Application Note 388
Hitless-Protection Switching with 1 + 1 Redundancy

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INTRODUCTION

Hitless protection refers to the ability to switch between the primary and backup line card without losing framing synchronization, in the event that there is a primary line card failure. This feature provides telecommunications customers with equipment that can provide uninterrupted or continuous service and have an extremely high-reliability rating.

This application note shows how Dallas Semiconductor transceivers and line interface units (LIUs) can support this feature.

One-to-one (1 + 1) redundancy refers to a configuration where each line card has a dedicated backup card waiting in case of failure. N + 1 redundancy is defined as a configuration in which multiple cards have only one backup card to share between them. These traditional protection designs often required the use of relay modules to switch the signal between the primary and the backup line card.

One disadvantage of using relays is that their switching times are slow, which causes data corruption on the line. This data corruption results in bit errors, data loss, and perhaps a loss-of-frame condition. A loss-of-frame condition further exacerbates the data loss because it takes a considerable amount of time to reframe (while in the process of reframing, all data is unaligned and therefore garbage). Secondly, the relay modules are bulky and occupy valuable board space. Finally, the relay modules require a large amount of power when used on boards with multiple T1/E1 lines.

Figure 1 shows a redundant scheme that supports hitless protection. The backup transceiver is receiving and framing in parallel with the primary transceiver. This is possible because the Dallas Semiconductor LIUs are designed with high-impedance receive inputs and transmitter outputs that can be tri-stated. Therefore, the backup line card inputs and outputs do not affect the signal that the primary line card is transmitting and receiving. This type of configuration eliminates the need for bulky mechanical relays.

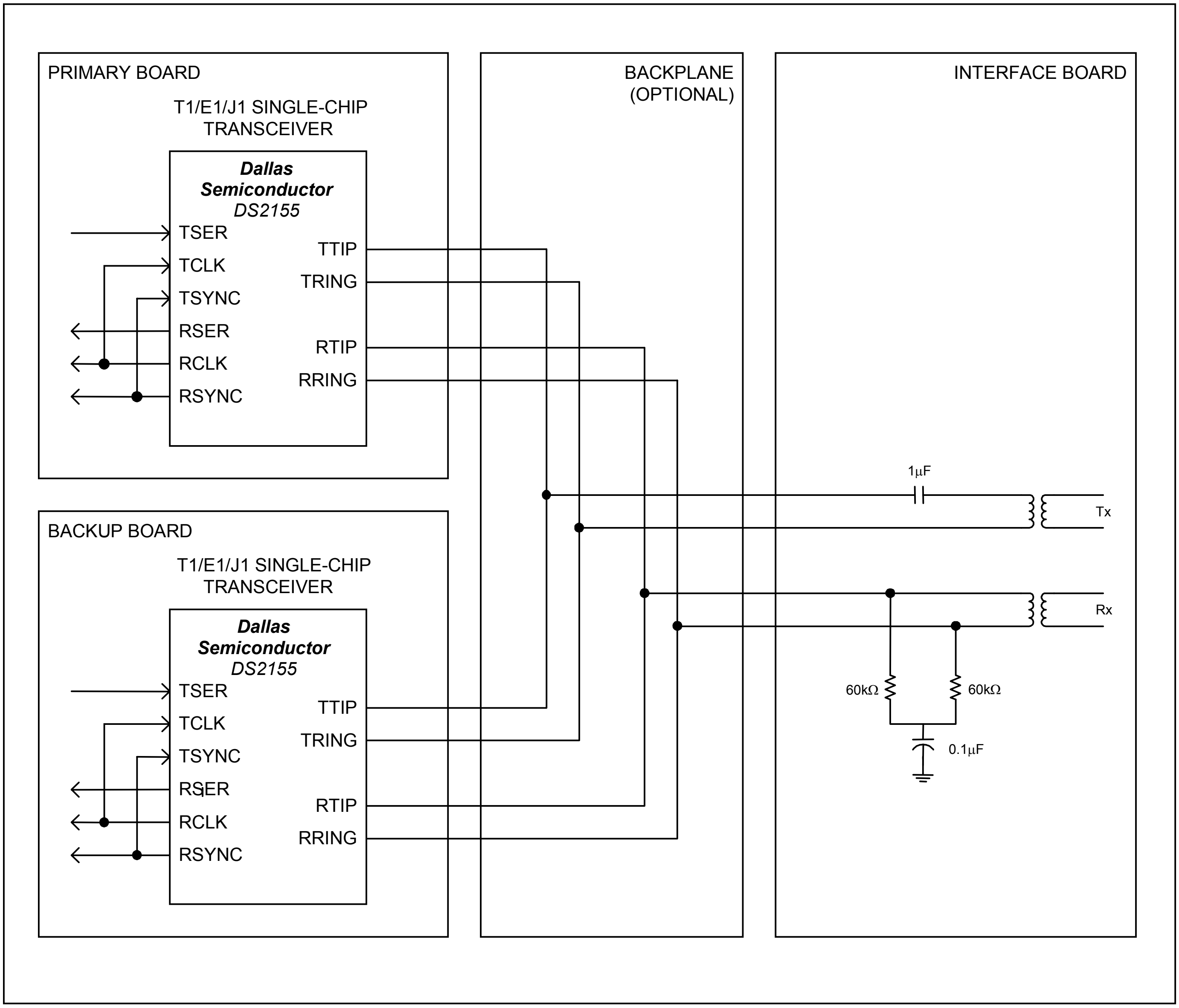

Figure 1. Example of Typical Connections

MICROPROCESSOR-CONTROLLED SWITCHING

To switch from the primary LIU card to the backup card, the following steps should performed:

1) Disable the transmit current limiter of the primary LIU and the backup LIU.
2) Enable the backup transmitter while the primary is still operating.
3) Disable the primary transmitter by tri-stating its output drivers.
4) Enable the transmit current limiter of the primary LIU and the backup LIU.

Tables 1, 2, and 3 list the register bits that should be set or cleared:

Table 1. Register Bits for DS2155 T1/E1 Transceiver

STEP	ACTION	DS2155 (T1/E1/J1) REGISTER ADDRESS
1	Set primary and backup LIC2.1 = 1	0 x 79
2	Set backup LIC1.0 = 1	0 x 78
3	Set primary LIC1.0 = 0	0 x 78
4	Set primary and backup LIC2.1 = 0	0 x 79

Table 2. Register Bits for DS21x52 and Ds21x54 Transceivers

STEP	ACTION	DS21X52 (T1) REGISTER ADDRESS	DS21X54 (E1) REGISTER ADDRESS
1	Set primary and backup LITEST2.4 = 1	0 x 09	0 x AC
2	Set backup LICR.0 = 0	0 x 7C	0 x 18
3	Set primary LICR.0 = 1	0 x 7C	0 x 18
4	Set primary and backup LITEST2.4 = 0	0 x 09	0 x AC

Note: The LITEST2 register is actually labeled TEST2 in the DS21x52 data sheet, and is labeled TEST3 in the DS21x54 data sheet.

Table 3. Register Bits for DS2148, DS21348 LIUs

STEP	ACTION	DS2148, DS21348 (T1/E1/J1) REGISTER ADDRESS
1	Set primary and backup CCR2.5 = 1	0 x 01
2	Set backup CCR4.0 = 0	0 x 03
3	Set primary CCR4.0 = 1	0 x 03
4	Set primary and backup CCR2.5 = 0	0 x 01

RECEIVE-SIDE SOFTWARE-SELECTED TERMINATION

On the DS2155, DS2148, DS21348 devices, which have internal software termination available, steps must be taken to ensure that the receive-side line interface is configured properly. When two pair of receiver inputs are connected to the transformer, only one device can control the software-selected termination. Having software-selected termination enabled on both devices would result in a line impedance mismatch and improperly terminated signals. To ensure this does not happen, simply have software-selected termination enabled only on the active line card (the line card that is currently recovering the signal) and disabled on the other. When the active card is removed or swapped from the system, simply switch which card is currently performing the software termination function. Information on enabling and disabling the internal software termination can be found in the product data sheet.

POWER-UP AND HOT SWAPPING

There are also some other features of the Dallas Semiconductor devices that must be considered upon power-up of the system and when replacing a bad line card. Upon power-up, the DS2155 clears its registers space, which leaves the device with the transmit drivers tri-stated. This is the ideal condition for the redundancy application because it prevents a card from interfering with another card that is already transmitting data. However, older generation devices (i.e., DS21x52, DS21x54, DS2148, DS21348) power-up with the transmitter drivers turned on. To prevent this condition from occurring, the user must implement the following in the system:

1) Wire the TEST pin such that the default state is a high. This will tri-state all output and I/O pins (including the parallel control port) including the transmitter outputs. In this state, the processor will be able to perform write operations to the parallel port but read operations will not work.
2) Initialize the device by writing 0x00 to the entire register addresses range.
3) Disable the transmitter of the device using the register bits mentioned in Tables 1, 2, and 3.
4) Set TEST pin state low to enable regular operation of the device.

TEST RESULTS

To ensure that the DS2155 devices operate in a hitless protection switching system, a test and simulation setup was designed. The test setup description is presented in the next section. The four scope plots presented in figures 2 through 5 demonstrate that the transmit pulse template is met when the two devices are coupled together in a hitless protection switching system. The pulse templates are divided into T1 and E1 pulses and each has a scope plot for both port 1 and port 2.

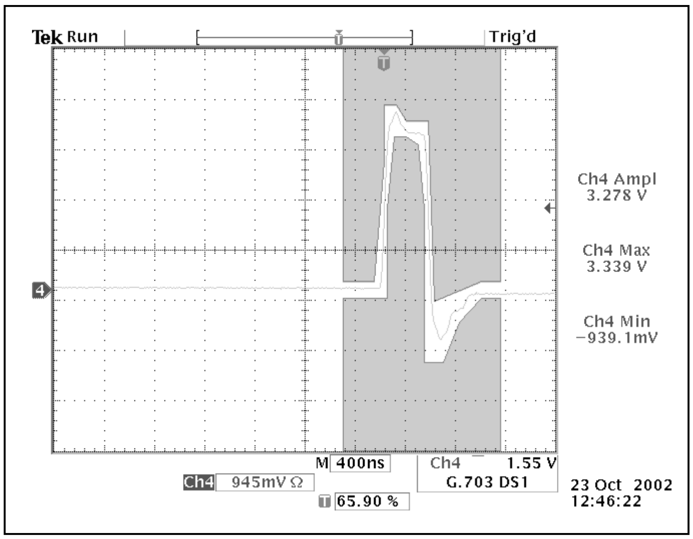

Figure 2. T1 Pulse Shape Port 1

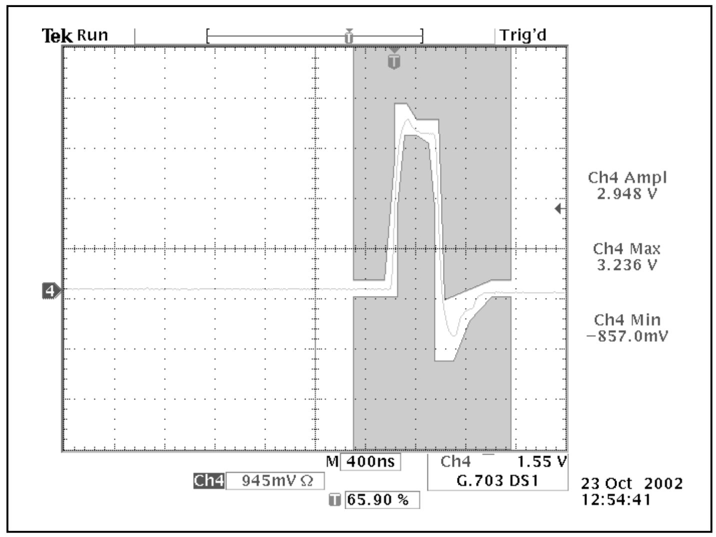

Figure 3. T1 Pulse Shape Port 2

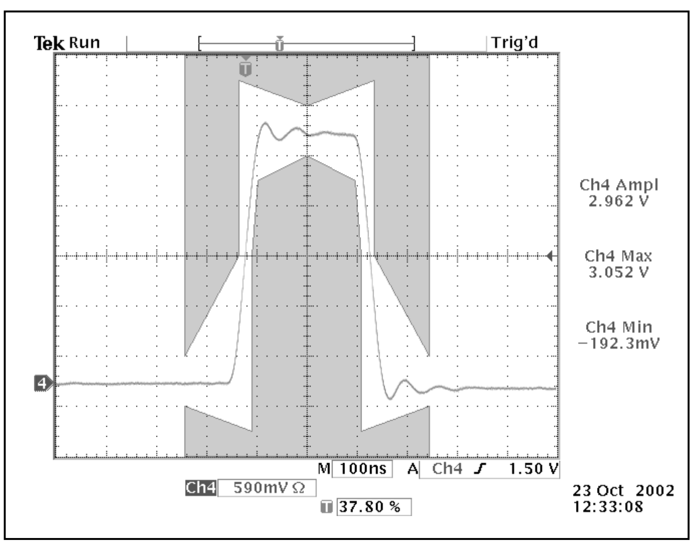

Figure 4. E1 Pulse Shape Port 1

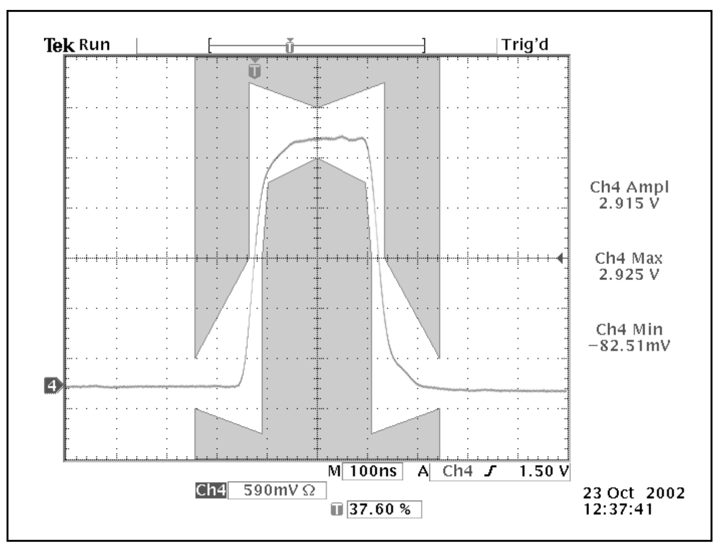

Figure 5. E1 Pulse Shape Port 2

TEST SETUP

The test setup in Figure 6 was used to generate the pulse template scope shots in Figures 2 though 5. The setup consists of a modified Dallas Semiconductor DS21Q55 demonstration kit, an Acterna T1 Fireberd, an Acterna E1 Fireberd, and a Tektronix TDS 3054 with pulse mask option and a differential signal adapter. The DS21Q55 was used in place of two DS2155 devices because the DS21Q55 board was readily available, and the switching between the primary and backup device could be done in software using the DS21Q55 demonstration kit. Since the DS21Q55 is actually four DS2155 devices placed on a single board, there should be no difference between the DS21Q55 results and those that would be obtained using two DS2155 devices. The board was modified so that ports 1 and 2 of the DS21Q55 shared the same network interface circuit on the transmit and receive sides. To simulate the longer-than-normal tip and ring signal routes that would be present in a real system, 60 inches of twisted-pair cable was used between the transformer and the tip and ring signals on the DS21Q55. The extra distance did not seem to degrade the performance of the DS21Q55 transmitter or receiver in any way.

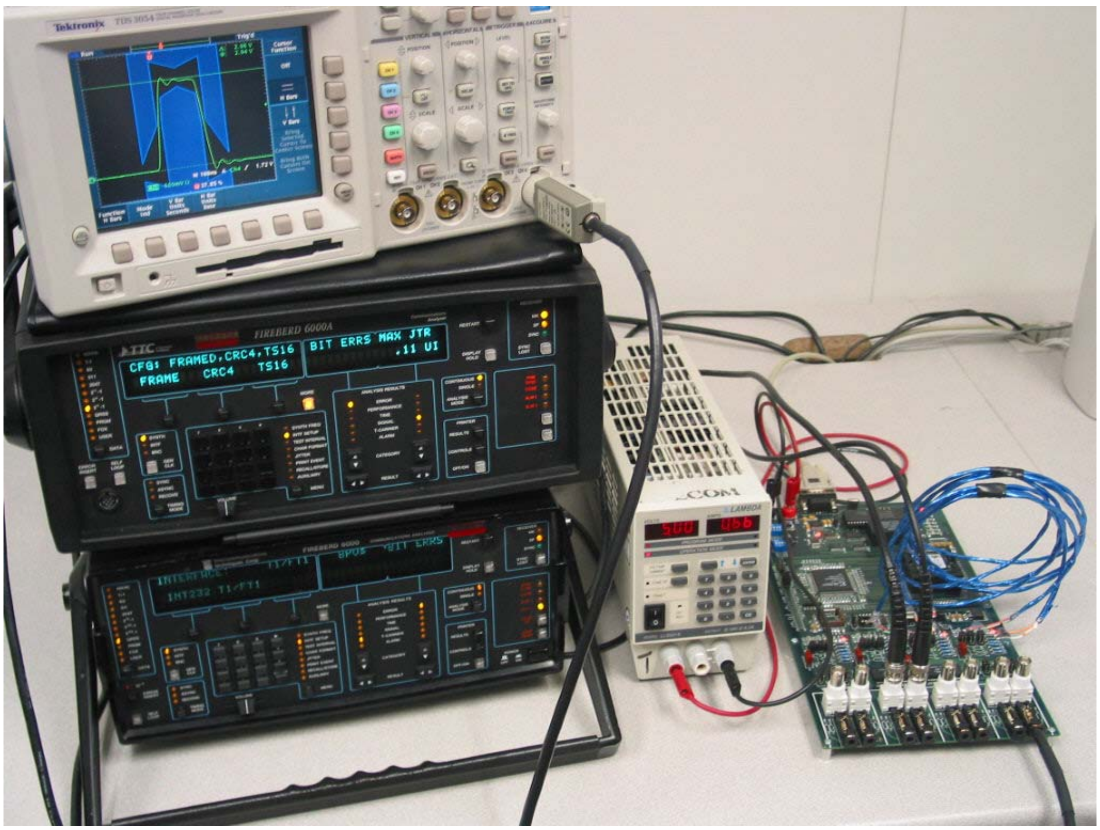

Figure 6. Hitless Protection Switching Test Setup