



APPLICATION NOTES

ELECTRICAL AND LAYOUT CONSIDERATIONS FOR 1553 TERMINAL DESIGN

INTRODUCTION

MIL-STD-1553B defines a terminal as "The electronic module necessary to interface the data bus with the subsystem and the subsystem to the data bus..." By definition, the terminal includes the isolation transformer as well as the analog transmitter/receiver and the digital protocol section.

Design of the terminal, therefore, includes selection and interconnection of the isolation transformer. In order to ensure proper terminal operation in compliance with the 1553 standard, there are a number of issues that need to be considered in this area.

Since most current terminal designs use integrated components such as a Small Terminal Interface Circuit (STIC) or Advanced Communications Engine (ACE), this application note will concentrate on the electrical and layout issues between the hybrid transceiver pins, the isolation transformers, and the system connector. Other matters discussed involve power distribution, layout strategy,

grounding, decoupling capacitors, and transceiver-related issues.

ISOLATION TRANSFORMERS

Figure 1 illustrates the interface between the various versions of the ACE and STIC series hybrids to a 1553 data bus. Connections for both direct (short stub) and transformer (long stub) coupling, as well as the peak-to-peak voltage levels that appear at various points (when transmitting) are indicated in the figure.

Table 1 lists the characteristics of the required isolation transformers for the various ACE hybrids and lists the DDC and Beta Transformer Technology Corporation (BTTC) corresponding part numbers, as well as the MIL (DESC) drawing number (if applicable). BTTC is a direct subsidiary of Data Device Corporation.

For both coupling configurations, the transformer that interfaces directly to the

ACE component is called the isolation transformer. As stated above, this is defined to be part of the terminal. For the transformer (long stub) coupling configuration, the transformer that interfaces the stub to the bus is the coupling transformer.

The turns ratio of the isolation transformer varies, depending upon the peak-to-peak output voltage of the specific ACE or STIC terminal. MIL-STD-1553B specifies that the turns ratio of the coupling transformer be 1.0 to 1.4.

The transmitter voltage of each model of the BU-65170/61580 or BUS-65153 varies directly as a function of the power supply voltage. The turns ratios of the respective transformers will yield a secondary voltage of approximately 28V p-p on the outer taps (used for direct coupling) and 20V p-p on the inner taps (used for stub coupling).

It should be noted that for the 15V or 12V ACE hybrids (BU-65170/61580X1[2]) or

TABLE 1. RECOMMENDED ISOLATION TRANSFORMERS

ACE, STIC PART NUMBERS	Turns Ratio		Recommended Transformer	
	Direct Coupled	Transformer Coupled	Plug-In	Surface Mount
BU-65170/61580X1, BUS-65153	1.41:1	2:1	BUS-25679, B-2203, M21038/27-02	B-2387, M21038/27-12, B-2343, M21038/27-17, LPB-5002, LPB-5009, HLP-6002, HLP-6009
BU-65170/61580X2, BUS-65154	1:0.83	1:0.60	BUS-29854, B-2204, M21038/27-03	BU-2388, M21038/27-13, B-2344, M21038/27-18, LPB-5004, LPB-5011, HLP-6004, HLP-6011
BU-65170/61580X3(6)	1:2.5	1:1.79	B-3067	B-3072
BU-61590, BUS-63149	1:1	1.41:1	BUS-27765, B-2202, DESC M21038/27-01	B-2386, B-2342, DESC M21038/27-11, DESC M21038/27-16, LPB-5003, LPB-5010, HLP-6003, HLP-6010

- Notes:**
- (1) The turns ratio for the direct coupled taps for the B-2204, B-2388, and B-2344 transformers varies slightly from that of the BUS-29854 transformer. They do, however, have the same turns ratios for transformer coupling. For transformer coupled applications, any of the transformers may be used.
 - (2) The transceiver in the BUS-65164(64), BU-65170X2, BU-61580X2 was designed to work with a 1:0.83 turns ratio for direct coupled applications.
 - (3) For direct coupled applications, the 1:0.83 turns ratio is recommended, but the 1.25:1.0 ratio may also be used. The 1.25:1.0 turns ratio will result in a slightly lower transmitter amplitude (approximately 4% lower) and a corresponding 4% decrease in the ACE's or STIC's receiver.

STIC (BUS-65153[54]), the isolation transformer has a step-down turns ratio in going from the ACE (STIC) to the stub. For the 5V ACE hybrids (BU-65170/61580X3), the isolation transformer has a step-up turns ratio in going from the ACE to the stub.

ISOLATION RESISTORS

For both coupling configurations, an isolation resistor is required to be in series with each leg connecting to the 1553 bus. This protects the bus against short circuit conditions in the transformers, stubs or terminal components.

For the direct coupled configuration, note that there is a 55 ohm isolation resistor in series with each transformer leg on the stub side. MIL-STD-1553B requires the isolation resistors to protect the bus from a short circuit condition in the stub path,

isolation transformer, or transceiver. This allows the 1553 bus to continue operating in the event of a short circuit in the terminal.

As stated in MIL-STD-1553B Notice 2, only the Navy permits the use of direct coupling. Both the Army and the Air Force permit only stub coupling to be used. For almost all system applications, transformer (stub) coupling is preferred over direct coupling.

ADVANTAGES OF TRANSFORMER COUPLING

Some of the advantages of transformer coupling are:

- (1) Looking from the 1553 bus towards the stub, the effect of the 1.4 to 1.0 stepdown ratio of the coupling trans-

former will be to double the impedance of the stub/terminal combination, as seen by the bus. Since the stub impedance decreases as a function of stub length due to distributed cable capacitance, this doubling effect serves to reduce the amount of impedance loading on the bus by individual terminals. Heavy stub loading can degrade bus performance by increasing reflections and reducing signal voltages. Stub coupled terminals may be located up to 20 feet from the bus; the distance for direct coupled terminals is limited to 12 inches.

- (2) For a stub-coupled terminal, the impedance seen looking into the stub side of the bus coupling transformer is Z_0 , assuming that the impedance of the coupling transformer is much higher than the bus impedance Z_0 (70 to 85 ohm).

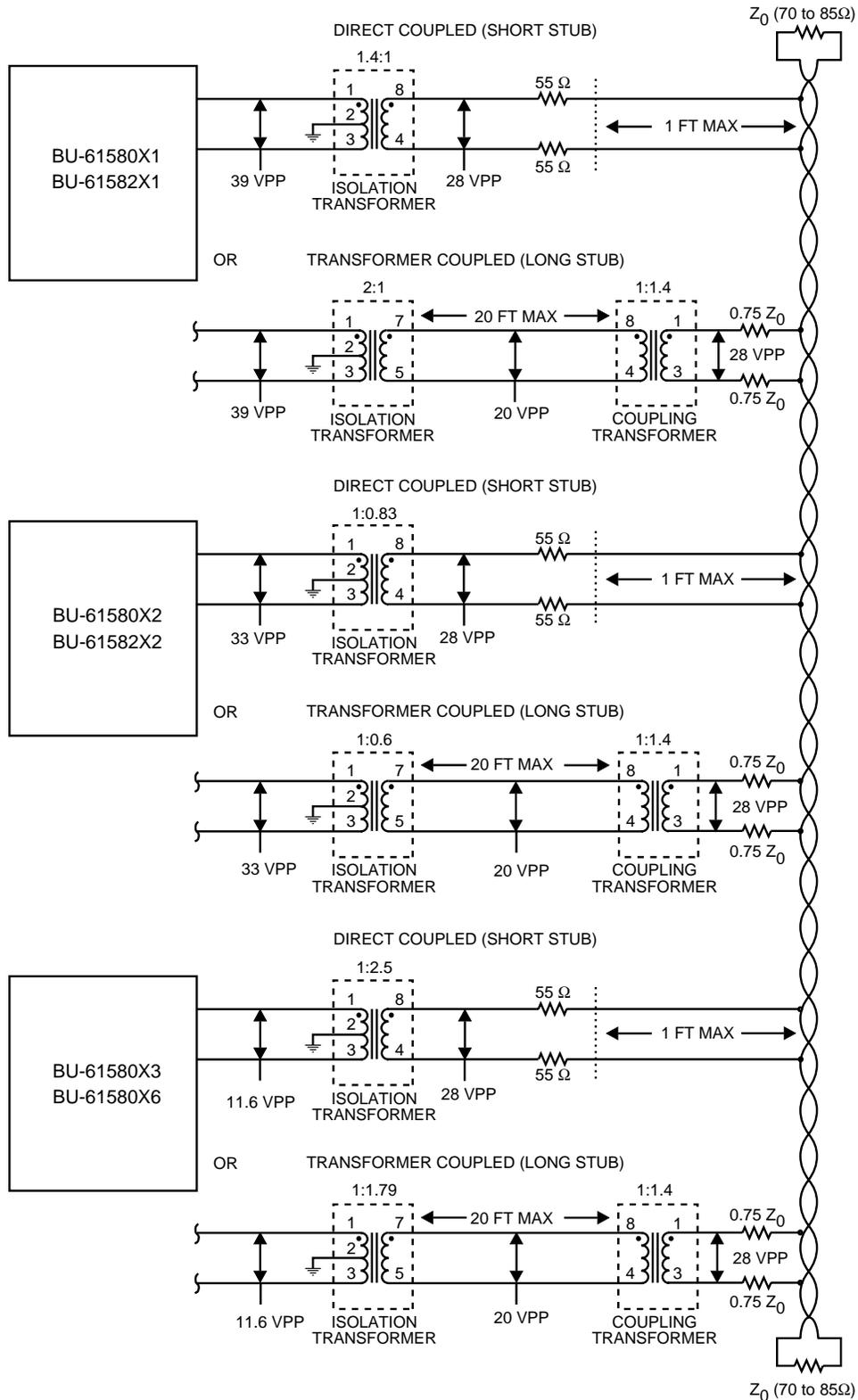
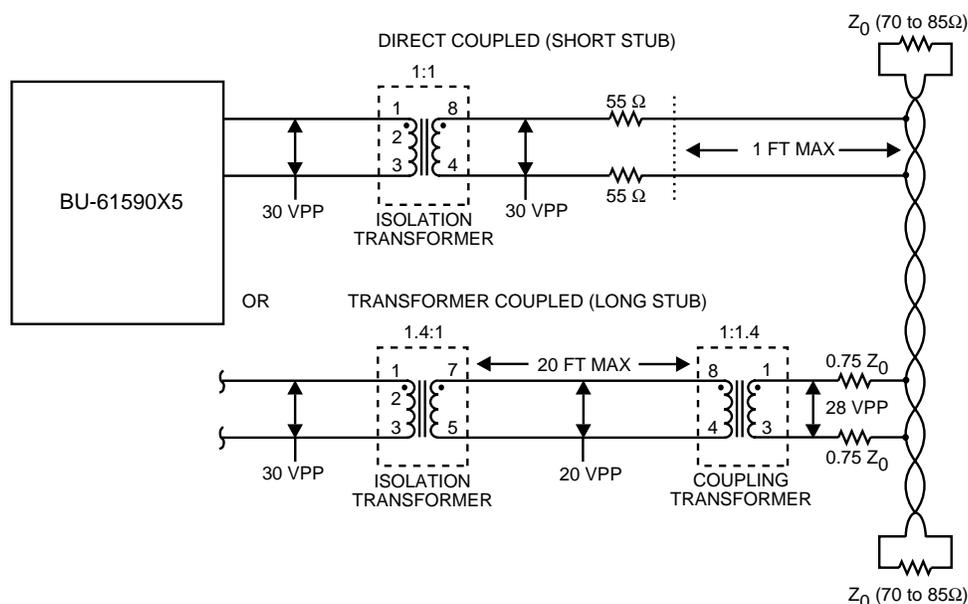


FIGURE 1. ACE/STIC, BUS-66549 INTERFACES TO 1553 BUS (CONTINUED ON NEXT PAGE)



Notes:

- (1) Shown for one of two redundant buses that interface to the BU-65170/61580 or BUS-65163.
- (2) Transmitted voltage level on 1553 bus is 6 Vp-p min, 7 Vp-p nominal, 9 Vp-p max.
- (3) Required tolerance on isolation resistors is $\pm 2\%$. Instantaneous power dissipation (when transmitting) is approximately 0.5 W (typ), 0.8 W (max).
- (4) Transformer pin numbering is correct for the DDC (e.g., BUS-25679) transmitters. For the Beta transformers (e.g., B-2203), or the QPL-21038-31 transformers (e.g., M21038/27-03), the winding sense and turns ratio are mechanically the same, but the pin numbering is reversed, therefore, it is necessary to reverse pins 8 and 4 or pins 7 and 5 for the Beta or QPL transformers. (Note: DDC part numbers begin with a BUS- prefix, while Beta transformer part numbers begin with a B- prefix.)

FIGURE 1. ACE/STIC, BUS-66549 INTERFACES TO 1553 BUS (CONTINUED FROM PREVIOUS PAGE)

1553B requires that the coupling transformer have a minimum impedance of 3k ohm, looking from the bus side. Therefore, the characteristic impedance of the stub cabling (78 ohm nominal) matches the stub's load impedance, minimizing reflections back toward the transmitter.

- (3) In a direct coupled terminal, the main bus is not protected against a short circuit in the stub cabling. For the transformer coupled case, the bus is protected against such a fault.
- (4) A transformer coupled terminal provides improved dc and common mode isolation over a direct coupled terminal.

TRANSFORMER CONNECTIONS

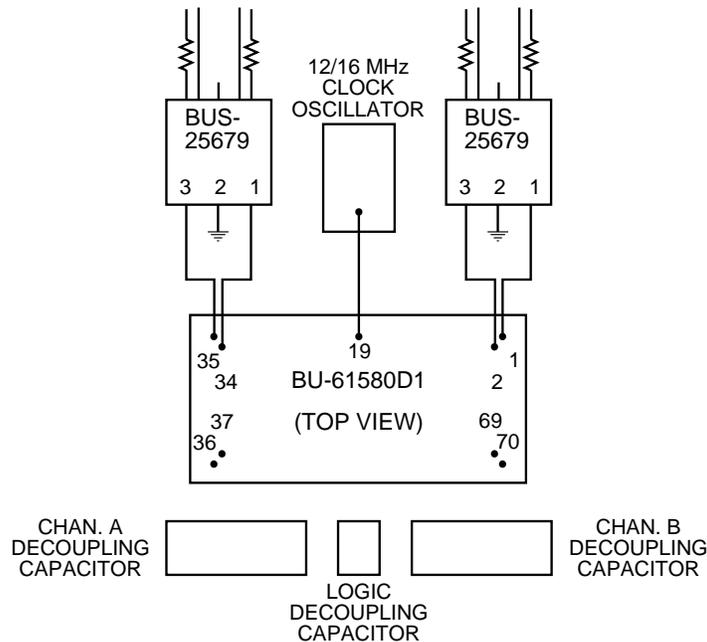
With the exception of the BU-61590 Universal ACE and the BUS-65149 RT, it is important to note that the transformer center tap on the "ACE" or "STIC" side, pin 2, must be grounded. The reason for this is that, at any point in time only one transformer leg is actively driven when the ACE (STIC) is transmitting. There is no instantaneous current in the alternate leg. Autotransformer action will result in an equal voltage excursion of the opposite polarity on the alternate leg of the transformer.

Using the BU-61580X1 as an example, during the first half of a Command/Status sync pulse, no current flows from TX/RX,

while $\overline{TX/RX}$ is driven to approximately -10V. Due to the autotransformer inductance TX/RX will swing to about +10V. The resulting primary voltage is nominally 20V peak, or about 40Vp-p.

For the BU-61590 Universal ACE and the BUS-65149RT hybrid, the transformer center tap, pin 2, MUST NOT be grounded. The transmitters in these hybrids include complimentary outputs that drive both transformer legs simultaneously (with the opposite signal polarity).

If the transformer center tap is grounded, there is a strong possibility that there will be a "dynamic offset" voltage (residual voltage) following the end of transmission by the BU-61590 or BUS-65149.



Notes:

- (1) Physical spacing between ACE (STIC) transformers must be kept to a minimum.
- (2) There must be **NO GROUND OR POWER SUPPLY PLANES** underneath the signal traces running to or from the transformers.
- (3) The grounds for the analog and digital sections of the ACE (STIC) are not connected internally.

FIGURE 2. SUGGESTED PC BOARD LAYOUT

LAYOUT CONSIDERATIONS

Figure 2 illustrates the suggested PC board layout for the BU-61580D1 version (+5/-15V) of the ACE hybrid, two BUS-25679 (or equivalent) transformers, the clock oscillator (16 or 12 MHz), and decoupling capacitors.

With regard to the suggested layout of Figure 2, there are a number of important factors to consider relating to component placement, circuit routing, power distribution, grounding, and decoupling capacitors.

ISOLATION TRANSFORMERS

The isolation transformers should be located as physically close as possible to the respective TX/RX pins of the hybrid. When transmitting, the typical peak currents in the primary legs are 150 to 200 mA for a 15V or 12V transceiver or 450 to

500 mA for a 5V transceiver. Resistive and inductive voltage drops are minimized by providing widened traces and minimizing the length of the traces. This is particularly important for the 5V (only) ACE.

CROSSTALK

In addition to limiting the inductive and resistive voltage drops in the analog signal traces when transmitting, reducing the hybrid-to-transformer spacing serves to minimize crosstalk to the terminal's receivers from other signals on the board. Severe crosstalk can increase the terminal's word error rate above the maximum level of 10^{-7} allowed by MIL-STD-1553B. Another important precaution regarding crosstalk is to avoid running other analog and digital signal traces (particularly high-speed digital signals) in close proximity to the 1553 analog signal traces.

This applies to the signal traces on both sides of the transformer.

It is most critical to avoid routing other signals on layers of the PC board that are adjacent to and in parallel with the 1553 analog signals. Such signals can result in the worst case crosstalk.

GROUND PLANES

As is the rule in all high-speed digital circuits, it is a good practice to use ground and power supply planes under the ACE as well as the host processor and any digital "glue" logic.

However, it is very important that there be no ground and/or power supply planes underneath the analog bus signal traces. This applies to the TX/RX signals running between the hybrid and the isolation transformer as well as the traces

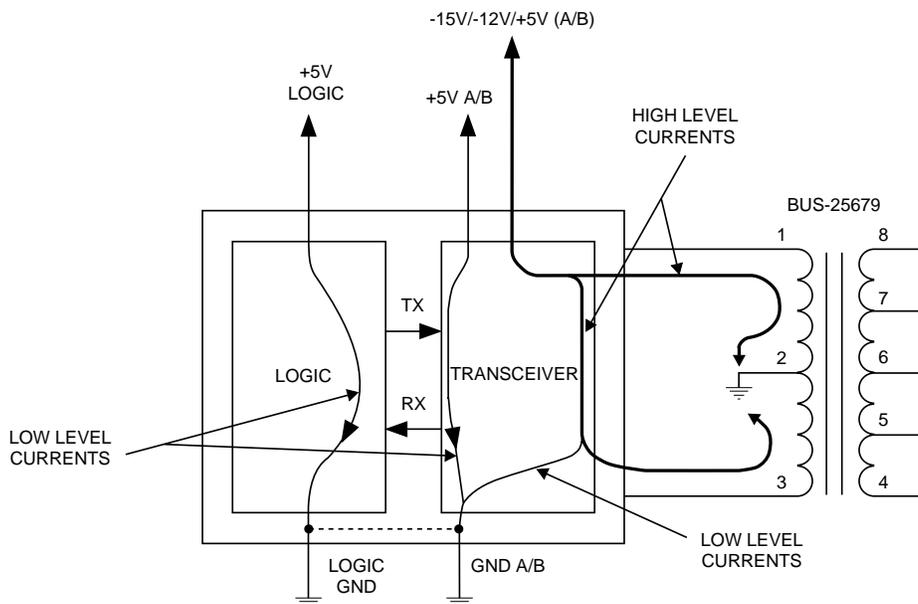


FIGURE 3. POWER/GROUND CURRENT DISTRIBUTION

between the transformers to any connectors or cables leaving the board.

The reason for avoiding running supply or ground planes under the analog signal traces is that the effect of the distributed capacitance will be to lower the input impedance of the terminal as seen from the MIL-STD-1553 bus. MIL-STD-1553B requires a minimum of 2k ohm input impedance for direct coupled terminals and 1k ohm for transformer (stub) coupled terminals. If there are ground planes under the analog signal traces, it is likely that the terminal will not meet this requirement. It has been found that placing a ground plane under the isolation transformers only slightly effects the input impedance. A ground and/or power plane may be placed under the transformers, if desired.

POWER AND GROUND DISTRIBUTION

Another important consideration for 1553 transceiver operation is power and ground distribution. Refer to Figure 3.

For the ACE (STIC) hybrid/transformer combination, the high current path when the ACE is transmitting will be from the -15V (or -12V or +5V) power supply, through the ACE's (STIC's) transmitter output stage, through one leg of the isolation transformer to the transformer center tap.

It is important to realize that the high current path is **through the transformer center tap and not through the ACE's (STIC's) GNDA and GNDB pins.**

Two exceptions to the operation described above are the BU-61590 universal terminal and the BUS-65149 RT hybrid. With these two units, it is important to note that the transmitter provides a differential output stage, actively driving both transformer legs with opposing polarity signals.

For the BU-61590 or BUS-65149, the transformer center tap must not be grounded. In this case, the heavy transmitter supply current runs from the

+15/12V (-15/-12V) supply, through the transformer primary and back to the -15/-12V (+15/-15V) supply. Like the other ACE and STIC units, there will not be a large transmitter return current flowing through GNDA and GNDB.

A worst-case system design should ensure that with minimum supply voltage and calculated voltage drops, the transceiver voltage provided between the ACE's (STIC's) transceiver supply pins and the center tap of the respective isolation transformer will be no less (in absolute value) than the specified minimum (-14.25V, -11.6V, or +4.75V).

In some cases, the voltage drop may be reduced by means of large decoupling capacitors, but the best practice is to minimize voltage drops in the power supply distribution.

ANALOG AND DIGITAL GROUNDS

It is important to note that the logic ground and transceiver grounds are connected together internally in the STIC or

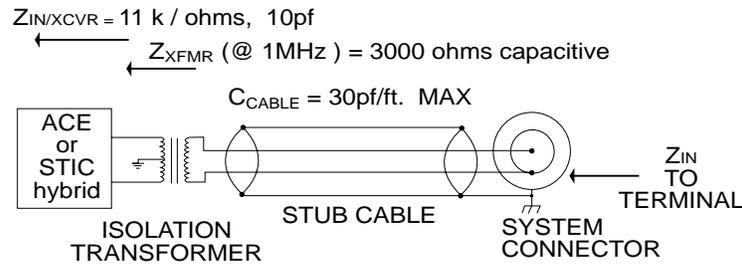


FIGURE 4. ISOLATION TRANSFORMER-TO-SYSTEM CONNECTOR IMPEDANCES

ACE hybrids. These grounds must be connected together externally.

As far as the ACE (STIC) and its associated isolation transformer are concerned, the optimal circuit layout would entail a single ground plane for both the digital and analog (transceiver) circuits. While this is sometimes possible, in many applications, there are system requirements for separate analog (-15/-12/+5 (analog)) and digital (+5V) power supply returns.

In this case, the transformer center tap should be connected through a low impedance path to the analog return, not the digital return.

This provides the advantage of separating the analog and digital ground currents. It is assumed that the two return paths are ultimately bonded with low impedance connections to the system ground near the power supply.

In order to minimize the possibility of ground noise corrupting the protocol/transceiver interface within the ACE (STIC), it is best that both the LOGIC GND pin as well as the GNDA and GNDB pins be connected to the logic ground as close as possible to the hybrid.

DECOUPLING CAPACITORS

When the ACE (or STIC) is transmitting, it is drawing relatively large pulsating currents from the active transceiver power

supply. For the -15V or -12V unit, this current will generally be in the range of 150 to 200 mA peak and can be as high as 300 mA. For a +5V unit, the peak current can be as high as 800 mA. The frequency content of the power supply current can include components in the ranges of DC to 30 kHz on the low end, and 500 kHz to 2 MHz (and above) on the high end.

Resistive and inductive voltage drops in the power distribution network can result in ripple voltages on the ACE's (STIC's) power supply inputs. It is strongly recommended that decoupling capacitors be used to reduce the level of the ripple voltage.

For the transceiver power inputs, it is generally necessary to use small decoupling capacitors to eliminate the high frequency (500 kHz to 2 MHz) power supply ripple. For -15V and -12V power inputs, 2.2 μ F low ESR/ESL capacitors should be sufficient. For the 5V only ACE, 6.8 μ F low ESR/ESL capacitors should be used.

If good power distribution practices are maintained, the small capacitors specified in the preceding paragraph should be sufficient. If, however, the trough of the ripple falls more than 5% below the nominal supply voltage, the transmitter output may fall below the minimum level of 6 Vp-p for a direct coupled output, 18 Vp-p for a MIL-STD-1553B transformer coupled

output, or 20 Vp-p for a MIL-STD-1760B transformer coupled output. In this case, a larger capacitor may be needed to sustain the minimum voltage level.

For the +5V LOGIC input and +5VA/B inputs (for a -15 or -12V ACE (STIC unit)), 0.01 μ F is generally sufficient.

Avoid Switching Power Supplies and DC-to-DC Converters.

The use of switching power supplies or DC-to-DC converters on the same board as the ACE or STIC hybrid should be avoided. The switching noise may result in poor performance of the ACE's (STIC's) transceiver. Some of the potential problems include high output noise as well as degraded zero-crossing tolerance and word error rate.

LOCATION OF CLOCK OSCILLATOR

As illustrated in Figure 2, the 16 MHz or 12 MHz clock oscillator should be located as close as possible to the ACE's (or STIC's) CLK IN input pin in order to minimize attenuation, distortion, and corrupting crosstalk of the clock signal. The duty cycle of the clock input should be between 40% and 60% in order to optimize operation of the Manchester decoders and processor/memory interface control logic. Some of these circuits utilize both edges of the clock input.



ELECTRICAL AND LAYOUT CONSIDERATIONS FOR 1553 TERMINAL DESIGN

ISOLATION TRANSFORMER INTERFACE TO SYSTEM CONNECTOR; INPUT IMPEDANCE CONSIDERATIONS

The general practice in connecting the stub side of a transformer (or direct) coupled terminal is to make use of 78 ohm twisted-pair shielded cable. This serves to minimize impedance discontinuities.

The decision of whether to isolate or make connections between the center tap of the isolation transformer's secondary, the stub shield, the bus shield, and/or chassis ground must be made on a system basis, as determined by an analysis of ESD, EM/RFI, and lightning considerations.

There is some controversy within the 1553 community as to where a terminal ends and a stub begins. The issue is not purely academic, since it has a profound effect on the testing of terminal input impedance. In order to pass the 1553 RT Validation Test Plan, a transformer (stub) coupled terminal must have an input impedance of at least 1k ohm over the frequency range from 75 kHz to 1 MHz. Paragraph 3.10 of MIL-STD-1553B asserts the definition of a terminal as "The electronic module necessary to interface the data bus with the subsystem and the subsystem to the data bus. Terminals may exist as separate line replaceable units (LRU's) or be contained within the elements of the subsystem."

For a transformer (stub) coupled terminal, it is the author's interpretation of Paragraph 3.10 (particularly the first sentence) that the terminal ends at the pins of the isolation transformer. This interpretation is consistent with Figures 9 and 10 in the 1553B standard. However, the armed services, faced with the practical task of testing and maintaining equipment, take a different interpretation. They

contend that the terminal includes the wiring path up to and including the system connector. As a result, the distributed capacitance of PC board and backplane traces, cabling and connectors are included in the impedance measurement.

For the -15V/+5V ACE and STIC hybrids the transceiver input impedance is specified as follows: 11k ohm min, 10 pF max. Reference Figure 4. This characterizes a differential measurement taken between the TX/RXA(B) and $\overline{\text{TX/RXA(B)}}$ pins of the hybrid. It includes both the transmitter and receiver (tied together internally), is applicable to both powered and unpowered conditions with power and ground pins connected, and assumes a 2 V_{rms} balanced, differential, sinusoidal input for making the impedance measurement.

At 1 MHz, 11k ohm and 10 pF represent a composite impedance of 9.05k ohms at -34.6°. Assuming an ideal ($Z_{in} = \infty$) 2:1 isolation transformer for a transformer coupled terminal, this reflects an impedance of 2.26k ohms at -34.6° on the stub side. Note this is "worst case." Typical numbers are about twice as high.

The -34.6° phase angle indicates a reflected ACE (STIC) input impedance that is somewhat more resistive than capacitive. The impedances of all the other elements in the path — the isolation transformer, PC board and backplane traces, cable, and connector — are capacitive. These capacitances add in parallel to form the "terminal's" input impedance (as defined by the armed services).

Assuming the worst case parameters for the ACE (STIC), these elements must have a minimum parallel impedance of 1.47k ohm (capacitive) to keep the parallel impedance of the "terminal" above 1k ohm. At 1 MHz, the highest frequency required for the 1553 impedance test, this translates to a maximum capacitance of

108 pF. Since most 1553 isolation transformers specify an input impedance of at least 3k ohms (some are higher), representing about 53 pF, this allows about 55 pF for the rest of the signal path. MIL-STD-1553B specifies that the cable capacitance of the bus cable be less than 30 pF/ft. 55 pF represents 1.8 feet of such "worst case" cable.

In order to ensure that the "terminal" input impedance complies with MIL-STD-1553B, it is important to try to minimize the distributed capacitance between the 1553 signals and ground. To achieve this, the length of internal stub wires must be kept to the shortest length possible. If this is not possible, approaches that can be used include not grounding the cable shield or using unshielded twisted pair cable.

Another approach is to use a pair of wires, rather than a twisted/shielded pair. In this case, the effect of the bus signals coupled from the unshielded wires on the rest of the system performance must be considered as a tradeoff against the benefit of the increased terminal impedance.

"SIMULATED BUS" (LAB BENCH) INTERCONNECTIONS

For purposes of software development and systems integration, it is generally not necessary to integrate all of the required couplers, terminators, etc. that comprise a complete MIL-STD-1553B bus. In most instances, a simplified electrical configuration will suffice.

The three connection methods illustrated in Figure 5 allow an ACE (or STIC) to be interfaced over a "simulated bus" to simulation and test equipment, such as a BUS-6517II board. It is important to note that if a compliant 1553 bus configuration is not used (as in Figure 1), the resistors shown in the diagram are necessary in order to ensure reliable communications between the ACE or STIC and the simulation/test equipment.

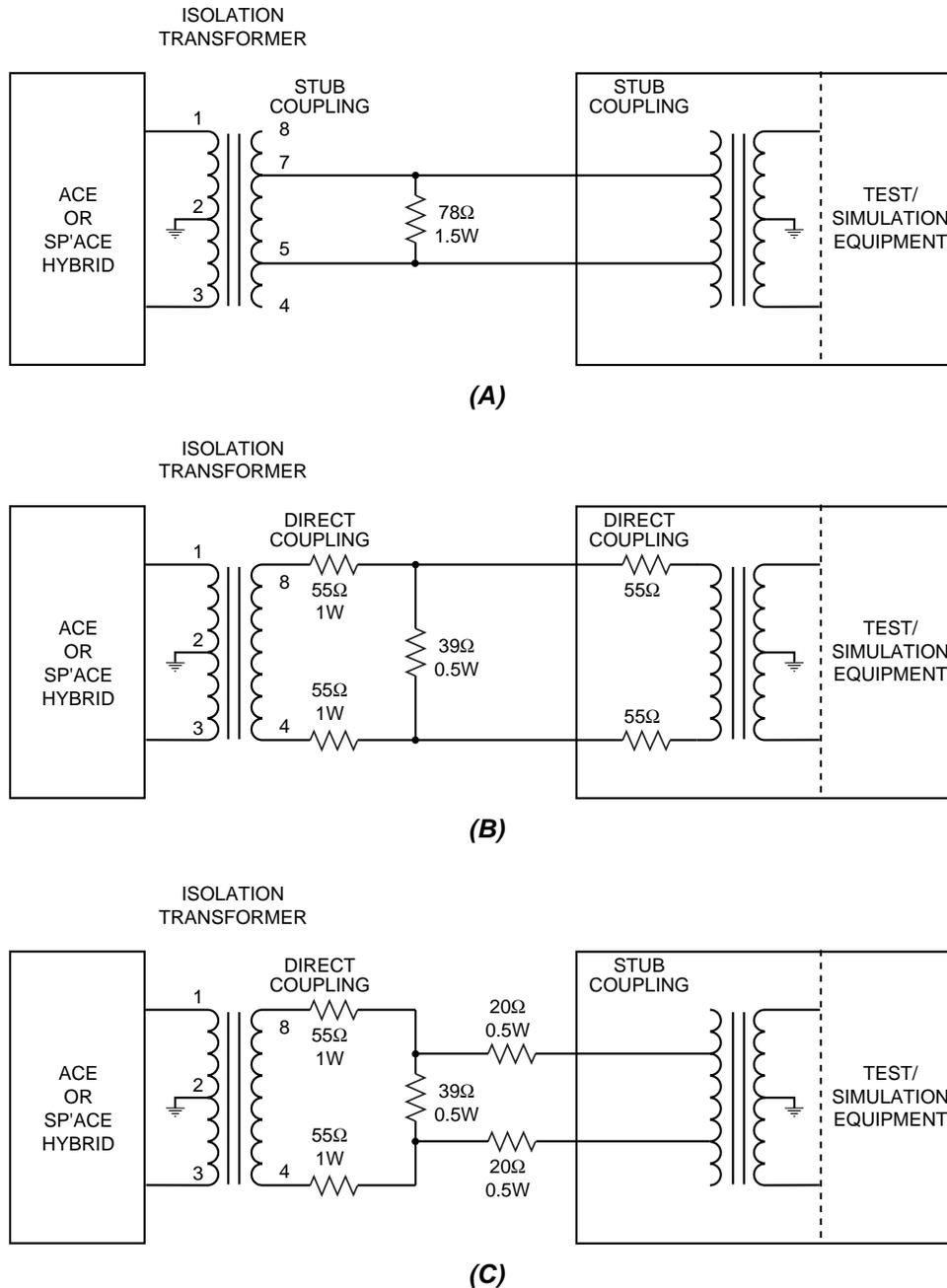


FIGURE 5. "SIMULATED BUS" INTERCONNECTIONS

- (A) Direct-Coupled-To-Direct-Coupled
- (B) Transformer-Coupled-To-Transformer-Coupled
- (C) Direct-Coupled-To-Transparent-Coupled

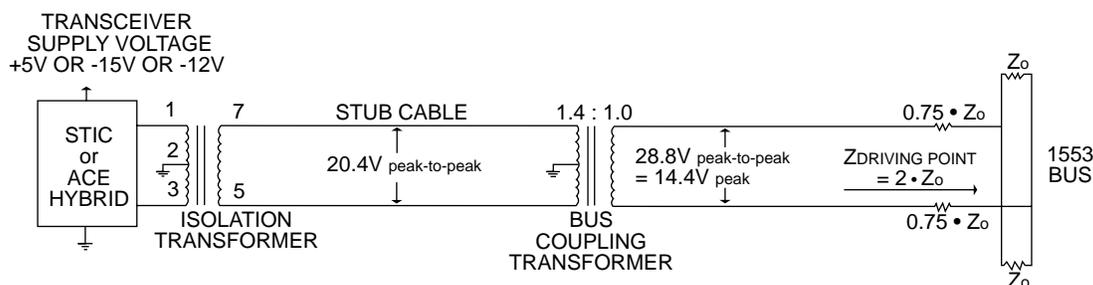


FIGURE 6. STUB COUPLED TERMINAL TO DATA BUS

TRANSCEIVER ISSUES

This application note considers a number of transceiver related issues that are commonly asked about. These include: voltage vs. current drivers, the effect of receiver threshold on MIL-STD-1553B validation testing, and consumed vs. dissipated power.

VOLTAGE VS. CURRENT DRIVERS

The transmitter in the -15/+5V and -12/+5V ACE and STIC terminals are voltage type transmitters. The transceiver in the +5V only ACE is a current type of driver. For both of these transceivers, only one leg of the isolation transformer primary is actively driven at any point in time. For the BUS-65149 and BU-61590 universal terminals, a true differential type of transmitter output stage is provided: for these hybrids, both legs are driven simultaneously.

Voltage source transmitters provide superior line driving capability for driving long cables and heavy amounts of stub/terminal loading. On the other hand, current source drivers, due to their simpler design, tend to consume and dissipate lower levels of power.

The transmitter requirements are a bit different for MIL-STD-1760B. In MIL-STD-

1553B, the output of a transformer coupled terminal is required to be in the range of 18 to 27Vp-p. MIL-STD-1760B is more stringent, requiring a transmitter stub voltage of 20 to 27Vp-p. This higher voltage ensures robust operation over a range of network topologies (stub and bus lengths, separation distances) for various aircraft. It is also recommended that a voltage, rather than a current source transmitter, be used in 1760 applications. A voltage source transmitter is more robust on a stores bus with its detaching stubs and the resulting variations in load impedance.

The transmitter in the -15/+5V versions of the STIC and ACE terminals provides a voltage source with a minimum stub voltage of 20Vp-p, making these products suitable for 1760 applications.

MIL-STD-1553B specifies that a transformer coupled terminal must be able to operate with an incoming line-to-line signal in the range of 0.86 to 14.0Vp-p. The standard also requires that a terminal not respond to a signal in the range of 0.0 to 0.20Vp-p. In DDC's terminals, the receiver threshold is generally trimmed for between 0.550 and 0.700 Vp-p. This range provides optimal performance for the Manchester decoders in the ACE and STIC terminals.

RECEIVER THRESHOLD

If receiver threshold is sufficiently below 0.550Vp-p, there is an increased possibility of failing the word error rate (noise) test of the RT Validation Test plan, even if the threshold is in spec. A 1553 terminal's word error rate is primarily a function of the threshold-to-noise ratio. Going to the other extreme, a receiver threshold that is too high (too close to 860 mV p-p) may cause problems in passing the zero crossing deviation and/or common mode rejection tests.

In the zero-crossing deviation test, the terminal must accept as valid a zero crossing-to-zero crossing time of 350 ns (500-150). If the receiver's threshold is too high, the pulse width (as seen by the terminals' Manchester decoder) will be reduced to an unacceptably short interval.

The validation test for common mode rejection involves superimposing a common mode voltage on a stub voltage of 0.86 Vp-p. Since the terminal's transformer has a finite common mode rejection ratio, this is tantamount to lowering the received signal level below 0.86V. Therefore, a threshold too close to 0.86 Vp-p may result in a failure of the validation common mode test.

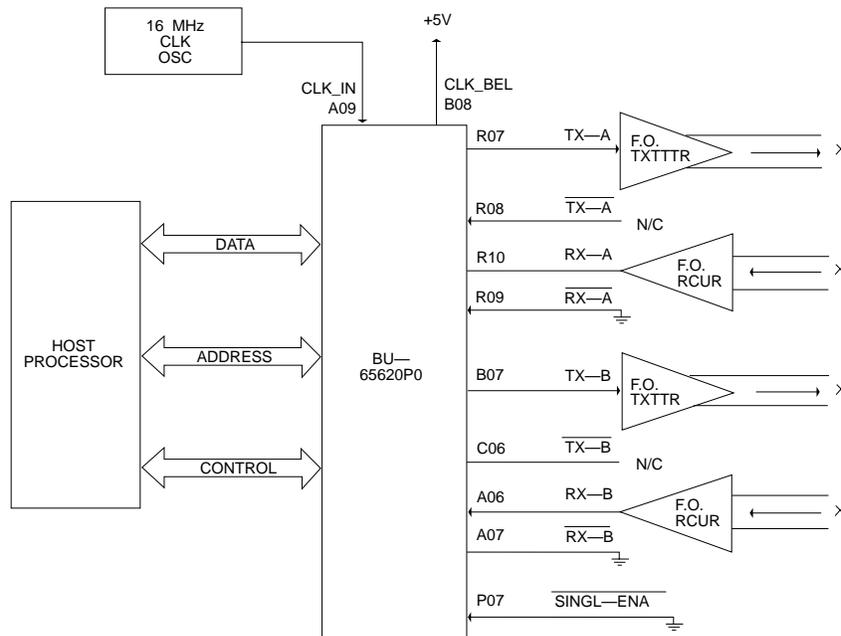


FIGURE 7. BU-65620 TO FIBER OPTIC TRANSCEIVER INTERFACE

POWER CONSUMPTION VS. DISSIPATION

Another common point of misunderstanding regarding transceivers involves power consumption and power dissipation. Figure 6 illustrates a typical configuration of a stub coupled terminal and a 1553 bus. When the terminal is not transmitting, the power consumption and dissipation are essentially equal.

However, when the terminal is transmitting, there will be a difference between the consumed and dissipated power. The difference in the two power numbers is the power dissipated in external isolation and termination resistors.

As shown in Figure 6, the voltage on the "bus" side of the coupling transformer is approximately 28.8Vp-p, or about 14.4Vpk.

That is, $V_{pk} = 14.4$.

The load resistance, as seen from this point, consists of the two termination

resistors (in parallel), in series with the two isolation resistors.

This is equal to

$$(0.75 \cdot Z_0) + (0.75 \cdot Z_0) + (Z_0/2) = 2 \cdot Z_0.$$

If the transmitter waveform is assumed, for the moment to be a square wave, its RMS value will be equal to its peak value, V_{pk} . With this assumption, the combined instantaneous dissipation of the isolation and termination resistors, when the terminal is transmitting, is calculated as follows:

$$P_{LOAD} = (V_{pk})^2 / (2 \cdot Z_0)$$

Since the 1553 waveform is a trapezoidal signal, rather than a square wave, the actual P_{LOAD} will be slightly less than that calculated by the equation given above. That is,

$$P_{LOAD} = K \cdot (V_{pk})^2 / (2 \cdot Z_0).$$

The exact value of K is a function of the transmitter's rise and fall times as well as

the actual transmitted data pattern. K decreases with an increase in rise/fall times and the number of signal transitions in the transmitted waveform. As a first approximation, a value of $K = 0.9$ may be used.

Consider a transformer coupled terminal with a transmitter stub voltage of 20.4Vp-p and a bus with a characteristic impedance of $Z_0 = 78$ ohm. These are typical values. The voltage on the "bus" side of the coupling transformer will be:

$$2 \cdot 20.4 = 28.85 \text{ Vp-p, therefore,}$$

V_{pk} will be $28.85/2 = 14.425V$. As a result,

$$P_{LOAD} = (0.9) \cdot (14.425)^2 / (2 \cdot 78) = 1.2W$$

1.2 W represents the instantaneous dissipation of the isolation and termination resistors when the terminal is transmitting.



ELECTRICAL AND LAYOUT CONSIDERATIONS FOR 1553 TERMINAL DESIGN

For a typical terminal, the actual transmitter duty cycle (portion of time transmitting) is typically between 1% and 10%. The average external dissipation is given by:

$$P_{LOAD /avg} = D \cdot 1.2W,$$

where D = transmitter duty cycle.

Both power supply current and terminal power dissipation vary linearly as functions of the transmitter duty cycle.

For example, consider a BU-61580D1 ACE terminal operating at 25% duty cycle. At 25% duty cycle, the average load dissipation is $(0.25) \cdot (1.2) = 0.3W$. Based on the "max" spec numbers, the total consumption:

$$\begin{aligned} &= (5V) \cdot (190 \text{ mA}) + (15V) \cdot (108 \text{ mA}) \\ &= 0.95 + 1.62 = 2.57W. \end{aligned}$$

This is consistent with the "total hybrid" power dissipation spec, listed as 2.25W max, at 25% duty cycle.

BU-65620-TO-FIBER-OPTIC- TRANSCEIVER INTERFACE

For MIL-STD-1773 applications involving a fiber optic transceiver, the BU-65620 digital monolithic version of the ACE may be easily interfaced to a fiber optic transceiver. To facilitate this interface, the Manchester decoders in the BU-65620 provide a pin-programmable option allowing them to accept the single-ended input signals from a fiber optic receiver.

As shown in Figure 7, this option is activated by strapping the input signal SNGL_ENA to ground.

The information in this application note is believed to be accurate; however, no responsibility is assumed by Data Device Corporation for its use, and no license or rights are granted by implication or otherwise in connection therewith. Specifications are subject to change without notice.

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