Agilent Technologies
Innovating the HP Way

Fiber Optic Components CookBook

Table of Contents

Objectives:

1) Explain some fundamental characteristics of digital fiber-optic communication links.

2) Provide proven digital fiber-optic transceiver solutions.

3) Provide Data Rate vs. Distance Graphs for Agilent's Fiber-Optic Components

4) Supply references to Agilent Application Notes and Data Sheets for additional details.

Why Use Optical Fibers?

When using fiber-optic data communication links, designers can develop new products which provide noise immunity that is superior to copper wire.

Optical fibers do not require rigorous grounding rules to avoid ground loop interference, and fiber-optic cables do not need termination resistors to avoid reflections.

Fiber-optic links also have an intrinsically higher probability of surviving lightning strikes than copper wire alternatives.

Optical connectors suited for field termination with minimal training and simple tools are now available. For additional details refer to the HFBR-4531/4532 crimpless connector data sheet, Agilent publication number 5965-1659E.

When using plastic optical fiber (POF) or hard clad silica (HCS®) the total cost of the data communication link is roughly the same as when using copper wire.

Fundamentals of Digital Fiber-optic Links

Digital fiber-optic links are normally used to transport serial data. When the length of the data communication channel increases parallel data transfer is generally avoided due to cost and time skew issues.

Parallel-to-serial and serial-to-parallel converters are normally used to interface computers and microprocessors to fiber-optic links.

When parallel data is serialized it is usually encoded, but not all serial communication protocols make use of encoding.

Some existing copper wire serial data communication protocols use no encoding or make use of protocols that send data in bursts or packets.

Encoding merges the clock and data into one serial data communication link. Encoding eliminates time skew, which can occur when separate communication links are used for the clock and serial data.

Why Encoding Is Desirable

Unencoded data has dc voltage offsets because unencoded data can remain in the "logic 0" or "logic 1" state for indefinite intervals of time.

Encoding algorithms ensure that data is continuously transmitted. Encoding also restricts duty cycle variations so that the average value of the encoded signal approaches half of the data's peak-to-peak amplitude.

Some encoding algorithms allow duty cycle variations between 40% and 60%, while other encoding algorithms provide data with an average duty cycle of 50%.

If no encoding is used the digital fiber-optic receiver needs to be dc coupled or must make use of edge detection techniques to accommodate the dc components of the serial data.

Burst mode or packetized data also requires use of dc coupled or unique ac coupled edge detecting receiver circuits.

Digital fiber-optic receivers can be dc coupled or ac coupled, but ac coupled receivers generally provide better sensitivity than dc coupled receivers.

A conventional ac coupled receiver will not provide satisfactory performance if the transmitted data contains dc components. Serial data that remains in the logic "1" or logic "0" state for indefinite time intervals is not compatible with the majority of ac coupled receiver circuits.

Why So Many Different Fiber-optic Components?

To meet all of the diverse requirements of the serial data communication market, Agilent manufactures both fully integrated dc coupled TTL-compatible receivers and disintegrated components that can be used to construct high performance ac coupled receivers.

Integrated dc-coupled TTL-compatible receivers are very convenient, but an integrated receiver cannot provide the sensitivity achievable with disintegrated receiver components.

How to Use Disintegrated Components

Disintegrated receivers are constructed using hybrid receiver components that contain a PIN diode optical detector and a transimpedance amplifier. The transimpedance amplifier converts PIN diode detector current to a voltage which is proportional to received optical power. The PIN diode plus transimpedance amplifier hybrid component is commonly called a PIN pre-amp.

The PIN pre-amp can be connected directly to a comparator to implement a simple, medium performance logic-compatible digital receiver.

To construct a high performance digital fiber-optic receiver, the PIN pre-amp is connected to a post amplifier comparator circuit commonly known as a quantizer.

Ideal quantizers provide excellent receiver sensitivity limited by the shott and thermal noise of the first stage of the PIN pre-amp's transimpedance amplifier.

High performance ac coupled receivers require that the serial data is encoded so that data will not remain in the logic "1" or logic "0" states for indefinite time intervals.

Parallel-to-Serial and Serial-to-Parallel Converters

Many readily available off-the-shelf parallel-to-serial and serial-to-parallel converters have integrated encoders and decoders.

Parallel-to-serial and serial-to-parallel converters are commonly called physical layer or PHY chips.

So What Happens When Data is Encoded?

The encoder in a PHY chip replaces individual bits with symbols, or groups of bits with groups of symbols.

Encoders commonly increase the fundamental frequency that the serial communication channel must transport, but duty factor variations are constrained when data is encoded.

Figure 1 shows the relationship between bits/second, symbols/second (Baud), and the fundamental frequency of serial data when using encoders commonly found in off-the-shelf PHY chips.

Note that F_O is the maximum fundamental frequency of the encoded data. The minimum fundamental frequency of the encoded data is determined by the encoder's run limit.

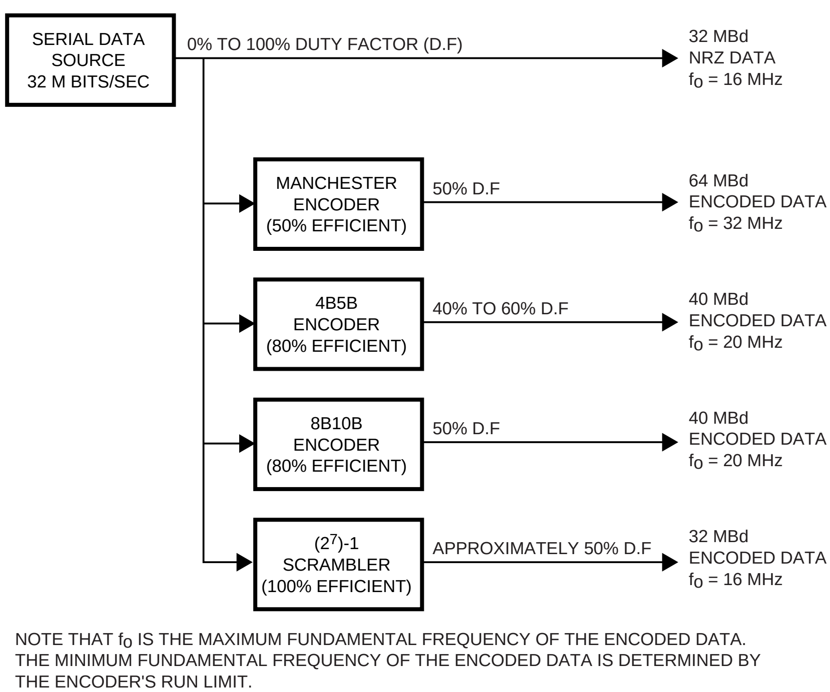

Figure 1. Attributes of Encoding

Encoding merges the clock and data into a single serial bit stream. Encoded data contains time reference information needed by the timing recovery circuit (aka PLL) located at the receiving end of the fiber-optic link.

So What Happens If Data Is Not Encoded?

If encoding is not used the time reference (clock) must be transmitted through a separate fiber-optic link, or the data must be oversampled by a local oscillator located at the receiving end of the fiber-optic link.

This local oscillator must operate at a significantly higher frequency than the fundamental frequency of the serial data to avoid excessive pulse width distortion. For more details see Application Note 1121, Agilent publication number 5968-5928E.

Agilent Fiber-optic Solutions for Unencoded Data

Since many existing copper wire communication protocols transmit unencoded data, Agilent has developed a wide range of dc-coupled TTL-compatible integrated fiber-optic receivers.

Agilent manufactures a wide range of fully integrated TTL-compatible receivers starting at dc to 40 KBd through dc to 10 MBd. For best results use the recommended circuits shown on pages 5 through 13 of this Fiber-Optic Cookbook.

For unencoded data transmission at rates between dc and 32 MBd see the disintegrated edge detector solutions shown on pages 14 to 17.

Low-cost Digital Transmitters

When using Agilent's LED optical sources, inexpensive logic-compatible fiber-optic transmitters can be implemented using off-the-shelf peripheral line drivers or advanced CMOS nand gates.

The logic-compatible circuits shown in this guide look deceptively simple, but have been carefully developed to deliver the best performance possible with Agilent's LED optical transmitter components.

Using Agilent's Recommended Solutions

To avoid problems, minimize development costs and minimize time-to-market, designers are encouraged to imbed the circuits shown in this cookbook. The complete solutions shown in this cookbook are based upon proven circuits and techniques that have been demonstrated to work in numerous applications.

Solution for dc to 40 KBd TTL Data at Distances Between 0 and 53 meters.

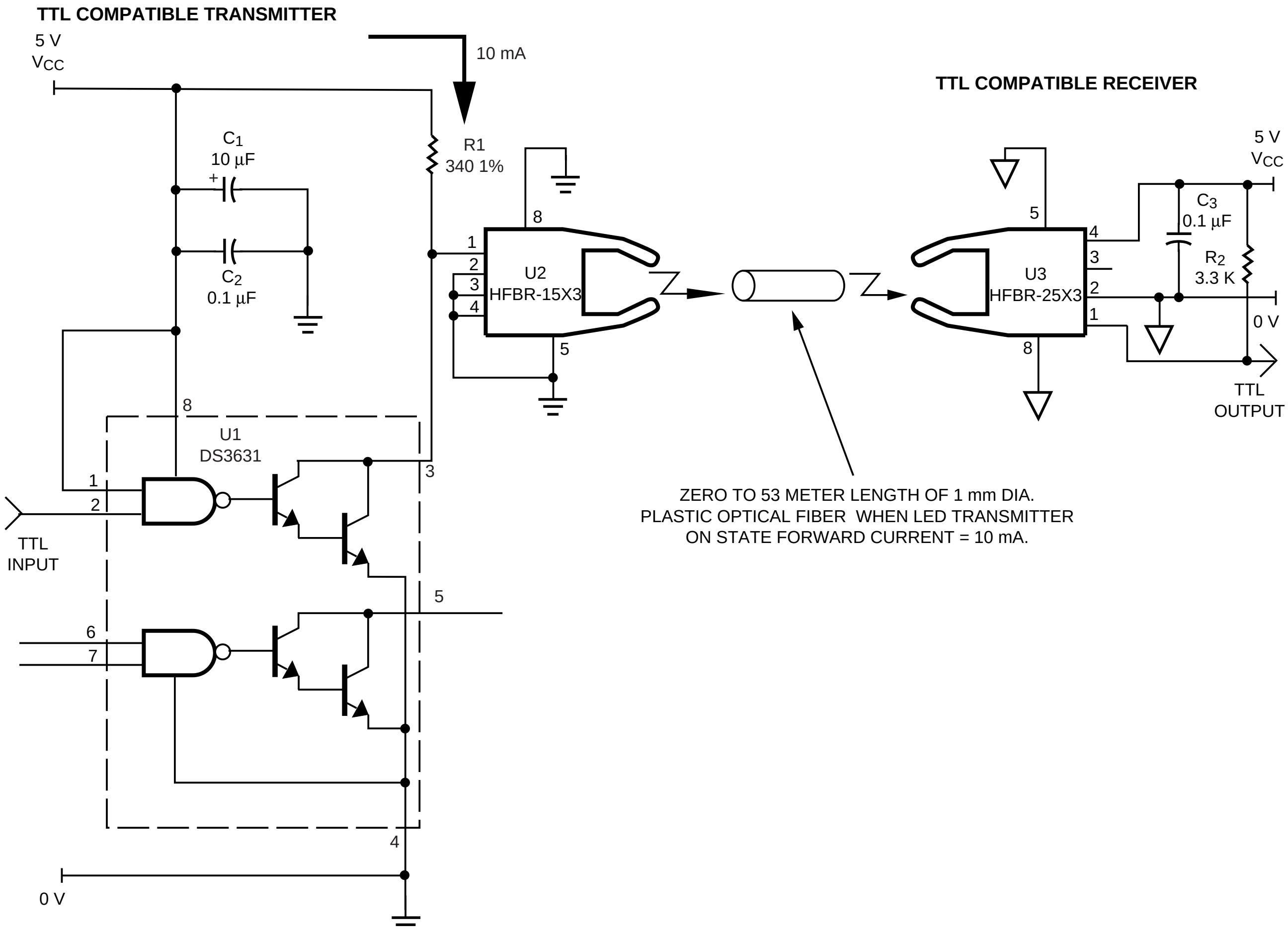

Figure 2.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS3631 costs roughly $0.25 and is available from National Semiconductor.
4) Uses lowest cost 1 mm dia. plastic optical fiber.
5) Uses Agilent's HFBR-4531 or HFBR-4532 crimpless connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0501 Series data sheet, Agilent pub. # 5968-1712E
2) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E
3) Application Note 1035, Agilent pub. # 5964-4027E

Solution for dc to 40 KBd TTL Data at Distances Between 0 and 1.5 kilometers.

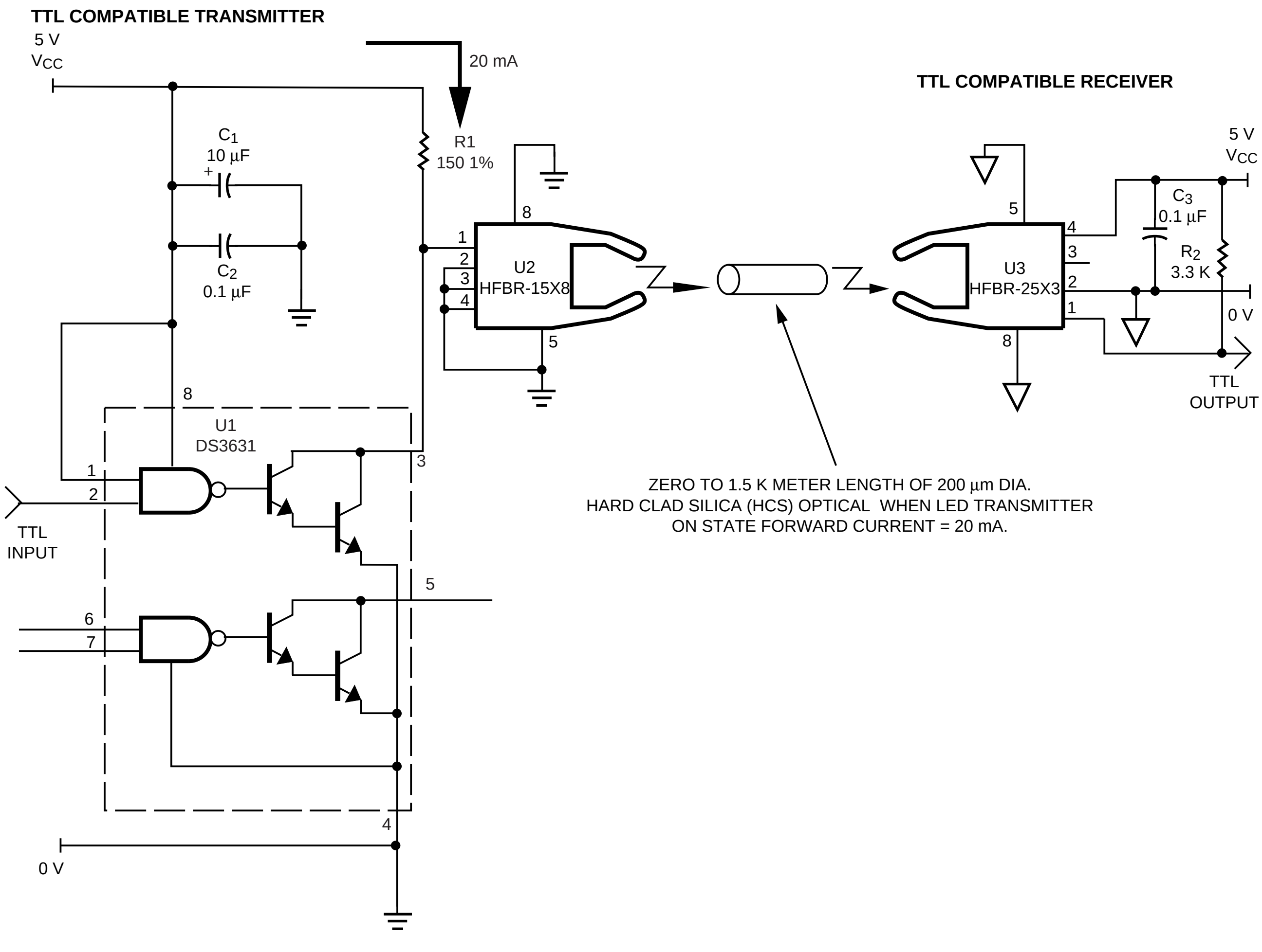

Figure 3.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS3631 costs roughly $0.25 and is available from National Semiconductor.
4) Uses low-cost 200 µm hard clad silica (HCS) optical fiber.
5) Uses Agilent's HFBR-4521 connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0501 Series data sheet, Agilent pub. # 5968-1712E
2) HFBR-0508 Series data sheet, Agilent pub. # 5965-6114E
3) Plastic Optical Fiber and HCS® Fiber Cables and Connectors, Agilent pub # 5963-3711E

Solution for dc to 1 MBd TTL Data at Distances Between 0 and 10 meters.

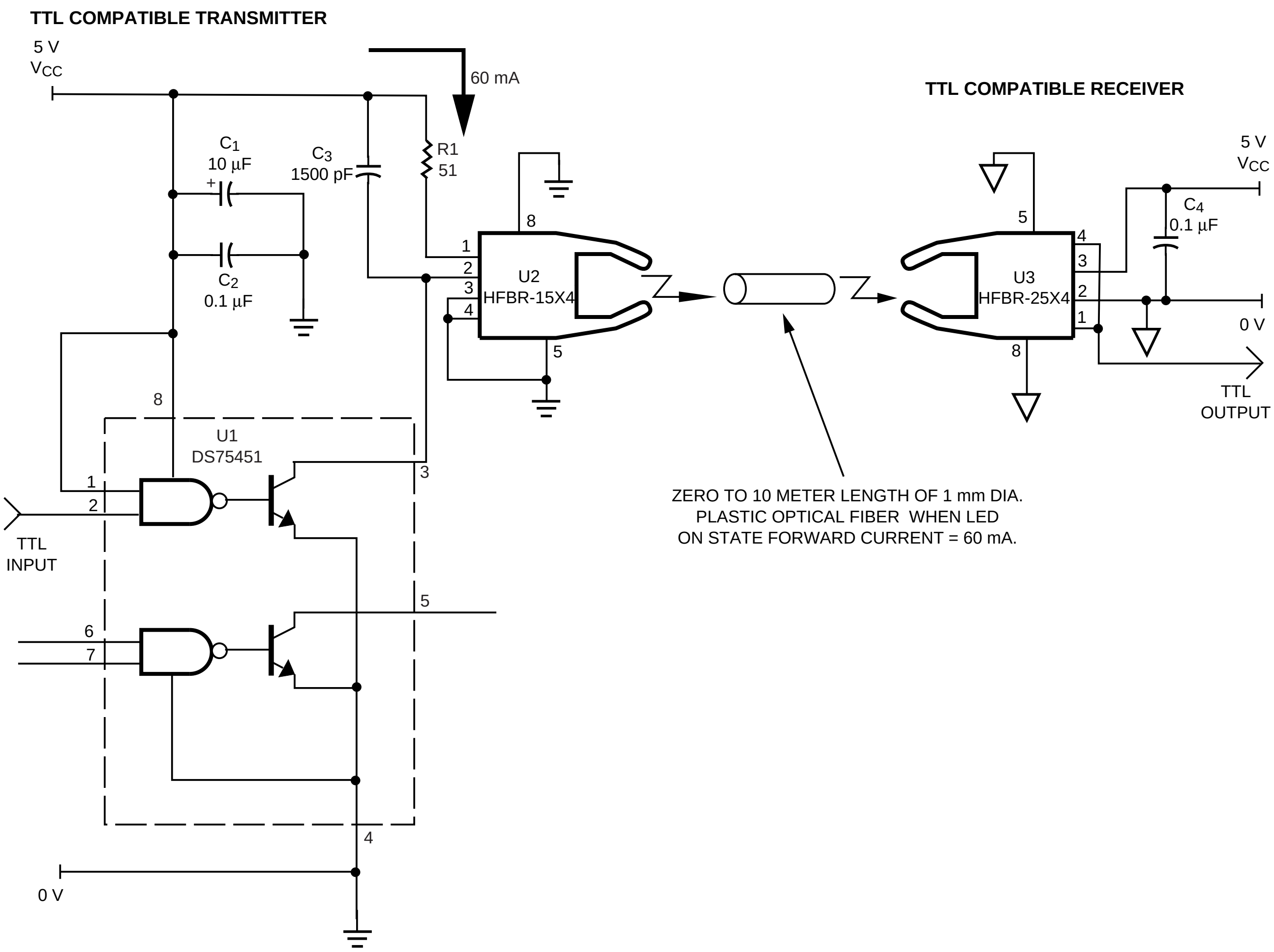

Figure 4.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses lowest cost 1 mm dia. plastic optical fiber.
5) Uses Agilent’s HFBR-4531 or HFBR-4532 crimpless connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0501 Series data sheet, Agilent pub. # 5968-1712E
2) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E
3) Application Note 1035, Agilent pub. # 5964-4027E

Solution for dc to 1 MBd TTL Data at Distances Between 0 and 45 meters.

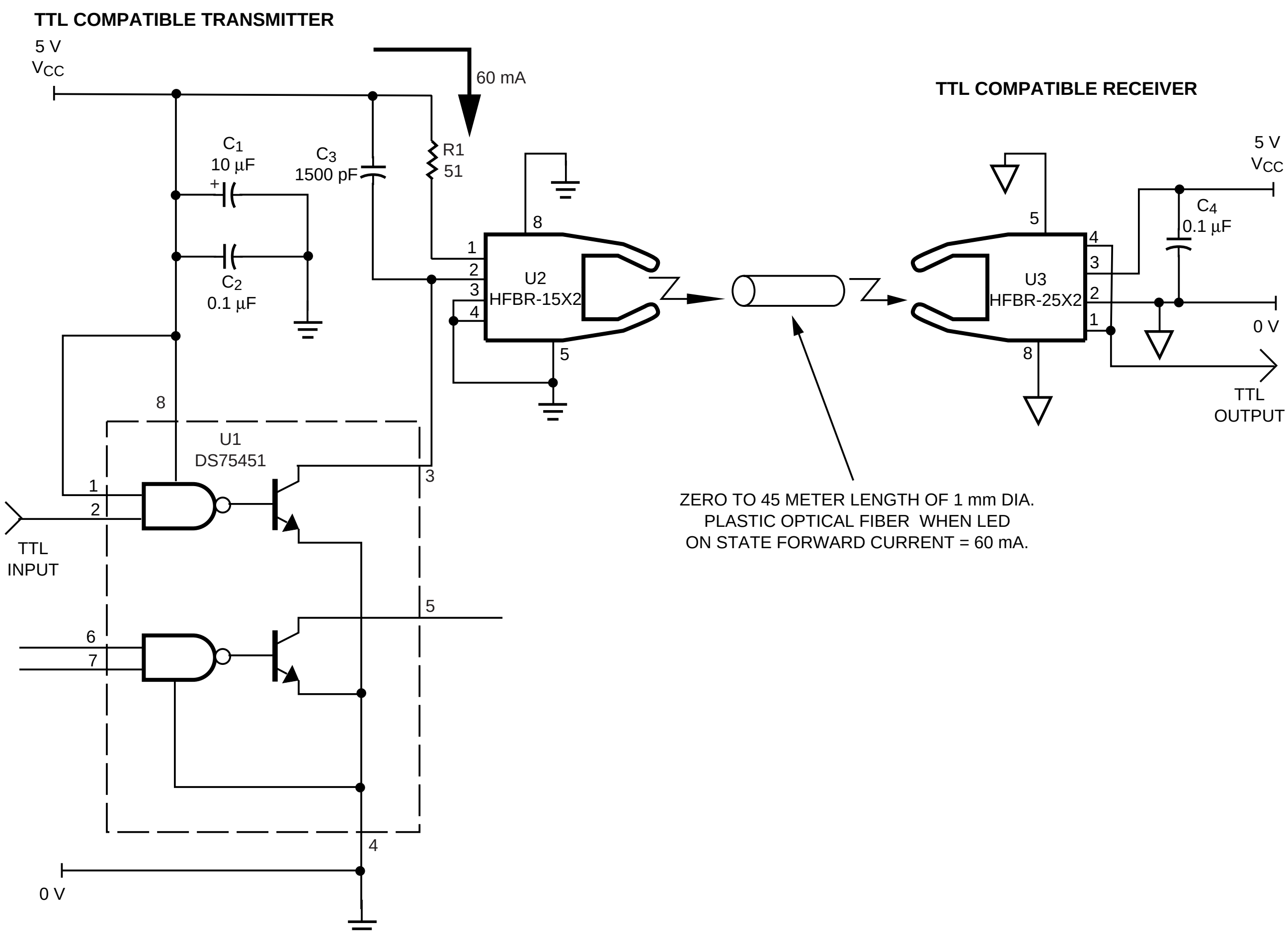

Figure 5.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses lowest cost 1 mm dia. plastic optical fiber.
5) Uses Agilent's HFBR-4531 or HFBR-4532 crimpless connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0501 Series data sheet, Agilent pub. # 5968-1712E
2) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E
3) Application Note 1035, Agilent pub. # 5964-4027E

Solution for dc to 5 MBd TTL Data at Distances Between 0 and 16 meters.

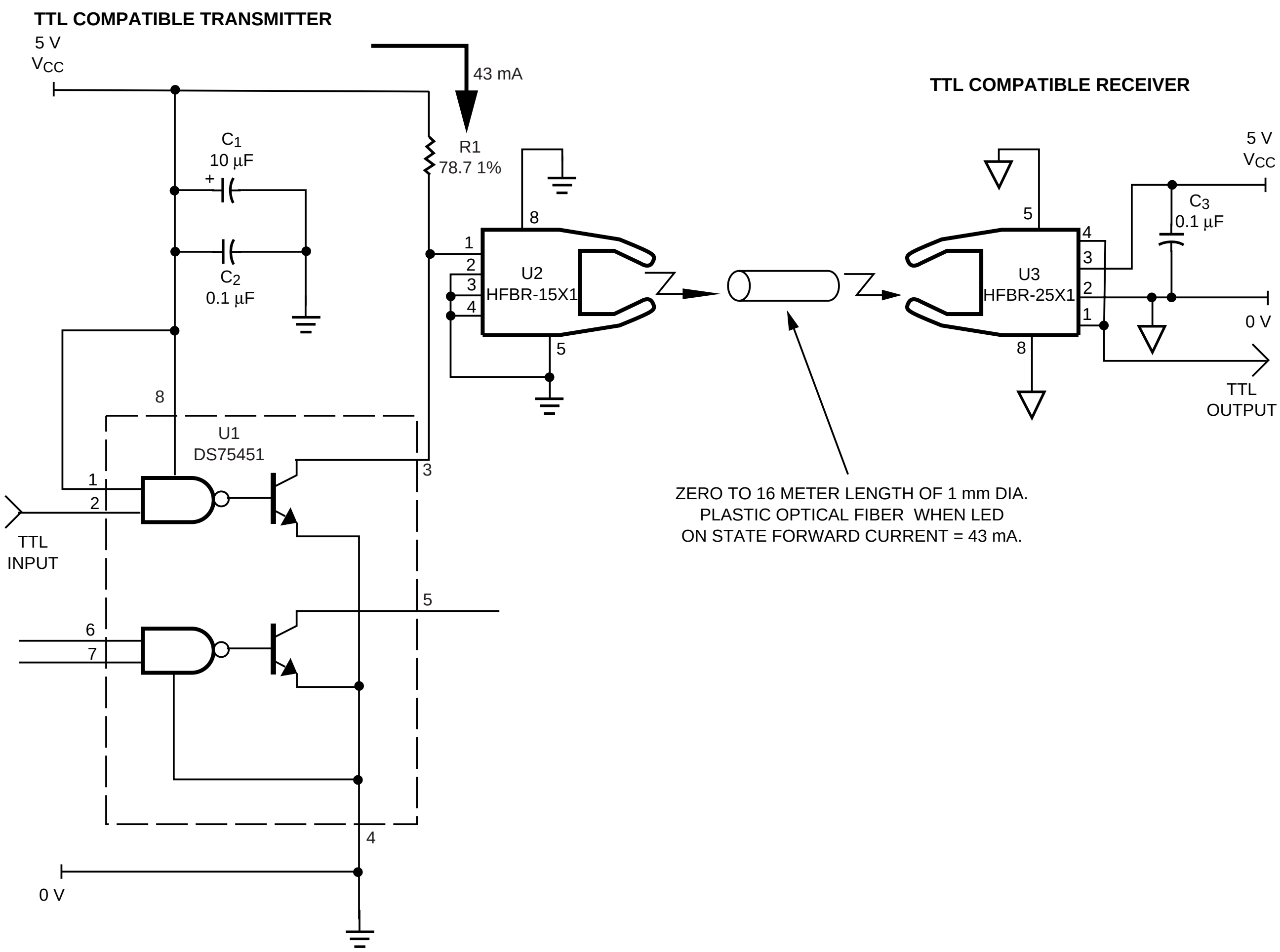

Figure 6.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses lowest cost 1mm dia. plastic optical fiber.
5) Uses Agilent's HFBR-4531 or HFBR-4532 crimpless connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0501 Series data sheet, Agilent pub. # 5968-1712E
2) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E
3) Application Note 1035, Agilent pub. # 5964-4027E

Solution for dc to 5 MBd TTL Data at Distances Between 0 and 700 meters.

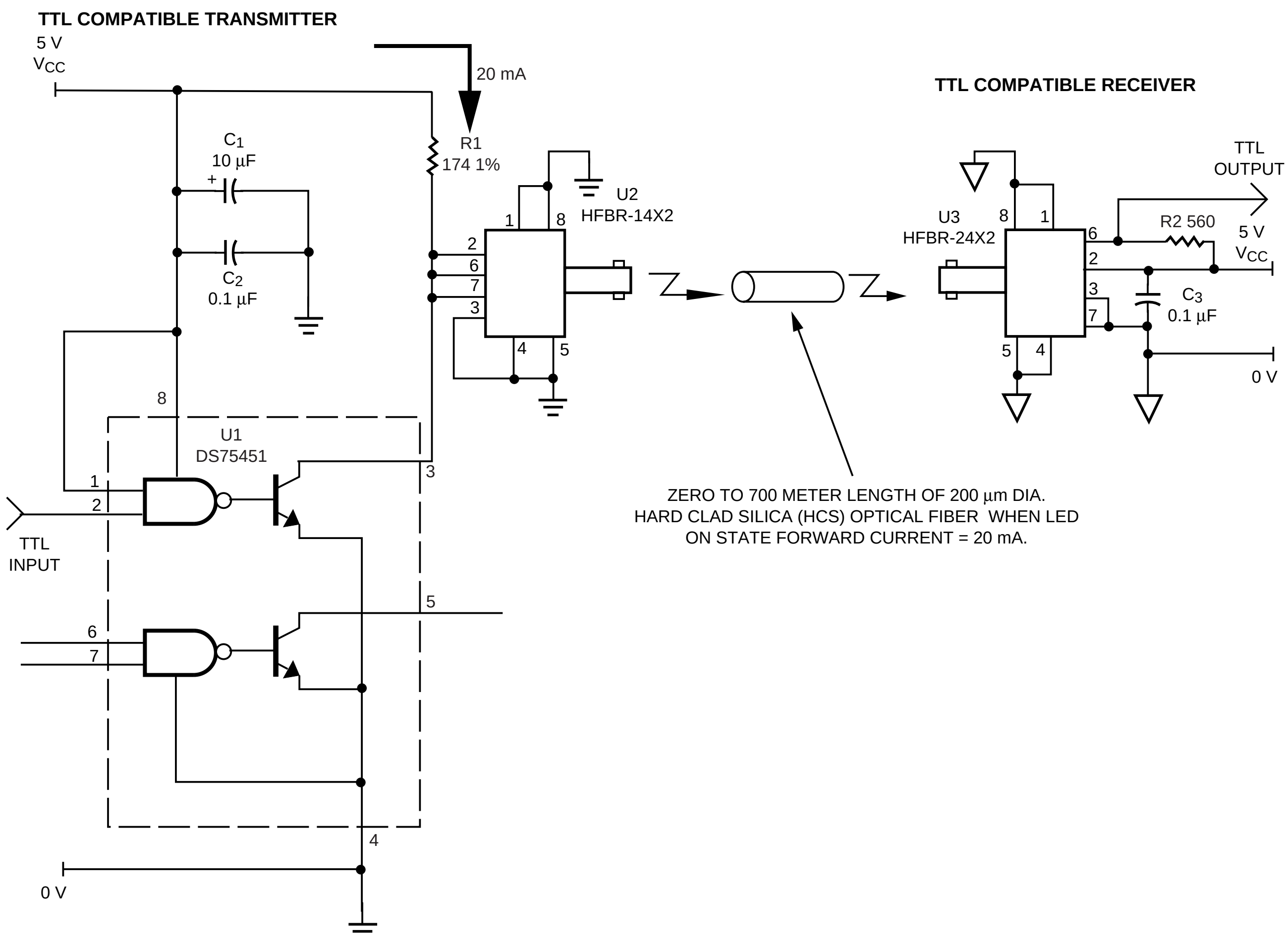

Figure 7.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses rugged 200 µm dia. hard clad silica (HCS) optical fiber.
5) Uses no-epoxy no-polish crimp and cleave ST or SMA optical connectors which can be field terminated.

Reference:

1) HFBR-0400 Series data sheet, Agilent pub. # 5965-1655E

Solution for dc to 5 MBd TTL Data at Distances Between 0 and 1.7 kilometers.

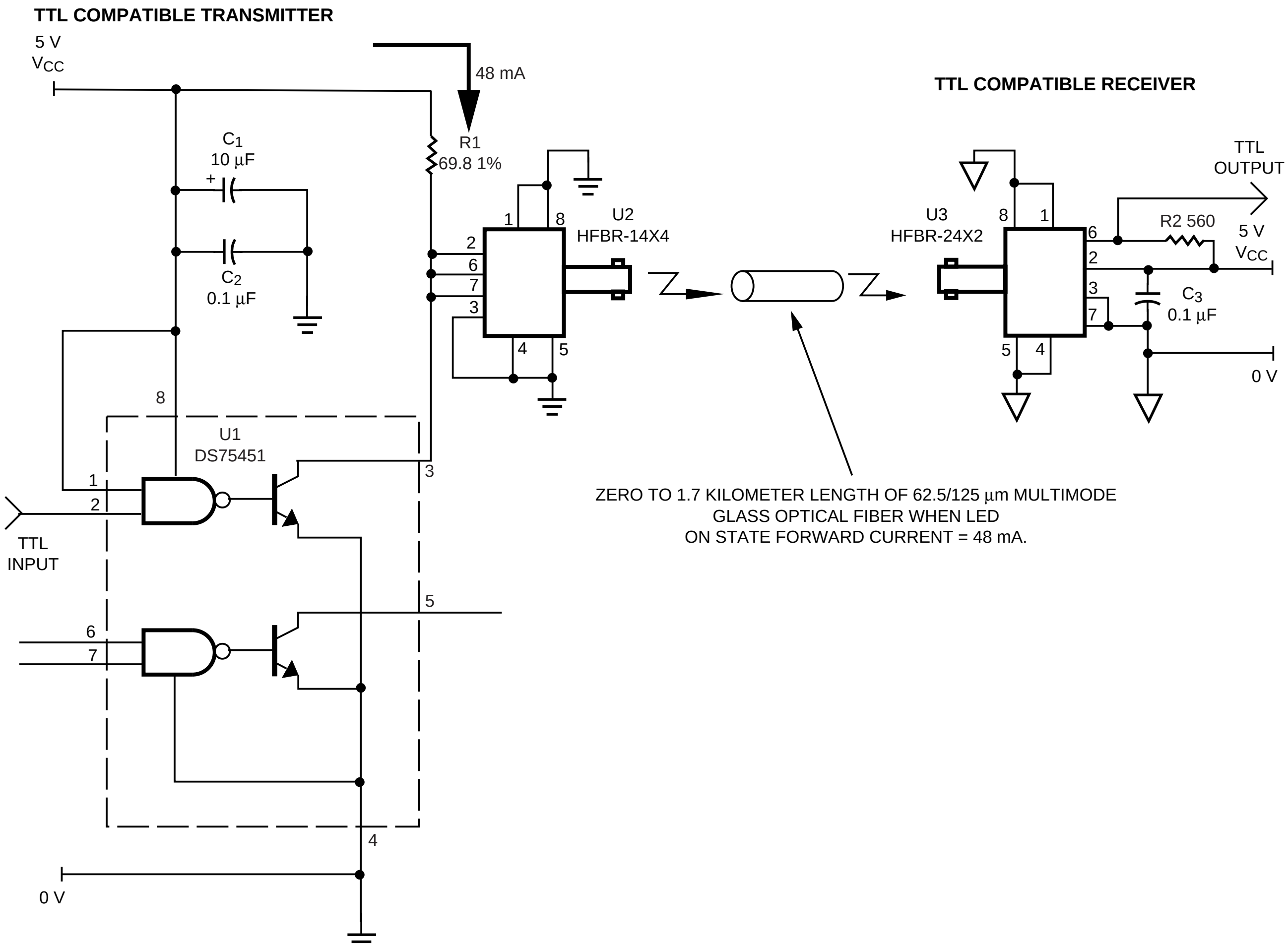

Figure 8.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses commonly available 62.5/125 µm dia. glass optical fiber.
5) Uses ST or SMA optical connectors.

Reference:

1) HFBR-0400 Series data sheet, Agilent pub. # 5965-1655E

Solution for dc to 10 MBd TTL Data at Distances Between 0 and 40 meters.

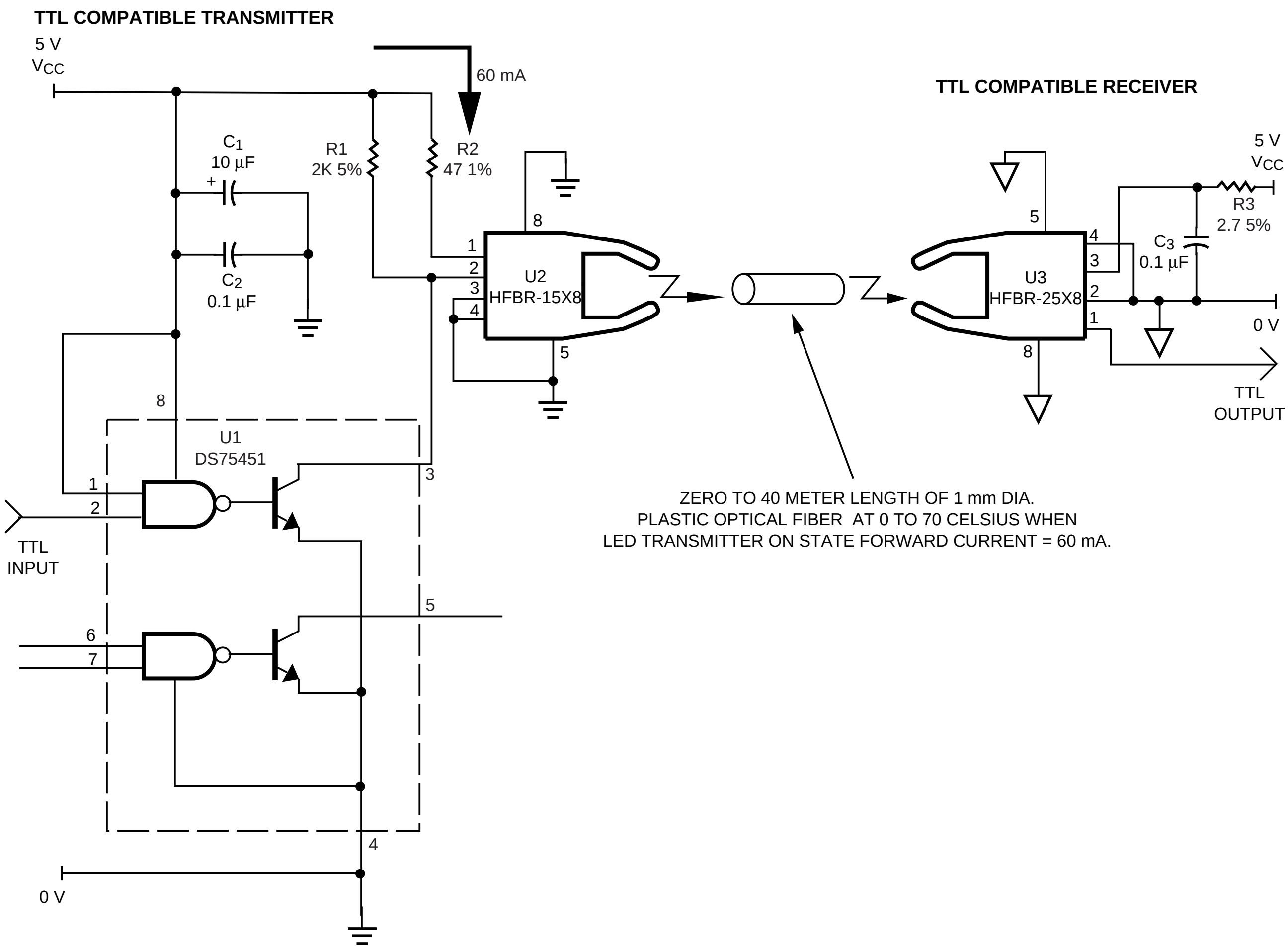

Figure 9.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses lowest cost 1 mm dia. plastic optical fiber.
5) Uses Agilent's HFBR-4531 or HFBR-4532 crimpless connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0508 Series data sheet, Agilent pub. # 5965-6114E
2) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E
3) Application Note 1080, Agilent pub. # 5963-6756E

Solution for dc to 10 MBd TTL Data at Distances Between 0 and 300 meters.

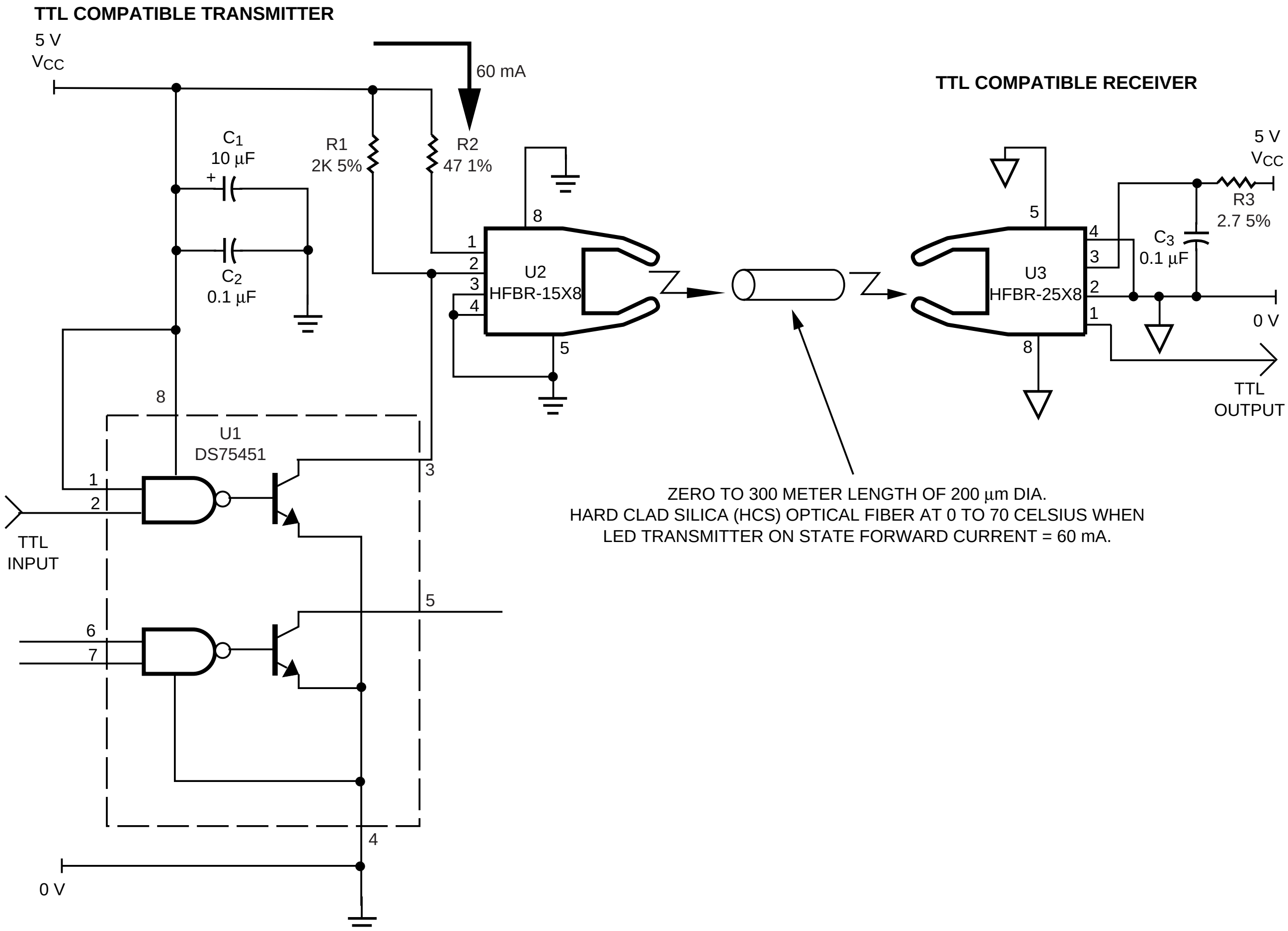

Figure 10.

Attributes:

1) No adjustments needed.
2) No receiver overdrive with short fiber-optic cables.
3) DS75451 costs roughly $0.25 and is available from National Semiconductor.
4) Uses low-cost 200 µm hard clad silica (HCS) optical fiber.
5) Uses Agilent’s HFBR-4521 connector which can be field terminated in less than 1 minute.

References:

1) HFBR-0508 Series data sheet, Agilent pub. # 5965-6114E
2) Application Note 1080, Agilent pub. # 5963-6756E
3) Plastic Optical Fiber and HCS® Fiber Cables and Connectors, Agilent pub. # 5963-3711E

Solution for dc to 32 MBd TTL Data at Distances Between 0 and 1.3 kilometers. (Pages 14 & 15)

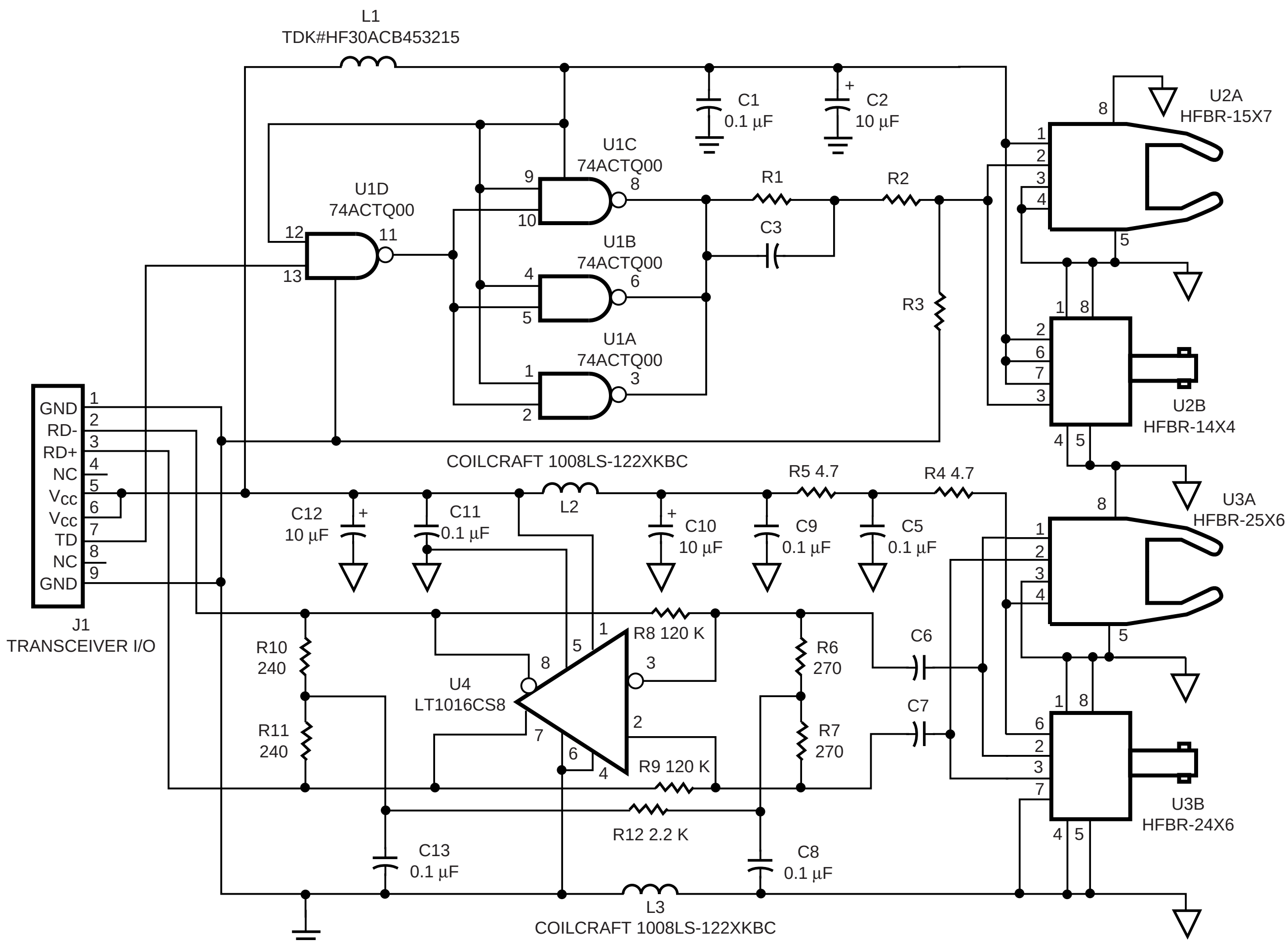

Figure 11. Transceiver Circuit

Table 1. Transceiver Component Values

DISTANCE @ 32 MBd	0 to 27 meters	0 to 690 meters	0 to 800 meters	0 to 1.3 K meters
TRANSMITTER	HFBR-15X7 650 nm LED	HFBR-15X7 650 nm LED	HFBR-14X4 820 nm LED	HFBR-13X2T 1300 nm LED
RECEIVER	HFBR-25X6	HFBR-25X6	HFBR-24X6	HFBR-23X6
FIBER TYPE	1 mm Plastic	200 µm HCS	62.5/125 µm	62.5/125 µm
R1	120 Ω	33 Ω	33 Ω	22 Ω
R2	120 Ω	33 Ω	33 Ω	27 Ω
R3	390 Ω	270 Ω	270 Ω	∞
C3	82 pF	470 pF	75 pF	150 pF

$$C6 = C7 = \frac{2}{(3)\,(R6 + R7)\left[\text{DATA RATE (Bd)}\right]}$$

Attributes:

1) Can be used with unencoded data.
2) No analog circuit design needed.
3) No printed circuit design needed.
4) Printed circuit design can be electronically imported from web address: http//www.agilent.com/Agilent-COMP/fiber/fiber_index.html#gerber by downloading trans1.exe
   Electronic files contain:
   a) Transceiver schematic
   b) Printed circuit artwork
   c) Material list
5) No adjustments needed.
6) No receiver overdrive with short fiber-optic cables.
7) Uses low-cost off-the-shelf integrated circuits from Fairchild and Linear Technology.
8) One transceiver design can be used to address a wide range of applications.
9) Can be used with 1 mm dia. POF for lowest cost, 200 µm HCS, or 62.5/125 µm multimode glass optical fibers for greater distances.
10) POF or HCS fiber connectors can be field terminated in less than 1 minute. For POF use the HFBR-4531 connector, for HCS fiber use HFBR-4521 connector.

References:

1) HFBR-0507 Series data sheet, Agilent pub. # 5965-6114E.
2) HFBR-0400 Series data sheet, Agilent pub. # 5965-1655E.
3) HFBR-0300 Series data sheet, Agilent pub. # 5965-3611E.
4) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E.
5) Plastic Optical Fiber and HCS® Fiber Cables and Connectors, Agilent pub # 5963-3711E.
6) Application Note 1121, Agilent pub. # 5968-5928E

Solution for dc to 32 MBd TTL Data at Distances Between 0 and 4.0 kilometers. (Pages 16 & 17)

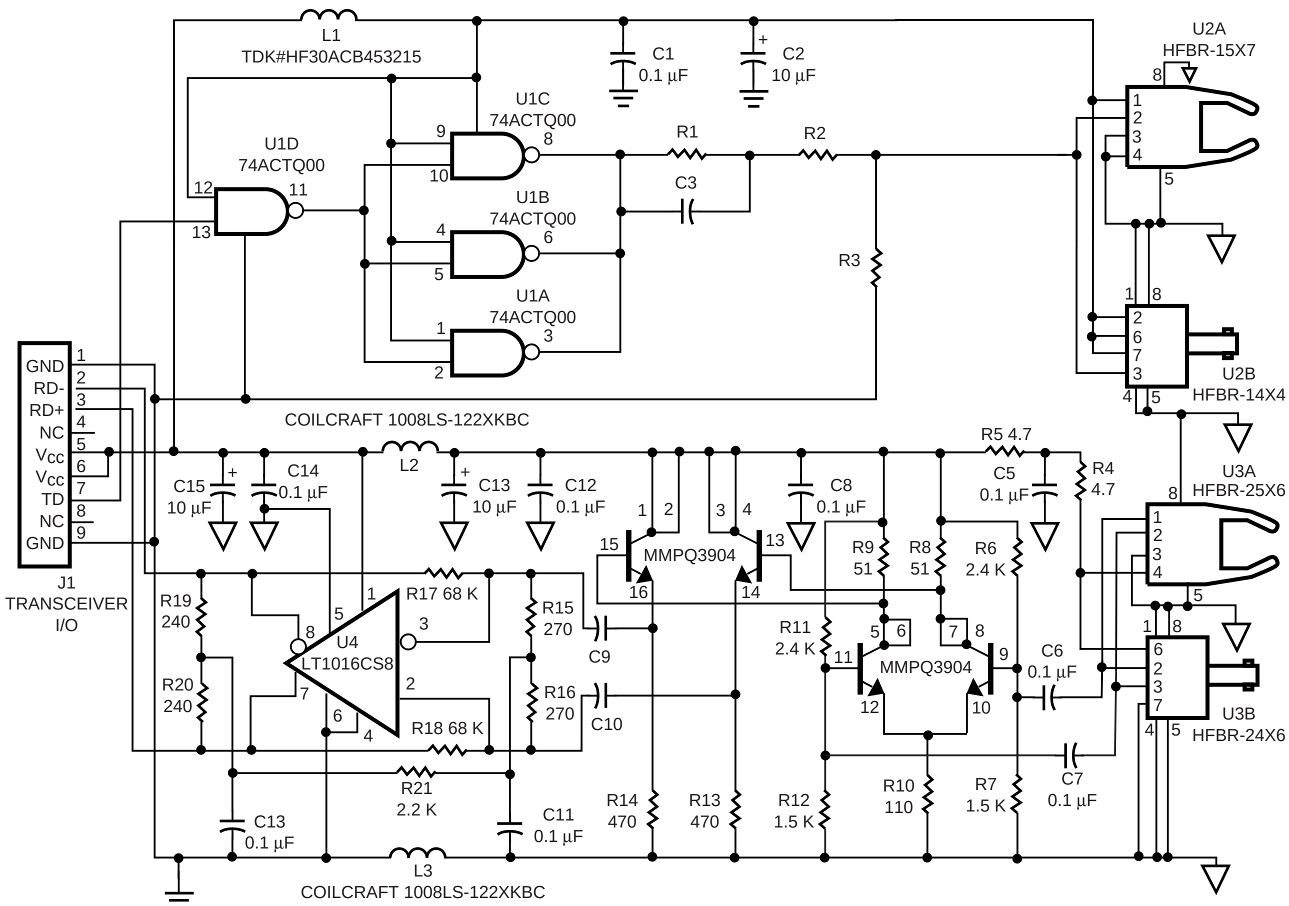

Figure 12. Transceiver Circuit

Table 2. Transceiver Component Values

DISTANCE @ 32 MBd	0 to 42 meters	0 to 1K meters	0 to 1.6K meters	0 to 3.3K meters	0 to 4.0K meters
TRANSMITTER	HFBR-15X7 650 nm LED	HFBR-15X7 650 nm LED	HFBR-14X4 820 nm LED	HFBR-13X2T 1300 nm LED	HFBR-1315 1300 nm ELED
RECEIVER	HFBR-25X6	HFBR-25X6	HFBR-24X6	HFBR-23X6	HFBR-2315
FIBER TYPE	1 mm Plastic	200 µm HCS	62.5/125 µm	62.5/125 µm	9/125 µm
R1	120 Ω	33 Ω	33 Ω	22 Ω	18 Ω
R2	120 Ω	33 Ω	33 Ω	27 Ω	18 Ω
R3	390 Ω	270 Ω	270 Ω	∞	390 Ω
C3	82 pF	470 pF	75 pF	150 pF	47 pF

$$C9 = C10 = \frac{2}{(3)\ (R6 + R7)\left[\text{DATA RATE (Bd)}\right]}$$

Attributes:

1) Can be used with unencoded data.
2) No analog circuit design needed.
3) No printed circuit design needed.
4) Printed circuit design can be electronically imported from
   web address:-
   http//www.agilent.com/Agilent-COMP/fiber/fiber_index.html#gerber
   by downloading trans2.exe
   Electronic files contain:
   a) Transceiver schematic
   b) Printed circuit artwork
   c) Material list
5) No adjustments needed.
6) No receiver overdrive with short fiber-optic cables.
7) Uses low-cost off-the-shelf integrated circuits from Fairchild, Motorola, and Linear Technology.
8) One transceiver design can be used to address a wide range of applications.
9) Can be used with 1 mm dia. POF for lowest cost, 200 µm HCS, 62.5/125 µm multimode glass or 9/125 single-mode glass optical fibers for greater distances.
10) POF or HCS fiber connectors can be field terminated in less than 1 minute. For POF use the HFBR-4531 connector, for HCS fiber use HFBR-4521 connector.

References:

1) HFBR-0507 Series data sheet, Agilent pub. # 5965-6114E.
2) HFBR-0400 Series data sheet, Agilent pub. # 5965-1655E.
3) HFBR-0300 Series data sheet, Agilent pub. # 5965-3611E.
4) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E.
5) Plastic Optical Fiber and HCS® Fiber Cables and Connectors, Agilent pub # 5963-3711E.
6) Application Note 1121, Agilent pub. # 5968-5928E

Solution for 2 to 70 MBd TTL Data at Distances Between 0 and 14.0 kilometers. (Pages 18 & 19)

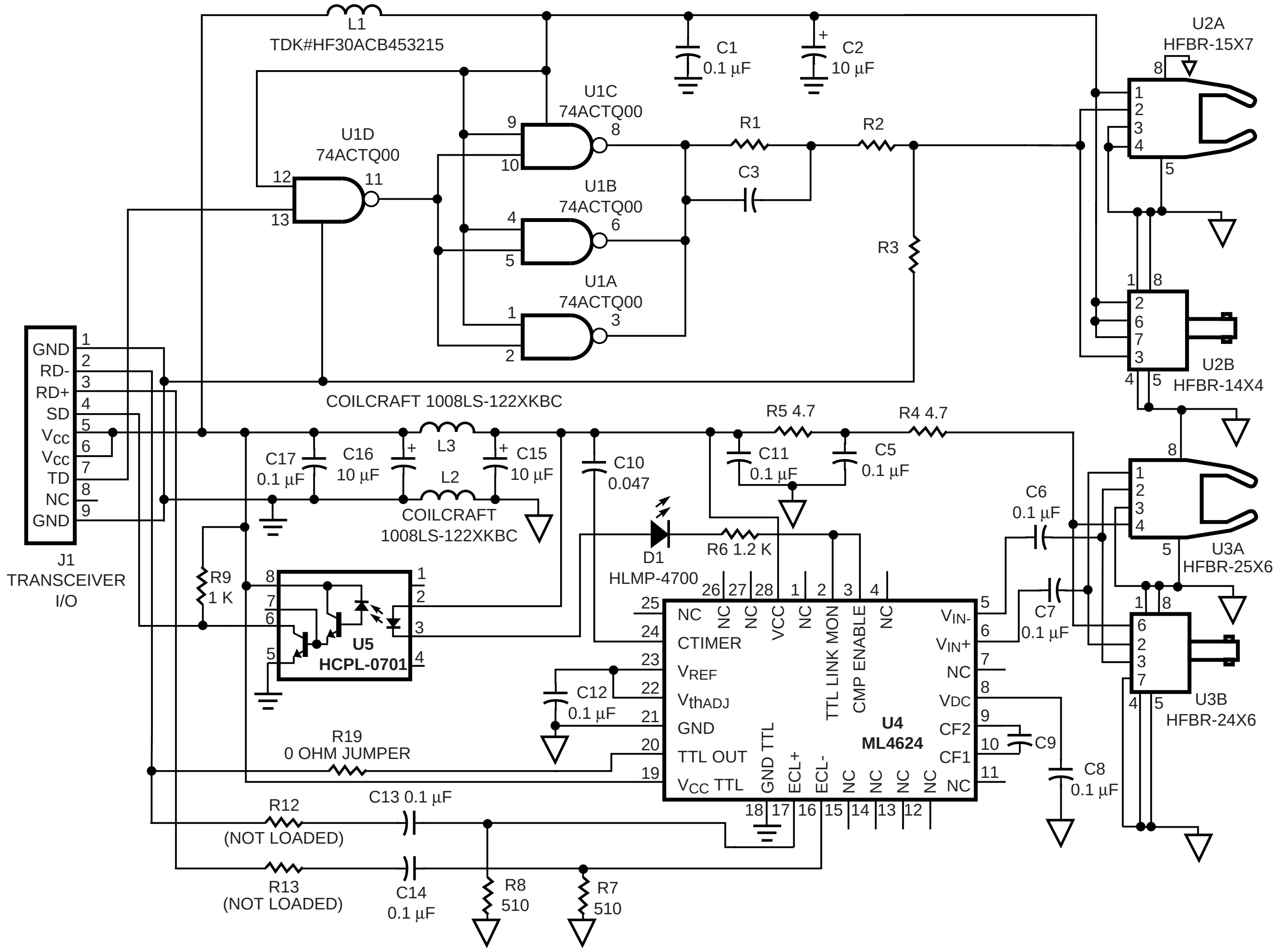

Figure 13. Transceiver Circuit

Table 3. Transceiver Component Values

DISTANCE @ 50 MBd	0 to 80 meters	0 to 300 meters	0 to 1.5K meters	0 to 3.8K meters	0 to 14.0K meters
TRANSMITTER	HFBR-15X7 650 nm LED	HFBR-15X7 650 nm LED	HFBR-14X4 820 nm LED	HFBR-13X2T 1300 nm LED	HFBR-1315 1300 nm ELED
RECEIVER	HFBR-25X6	HFBR-25X6	HFBR-24X6	HFBR-23X6	HFBR-2315
FIBER TYPE	1 mm Plastic	200 µm HCS	62.5/125 µm	62.5/125 µm	9/125 µm
R1	120 Ω	33 Ω	33 Ω	22 Ω	18 Ω
R2	120 Ω	33 Ω	33 Ω	27 Ω	18 Ω
R3	390 Ω	270 Ω	270 Ω	∞	390 Ω
C3	82 pF	470 pF	75 pF	150 pF	47 pF

When data rate is ≤ 20 MBd then $C9 = \left[\frac{1}{2\pi 800\,(Bd)}\right] - [4\,(pF)]$

When data rate ≥ 20 MBd delete C9.

Attributes:

1) Intended for applications that use encoded data.
2) No analog circuit design needed.
3) No printed circuit design needed.
4) Printed circuit design can be electronically imported from
   web address:-
   http//www.agilent.com/Agilent-COMP/fiber/fiber_index.html#gerber
   by downloading rll70.exe
   Electronic files contain:
   a) Transceiver schematic
   b) Printed circuit artwork
   c) Material list
5) No adjustments needed.
6) No receiver overdrive with short fiber-optic cables.
7) Uses low-cost off-the-shelf integrated circuits from Fairchild and Micro Linear.
8) One transceiver design can be used to address a wide range of applications.
9) Can be used with 1 mm dia. POF for lowest cost, 200 µm HCS, 62.5/125 µm multimode glass or 9/125 single-mode glass optical fibers for greater distances.
10) POF or HCS fiber connectors can be field terminated in less than 1 minute.
   For POF use the HFBR-4531 connector, for HCS fiber use HFBR-4521 connector.

References:

1) HFBR-0507 Series data sheet, Agilent pub. # 5965-6114E.
2) HFBR-0400 Series data sheet, Agilent pub. # 5965-1655E.
3) HFBR-0300 Series data sheet, Agilent pub. # 5965-3611E.
4) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E.
5) Plastic Optical Fiber and HCS® Fiber Cables and Connectors,
   Agilent pub # 5963-3711E.
6) Application Note 1122, Agilent pub. # 5966-1270E

Solution for 20 to 160 MBd +5V ECL (PECL) Data at Distances between 0 and 6 kilometers. (Pages 20-22)

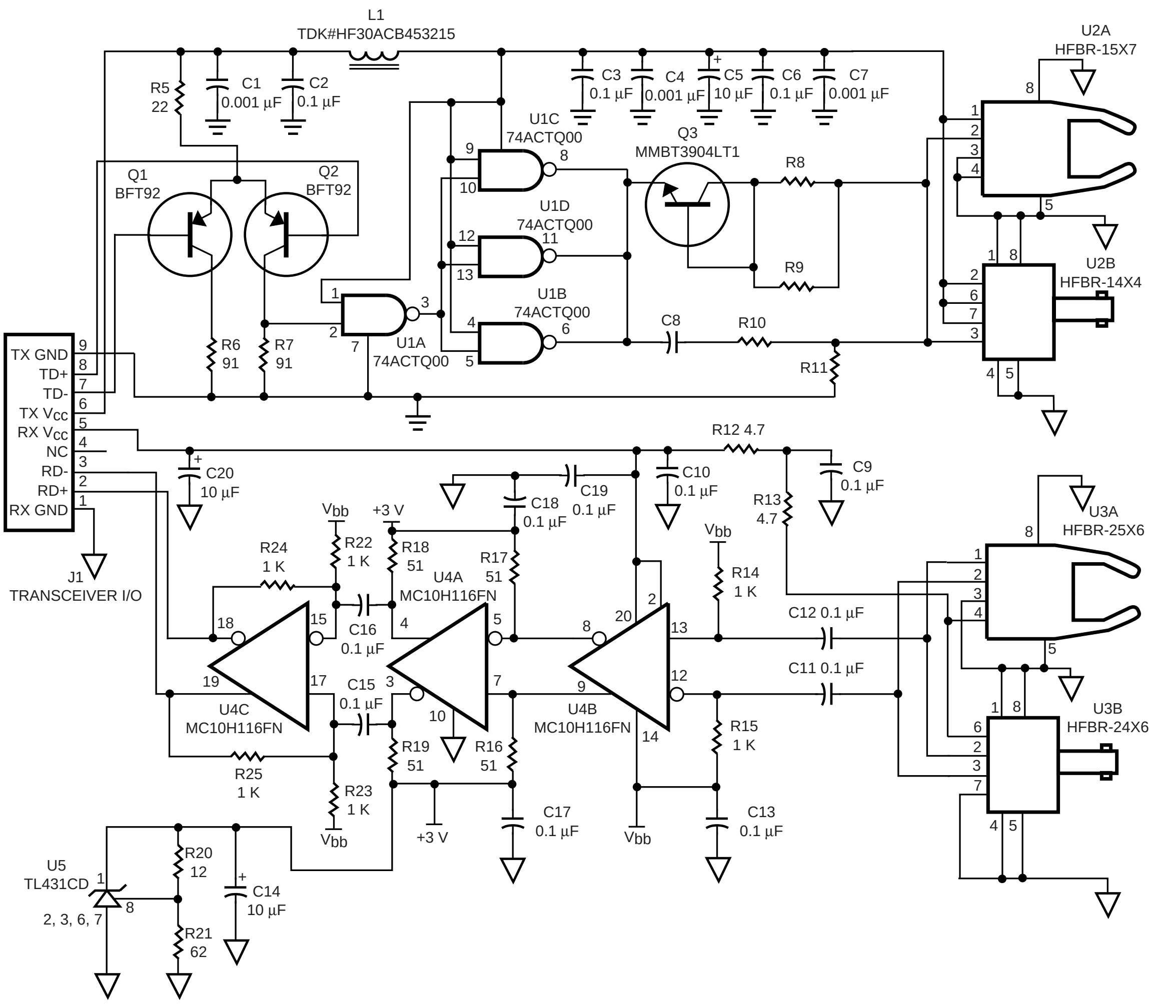

Figure 14. Transceiver Circuit

Table 4. Transceiver Component Values

DISTANCE @ 160 MBd	0 to 50 meters	0 to 50 meters	0 to 500 meters	0 to 2K meters	0 to 6K meters
TRANSMITTER	HFBR-15X7 650 nm LED	HFBR-15X7 650 nm LED	HFBR-14X4 820 nm LED	HFBR-13X2T 1300 nm LED	HFBR-1315 1300 nm ELED
RECEIVER	HFBR-25X6	HFBR-25X6	HFBR-24X6	HFBR-23X6	HFBR-2315
FIBER TYPE	1 mm Plastic	200 µm HCS	62.5/125 µm	62.5/125 µm	9/125 µm
R8	301 Ω	82.5 Ω	84.5 Ω	78.7 Ω	53.6 Ω
R9	301 Ω	82.5 Ω	84.5 Ω	78.7 Ω	53.6 Ω
R10	15 Ω	15 Ω	56 Ω	47 Ω	33 Ω
R11	1K Ω	475 Ω	2.2K Ω	∞	1.2K Ω
C8	43 pF	120 pF	33 pF	56 pF	56 pF

Note the transceiver only requires a +5V power supply. The receiver circuit's +3 V bus is created using the TL431CD shunt regulator, and Vbb, which equals +3.7 V, is a bias source located within the MC10H116FN.

Attributes:

1) Intended for applications that use encoded data.
2) Can be used with off-the-shelf physical layer chips such as the Cypress HOTLink™ to build low-cost byte-to-light protocol-independent data communication links.
3) No analog circuit design needed.
4) No printed circuit design needed.
5) Printed circuit design can be electronically imported from web address:-
   http//www.agilent.com/Agilent-COMP/fiber/fiber_index.html#gerber
   by downloading raftv3.exe
   Electronic files contain:
   a) Transceiver schematic
   b) Printed circuit artwork
   c) Material list
6) No adjustments needed.
7) No receiver overdrive with short fiber-optic cables.
8) Uses low-cost off-the-shelf integrated circuits from Fairchild, Motorola, and Texas Instruments.
9) One transceiver design can be used to address a wide range of applications.
10) Can be used with 1 mm dia. POF for lowest cost, 200 µm HCS, 62.5/125 µm multimode glass or 9/125 single-mode glass optical fibers for greater distances.
11) POF or HCS fiber connectors can be field terminated in less than 1 minute. For POF use the HFBR-4531 connector, for HCS fiber use HFBR-4521 connector.

References:

1) HFBR-0507 Series data sheet, Agilent pub. # 5965-6114E.
2) HFBR-0400 Series data sheet, Agilent pub. # 5965-1655E.
3) HFBR-0300 Series data sheet, Agilent pub. # 5965-3611E.
4) HFBR-4531/4532 Crimpless Connector data sheet, Agilent pub # 5965-1659E.
5) Plastic Optical Fiber and HCS® Fiber Cables and Connectors, Agilent pub # 5963-3711E.
6) Application Note 1123, Agilent pub. # 5968-5927E

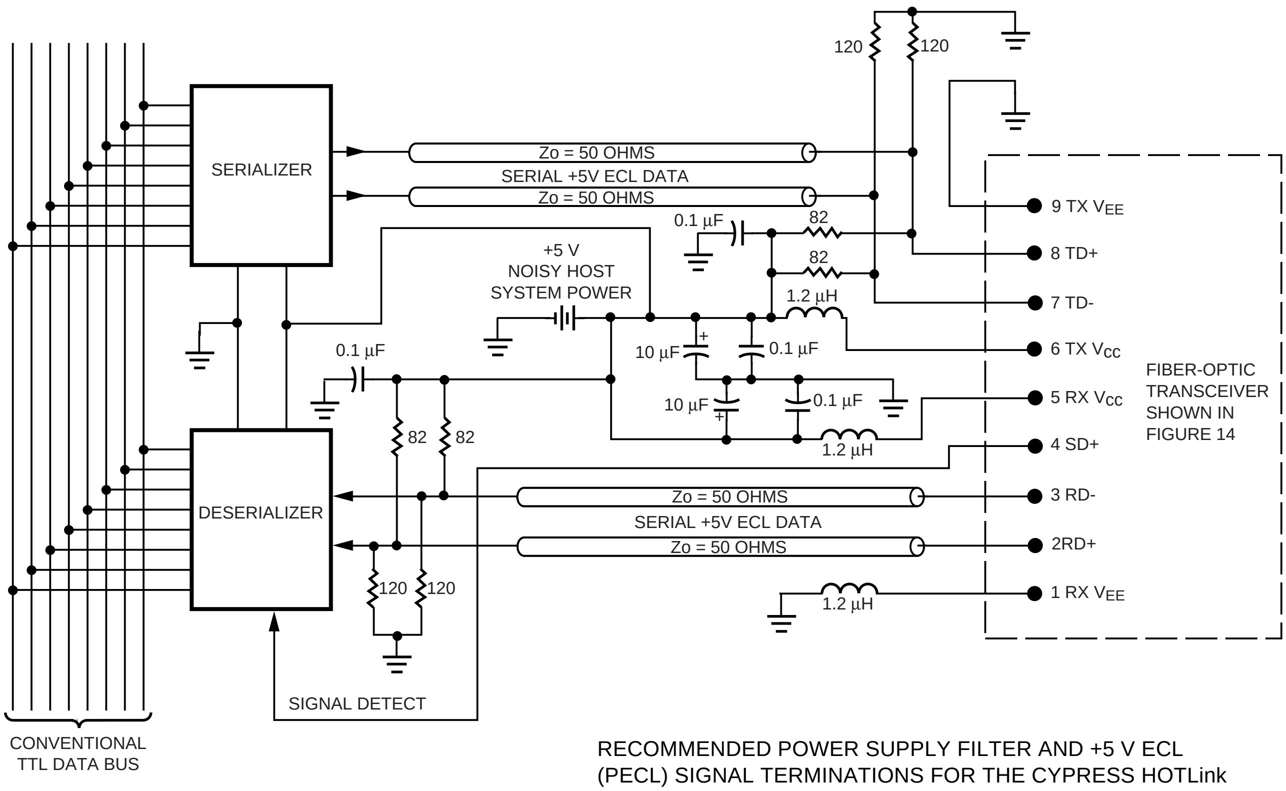

Figure 15. Byte-to-light interface between PECL-compatible fiber-optic transceivers and off-the-shelf PHY chips, such as Cypress Semiconductor's HOTLink™.

Distance vs. Data rate HFBR-14X4 and HFBR-24X6, PECL Transceiver with 62.5 μm Fiber

Figure 16 shows the distances and data rates achievable when Agilent's HFBR-14X4 and HFBR-24X6 820 nm components are used with 62.5/125 μm graded index multimode glass fibers.

To obtain this performance the recommended circuits shown in Application Bulletin 78, or Application Note 1123, **MUST** be used.

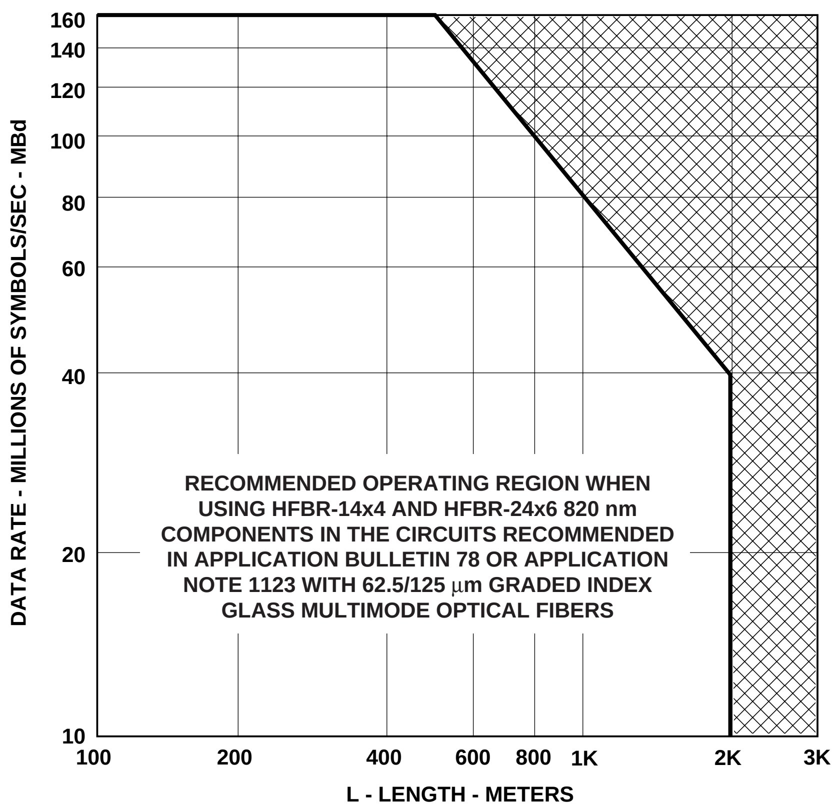

Figure 16.

Distance vs. Data rate HFBR-14X4 and HFBR-24X6, TTL Transceiver with 62.5 μm Fiber

Figure 17 shows the distances and data rates achievable when Agilent's HFBR-14X4 and HFBR-24X6 820 nm components are used with 62.5/125 μm graded index multimode glass fibers.

To obtain this performance the recommended circuits shown in Application Note 1038, Application Note 1065, or Application Note 1122 **MUST** be used.

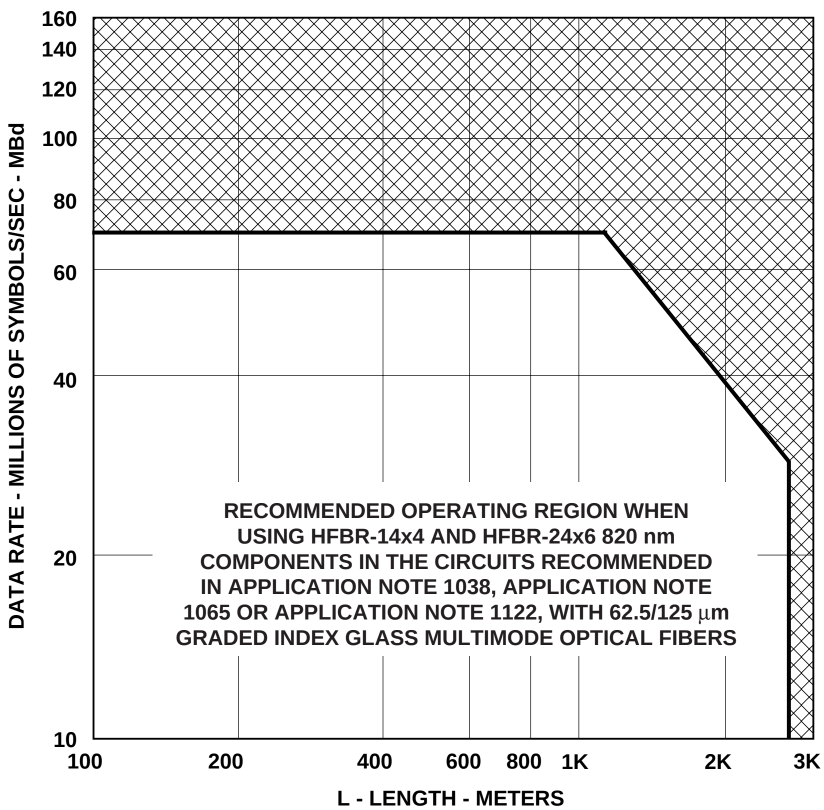

Figure 17.

Distance vs. Data rate HFBR-15X7 and HFBR-25X6, PECL Transceiver with 1 mm POF Fiber

Figure 18 shows the distances and data rates achievable when using Agilent's HFBR-15X7 and HFBR-25X6 650 nm components with low numerical aperture 1 mm diameter POF.

To obtain this performance the recommended circuits shown in Application Note 1066, or Application Note 1123, **MUST** be used.

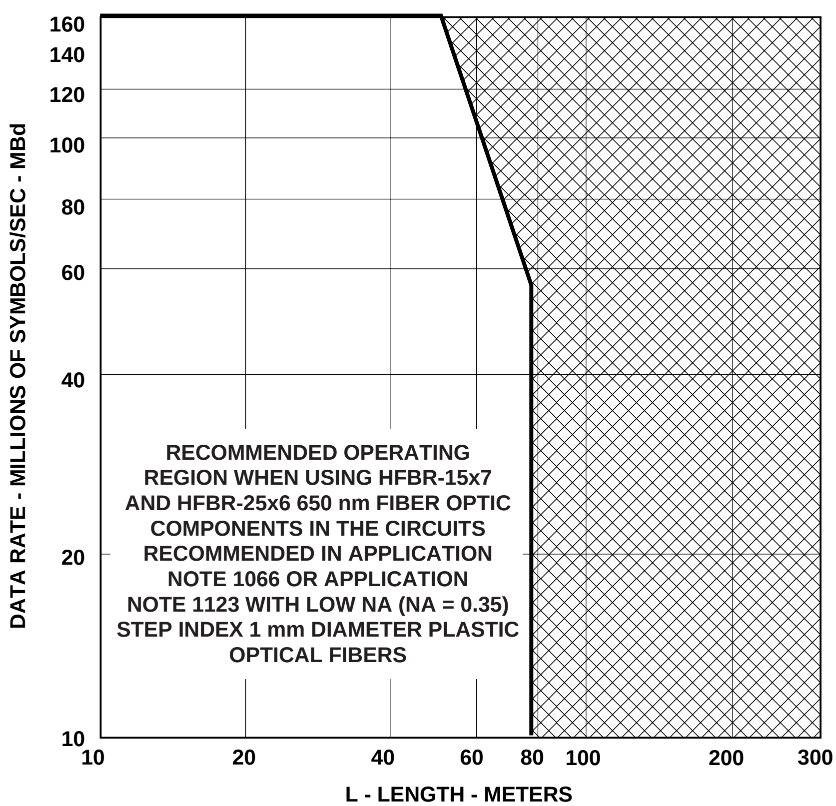

Figure 18.

Distance vs. Data rate HFBR-15X7 and HFBR-25X6, TTL Transceiver with 1 mm POF Fiber

Figure 19 shows the distances and data rates achievable when using Agilent's HFBR-15X7 and HFBR-25X6 650 nm components with low numerical aperture 1 mm diameter POF.

To obtain this performance the recommended circuits shown in Application Note 1122 **MUST** be used.

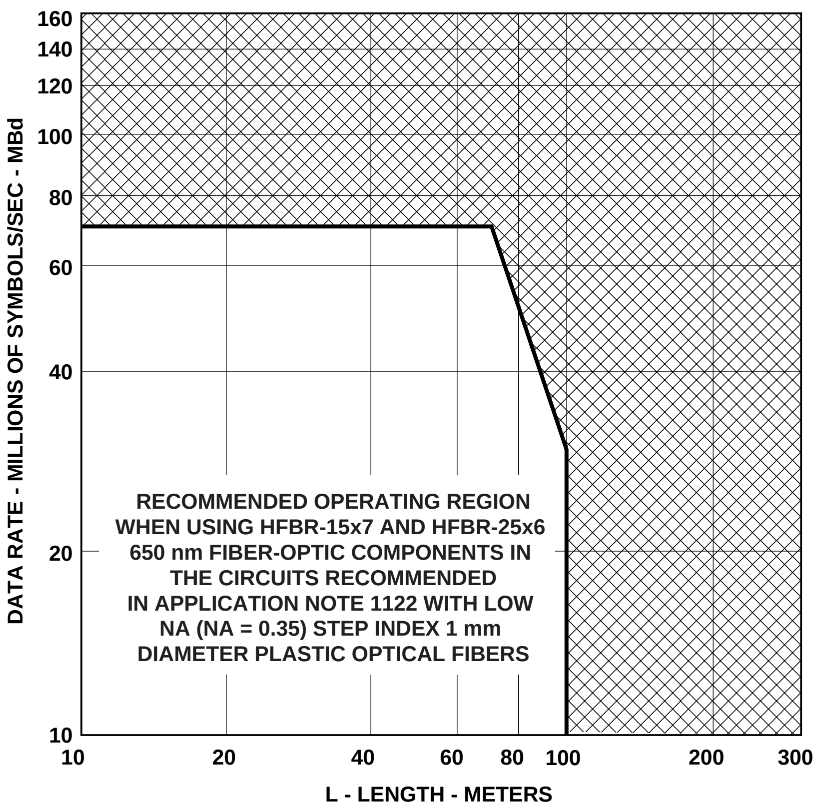

Figure 19.

Distance vs. Data rate HFBR-15X7 and HFBR-25X6, PECL Transceiver with 200 µm HCS Fiber

Figure 20 shows the distances and data rates achievable when using Agilent's HFBR-15X7 and HFBR-25X6 650 nm components with 200 µm diameter HCS.

To obtain this performance the recommended circuits shown in Application Note 1066, or Application Note 1123, **MUST** be used.

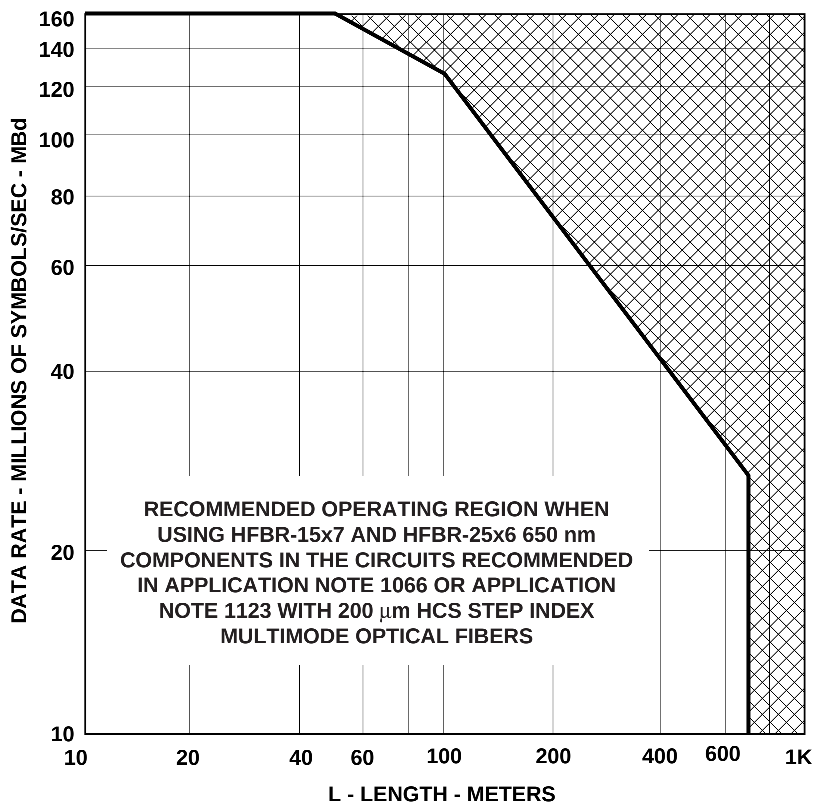

Figure 20.

Distance vs. Data rate HFBR-15X7 and HFBR-25X6, TTL Transceiver with 200 μm HCS Fiber

Figure 21 shows the distances and data rates achievable when using Agilent's HFBR-15X7 and HFBR-25X6 650 nm components with 200 μm diameter HCS.

To obtain this performance the recommended circuits shown in Application Note 1122 **MUST** be used.

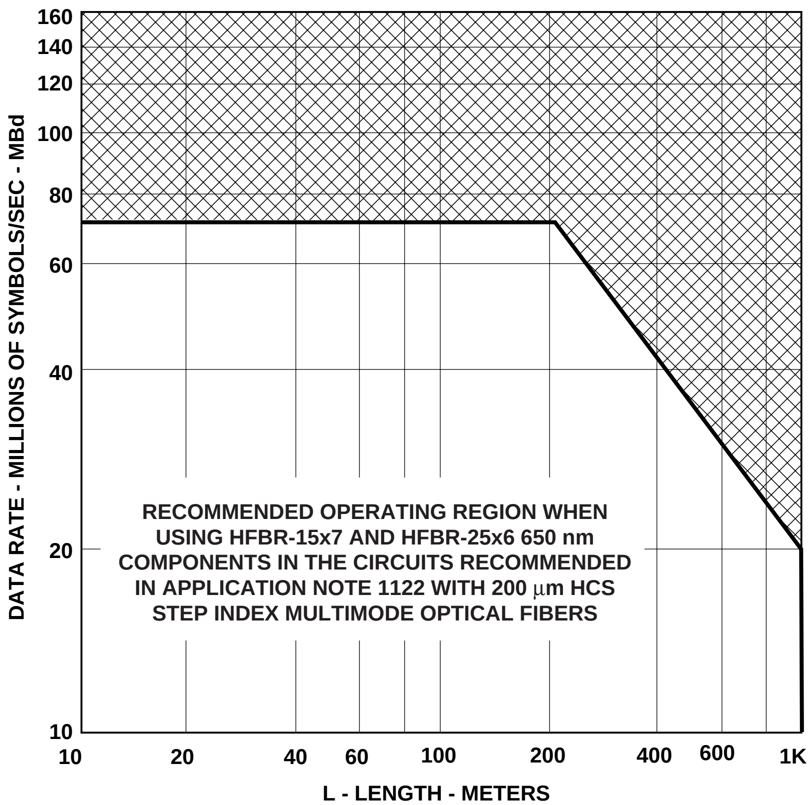

Figure 21.

Distance vs. Data rate HFBR-13X2 and HFBR-23X6, PECL Transceiver with 62.5 µm Fiber

Figure 22 shows the distances and data rates achievable when Agilent's HFBR-13X2 and HFBR-23X6 1300 nm components are used with 62.5/125 µm graded index multimode glass fibers.

To obtain this performance the recommended circuits shown in Application Note 1123 **MUST** be used.

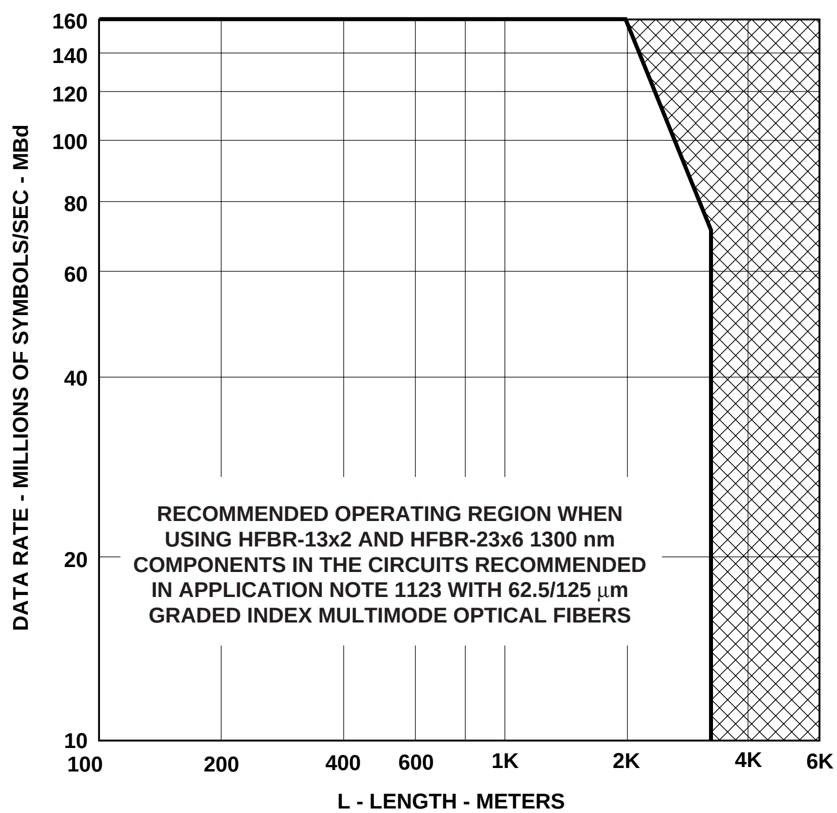

Figure 22.

Distance vs. Data rate HFBR-13X2 and HFBR-23X6, TTL Transceiver with 62.5 µm Fiber

Figure 23 shows the distances and data rates achievable when Agilent's HFBR-13X2 and HFBR-23X6 1300 nm components are used with 62.5/125 µm graded index multimode glass fibers.

To obtain this performance the recommended circuits shown in Application Note 1122 **MUST** be used.

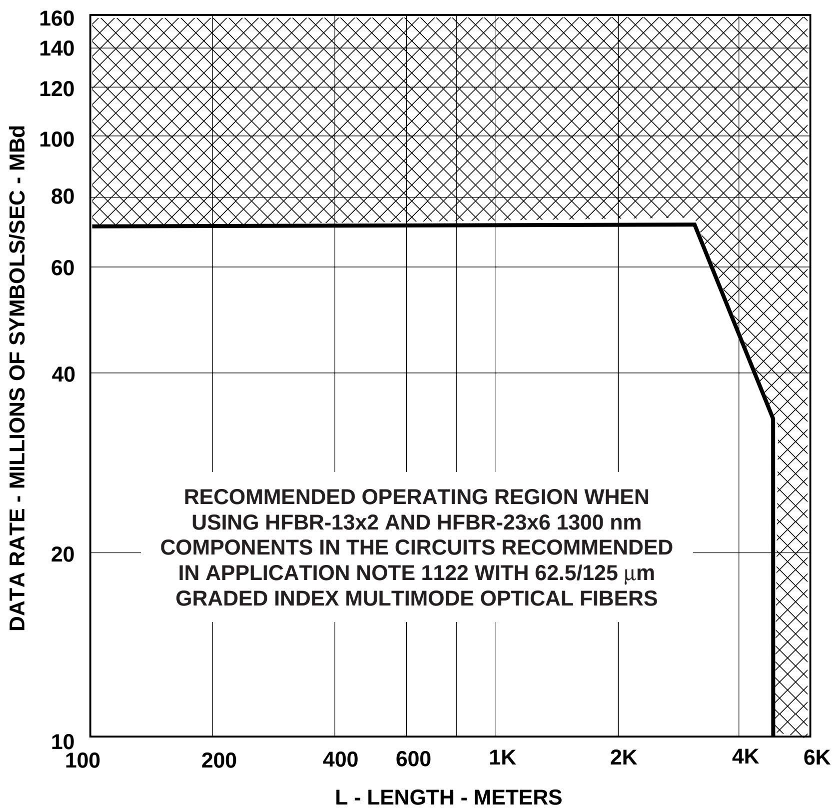

Figure 23.

Distance vs. Data rate HFBR-1315 and HFBR-2315, PECL Transceiver with 9 µm Fiber

Figure 24 shows the distances and data rates achievable when Agilent's HFBR-1315 and HFBR-2315 1300 nm components are used with 9/125 µm single-mode glass fibers.

To obtain this performance the recommended circuits shown in Application Note 1123 **MUST** be used.

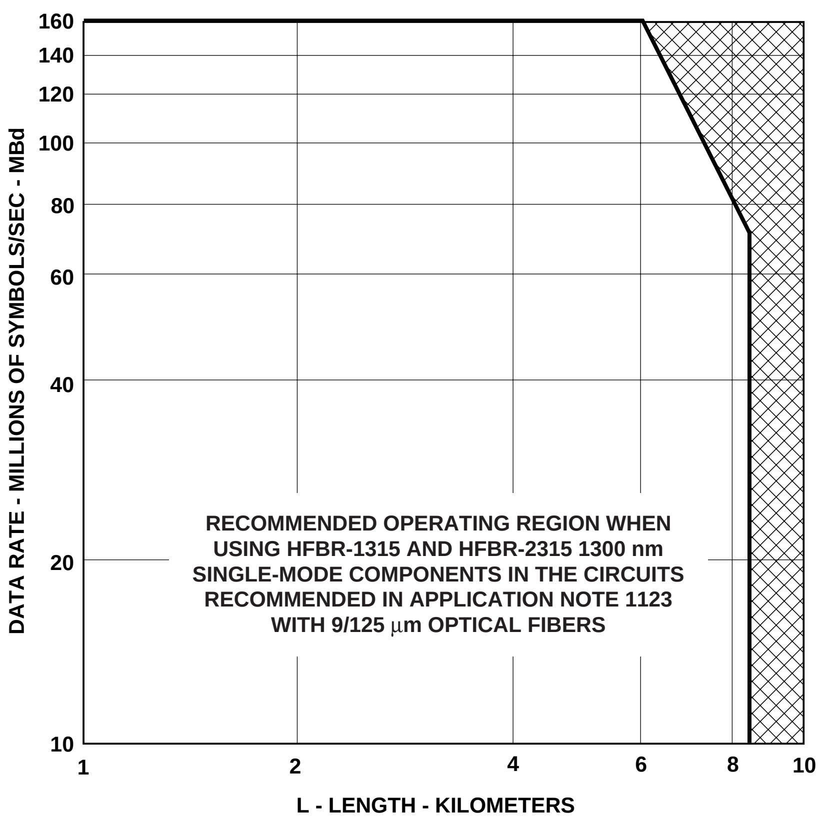

Figure 24.

Distance vs. Data rate HFBR-1315 and HFBR-2315, TTL Transceiver with 9 µm Fiber

Figure 25 shows the distances and data rates achievable when Agilent's HFBR-1315 and HFBR-2315 1300 nm components are used with 9/125 µm single-mode glass fibers.

To obtain this performance the recommended circuits shown in Application Note 1122 **MUST** be used.

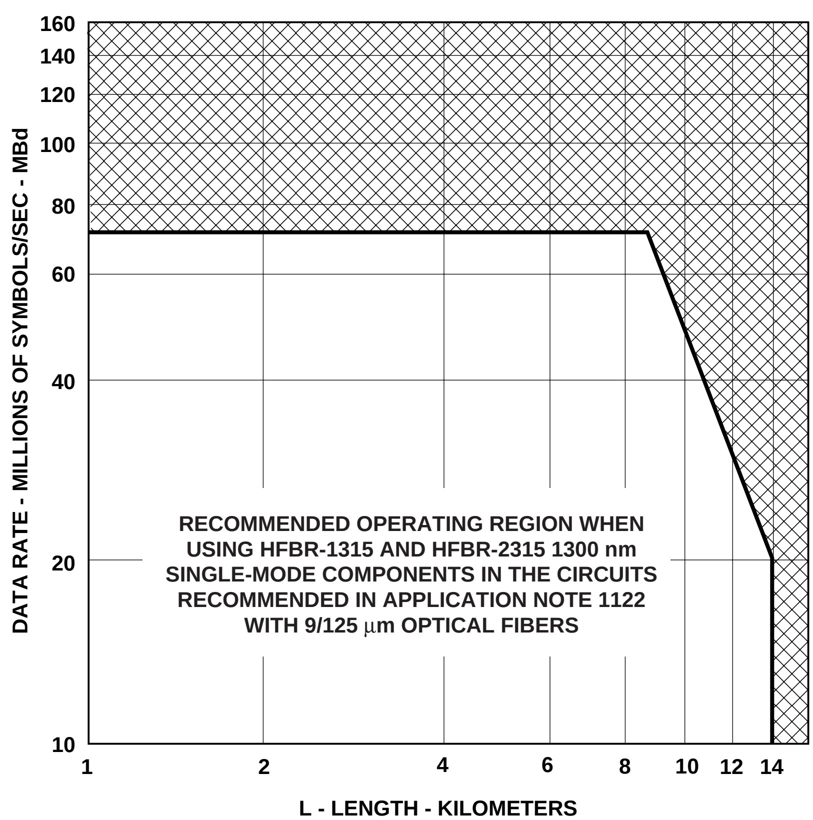

Figure 25.

Application Notes for Plastic and Glass Optical Fiber Components

Title

Low-Cost Fiber-Optic Links for Digital Applications up to 155 MBd (AB78)
Data Rate & Logic Interfaces 1 to 155 MBd ECL, +5V ECL (PECL), TTL

Versatile Link (AN 1035)
Data Rate & Logic Interfaces dc to 5 Mbd TTL, CMOS

Fiber-Optic Solutions for 125 MBD Data Communication Applications at Copper Wire Prices (AN 1066)
Data Rate & Logic Interfaces 1 to 155 MBd +5V ECL (PECL)

DC to 10 MBd Versatile Link (AN 1080)
Data Rate & Logic Interfaces dc to 10 MBd TTL, CMOS

DC to 32 MBd Fiber-Optic Solutions for Industrial, Medical, Telecom, and Proprietary Data Communication Applications (AN 1121)
Data Rate & Logic Interfaces dc to 32 MBd TTL

2 to 70 MBd Fiber-Optic Solutions for Industrial, Medical, Telecom, and Proprietary Data Communication Applications (AN 1122)
Data Rate & Logic Interfaces 2 to 10 MBd TTL

20 to 160 MBd Fiber-Optic Solutions for Industrial, Medical, Telecom, and Proprietary Data Communication Applications (AN 1123)
Data Rate & Logic Interfaces 20 to 160 MBd +5V ECL (PECL)

Generic Printed Circuit Layout Rules for Agilent's Low-Cost Fiber-Optic Components (AN 1137)

Best Practices for Using Fiber-Optic Components (Common Do's and Don'ts)

#	Do's	Don'ts
1	Whenever possible use the circuits recommended in Agilent's published application notes.	Avoid changing the recommended circuits. Small changes in circuit topology can dramatically impact the performance of the fiber-optic data link.
2	When possible use the components recommended in the material lists provided in Agilent's application notes	Do not change the recommended components. Component changes can dramatically impact the performance of the data communication link.
3	Use Agilent's printed circuit layout when it is compatible with internal construction/assembly techniques.	Don't assume circuit layout is trivial. If you must change the layout follow the design rules in AN-1137.
4	If you need to make circuit or component changes contact the Customer Response Center at 1-800-235-0312 to access the impact.	Don't assume that the changes you desire are harmless. The simple robust circuits shown in Agilent's published application notes took many man-years to develop.
5	Use the LED driver circuits recommended in Agilent's application notes.	Do not assume that LED driver design is trivial. The LED drivers in Agilent's application notes have been optimized to minimize cost and maximize performance.
6	Data communication LEDs should only be operated in forward biased or zero biased modes.	Data communication LEDs are not intended to be operated in the reversed biased mode.
7	Forward bias current must be limited to a value less than the absolute maximum value specified on Agilent's published data sheets. When connected to a voltage source a series current limiting resistor is required.	Do not connect LEDs directly to voltage sources. LEDs are current operated devices, so excessive current can flow when directly connected to a low impedance voltage source.
8	Be careful when using in circuit (bed of nails) testers. In circuit testers with adjustable current limits must be set to values less than the absolute maximum current allowed by the LED's data sheet. Use external resistors to limit the current applied if the in circuit tester does not have programmable current limits.	Do not assume that the ac stimulus sources embedded inside your in circuit tester are safe to use with data communication LED transmitters. LEDs are current operated devices that can be electrically overstressed when directly connected to voltage sources.

#	Do’s	Don’ts
9	Semi-discrete fiber-optic receivers can be damaged by in circuit testers. Limit the amplitude to 100 mV peak-to-peak if you want to apply ac stimulus at the input stage of the receiver’s post-amplifier comparator (quantizer).	Do not assume that the ac stimulus applied by your in circuit tester can safely be connected to quantizer’s input. In circuit testers can apply 5-volt logic compatible signals that will damage the output stage of the PIN pre-amp hybrid circuit used as the first stage of the semi-discrete receiver.
10	The PECL logic outputs of high-speed fiber-optic receivers could potentially be damaged by in circuit testers. When testing the PECL compatible inputs of physical layer integrated circuits restrict ac stimulus to less than 100 mV peak-to-peak.	Do not assume that the ac stimulus applied by your in circuit tester can safely be connected to the physical layer chip’s serial input. In circuit testers can apply 5-volt logic compatible signals that could potentially damage the output stage of PECL compatible receiver circuits.
11	Use the recommended power supply filter circuits shown in Agilent’s published application notes.	Do not disregard Agilent’s power supply filter recommendations.
12	If you use a switching power supply know the frequency it operates at and check to see if additional power supply filtering is needed at that frequency.	Do not assume that Agilent’s recommended filter circuit will protect the fiber-optic transceiver from a noisy switching power supply.
13	If your system contains other low-frequency noise sources be sure that your system contains enough power supply filtering to control power supply ripple.	Do not assume that Agilent’s recommended filter circuit will protect the fiber-optic transceiver from low frequency noise sources. Agilent’s recommended power supply filters are very effective against noise at frequencies greater than 1 MHz.