

Interfacing the DP8344 to Twinax

National Semiconductor
Application Note 516
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March 1988



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OVERVIEW

The DP8344, or **Biphase Communications Processor** from National Semiconductor's Advanced Peripherals group brings a new level of system integration and simplicity to the IBM® connectivity world. Combining a 20 MHz RISC architecture CPU with a flexible multi-protocol transceiver and remote interface, the BCP is well suited for IBM 3270, 3299 and 5250 protocol interfaces. This Application Note will show how to interface the BCP to twinax, as well as provide some basics about the IBM 5250 environment.

5250 ENVIRONMENT

The IBM 5250 environment encompasses a family of devices that attach to the IBM System/34, 36 and 38 mid-size computer systems. System unit model numbers include the 5360, 5362, 5364, 5381, and 5382, and remote controller models 5294 and 5251 model 12. The system units have integral work station controllers and some may support up to 256 native mode twinax devices locally. Native mode twinax devices are ones that connect to one of these host computers or their remote control units via a multi-drop, high speed serial link utilizing the 5250 data stream. This serial link is primarily implemented with twinaxial cable but may be also found using telephone grade twisted pair. Native mode 5250 devices include mono-chrome, color and graphics terminals, as well as a wide range of printers and personal computer emulation devices.

TWINAX AS A TRANSMISSION MEDIA

The 5250 environment utilizes twinax in a multi-drop configuration, where eight devices can be "daisy-chained" over a total distance of 5000 ft. and eleven splices, (each physical device is considered a splice) see *Figure 1*. Twinax can be routed in plenums or conduits, and can be hung from poles between buildings (lightning arrestors are recommended for this). Twinax connectors are bulky and expensive, but are very sturdy. Different sorts may be purchased from IBM or a variety of third party vendors, including Amphenol. Twinax should not be spliced; to connect cables together both cables should be equipped with male connectors and a quick-disconnect adapter should be used to join them (Amphenol #82-5588).

Twinaxial cable is a shielded twisted pair that is nearly 1/3 of an inch thick. This hefty cable can be either vinyl or teflon jacketed and has two internal conductors encased in a stiff polyethylene core. The cable is available from BELDEN (type #9307) and other vendors, and is significantly more expensive than coax.

The cable shield must be continuous throughout the transmission system, and be grounded at the system unit and each station. Since twinax connectors have exposed metal connected to their shield grounds, care must be taken not to expose them to noise sources. The polarity of the two inner conductors must also be maintained throughout the transmission system.

The transmission system is implemented in a balanced current mode; every receiver/transmitter pair is directly coupled to the twinax at all times. Data is impressed on the transmission line by unbalancing the line voltage with the driver current. The system requires passive termination at both ends of the transmission line. The termination resistance value is given by:

$$R_t = Z_0/2; \text{ where}$$

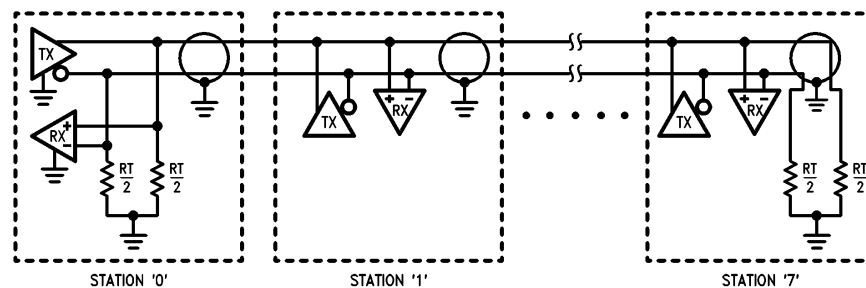
R_t : Termination Resistance

Z_0 : Characteristic Impedance

In practice, termination is accomplished by connecting both conductors to the shield via 54.9Ω, 1% resistors; hence the characteristic impedance of the twinax cable of 107Ω ± 5% at 1.0 MHz. Intermediate stations must not terminate the line; each is configured for "pass-through" instead of "terminate" mode. Stations do not have to be powered on to pass twinax signals on to other stations; all of the receiver/transmitter pairs are DC coupled. Consequently, devices must never output any signals on the twinax line during power-up or down that could be construed as data, or interfere with valid data transmission between other devices.

WAVEFORMS

The bit rate utilized in the 5250 protocol is 1 MHz ± 2% for most terminals, printers and controllers. The IBM 3196 dis-



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FIGURE 1. Multi-Drop Transmission Lines

The eight stations shown include the host device as a station. The first and last stations are terminated while intermediate stations are not.

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play station has a bit rate of $1.0368 \text{ MHz} \pm 0.01\%$. The data are encoded in biphase, NRZI (non-return to zero inverted) manner; a "1" bit is represented by a positive to negative transition, a "0" is a negative to positive transition in the center of a bit cell. This is opposite from the somewhat more familiar 3270 coax method. The biphase NRZI data is encoded in a pseudo-differential manner; i.e. the signal on the "A" conductor is subtracted from the signal on "B" to form the waveform shown in *Figure 2*. Signals A and B are not differentially driven; one phase lags the other in time by 180° . *Figures 3* and *4* show actual signals taken at the driver and receiver after 5000 ft. of twinax, respectively.

The signal on either the A or B phase is a negative going pulse with an amplitude of $-0.32\text{V} \pm 20\%$ and duration of $500 \pm 20 \text{ ns}$. During the first $250 \pm 20 \text{ ns}$, a predistortion or pre-emphasis pulse is added to the waveform yielding an amplitude of $-1.6\text{V} \pm 20\%$. When a signal on the A phase is considered together with its B phase counterpart, the resultant waveform represents a bit cell or bit time, comprised of two half-bit times. A bit cell is $1 \mu\text{s} \pm 20 \text{ ns}$ in duration and must have a mid bit transition. The mid bit transition is the synchronizing element of the waveform and is key to maintaining transmission integrity throughout the system.

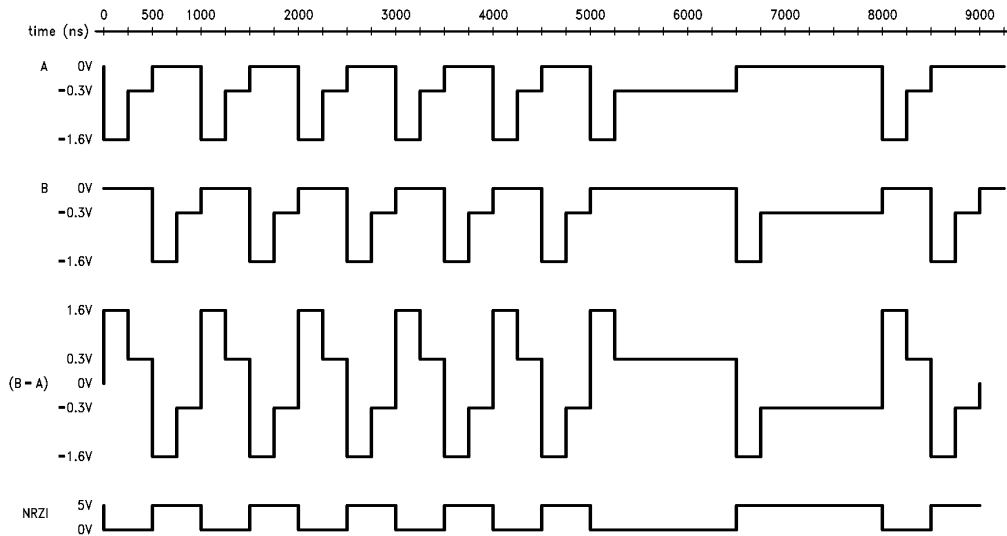
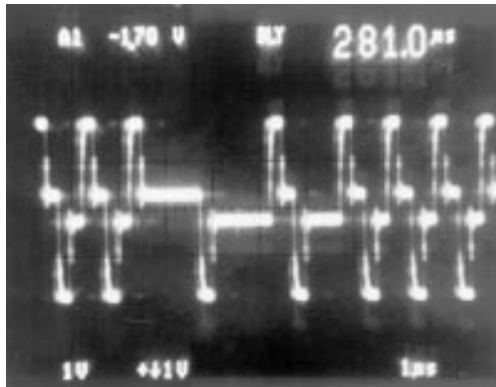


FIGURE 2. Twinax Waveforms

The signal on phase A is shown at the initiation of the line quiesce/line violation sequence.
Phase B is shown for that sequence, delayed in time by 500 ns.
The NRZI data recovered from the transmission.

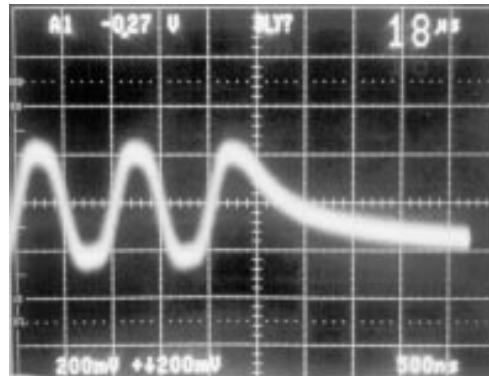
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FIGURE 3. Signal at the Driver

The signal shown was taken with channel 1 of an oscilloscope connected to phase B, channel 2 connected to A, and then channel 2 inverted and added to channel 1.



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FIGURE 4. Signal at the Receiver

The signal shown was viewed in the same manner as *Figure 3*. The severe attenuation is due to the filtering effects of 5000 ft. of twinax cable.

As previously mentioned, the maximum length of a twinax line is 5000 ft. and the maximum number of splices in the line is eleven. Devices count as splices, so that with eight devices on line, there can be four other splices. The signal 5000 ft. and eleven splices from the controller has a minimum amplitude of 100 mV and a slower edge rate. The bit cell transitions have a period of $1 \mu\text{s} \pm 30 \text{ ns}$.

5250 BIT STREAM

The 5250 Bit stream used between the host control units and stations on the twinax line consists of three separate parts; a bit synchronization pattern, a frame synchronization pattern, and one or more command or data frames. The bit sync pattern is typically five one bit cells. This pattern serves to charge the distributed capacitance of the transmission line in preparation for data transmission and to synchronize receivers on the line to the bit stream. Following the bit sync or line quiesce pattern is the frame sync or line violation. This is a violation of the biphas, NRZI data mid bit transition rule. A positive going half bit, 1.5 times normal duration, followed by a negative going signal, again 1.5 times normal width, allows the receiving circuitry to establish frame sync.

Frames are 16 bits in length and begin with a sync or start bit that is always a 1. The next 8 bits comprise the command or data frame, followed by the station address field of three bits, a parity bit establishing even parity over the start, data and address fields, and ending with a minimum of three fill bits (fill bits are always zero). A message consists of a bit sync, frame sync, and some number of frames up to 256 in total. A variable amount of inter-frame fill bits may be used to control the pacing of the data flow. The SET MODE command from the host controller sets the number of bytes of zero fill sent by attached devices between data frames. The zero fill count is usually set to zero. The number of zero fill bits injected between frames by the BCP is set by the Fill Bit select register {FBR}. This register contains the one's complement of the number of BITS sent, not bytes.

Message routing is accomplished through use of the three-bit address field and some basic protocol rules. As mentioned above, there is a maximum of eight devices on a given twinax line. One device is designated the controller or

host and the remaining seven are slave devices. All communication on the twinax line is host initiated and half duplex. Each of the seven devices is assigned a unique station address from zero to six. Address seven is used for an End Of Message delimiter, or EOM. The first or only frame of a message from controller to device must contain the address of the device. Succeeding frames do not have to contain the same address for the original device to remain selected, although they usually do.

The last frame in a sequence must contain the EOM delimiter. For responses from the device to the controller, the responding device places its own address in the address field in frames 1 to $(n - 1)$, where $n \leq 256$, and places the EOM delimiter in the address field of frame n . However, if the response to the controller is only one frame, the EOM delimiter is used. The controller assumes that the responding device was the one addressed in the initiating command.

Responses to the host must begin in $60 \pm 20 \mu\text{s}$, although some specifications state a $45 \pm 15 \mu\text{s}$ response time. In practice, controllers do not change their time out values per device type so that anywhere from $30 \mu\text{s}$ to $80 \mu\text{s}$ response times are appropriate.

DRIVER CIRCUITS FOR THE DP8344

The transmitter interface on the DP8344 is sufficiently general to allow use in 3270, 5250, and 8-bit transmission systems. Because of this generality, some external hardware is needed to adapt the outputs to form the signals necessary to drive the twinax line. The chip provides three signals: DATA-OUT, DATA-DLY, and TX-ACT. DATA-OUT is bi-phase serial data (inverted). DATA-DLY is the biphas serial data output (non-inverted) delayed one-quarter bit-time. TX-ACT, or transmitter active, signals that serial data is being transmitted when asserted. DATA-OUT and DATA-DLY can be used to form the A and B phase signals with their three levels by the circuit shown in Figure 5. TX-ACT is used as an external transmitter enable. The BCP can invert the sense of the DATA-OUT and DATA-DLY signals by asserting TIN {TMR[3]}. This feature allows both 3270 and 5250 type biphas data to be generated, and/or utilization of inverting or non-inverting transmitter stages.

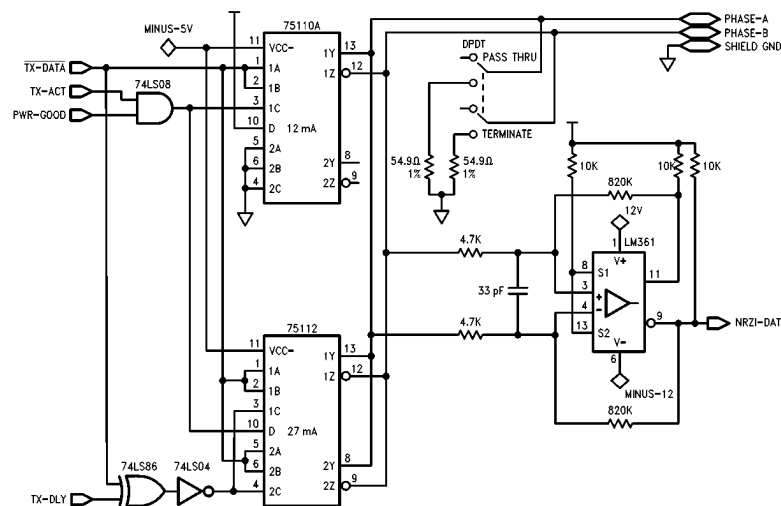


FIGURE 5. Schematic

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The current mode drive method used by native twinax devices has both distinct advantages and disadvantages. Current mode drivers require less power to drive properly terminated, low-impedance lines than voltage mode drivers. Large output current surges associated with voltage mode drivers during pulse transition are also avoided. Unwanted current surges can contribute to both crosstalk and radiated emission problems. When data rate is increased, the surge time (representing the energy required to charge the distributed capacitance of the transmission line) represents a larger percentage of the driver's duty cycle and results in increased total power dissipation and performance degradation.

A disadvantage of current mode drive is that DC coupling is required. This implies that system grounds are tied together from station to station. Ground potential differences result in ground currents that can be significant. AC coupling removes the DC component and allows stations to float with respect to the host ground potential. AC coupling can also be more expensive to implement.

Drivers for the 5250 environment may not place any signals on the transmission system when not activated. The power-on and off conditions of drivers must be prevented from causing noise on the system since other devices may be in operation. Figure 5 shows a "DC power good" signal enabling the driver circuit. This signal will lock out conduction in the drivers if the supply voltage is out of tolerance.

Twinax signals can be viewed as consisting of two distinct phases, phase A and phase B, each with three levels, off, high and low. The off level corresponds with 0 mA current being driven, the high level is nominally 62.5 mA, +20%–30%, and the low level is nominally 12.5 mA, +20%–30%. When these currents are applied to a properly terminated transmission line the resultant voltages impressed at the driver are: off level is 0V, low level is 0.32V ±20%, high level is 1.6V ±20%. The interface must provide for switching of the A and B phases and the three levels. A bi-modal constant current source for each phase can be built that has a TTL level interface for the BCP.

An integrated solution can be constructed with a few current mode driver parts available from National and Texas Instruments. The 75110A and 75112 can be combined to provide both the A and B phases and the bi-modal current drive required as in Figure 5. The external logic used adapts the coax oriented BCP outputs to the twinax interface circuit, and prevents spurious transmissions during power-up or down. The serial NRZ data is inverted prior to being output by the BCP by setting TIN, {TMR[3]}.

RECEIVER CIRCUITS

The pseudo-differential mode of the twinax signals make receiver design requirements somewhat different than the coax 3270 world. Hence, the analog receiver on the BCP is not well suited to receiving twinax data. The BCP provides both analog inputs to an on-board comparator circuit as well as a TTL level serial data input, TTL-IN. The sense of this serial data can be inverted by the BCP by asserting RIN, {TMR[4]}.

The external receiver circuit must be designed with care to ensure reliable decoding of the bit-stream in the worst environments. Signals as small as 100 mV must be detected. In order to receive the worst case signals, the input level switching threshold or hysteresis for the receiver should be

nominally 29 mV ±20%. This value allows the steady state, worst case signal level of 100 mV 66% of its amplitude before transitioning.

To achieve this, a differential comparator with complementary outputs can be applied, such as the National LM361. The complementary outputs are useful in setting the hysteresis or switching threshold to the appropriate levels. The LM361 also provides excellent common mode noise rejection and a low input offset voltage. Low input leakage current allows the design of an extremely sensitive receiver, without loading the transmission line excessively.

In addition to good analog design techniques, a low pass filter with a roll-off of approximately 1 MHz should be applied to both the A and B phases. This filter essentially conducts high frequency noise to the opposite phase, effectively making the noise common mode and easily rejectable.

Layout considerations for the LM361 include proper bypassing of the ±12V supplies at the chip itself, with as short as possible traces from the pins to 0.1 μF ceramic capacitors. Using surface mount chip capacitors reduces lead inductance and is therefore preferable in this case. Keeping the input traces as short and even in length is also important. The intent is to minimize inductance effects as well as standardize those effects on both inputs. The LM361 should have as much ground plane under and around it as possible. Trace widths for the input signals especially should be as wide as possible; 0.1 inch is usually sufficient. Finally, keep all associated discrete components nearby with short routing and good ground/supply connections.

Design equations for the LM361 in a 5250 application are shown here for example. The hysteresis voltage, V_h , can be expressed the following way:

$$V_h = V_{rio} + ((R_{in}/(R_{in} + R_f) \times V_{ol}) - (R_{in}/(R_{in} + R_f) \times V_{oh}))$$

where

- V_h — Hysteresis Voltages, Volts
- R_{in} — Series Input Resistance, Ohms
- R_f — Feedback Resistance, Ohms
- C_{in} — Input Capacitance, Farads
- V_{rio} — Receiver Input Offset Voltage, Volts
- V_{oh} — Output Voltage High, Volts
- V_{ol} — Output Voltage Low, Volts

The input filter values can be found through this relationship:

$$V_{cin} = V_{in1} - V_{in2}/1 + jwC_{in}(R_{in1} + R_{in2})$$

where $R_{in1} = R_{in2} = R_{in}$:

$$\begin{aligned} F_{ro} &= w/2\pi \\ F_{ro} &= 1/(2\pi \times R_{in} \times C_{in}) \\ C_{in} &= 1/(2\pi \times R_{in} \times F_{ro}) \end{aligned}$$

where

- V_{in1}, V_{in2} — Phase A and B signal voltages, Volts
- V_{cin} — Voltage across C_{in} , or the output of the filter, Volts
- R_{in1}, R_{in2} — Input resistor values, $R_{in1} = R_{in2}$, Ohms
- F_{ro} — Roll-Off Frequency, Hz
- W — Frequency, Radians

The roll-off frequency, F_{ro} , should be set nominally to 1 MHz to allow for transitions at the transmission bit rate. The transition rate when both phases are taken together is 2 MHz, but then R_{in1} and R_{in2} must be considered, so:

$$F_{ro2} = 1/(2\pi \times (R_{in1} + R_{in2}) \times C_{in})$$

or,

$$F_{ro2} = 1/(2\pi \times 2 \times R_{in} \times C_{in})$$

where $F_{ro2} = 2 \times F_{ro}$, yielding the same results.

The following table shows the range of values expected:

TABLE I

Value	Maximum	Minimum	Nominal	Units	Tolerance
R_{IN}	4.935E+03	4.465E+03	4.700E+03	Ω	0.05
R_F	8.295E+05	7.505E+05	7.900E+05	Ω	0.05
C_{IN}	4.4556E-11	2.6875E-11	3.3863E-11	F	
V_{OH}	5.250E+00	4.750E+00	5.000E+00	V	
V_{OL}	4.000E-01	2.000E-01	3.000E-01	V	
V_{IN+}	1.920E+00	1.000E-01		V	
V_{IN-}	1.920E+00	1.000E-01		V	
V_{RIO}	5.000E-03	0.000E+00	1.000E-03	V	
R	6.533E-03	5.354E-03	5.914E-03	Ω	
F_{ro}	1.200E+06	8.000E+05	1.000E+06	Hz	0.2
V_H	3.368E-02	2.691E-02	2.880E-02	V	
X_c	7.4025E+03	2.9767E+03	4.7000E+03	Ω	

The BCP has a number of advanced features that give designers much flexibility to adapt products to a wide range of IBM environments. Besides the basic multi-protocol capability of the BCP, the designer may select the inbound and outbound serial data polarity, the number of received and transmitted line quiesces, and in 5250 modes, a programmable extension of the TX-ACT signal after transmission.

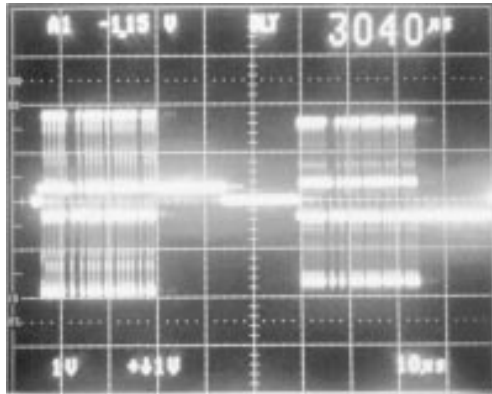
The polarity selection on the serial data stream is useful in building single products that handle both 3270 and 5250 protocols. The 3270 biphasic data is inverted with respect to 5250.

Selecting the number of line quiesces on the inbound serial data changes the number of line quiesce bits that the receiver requires before a line violation to form a valid start

sequence. This flexibility allows the BCP to operate in extremely noisy environments, allowing more time for the transmission line to charge at the beginning of a transmission. The selection of the transmitted line quiesce pattern is not generally used in the 5250 arena, but has applications in 3270. Changing the number of line quiesces at the start of a line quiesce pattern may be used by some equipment to implement additional repeater functions, or for certain inflexible receivers to sync up.

The most important advanced feature of the BCP for 5250 applications is the programmable TX-ACT extension. This feature allows the designer to vary the length of time that the TX-ACT signal from the BCP is active after the end of a transmission. This can be used to drive one phase of the

twinax line in the low state for up to 15.5 μ s. Holding the line low is useful in certain environments where ringing and reflections are a problem, such as twisted pair applications. Driving the line after transmitting assures that receivers see no transitions on the twinax line for the specified duration. The transmitter circuit shown in *Figure 5* can be used to hold either the A or B phase by using the serial inversion capability of the BCP in addition to swapping the A and B phases. Choosing which phase to hold active is up to the designer; 5250 devices use both. Some products hold the A phase, which means that another transition is added after the last half bit time including the high and low states, with the low state held for the duration, see *Figure 6*. Alternatively, some products hold the B phase. Holding the B phase does not require an extra transition and hence is inherently quieter.



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FIGURE 6. Line Hold Options

The signal was viewed in the same manner as *Figures 3* and *4*. The lefthand portion of the signal is a transmitting device utilizing line hold on phase A. The right hand side shows the IBM style (phase B) line hold.

To set the TX-ACT hold feature, the upper five bits of the Auxilliary Transceiver Register, {ATR [3-7]}, are loaded with one of thirty-two possible values. The values loaded select a TX-ACT hold time between 0 μ s and 15.5 μ s in 500 ns increments.

SOFTWARE INTERFACE

The BCP was designed to simplify designing IBM communications interfaces by providing the specific hardware necessary in a highly integrated fashion. The power and flexibility of the BCP, though, is most evident in the software that is written for it. Software design for the BCP deserves careful attention.

When designing a software architecture for 5250 terminal emulation, for example, one concern the designer faces is how to assure timely responses to the controller's commands. The BCP offers two general schemes for handling the real time response requirements of the 5250 data stream: interrupt driven transceiver interface mode, and polled transceiver interface mode. Both modes have strengths that make them desirable. The excellent interrupt

response and latency times of the BCP make interrupts very useful in most 5250 applications.

Although factors such as data and instruction memory wait states and remote processors waiting BCP data memory accesses can degrade interrupt response times, the minimum latency is 2.5 T-states. The BCP samples all interrupt sources by the falling edge of the CPU clock; the last falling edge prior to the start of the next instruction determines whether an interrupt will be processed. When an interrupt is recognized, the next instruction in the present stream is not executed, but its address is pushed on the address stack. A two T-state call to the vector generated by the interrupt type and the contents of {IBR} is executed and {GIE} (Global Interrupt Enable) is cleared. If the clock edge is missed by the interrupt request or if the current instruction is longer than 2 bytes, the interrupt latency is extended.

Running in an interrupt driven environment can be complex when multiple sessions are maintained by the same piece of code. The software has the added overhead of determining the appropriate thread or session and handling the interrupt accordingly. For a multi-session 5250 product, the transceiver interrupt service routines must determine which session is currently selected through protocol inferences and internal semaphores to keep the threads separate and intact.

In a polled environment, the biggest difficulty in designing software is maintaining appropriate polling intervals. Polling too often wastes CPU bandwidth, not polling frequently enough loses data and jeopardizes communication integrity. Standard practice in servicing polled devices is to count CPU clock cycles in the program flow to keep track of when to poll. A program change can result in lengthy recalculations of polling intervals and requalifications of program functionality. Using the programmable timer on board the BCP to set the polling interval alleviates the need to count instructions when code is changed or added. In both polled or interrupt environments, the latency effects of remote processors waiting memory accesses must be limited to a known length of time and figured into both polling intervals and worst case interrupt latency calculations. Using the programmable timer on the BCP makes both writing and maintaining polled software easier.

SOFTWARE ARCHITECTURE FOR 5250 EMULATION

The 5250 data rate is much lower than that of the 3270 data stream, hence it is possible for the BCP to emulate all seven 5250 sessions with a CPU frequency of 8 MHz. Choosing a 16 MHz crystal allows the transceiver to share the CPU clock at OCLK/2, eliminating an extra oscillator circuit. The 8 MHz rate yields a 125 ns T-state, or 250 ns for most instructions. Interrupt latency is typically one instruction (assuming no wait states or remote accesses) which is suitable for 5250 operation. If more speed is desired, the CPU could be switched to 16 MHz operation.

A MULTI-MODE TRANSCEIVER

The BCP provides two 5250 protocol modes, promiscuous and non-promiscuous. These two modes afford the designer a real option only when the end product will attach to one 5250 address at a time. The non-promiscuous mode is configured with an address in the {ATR} register and only re-

ceives messages whose first frame address matches that address, or an error occurs in the first frame of the message. Filtering out unwanted transmissions to other addresses leaves more CPU time for other non-protocol related tasks, but limits the device to one address at a time. The promiscuous mode allows messages to any and all addresses to be received. Resetting the transceiver during a message destined to another device forces the transceiver to begin looking for a start sequence again, effectively discarding the entire unwanted message. Because of its flexibility, the promiscuous mode is used in this illustration.

REAL TIME CONSIDERATIONS

Choosing a scheme for servicing the transceiver is basic to the design of any emulation device. The BCP provides both polled and interrupt driven modes to handle the real time demands of the chosen protocol. In this example, the interrupt driven approach is used. This implies the extra overhead of setting up interrupt vectors and initializing the interrupt masks appropriately. This approach eliminates the need to figure polling intervals within the context of other CPU tasks.

5250 CONFIGURATION

Configuring a complex device like the BCP can be difficult until a level of familiarity with the device is reached. To help the 5250 product designer through an initial configuration, a register by register description follows, along with the reasons for each configuration choice. Certainly, most applications will use different configurations than the one shown here. The purpose is to illustrate one possible setup for a 5250 emulation device.

There are two major divisions in the BCP's configuration registers: CPU specific and transceiver specific ones.

CPU SPECIFIC CONFIGURATION REGISTERS:

{DCR}—Device Control Register—This register controls the clocks and wait states for instruction and data memory. Using a value of H#A0 sets the CPU clock to the OCLK/2 rate, the transceiver to OCLK/2, and no wait states for either memory bank. As described above, the choice of a 16 MHz crystal and configuring this way allows 8 MHz operation now, with a simple software change for straight 16 MHz operation in the future.

{ACR}—Auxiliary Control Register—Loading this register with H#20 sets the timer clock source to CPU-CLK/2, sets [BIC], the Bidirectional Interrupt Control to configure BIRQ as an input, allows remote accesses with [LOR] cleared, and disables all maskable interrupts through [GIE] low. When interrupts are unmasked in [ICR], [GIE] must be set high to allow interrupts to operate. [GIE] can be set and cleared by writing to it, or through a number of instructions including RET and EXX.

{IBR}—Interrupt Base Register—This register must be set to the appropriate base of the interrupt vector table located in data RAM. The DP8344 development card and monitor software expect [IBR] to be at H#1F, making the table begin at H#1F00. The monitor software can be used without the interrupt table at H#1F00, but doing so is simplest for this illustration.

{ICR}—Interrupt Control Register—This register contains both CPU and transceiver specific controls. From the

CPU point of view, the interrupt masks are located here. In this illustration, the system requires receiver, transmitter, BIRQ, and timer interrupts, so that in operation those interrupt bits should be unmasked. For initialization purposes, though, interrupts should be masked until their vectors are installed and the interrupt task is ready to be started. Therefore, loading [ICR] with H#7F is prudent. This also sets the receiver interrupt source, but that will be discussed in the next section.

TRANSCIEVER CONFIGURATION REGISTERS:

{TMR}—Transceiver Mode Register—This register controls the protocol selection, transceiver reset, loopback, and bit stream inversion. Loading this register with H#0D sets up the receiver in 5250 promiscuous mode, inverts serial data out, does not invert incoming serial data, does not allow the transmitter and receiver to be active at the same time, disables loopback, and does not reset the transceiver. Choosing to set [RIN] low assumes that serial data will be presented to the chip in NRZI form. Not allowing the receiver and transmitter to operate concurrently is not an issue in 5250 emulation, since there is no defined repeater function in the protocol as in 3270 (3299). Bits [B5, 6], [RPEN] and [LOOP] are primarily useful in self testing, where [LOOP] routes the transmitted data stream into the receiver and simultaneous operation is desirable. Please note that for loopback operation, [RIN] must equal [TIN]. [TRES] is used regularly in operation, but should be left off when not specifically needed.

{TCR}—Transceiver Command Register—This register has both configuration and operation orientated bits, including the transmitted address and parity bits. For this configuration, the register should be set to H#00 and the specific address needed summed into the three LSBs, as appropriate. The [SEC] or Select Error Codes bit is used to enable the {ECR} register through the {RTR} transceiver FIFO port, and should be asserted only when an error has been detected and needs to be read. [SLR], or Select Line Receiver is set low to enable the TTL-IN pin as the serial data in source. The BCP's on chip comparator is best suited to transformer coupled environments, and National's LM361 high speed differential comparator works very well for the twinax line interface. [ATA], or Advance Transmitter Active is normally used in the 3270 modes to change the form of the first line quiesce bit for transmission. Some twinax products use a long first line quiesce bit, although it is not necessary. The lower four bits in {TCR} are used to form the frame transmitted when data is written into {RTR}, the transceiver FIFO port. Writing into {RTR} starts the transmitter and/or loads the transmit FIFO. The least significant three bits in {TCR} form the address field in that transmitted frame, and B3, [OWP] controls the type of parity that is calculated and sent with that frame. [OWP] set to zero calculates even parity over the eight data bits, address and sync bit as defined in the IBM 5250 PAI.

{ATR}—Auxiliary Transceiver Register—Since this application is configured for promiscuous mode, the {ATR} register serves only to set the line hold function time. In non-promiscuous mode, the three least significant bits of this register are the selected address. Setting this register to H#50 allows a 5 μ s hold time and clears the address field to 0, since promiscuous mode is used.

{FBR}—Fill Bit Register—This register controls the number of biphasic zeros inserted between concatenated frames when transmitting. This register should be set upon reception of the SET MODE instruction from the host. {FBR} contains the one's complement of the number of inter-frame fill bits so that H#FF sends no extra fill bits.

{ICR}—Interrupt Control Register—As discussed in the CPU configuration section, this register sets [RIS] or Receiver Interrupt Select as well as the interrupt mask. Setting the register to H#7F selects [DA + ERR], Data Available or transceiver ERROR, as the interrupt source. This interrupt is asserted when either a valid frame has been clocked into the receive FIFO or an error has occurred. Other interrupt options are available including: [RA], Receiver Active; and [RFF + ERR], Receive FIFO Full or transceiver ERROR. For 5250 protocols the [DA + ERR] is most efficient. The [RFF + ERR] interrupt will not assert until the FIFO is full . . . regardless of whether the incoming message is single or multi-frame. [RA] provides plenty of notice that a frame is incoming, but due to the speed of the BCP, this advanced warning is not generally needed. [DA + ERR] provides a notification just after the parity bit has been decoded from the incoming frame which is almost 3 μ s prior to the end of the frame. With the CPU running at 8 MHz, that allows typically nine instructions $((4 * 3) - 3))$ for interrupt latency, trap and bank switch after interrupting.

MULTI-SESSION POWER

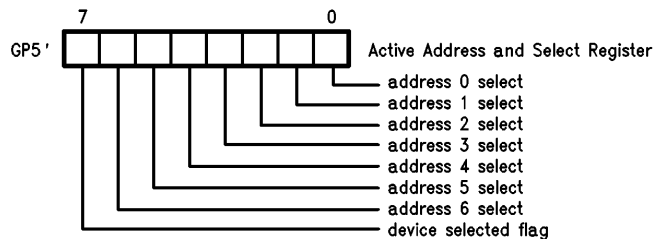
Handling multiple sessions in software is not trivial, and making the receiver service routines interrupt driven complicates the task further. The BCP is so fast, that at 8 MHz handling a multi-frame message by interrupting on the first frame and polling for succeeding frames is very inefficient. To maximize bandwidth for non-protocol related tasks, the CPU should handle each frame separately on interrupt and exit. To do this, a number of global state variables must be maintained. Since the alternate B register bank is primarily used for transceiver functions anyway, dedicating the other registers in that bank permanently as state variables is acceptable in most cases; doing so speeds and simplifies access to them. Defining the following registers as:

enables the software to keep track of the various states the protocol must handle.

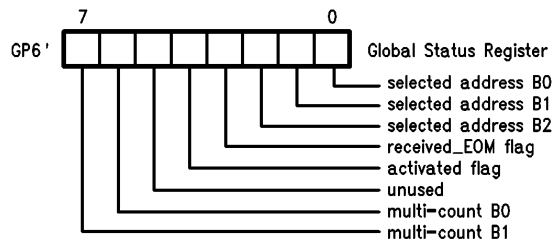
The active address bits in GP5' allow individual addresses to be active, or any combination of addresses. When interrupted by a message to a non-selected address, [TRES] is toggled to reset the receiver until the beginning of the next message is detected. [B7] is used to determine if any particular address is "selected" and in the process of receiving data. The selected flag is set and cleared according to specific protocol rules set up in the IBM PAI.

Register GP6' contains the selected address storage [B0–2], where the address of the device expecting at least one other frame is stored when exiting the interrupt service routine, so that upon interruption caused by the reception of that frame, the address is still available. The received__EOM flag, [B3] is set when a message is decoded that contains B#111 or EOM delimiter. It is stored in this global status register to allow the protocol to determine the end of a transmission. In most multi-byte transmissions, the number of data frames expected is dictated by the protocol. However, ACTIVATE WRITE commands to printers can have any number of data frames associated with them up to 256. In this situation, the activated flag, [B4] is set to signal a variable length stream. Certain host devices also concatenate commands within messages, obscuring the determination of end of message. This scheme allows the software to keep track during such scenarios. The multi-count bits, [B6–7] are used in addition to the EOM delimiter to determine the end of a transmission. The number of additional frames expected in a given multi-byte command is written into these bits (note that a maximum of three bytes can be planned for in this way). When the count is terminated and no EOM delimiter is present, the algorithm then assumes a multi-command message is in progress. [B5] is unused.

Register GP7' is used to store the received data or error code for passage to other routines. The data can be passed on the stack, but dedicating a register to this function simplifies transactions in this case. Keeping track of received data is of utmost importance to communications devices.



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GP7'—Bits [0–7] Received Data or Error Register

RECEIVER INTERRUPT

The receiver interrupt algorithm handles any or all seven addresses possible on the twinax line. The same code is used for each address by utilizing a page oriented memory scheme. Session specific variables are stored in memory pages of 256 bytes each. All session control pages, or SCPs are on 256-byte even boundaries. By setting the high order byte of a BCP index register to point to a particular page or SCP, the low order byte then references an offset within that page. Setting up data memory in such a way that the first SCP begins at an address of B#xxxx x000 0000 0000 further enhances the usefulness of this construct. In this scheme, the high byte of the SCP base pointer can be used to set the particular SCP merely by summing the received or selected address into the lower three bits of the base register.

NORMAL OPERATION

In normal operation, the configuration described thus far is used in the following manner: After initializing the registers, data structures are initialized, and interrupt routines should be activated. This application utilizes the receiver, transmitter, timer, and bi-directional interrupts. Since {IBR} is set to H#1F, the interrupt table is located at H#1F00. A LJMP to the receiver interrupt routine should be installed at location H#1F104, the transmitter interrupt vector at H#1F08, the BIRQ interrupt vector at H#1F10, and the Timer interrupt vector at H#1F14. Un-masking the receiver interrupt and BIRQ at start up allows the device to come on-line.

When interrupt by the receiver, the receiver interrupt service routine first checks the [ERR] flag in {TSR [B5]}. If no errors have been flagged, the received_EOM flag is either set or cleared. This is accomplished by comparing {TSR [B0-2]} with the B#111 EOM delimiter. A test of the selected flag, {GP5' [B7]} determines if any of the active addresses are selected. Assuming that the system is just coming on line, none of the devices would be selected. If the frame is addressed to an active device, the SCP for that device is set, and the command is parsed. Parsing the command sets the appropriate state flags, so that upon exiting, the interrupt routine will be prepared for the next frame. Once parsed, the command can be further decoded and handled. If the command is queue-able, the command is pushed on the internal command queue, and the receiver interrupt routine exits. If the command requires an immediate response, then the response is formulated, the timer interrupt is setup, and the routine is exited.

The timer interrupt is used in responding to the host by waiting an appropriate time to invoke the transmit routine. The typical response delay is $45 \pm 15 \mu\text{s}$ after the last valid fill bit received in the command frame. Some printers and terminals are allowed a full $60 \pm 20 \mu\text{s}$ to respond. In either case, simply looping is very inefficient. The immediate response routine simply sets the timer for the appropriate delay and unmask the timer.

In the transmit routine, the data to be sent is referenced by a pointer and an associated count. The routine loads the appropriate address in the three LSBs of {TCR}, and writes the data to be sent into {RTR}. This starts the transmitter. If the data count is greater than the transmit FIFO depth (three bytes), the Transmit FIFO Empty interrupt [TFE] is

setup. This vectors to code that refills the FIFO and re-enables that interrupt again, if needed. This operation must be carried out before the transmitter is finished the last frame in the FIFO or the message will end prematurely.

The last frame transmitted must contain the EOM delimiter. It can be loaded into {TCR} and data into {RTR} while the transmitter is running without affecting the current frame. In other words, the transmit FIFO is 12 bits wide, including address and parity with data; the address field is clocked along with the data field. In this way, multi-byte response may be made in efficient manner.

ERROR HANDLING

In 5250 environments, the time immediately after the end of message is most susceptible to transmission errors. The BCP's receiver does not detect an error after the end of a message unless transitions on the line continue for a complete frame time or resemble a valid sync bit of a multi-frame transmission. If the twinax line is still active at the end of what could be an error frame, the receiver posts the LMBT error. For example, if noise on the twinax line continues for up to $11 \mu\text{s}$ after the three required fill bits, the receiver will reset without flagging an error. If noise resembles a start bit, the receiver now expects a new frame and will post an error if a loss of synchronization occurs. If the noisy environment is such that transitions on the receiver's input continue for $11 \mu\text{s}$, or the receiver really has lost sync on a real frame, the error is posted.

Basically, the receiver samples [LA] in addition to the loss of synchronization indication to determine when to reset or to post an error. After a loss of synchronization in the fill bit portion of a frame, if the [LA] flag's time-out of $2 \mu\text{s}$ is reached prior to the end of what could be the next frame, the receiver will reset. If the transitions prevent [LA] from timing out for an entire $11 \mu\text{s}$ frame time, a LMBT error is posted. This method for resetting the receiver is superior in that not only are the spurious loss of mid bit errors eliminated, the receiver performs better in noisy environments than other designs.

SUMMARY

The IBM 5250 twinax environment is less understood and in some ways more complex than the 3270 environment to many developers. This application note has attempted to explain some basics about twinax as a transmission medium, the hardware necessary to interface the DP8344 to that medium, and some of the features of the BCP that make that task easier. Schematics are included in this document to illustrate possible designs. Details of the twinax waveforms were discussed and figures included to illustrate some of the more relevant features. Also, some different software approaches to handling the transceiver interface were discussed.

REFERENCES

5250 Information Display to System/36 and System/38 System Units Product Attachment Information, IBM, November 1986.

Transmission Line Characteristics, Bill Fowler, National Semiconductor Application Note AN-108.

Basic Electromagnetic Theory, D.T. Paris, F.K. Hurd McGraw-Hill Inc., 1969.

APPENDIX A: EXAMPLE CODE

The following code was assembled with the HILEVEL assembler. Table II shows the correlation between HILEVEL mnemonics and the mnemonics used in National data sheets for the DP8344V.

TABLE II

HILEVEL	National Semiconductor
---------	------------------------

MOVE Rs,Rd	MOVE Rs,Rd
LD Ptr,Rd{,Mde}	MOVE [mIr],Rd
ST Rs,Ptr{,Mde}	MOVE Rs,[mIr]
LDAX Ptr,Rd	MOVE [Ir + A],Rd
STAX Rs,Ptr	MOVE Rs,[Ir + A]
LDNZ n,Rd	MOVE [IZ + n],rd
STNZ Rs,n	MOVE rs,[IZ + n]
LDI n,Rd	MOVE n,rd
STI n,Ptr	MOVE n,[Ir]
ADD Rs,Rd	ADDA Rs,Rd
ADDRI Rs,Ptr{,Mde}	ADDA Rs,[mIr]
ADDI n,Rsd	ADD n,rsd
ADC Rs,Rd	ADCA Rs,Rd
ADCRI Rs,Ptr{,Mde}	ADCA Rs,[mIr]
SUBT Rs,Rd	SUBA Rs,Rd
SUBRI Rs,Ptr{,Mde}	SUBA Rs,[mIr]
SUBI n,Rsd	SUB n,rsd
SBC Rs,Rd	SBCA Rs,Rd
SBCRI Rs,Ptr{,Mde}	SBCA Rs,[mIr]
AND Rs,Rd	ANDA Rs,Rd
ANDRI Rs,Ptr{,Mde}	ANDA Rs,[mIr]
ANDI n,Rsd	AND n,rsd
OR Rs,Rd	ORA Rs,Rd
ORRI Rs,Ptr{,Mde}	ORA Rs,[mIr]
ORI n,Rsd	OR n,rsd
XOR Rs,Rd	XORA Rs,Rd
XORRI Rs,Ptr{,Mde}	XORA Rs,[mIr]
XORI n,Rsd	XOR n,rsd
CMP Rs,n	CMP rs,n
CPL Rsd	CPL Rsd
BIT Rs,n	BIT rs,n
SRL Rsd,n	SHR Rsd,b
SLA Rsd,n	SHL Rsd,b
ROT Rsd,n	ROT Rsd,b

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JMP n	JMP n
LJMP n	LJMP nn
JMPR Rs	JMP Rs
JMPI Ptr	LJMP [Ir]
JRMC Rs,n,m	JRMC Rs,b,m
JMPB Rs,s,p,n	LJMP Rs,p,s,nn
JMPF s,f,n	JMP f,s,n
	Jcc n - opt. syntax for JMP f-
CALL n	CALL n
LCALL n	LCALL nn
CALLB Rs,s,p,n	LCALL Rs,p,s,nn
RET {g{,rf}}	RET {g {,rf}}
RETF s,f{,g{,rf}}	RETF f,s,{,g} {,rf}}
	Rcc {g {,rf}} - opt. syntax -
EXX a,b{,g}	EXX ba,bb,{,g}
TRAP n{,g}	TRAP n {,gU}

Table 2.

Addr	Line
1	.REL
2	TAB 8
3	WIDTH 132
4	LIST S,F
5	TITLE RXINT
6	-----
7	; RXINT - 9/21/87
8	;
9	; pseudo code
10	;
11	;bool selected; /* station is selected
12	;byte seladdr; /* address of selected station
13	;byte multicount; /* number of frames in this multi
14	;bool activated; /* command has been activated
15	;
16	;rxint()
17	;byte data; /* data storage
18	;bool rx_eom; /* received EDM
19	;bool lta; /* line turn around flag
20	{
21	; if (error) {
22	; if (logerror()== true) return; /* receiver errors
23	; }
24	; else {
25	; if (TSR == EDM) rx_eom = true; /* set received EDM flag
26	; else rx_eom = false;
27	;
28	; if (!selected) {

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```

29 ;           if (active) {
30 ;               if (!rx_eom) {
31 ;                   seladdr = (TSR * EDM);
32 ;                   IZ = (SCPBASE + seladdr); /* set SCP to appropriate session */
33 ;                   data = rtr;
34 ;               }
35 ;               else {
36 ;                   proto_error(); /* should not get here
37 ;                   reset_xcvr();
38 ;                   return();
39 ;               }
40 ;           }
41 ;           else {
42 ;               reset_xcvr(); /* not of interest
43 ;               return();
44 ;           }
45 ;           if (multiframe) { /* activate write, etc...
46 ;               multicount = parse(data); /* set number of frames */
47 ;               selected = true; /* only way to select */
48 ;               queue(data);
49 ;           }
50 ;           else { /* not multi
51 ;               if ((var = single_decode(data)) == queable)
52 ;                   queue(data);
53 ;               else if (var == immed) immediate(data);
54 ;           }
55 ;           else { /* selected */
56 ;               IZ = (SCPBASE + seladdr);

```

Addr Line RXINT

```

56 ;           data = rtr
57 ;           if (activated) { /* in the middle of transmission
58 ;               act_data(data);
59 ;               if (rx_eom) { /* end of message
60 ;                   selected = false;
61 ;                   activated = false;
62 ;               }
63 ;               return();
64 ;           }
65 ;           if (multicount > 0) {
66 ;               queue(data);
67 ;               if (multicount-- == 0) {
68 ;                   if (rx_eom) selected = false;
69 ;               }
70 ;           }
71 ;           else {
72 ;               if (multiframe) {
73 ;                   multicount = parse(data);
74 ;                   queue(data);
75 ;               }
76 ;               else {
77 ;                   if ((var = single_decode(data)) == queable)
78 ;                       queue(data);

```

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```

79 ;                                     else if (var == immed) immediate(data);
80 ;                                     if (rx_eom) selected = false;
81 ;                                     }
82 ;                                     }
83 ;                                     }
84 ;                                     }
85 ;                                     }
86 ;         return();
87 ;}
88 ;logerror()
89 ;{
90 ; bool result;
91 ;     switch (error_type) {
92 ;         case RDIS:
93 ;             result = err_rdis();                /* receiver disabled while active
94 ;             break;
95 ;         case LMBT:
96 ;             result = err_lmvt();                /* loss of midbit error
97 ;             break;
98 ;         case PARR:
99 ;             result = err_parr();                /* parity error
100 ;            break;
101 ;         case OVF:
102 ;             result = err_ovf();                /* receiver FIFO overrun
103 ;            break;
104 ;         default:
105 ;             result = err_unknown();            /* strange error handler
106 ;            break;
107 ;         }
108 ;     return(result);
109 ; }
110 ;

```

Addr Line RXINT

```

111 ;err_lmvt()
112 ;{
113 ;     if (!DA && !selected && !delay(LA)) return(false); /* delay of 6 usec
114 ;     else {
115 ;         log();                /* bump error counters
116 ;         return(true);         /* admit defeat
117 ;     }
118 ; }
119 ;-----
120 ;     name:          RXINT
121 ;     description:   receiver interrupt handler
122 ;
123 ;         received datum is sent to other routines thru gp7'
124 ;         SCP is set appropriately in IZ
125 ;         GPSP - active addresses:bits 0-6
126 ;         selected flag: bit 7
127 ;         GP6P - multicount: bit 7-6
128 ;         unused: bit 5

```

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```

129 ;          activated:    bit 4
130 ;          rx_eom flag:  bit 3
131 ;          seladdr:      bits 2-0
132 ;          GP7P - received data
133 ;
134 ;          entry:         DA interrupt, GP5', GP6'
135 ;          exit:          ACC',GP7' ARE DESTROYED
136 ;          history:       tjq 9/16/87 create
137 ;-----
138 PUBLIC RCVRINT
139
140 EXTRN PARSE,QUEUE,IMMECODE,RESXCVR
141 EXTRN MIDERRL,MIDERRH,OVFERRL,OVFERRH,PARERRL,PARERRH
142 EXTRN RXERRL,RXERRH,RSPCTL,RSPCTH,BASESCP,IESERRL,IESERRH
143
144
145 SELERR: EQU B#01000000 ; select the error register
146 RXEOM: EQU B#00001000 ; rx_eom flag
147 EDM: EQU B#00000111 ; EDM delimiter
148 MULTI: EQU B#11000000 ; multicount
149 SELECT: EQU B#10000000 ; selected flag
150 LTA: EQU B#101 ; "
151 CFLAG: EQU B#00000010 ; CARRY FLAG
152
00000 153 RCVRINT:
154 EXX MA,AB,DI ; SET APPROPRIATE BANK
00000 AEE8 154
00001 D500 155 JMPF NS,RERR,NOERROR
00002 CC00 156 CALL RXERROR ; ERROR IN FRAME
00003 D900 157 JMPF S,C,EXIT ; ABORT
00004 D900 158 NOERROR:
00004 B078 159 LDI EDM,ACC ; LOAD MASK
160 AND TSR,GP7 ; FORM ADDRESS
00005 F165 160
161 CMP GP7,EDM ; TEST
00006 3078 161
00007 D000 162 JMPF NS,Z,C1RXINT ; IF NOT EQUAL, JUMP

Addr Line RXINT

00008 508A 163 ORI RXEOM,GP6 ; ELSE SET EDM FLAG
00009 CB00 164 JMP C2RXINT ;
0000A CB00 165 C1RXINT:
0000A 4F7A 166 ANDI RXEOM*,GP6 ; CLEAR IT
167 ;
168 ; DECIDE IF WE'RE ALREADY SELECTED
169 ;
0000B 170 C2RXINT:
171 JMPB GP5,S,B7,DEVSELECT ; IF ALREADY SELECTED
0000B BDE9 171
0000C 0000 171
172 ;
173 ; NOT SELECTED...DECIDE IF ADDRESS IS ACTIVE, IE; VALID FOR US

```

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```

174 ;
0000D 175 DEVTABLE: ; ELSE, SEE IF ACTIVE
176 JRNK TSR,ROT6,MSK3 ; JUMP BASED ON THE ADDRESS FIELD*4
0000D B3C5 176
177 JMPB GP5,NS,B0,RSTRX ; ADDR 0 - IF NOT ACTIVE, RESET RX
0000E BC09 177
0000F 0000 177
178 LJMP LOADSCP ; ACTIVE DEVICE, SET scp
00010 CE00 178
00011 0000 178
179 JMPB GP5,NS,B1,RSTRX ; ADDR 1 - IF NOT ACTIVE, RESET RX
00012 BC29 179
00013 0000 179
180 LJMP LOADSCP ; ACTIVE DEVICE, SET scp
00014 CE00 180
00015 0000 180
181 JMPB GP5,NS,B2,RSTRX ; ADDR 2 - IF NOT ACTIVE, RESET RX
00016 BC49 181
00017 0000 181
182 LJMP LOADSCP ; ACTIVE DEVICE,
00018 CE00 182
00019 0000 182
183 JMPB GP5,NS,B3,RSTRX ; ADDR 3 - IF NOT ACTIVE,
0001A BC69 183
0001B 0000 183
184 LJMP LOADSCP ; ACTIVE DEVICE,
0001C CE00 184
0001D 0000 184
185 JMPB GP5,NS,B4,RSTRX ; ADDR 4 - IF NOT ACTIVE,
0001E BC89 185
0001F 0000 185
186 LJMP LOADSCP ; ACTIVE DEVICE,
00020 CE00 186
00021 0000 186
187 JMPB GP5,NS,B5,RSTRX ; ADDR 5 - IF NOT ACTIVE,
00022 BC49 187
00023 0000 187
188 LJMP LOADSCP ; ACTIVE DEVICE,
00024 CE00 188
00025 0000 188
189 JMPB GP5,NS,B6,RSTRX ; ADDR 6 - IF NOT ACTIVE,
00026 BCC9 189

Addr Line RXINT

00027 0000 189
190 LJMP LOADSCP ; ACTIVE DEVICE,
00028 CE00 190
00029 0000 190
191 LCALL RESXCVR ; ADDR 7 - RECEIVED EOM ...WE'RE NOT INTERESTED
0002A CE80 191
0002B 0000 191
0002C CB00 192 JMP EXIT ; QUIT

```

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```

193 ;
194 ; LOAD THE SCP POINTER, IZ
195 ;
0002D 196 LOADSCP:
197     XOR    ACC,ACC    ; CLEAR
0002D F908 197
198     MOVE   ACC,ZLO    ; LOW BYTE
0002E FE48 198
0002F B008 199     LDI    BASESCP,ACC ; SET UP UPPER BYTE OF SCP POINTER
200     MOVE   ACC,ZHI    ;
00030 FE68 200
00031 B07B 201     LDI    EDM,ACC    ; EDM MASK
202     AND    TSR,ACC    ; LEAVE IN ACC
00032 F105 202
203     ADD    ZHI,ZHI    ; ADD INTO Z POINTER
00033 E273 203
204 ;
205 ; DECODE THE COMMAND FRAME
206 ;
00034 207 DECODE:
208     MOVE   RTR,GP7    ; GET RX DATA
00034 FD64 208
209     JMPB   GP7,S,B0,MULTIFRM; IF MULTIFRAME
00035 BD0B 209
00036 0000 209
210     LCALL  IMMEDECODE ; ELSE, IMMEDIATE ACTION REQUIRED
00037 CE80 210
00038 0000 210
00039 CB00 211     JMP    EXIT
0003A CB00 212 MULTIFRM:
213     LCALL  PARSE      ; SET MULTI COUNT
0003A CE80 213
0003B 0000 213
0003C 5809 214     ORI    H#80,GP5    ; SELECTED = TRUE
0003D 4F8A 215     ANDI   EDM*,GP6    ; CLEAR SELECTED ADDRESS
0003E B07B 216     LDI    EDM,ACC    ; MASK ADDRESS
217     AND    TSR,ACC    ; LEAVE IN ACC
0003F F105 217
218     OR     GP6,GP6    ; SET NEW ADDRESS
00040 F54A 218
219     LCALL  QUEUE      ; PLACE ON QUEUE
00041 CE80 219
00042 0000 219
00043 CB00 220     JMP    EXIT      ;
221 ;
222 ; THIS CODE IS BRANCHED TO IF THE DEVICE IS SELECTED
223 ;     FIRST, SET SCP BASED ON SELECTED ADDRESS

Addr    Line RXINT

00044 224 ;
225 DEVSELECT:
226     XOR    ACC,ACC    ; CLEAR ACC

```

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```

00044 F908 226
227      MOVE    ACC,ZLO      ; CLEAR LOW BYTE OF POINTER
00045 FE48 227
00046 B008 228      LDI     BASESCP,ACC  ; BASE OF SESSION CONTROL PAGE
229      MOVE    ACC,ZHI      ; UPPER BYTE
00047 FE68 229
00048 B078 230      LDI     EOM,ACC    ; MASK ADDRESS
231      AND     GP6,ACC      ; LEAVE IN ACC
00049 F10A 231
232      ADD     ZHI,ZHI      ; FORM SCP POINTER
0004A E273 232
233      ;
234      ; NOW DECIDE ABOUT MULTIFRAME POSSIBILITIES
235      ;
236      MOVE    RTR,GP7      ; GET DATA
0004B FD64 236
0004C BC08 237      LDI     MULTI,ACC    ; MULTI MASK
238      AND     GP6,ACC      ; COUNT IN UPPER NIBBLE
0004D F10A 238
239      SRL     ACC,ROT6     ; POSITION IN LOWER NIBBLE
0004E C8C8 239
0004F D800 240      JMPF    S,Z,NEWCOMM  ; NOT in A MULTIBYTE
241      LCALL   QUEUE        ; MULTI, SO PUSH ON QUEUE
00050 CE80 241
00051 0000 241
00052 2018 242      SUBI     H#01,ACC    ; DECREMENT MULTICOUNT
00053 D800 243      JMPF    S,Z,TERMULTI ; IF ZERO, MULTI HAS TERMINATED
244      ;
245      ; MULTI STILL IN PROGRESS
246      ;
00054 43FA 247      ANDI     MULTI*,GP6  ; CLEAR OUT OLD COUNT
248      SLA     ACC,ROT6     ; REPOSITION COUNT
00055 C948 248
249      OR      GP6,GP6      ; SUM INTO STATUS
00056 F54A 249
00057 CB00 250      JMP     EXIT
251      ;
252      ; MULTICOUNT HAS REACHED ZERO, SO TERMINATE
253      ;
00058 254      TERMULTI:
00058 43FA 255      ANDI     MULTI*,GP6  ; CLEAR OLD COUNT TO ZERO
256      JMPB    GP6,NS,B3,C1TERM; IF NOT EOM,
00059 BC6A 256
0005A 0000 256
0005B 47F9 257      ANDI     SELECT*,GP5  ; ELSE, SELECT = FALSE
0005C CB00 258      JMP     RSTRX      ; RESET THE TRANSCEIVER
0005D CB00 259      C1TERM:
0005D CB00 260      JMP     EXIT
261      ;
262      ; NEW COMMAND; MULTI OR SINGLE
263      ;
0005E 264      NEWCOMM:

```

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Addr	Line	RXINT
	265	JMPB GP7,NS,B0,SINGLE; IF NEW COMMAND IS NOT MULTI,
0005E BC0B	265	
0005F 0000	265	
	266	LCALL PARSE ; IS MULTI, SET COUNT
00060 CEB0	266	
00061 5000	266	
	267	LCALL QUEUE ; PUSH ON QUEUE
00062 CEB0	267	
00063 0000	267	
00064 CB00	268	JMP EXIT ; QUIT, TIL NEXT FRAME
	269	;
	270	; NEW COMMAND IS SINGLE AND/OR NEEDS IMMEDIATE RESPONSE
	271	;
00065	272	SINGLE:
	273	LCALL IMMEDECODE ; SINGLE...GO DO IT
00065 CEB0	273	
00066 0000	273	
	274	JMPB GP6,NS,B3,EXIT ; IF NOT EOM...
00067 BC6A	274	
00068 0000	274	
00069 47F9	275	ANDI SELECT*,GP5 ; CLEAR SELECTED BIT
0006A 47F9	276	RSTRX:
	277	LCALL RESXCVR ; RESET, CLEAR DATA OUT
0006A CEB0	277	
0006B 0000	277	
0006C 0000	278	EXIT:
0006C AFB0	279	RET RI,RF ; RETURN GRACEFULLY
	280	
	281	;
	282	; name: RXERROR
	283	; description: receiver ERROR handler
	284	;
	285	; entry: DA + ERR interrupt, GP5', GP6'
	286	; exit: ACC',GP7' ARE DESTROYED
	287	; history: tjq 9/16/87 create
	288	;
	289	;
	290	; RECEIVER ERROR HANDLER
	291	;
0006D	292	RXERROR:
0006D 5406	293	ORI SELERR,TCR ; SET ECR BIT
	294	MOVE RTR,GP7 ; GET ERROR TYPE
0006E FD64	294	
0006F 4BF6	295	ANDI SELERR*,TCR ; RESET TCR
	296	JMPB GP7,S,B1,LMBTERR; LOSS OF MIDBIT
00070 BD2B	296	
00071 0000	296	
	297	JMPB GP7,S,B3,PARERR ; PARITY
00072 BD6B	297	
00073 0000	297	
	298	JMPB GP7,S,B4,OVFERR ; OVERFLOW

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00074 BDBB 298
00075 0000 298
00076 0000 299  ILLEGAL:
00076 B00B 300      LDI    ILLEGAL,ACC    ; WHAT ERROR IS THIS?

Addr      Line  RXINT

00077 CB00 301      JMP     BUMPERR      ; SHOULD NOT GET HERE!!
00078 CB00 302  LMBTERR:
00078 DE00 303      JMPF    S,DA,CLEARC    ; if DA, THEN NO ERROR
00078 DE00 304      JMPB    GPS,S,B7,LOGIT  ; IF SELECTED, POST
00079 BDE9 304
0007A 0000 304
0007B CC00 305      CALL    SDLY          ; DELAY FOR 6 USEC
0007B CC00 306      JMPB    NCF,NS,B5,CLEARC; IF NOT ACTIVE - DISCARD, ELSE POST
0007C BCA1 306
0007D 0000 306
0007E 0000 307  LOGIT:
0007E B008 308      LDI     MIDERRL,ACC    ; LOSS OF MIDBIT
0007F CB00 309      JMP     BUMPERR      ; INCREMENT COUNTER
00080 CB00 310  PARERR:
00080 B008 311      LDI     PARERRL,ACC    ; PARITY
00081 CB00 312      JMP     BUMPERR
00082 CB00 313  OVFERR:
00082 B008 314      LDI     OVFERRL,ACC    ; OVERFLOW...VERY BAD!
00083 B00B 315  BUMPERR:
00083 B00B 316      ADD     ZLD,YLD      ; FORM NEW POINTER
00083 E212 316
00084 B018 317      LDI     H#01,ACC      ; INCREMENT
00084 B018 318      LD      PTRY,GP6      ; FETCH OLD COUNT
00085 C0CA 318
00085 C0CA 319      ADDR1   GP6,PTRY,POSTD  ; WRITE OUT NEW
00086 A04A 319
00087 D100 320      JMPF    NS,C,RXEXIT    ; GET OUT
00087 D100 321      LD      PTRY,GP6      ; FETCH UPPER BYTE
00088 C0CA 321
00088 C0CA 322      ADDR1   GP6,PTRY      ;
00089 A0CA 322
0008A 5020 323      ORI     CFLAG,CCR      ; SET CARRY
0008B 5020 324  RXEXIT:
0008B AFB0 325      RET          ; DO NOT restore flags
0008C AFB0 326  CLEARC:
0008C 4FD0 327      ANDI    CFLAG*,CCR    ; CLEAR CARRY
0008D CB00 328      JMP     RXEXIT
0008D CB00 329 ; -----
0008D CB00 330 ;      name:      SDLY
0008D CB00 331 ;      description:  delay routine, MULTIPLES OF 4.8usec,
0008D CB00 332 ;                  1.4 usec OVERHEAD, MAX OF 410usec
0008D CB00 333 ;      entry:      delay count on stack
0008D CB00 334 ;      exit:       acc destroyed
0008D CB00 335 ;      WARNING:    DONT CALL THIS WITH COUNT = 0!
0008D CB00 336 ;      history:    tqj 9/16/87  create
0008D CB00 337 ; -----

```

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338
000BE 339 SDLY:
340 EXX MA,MB,NAI ; BANK, ALLOW INTERRUPTS
000BE AE80 340
341 MOVE DS,ACC ; SET COUNT
000BF FD1F 341
342 MOVE GP7,DS ; PUSH GP7 REGISTERS USED
00090 FFEB 342
343 MOVE GP6,DS
Addr Line RXINT

00091 FFEA 343
344 MOVE ACC,GP7 ; USE GP7 FOR COUNT ALSO
00092 FB68 344
00093 FD68 345 SDLYLP1:
00093 B03A 346 LDI H#03,GP6 ; LOAD FOR 4.8ussec COUNTS
00094 B03A 347 SDLYLP2:
00094 201A 348 SUBI H#01,GP6 ; DECREMENT COUNT
00095 D000 349 JMPF NS,2,SDLYLP2 ; CONTINUE UNTIL EXHAUSTED
00096 201B 350 SUBI H#01,GP7 ; DECREMENT OUTER COUNT
00097 D000 351 JMPF NS,2,SDLYLP1 ; CONTINUE IF NOT ZERO
352 MOVE DS,GP6 ; POP REG
0009B FD5F 352
353 MOVE DS,GP7 ;
00099 FB7F 353
0009A AFB0 354 RET RI,RF ; RETURN, RESTORE FLAGS
355
356
357 END
```

Assembly Phase complete.
0 error(s) detected.

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Lit. # 100516

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