver, one must have a working knowledge of 8B/10B encoding.

2 8B/10B Primer:

8B/10B is an encoding scheme that takes an 8-bit word, and converts it to a 10-bit value for transmission. The encoding scheme was developed by IBM, and has several advantages over transmitting raw data without encoding.

1. DC balance. The running disparity will always be bounded between +2 and -2. The running disparity is defined as the difference in the number of 1 s and 0 s transmitted.

2. Maximum run length is bounded. The encoding scheme ensures that no more than 5 consecutive 1 s or 0 s will occur. This insures that a minimum transition density exists for proper clock recovery.

3. Defined control codes, and specifically the "comma" character to align 8-bit boundary at receiver. The comma character is contained in a K28.5, that gets decoded to a (0011111)010 or 1100000101. The () indicates the comma value that the TLK2711 needs for alignment.

8B/10B uses tables to encode the transmitted word, and to decode it at the receiver. It actually uses two sets of codes. 8B/10B is defined by a 5B/6B and a 3B/4B code. The common convention used to describe the 8B/10B values is to utilize upper case for 8B, and lower case for the 10B. For example an 8-bit word is defined as ABCDEFGH with A being the least significant bit. This gets broken down as EDCBA HGF. This is commonly referred to as Dx.y. Where X is 0-31, and Y is 0-7 and represents the 5b and 3b bit values. An 8-bit value of 0xBC breaks down as 101 11100 and is D28.5. Encoding tables for 5B/6B and 3B/4B shown below.

A full table of all 8B/10B values is published within the IEEE 802.3.2000 specification. Within the tables, many of the 5B, and 3B codes have multiple encodings. The appropriate coding is selected based on the current running disparity.

Table 1. 5B/6B Table Lookup

INPUT		RD = -1	RD = +1		INPUT		RD = -1	RD = +1
	EDCBA	abcdei				EDCBA	abcdei	
D.00	00000	100111	011000		D.16	10000	011011	100100
D.01	00001	011101	100010		D.17	10001	100011	
D.02	00010	101101	010010		D.18	10010	010011	
D.03	00011	110001			D.19	10011	110010	
D.04	00100	110101	001010		D.20	10100	001011	
D.05	00101	101001			D.21	10101	101010	
D.06	00110	011001			D.22	10110	011010	
D.07	00111	111000	000111		D.23	10111	111010	000101
D.08	01000	111001	000110		D.24	11000	110011	001100
D.09	01001	100101			D.25	11001	100110	
D.10	01010	010101			D.26	11010	010110	
D.11	01011	110100			D.27	11011	110110	001001
D.12	01100	001101			D.28	11100	001110	
D.13	01101	101100			D.29	11101	101110	010001
D.14	01110	011100			D.30	11110	011110	100001
D.15	01111	010111	101000		D.31	11111	101011	010100

Table 2. 3B/4B Table Lookup

INPUT		RD = -1	RD = +1
	HGF	fghj	
D.x.0	000	1011	0100
D.x.1	001	1001	
D.x.2	010	0101	
D.x.3	011	1100	0011
D.x.4	100	1101	0010
D.x.5	101	1010	
D.x.6	110	0110	
D.x.P7	111	1110	0001
D.x.A7	111	0111	1000

Table 3. Control Code Lookup

| INPUT		RD = -1	RD = +1
	HGF EDCBA	abcdei fghj	abcdei fghj
K.28.0	000 11100	001111 0100	110000 1011
K.28.1	001 11100	001111 1001	110000 0110
K.28.2	010 11100	001111 0101	110000 1010
K.28.3	011 11100	001111 0011	110000 1100
K.28.4	100 11100	001111 0010	110000 1101
K.28.5	101 11100	001111 1010	110000 0101
K.28.6	110 11100	001111 0110	110000 1001
K.28.7	111 11100	001111 1000	110000 0111
K.23.7	111 10111	111010 1000	000101 0111
K.27.7	111 11011	110110 1000	001001 0111
K.29.7	111 11101	101110 1000	010001 0111
K.30.7	111 11110	011110 1000	100001 0111

Within the 8B/10B encoding, there are special symbols defined for control information. These are commonly referred to as K characters. These characters are used for higher level control such as start of frame (SOF), end of frame (EOF), retransmit, errors, etc. The single most important K character is the comma. The TLK2711 uses the comma for byte alignment of the parallel data at the receiver. The comma is contained in multiple K characters, but for practical purposes it is defined as the K28.5. From Table 3, K28.5 is decoded as a 001111 1010 or a 1100000101 depending on current running disparity. Note, the TLK2711 only achieves alignment on the 001111 1010 comma. Specifically it is looking for the 0011111. This has a significant implication. This implies that the user must send the 0011111 comma. However, a single K28.5 may not generate this comma, as the current running disparity is not deterministic. This is solved by sending two inverting (or correcting) idles back to back. An inverting IDLE is two words that taken as a whole will cause the running disparity to flip. So two back-to-back inverting idles will ensure that one of them will be the correct decoding of the K28.5. The inverting idle is defined as a /K28.5/D5.6/. There are other data values that will cause an inversion when paired with the K28.5. However, this symbol pair is the standard.

3   Quick Experiment to Obtain Byte-Alignment With TLK2711-SP EVM

This is a trivial example, to help visually explain the minimum requirements to achieve byte-alignment utilizing the TLK2711-SP EVM. With TXCLK being driven at a clock frequency within the operational range of 80 Mhz to 125 Mhz, the comma character can be sent by configuring jumper pins on the TXD interface.

Start with a configuration that is only sending data with internal loopback.

The jumper settings show a D28.5/D5.6 being transmitted on the TX bus. Note, that this does not include the comma, as it is coded as data with TKLSB set to low.
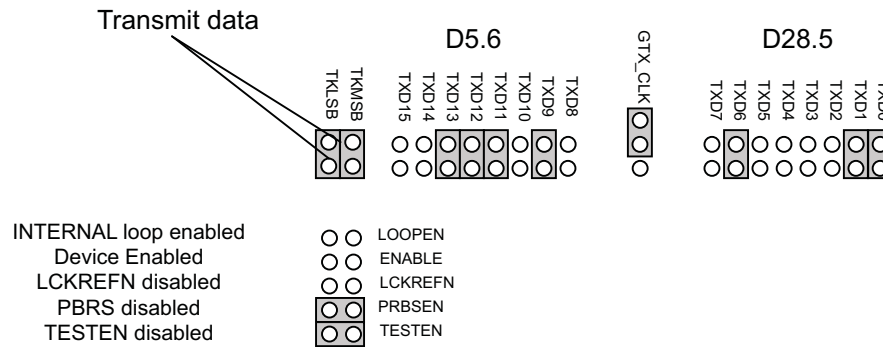
Figure 1. EVM Jumper Settings

Internal LOOPEN may be disabled (add jumper), if external loopback is used. Connect TXP to RXP and TXN to RXN via SMA cables. With LOOPEN enabled, the transmitted signal is routed internally to receiver.

Next, supply power and TXCLK to board.

The user can now probe the received signals on the RXD buss. When probing signals, notice that the data does not represent what is on the transmit buss. It is possible, but unlikely that device will happen to align to proper boundary.

Now, remove and replace the TKLSB jumper.

This will cause many inverting idles to be sent on the buss, and will give the TLK2711 the necessary comma character to achieve byte alignment. Now probe the RXD bus. Signals should now match the D28.5/D5.6 mirroring the TXD buss.

4   Defining a Simple Protocol

The simplest protocol would be transmitting raw data, with a periodic transmission of 2 inverting idles, then resume transmitting raw data. A step beyond this would be the inclusion of framing or packetizing the data. Sending periodic commas in the stream is necessary, as an error in the bit stream could cause false byte-alignment on receiver.

A simple and effective protocol can be implemented as follows.

- K28.5 D5.6
- K28.5 D5.6
- K28.5 D11.5 (SOF optional and user definable)
- Dxx Dxx (Transmitted packet. Repeat for packet depth.)
- Dxx Dxx (Packet CRC if desired)
- K28.5 D5.6
- K28.5 D5.6
- K28.5 D11.5 (SOF optional)

Repeat with next packet.

Note, that a packet begins with 2 inverting idles. This will achieve byte alignment on the receiver, and provide for re-alignment if a bit error causes a mis-alignment at some point during operation.

The (SOF) sequence is not necessary, but can be used by receiving link layer to manage capturing the data.

The use of a CRC is also optional, but depending on source of the data, this is a convenient means to detect if an error occurred in the data. A more elaborate scheme could include a bidirectional control path. On receipt of a data error, the receiving link could transmit back to request a retransmit of the erroneous packet. This is beyond the scope of this document.

5   References:

A.X. Widmer, Peter A. Franaszek (1983). "A DC-Balanced, Partitioned-Block, 8B/10B Transmission Code" *IBM Journal of Research and Development* **27**(5): 440.

Texas Instruments TLK2711-SP Data sheet (SGLS307D)

Texas Instruments TLK2711-SP EVM manual (SGLU001)

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