Laboratory # 2
Laboratory Title: RS232 Communication and Control

Appendix A: Additional Background Information and Helpful Hints on RS232

Every RS232 device is either a DTE (Data Terminal Equipment) or a DCE (Data Communications Equipment). DTE is usually a device such as a computer and DCE is normally a modem-like device, although the distinctions are quite vague. A DTE can communicate with a DCE or another DTE using an appropriate set of handshakes. The same is true for a DCE.

1. Refer to Figures 1, 2, and 3 to understand the pin functions. The functions should make sense when seen in the reference frame of the DTE.

2. All the pin numbers described below refer to the pin numbers on a 25-pin connector. Connectors have either 25 pins or 9 pins. In both cases you find male and female connectors. Be extremely clear about the scheme (25-pin/9-pin) in use when referring to pin numbers. A mapping from 25-pin to 9-pin and vice-versa has been shown in Figure 1.

3. To connect a 9-pin cable/device to a 25-pin cable, many people use an adapter that maps the functions between the two kinds of connectors. You should not necessarily trust these adapters, since some of these adapters interchange certain pins or leave some pins open that don't correspond to the typical 9-pin to 25-pin mapping. The solution to this problem is very simple. Power on the HP Digital multimeter and find the CONT button on the front panel. This is continuity check function and it beeps when the positive and negative probes of the multimeter are shorted. This can be used to determine the exact pin-to-pin mapping that the adapter is using.

4. RS232 is often described as a "non-standard" standard, which students will appreciate by the time they finish this lab.

RS232 Pin descriptions and functions

Data lines (TxD and RxD) pins 2 and 3

There are two lines for serial data transport.

TxD (Transmitted Data) is an output line of the device. The data is sent from this pin by the DTE and received on this pin by the DCE.

RxD (Received Data) is the receive line. The DTE receives data on this pin, which means that the DCE ***transmits*** data on this pin.

The pin sending the data has to be connected to the pin receiving the data. Therefore, when connecting a DTE to DCE, you connect pin 2 (DTE) to pin 2 (DCE) and pin 3 (DTE) to pin 3 (DCE). However if you are connecting 2 devices that both decide to act as DTEs, then you have to connect pin 2 (DTE1) to pin 3 (DTE2) and pin 3 (DTE1) to pin 2 (DTE2), that is, cross the connections. Note that these pin numbers correspond to 25-pin connectors.

Request To Send (RTS) pin 4 and Clear to Send (CTS) pin 5

The functions of these pins are exactly what the names suggest. They are handshake commands that devices use before sending data. When a DTE has data to send, it pulls RTS high and if the DCE is willing to accept the data, it will respond by pulling CTS high.

Again if connecting 2 DTE devices, you have to cross the connections between the RTS and CTS pins (that is, pins 4 and 5 on the 25-pin scheme). A pin 4 (DTE) to pin 4 (DCE) and a pin 5 (DTE) to pin 5 (DCE) connection should be used when linking a DCE to DTE.

The situation is not as simple as that of the TxD and RxD pins, however, because many "RS232 compatible" devices simply choose not to use this set of handshakes at all. For instance, a DTE will assert the RTS and keep waiting for the CTS that never arrives. Remember -- R232 is a "non-standard" standard.

Therefore, we need to fool the device which implements this handshake by looping its RTS back to its CTS. That is, connect pin 4 of the device to its own pin 5. For the device that does not implement this protocol, the RTS and CTS pins can remain floating.

Data Terminal Ready (DTR) pin 20 and Data Set Ready (DSR) pin 6

DTR and DSR is another set of handshakes used by some of the devices that support the serial port. The purpose of the handshake is to determine only if there is device connected at the other end. The story with these two pins is exactly the same as that of the RTS and CTS pins. Specifically, connect pin 20 (DTE) to pin 20 (DCE) and pin 6 (DTE) to pin 6 (DCE) when you are trying to connect a DTE and DCE that both implement the DTR/DSR handshake protocol. If you are connecting 2 DTEs that implement this handshake then you will cross the connections between pins 20 and 6. If only one of the devices implements the protocol, then connect its own pin 6 to its own pin 20 and leave the DTR and DSR pins on the device that does not implement the protocol floating.

Data Carrier Detect (DCD) pin 8

Some DTE's require this line to be asserted before they will start doing anything. The DCD pin essentially tells the DTE that a carrier wave has been detected. Recall that a carrier wave is the pulse on which data bits are modulated and sent. The DCE may set this pin high after initial synchronization of the carrier wave.

DCD pins are normally connected simply that is, pin 8 (DTE) to pin 8 (DCE). If that does not work, then try connecting them to either the DSR or the DTR pin, or both (on the same device) as a data set ready signal or a data terminal ready signal can be taken as an indication of readiness to transmit data.

Pins 1 and 7 and other pins

Pin 1 is protected ground and pin 7 is signal ground. In the 9-pin scheme, pin 5 corresponds to pin 7 on the 25-pin scheme. However, there is no pin on the 9-pin connector corresponding to pin 1 on the 25-pin scheme. Some other pins in the 25-pin scheme are used for clocking signals and synchronizing devices for high data rate communication. We will not be using them in this laboratory.

This excerpt from Horowitz and Hill, *The Art of Electronics* (pg. 726) "How to become an RS232 genius" sums up things succinctly: "Look at the lights to get TxD and RxD connected right, then look again to see who asserts the handshakes. If a device asserts RTS, it probably looks at CTS. If both devices assert RTS, then cross-connect the RTS and CTS lines of the two devices; otherwise, loop each device's CTS back to its own RTS. Play the same game with DTR and DSR. If only one pair of handshakes is implemented, it is usually DTR/DSR. In general, the DTR/DSR pair is used to make sure the other side is connected and turned on, while the RTS/CTS pair is used to start and stop transmission as one side gets ahead of the other."

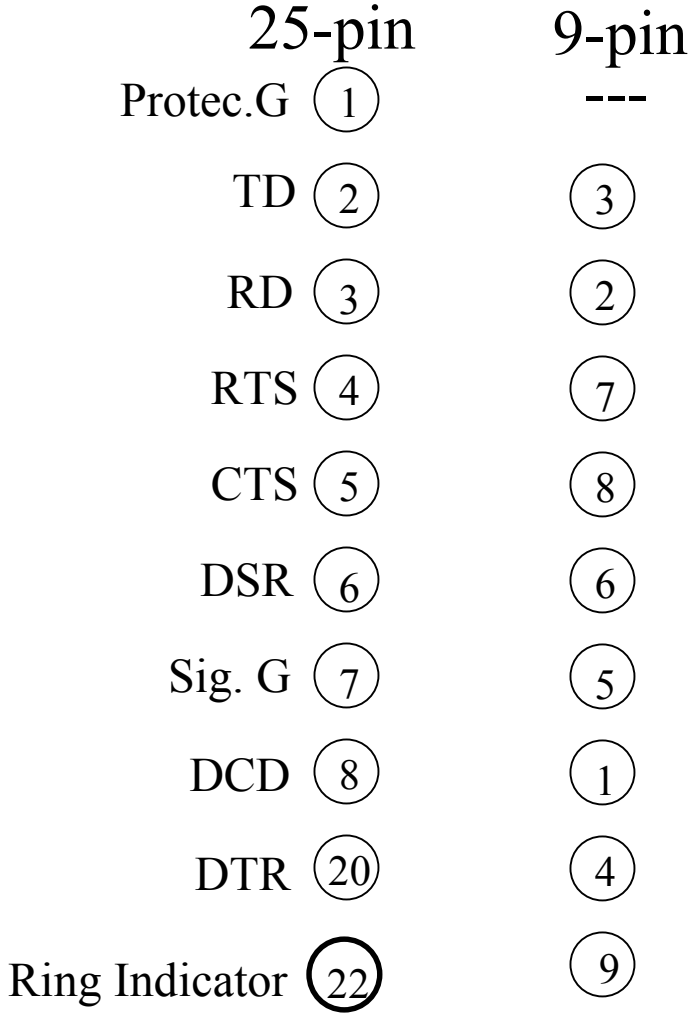

Figure 1: Detailed mapping between 25-pin and 9-pin connectors.

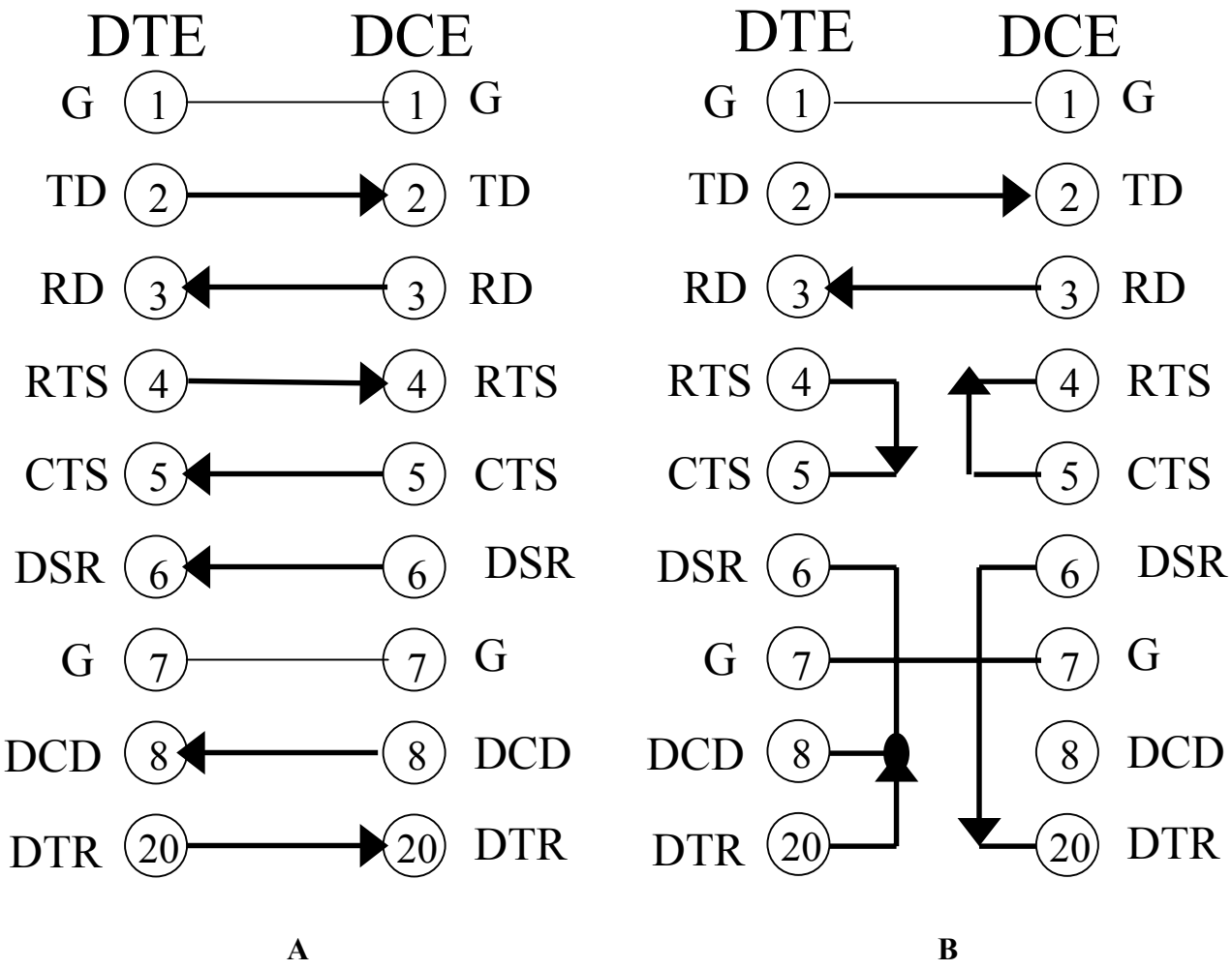

Figure 2(A-B): Two of the most common RS232 interconnections between a DTE and a DCE (pins refer to 25-pin connector).

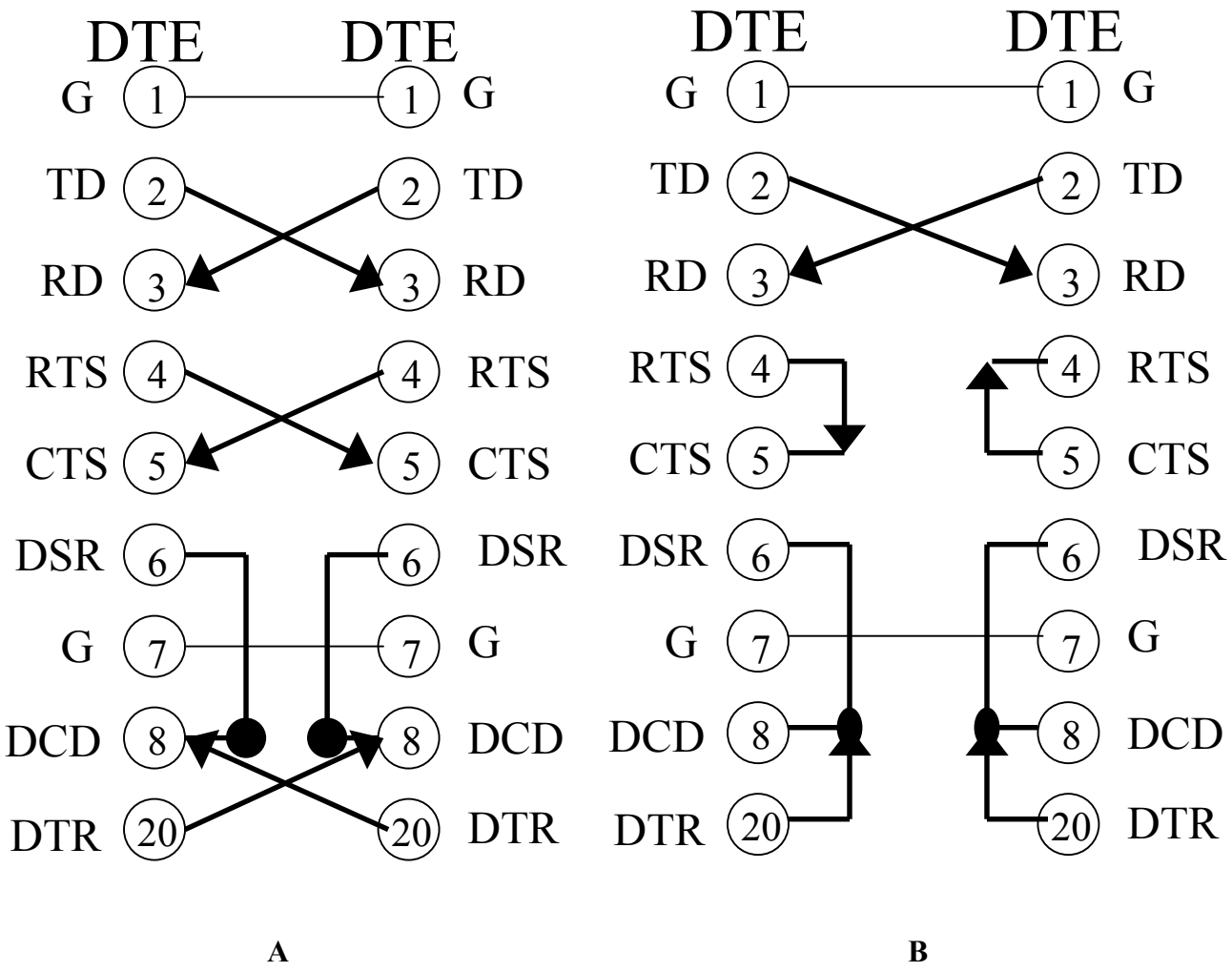

Figure 3(A-B): Two of the most common RS232 interconnections between two DTEs (pins refer to 25-pin connector).

RS232 Break-Out Box

The break-out box is a convenient method for making RS232 connections. It is essentially two 25-pin RS232 connectors connected together using dip switches and jumper holes. In the ON position, the dip switches connect the corresponding pins directly, whereas the jumper holes can be used to cross-connect pins using jumpers provided with the box. It also provides tri-state LEDs to monitor the signals on the lines. Signals from one direction will be positive (green), and from the other direction will be negative (red) usually. Monitoring these signals can help you discover which device is acting as a DTE and which one as a DCE.

- Remember that the numbers on the actual dip switches DON'T line up with actual pin numbers printed on the faceplate on some break-out boxes. The holes for the jumpers DO line up with the printed numbers on the faceplate.

- ALWAYS USE THE NUMBERS PRINTED ON THE FACEPLATE! TRANSLATE 9-PIN FUNCTIONS TO 25-PIN FUNCTIONS.

- REMEMBER THAT DOING A **CONTINUITY CHECK** USING THE MULTIMETER ON THE END CONNECTIONS AT THE 9-PIN ENDS NEAR THE DEVICES AFTER YOU HAVE MADE CONNECTIONS USING THE BREAK-OUT BOX IS OFTEN THE ONLY WAY TO ACHIEVE THE COMMUNICATION LINK.