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Integral Modem Design Alternatives

Mini/Micro Southwest-84
1984 Computer Conference and Exhibition
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Central U.S. Council ERA; Southwest and Chicagoland Chapters, ERA

Session 1 — Integral Modem Design Alternatives

Session Organizer and Chairman
Stephen J. Durham
Cermetek Microelectronics, Inc.
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1/1 — 1200 BPS Full Duplex Modems - No Longer State of the Art Technology

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Jeffrey T. Higgins
Rockwell International
Newport Beach, CA

1/2 — Changing Trends of Modem IC's

Al Mouton
Motorola, Inc.
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1/3 — Integrating Low Speed to Medium and High Speed Modems

Peter Ehlig
Raj Chirayil
Texas Instruments
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1/4 — Modem Modules: The Complete Data Communications Solution

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SESSION INDEX OF THE MINI/MICRO SOUTHWEST 84 PROGRAM

1200 BPS FULL-DUPLEX MODEMS - NO LONGER STATE-OF-THE-ART TECHNOLOGY

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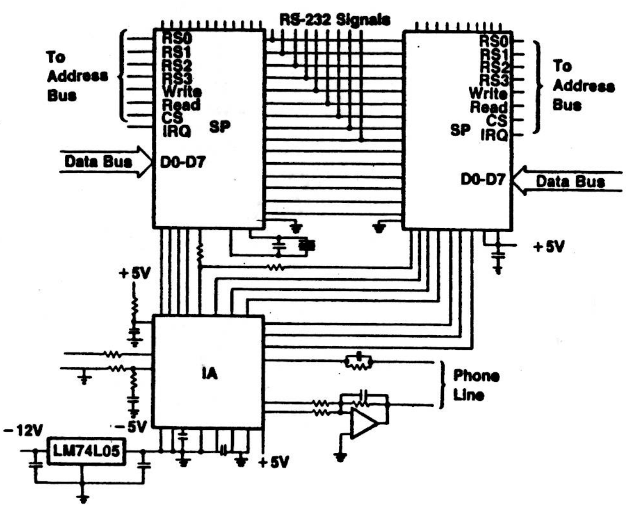
Signal processors (SP) and integrated analog (IA) devices enhance full-duplex modems. Not only do the high efficiency and versatility of the devices provide many functions, but they also supply benefits that typically are not found with other implementations.

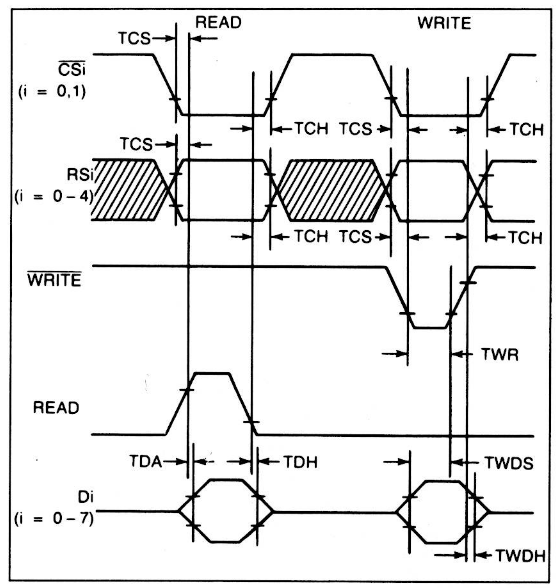
A V.22 bis modem can be implemented with three devices: two signal processors and one integrated analog device. The two SP's would divide the transmit and receive functions between the two of them. One SP would do all functions pertaining to the transmitter and the other the receiver functions. The IA device would contain all the necessary filters etc. to implement the full-duplex two wire transmission and reception.



INTERFACE

The signal processor gives the user two methods of interfacing the modem: serially with an RS-232-C port and over an 8-bit microprocessor bus.

Most new designs require the use of a microprocessor. If the design also needs to provide communications capabilities, why not use a modem with an interface that all engineers are familiar with--a microprocessor peripheral interface. Like other peripherals, the R2424DC V.22 bis modem interface needs little "glue" circuitry to make it work. Just some chip select logic (this may already be available due to the other peripherals on the board) is all that's needed.



Microprocessor Interface Timing Diagram

Characteristic	Symbol	Min	Max	Units
CSi, RSi setup time prior to Read or Write	TCS	30	—	NS
Data Access time after Read	TDA	—	140	NS
Data hold time after Read	TDH	10	50	NS
CSi, RSi hold time after Read or Write	TCH	10	—	NS
Write data setup time	TWDS	75	—	NS
Write data hold time	TWDH	10	—	NS
Write strobe pulse width	TWR	75	—	NS

Critical Timing Requirements

The 8-bit bus is the only way to configure the modem because the scratch pad memory contains the configuration registers. Other registers are for status reporting, handshake, interrupts, and diagnostics.

Register \ Bit	7	6	5	4	3	2	1	0
0								
1								
2	Diagnostic Data Real Low							
3	Diagnostic Data Real High							
4	Diagnostic Data Imaginary Low							
5	Diagnostic Data Imaginary High							
6								
7								
8	TONE						RDLI	RLSD
9			Speed					
A	ERDL	RDL	DL	ST	Mode			
B								AL
C				CHAR				
D	BUS	CRQ				LCD	RSD	
E	IRQ	ENSI	NEWS		NEWC			
F	Diagnostic Control Register							

Receiver Interface Memory Bank 0 (CS0)

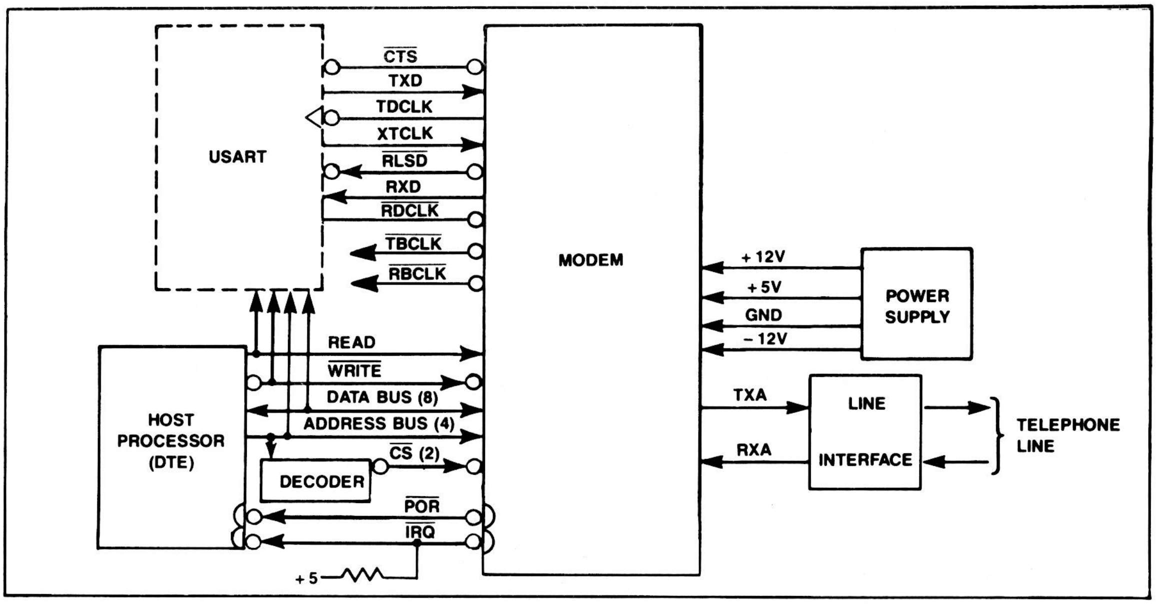
Register \ Bit	7	6	5	4	3	2	1	0
0	Dial Digit Register							
1								
2	Diagnostic Data Real Low							
3	Diagnostic Data Real High							
4	Diagnostic Data Imaginary Low							
5	Diagnostic Data Imaginary High							
6								
7								
8	DLO	CTS	DSR	RI				
9			ORG					
A	ERDL	RDL	DL	ST	Mode			
B	TX LEVEL			GTE	GTS	3DB	DTMF	AL
C	DSRA	TXCLK		CHAR				
D	BUS	CRQ	DATA	AAE	DTR			SSD
E	IRQ	ENSI	NEWS		NEWC	DDEI		DDRE
F	Diagnostic Control Register							

Transmitter Interface Memory Bank 1 (CS1)

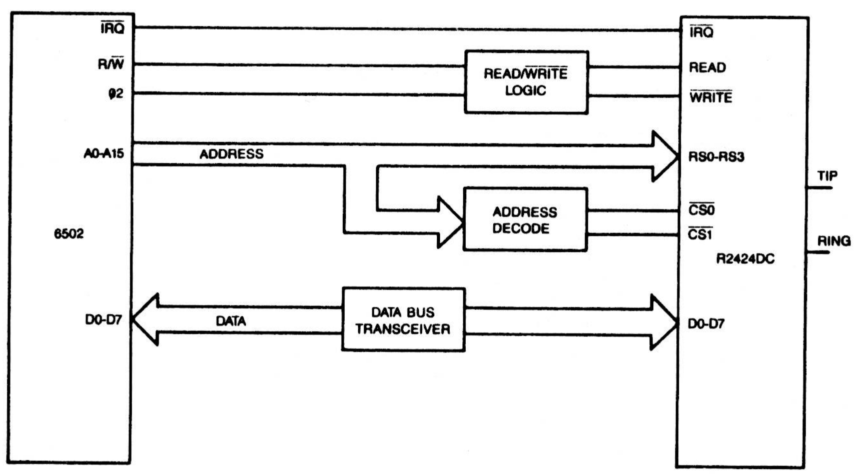
Name	Type	Pin No.	Description
A. OVERHEAD			
DGND	G	5A, 10A, 3C, 8C	Digital Ground
AGND	G	31C, 32C	Analog Ground
+5 VDC	P	19C, 23C, 26C, 30C	+5 Volt Supply
+12 VDC	P	15A	+12 Volt Supply
−12 VDC	P	12A	−12 Volt Supply
POR	OC	13C	Power-On-Reset
B. MICROPROCESSOR INTERFACE			
D7	B	1C	Data Bus (8-Bits)
D6	B	1A	
D5	B	2C	
D4	B	2A	
D3	B	3A	
D2	B	4C	
D1	B	4A	
D0	B	5C	
RS3	I	6C	Register Select (4-Bits)
RS2	I	6A	
RS1	I	7C	
RS0	I	7A	
CS0	I	10C	Chip Select for Bank 0
CS1	I	9C	Chip Select for Bank 1
READ	I	12C	Read Enable
WRITE	I	11A	Write Enable
IRQ	OC	11C	Interrupt Request
C. V.24 INTERFACE			
XTCLK	I	22A	External Transmit Clock
TDCLK	O	23A	Transmit Data Clock
RDCLK	O	21A	Receive Data Clock
CTS	O	25C	Clear-to-Send
TXD	I	24C	Transmit Data
RXD	O	22C	Receive Data
RLSD	O	24A	Received Line Signal Detector
DTR	I	21C	Data Terminal Ready
DSR	O	20A	Data Set Ready
RI	O	18A	Ring Indicator In
D. ANALOG SIGNALS (R2424M ONLY)			
RXA	I	32A	Receive Analog
TXA	O	31A	Transmit Analog
E. SIGNALS TO DAA (R2424M ONLY)			
RD	I	27A	Ring Detect
RCCT	O	28A	Request Coupler Cut Through
CCT	I	29C	Coupler Cut Through
OH	O	29A	Off-Hook Relay Control
F. ANCILLARY FUNCTIONS			
TBCLK	O	27C	Transmit Baud Clock
RBCLK	O	26A	Receive Baud Clock
TLK	I	28C	Talk TLK = Data
ORG	I	16C	Originate ORG = Answer

B Bidirectional
I Input
O Output
OC Open Collector
P Power
G Ground

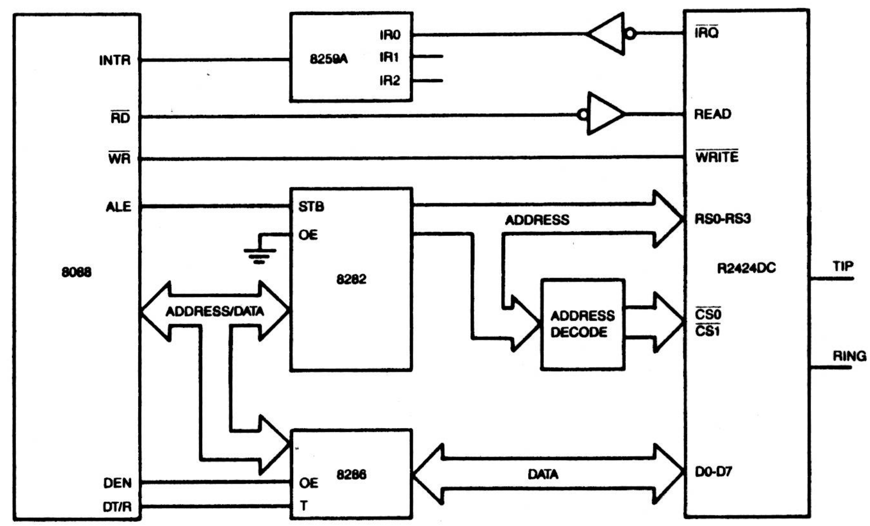
R2424 Hardware Supervisory Circuits



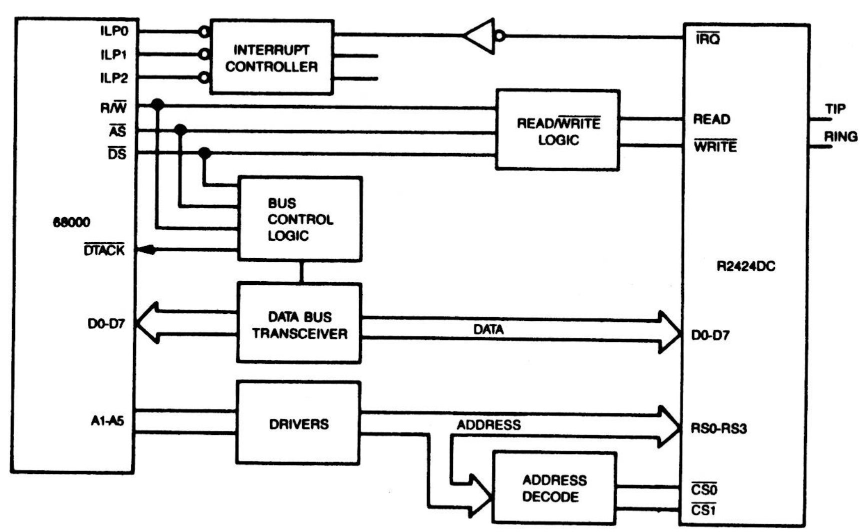
R2424 Functional Interconnect Diagram



6502 Microprocessor Bus Interface



8088 Microprocessor Bus Interface



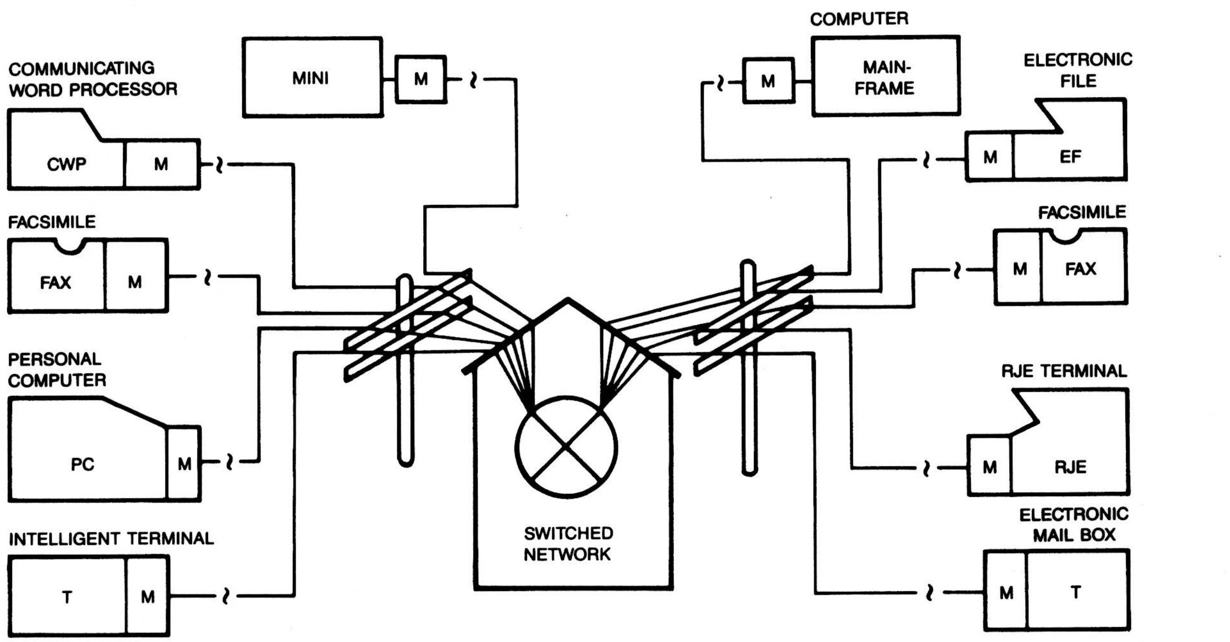
68000 Microprocessor Bus Interface

FUNCTIONS/FEATURES

Communication data rates continue to increase in speed to meet the needs of new applications. The full-duplex modem speeds are also increasing. The Bell 103 300 bps modems had their time but they are quickly becoming obsolete. To take their place, 1200 bps Bell 212A modems are now the most popular in the United States (C.C.I.T.T. V.22 1200 bps modems in Europe). 2400 bps full-duplex two-wire modems are now appearing. The C.C.I.T.T. V.22 bis modem is the accepted standard for 2400 bps full-duplex operation.

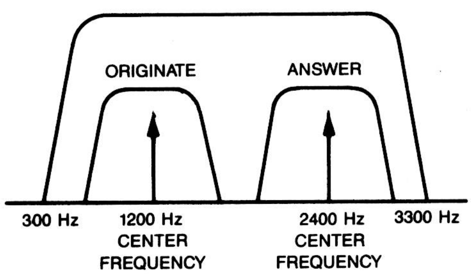
Although the higher speed modems are becoming available, it is still necessary to communicate with the existing installed base of equipment. That means the new modems must contain not only the new standards but also the older ones as well. This concern can be resolved with creative programming techniques using the signal processors. This creativeness can be used to supply a modem with many functions, bells and whistles.

A 1200 bps two-wire full-duplex modem chip set should contain the following compatibilities: Bell 212A (this includes Bell 103) and C.C.I.T.T. V.22. The only difference between the two is the initial handshake, guard tone transmission, which is required in Europe, and a different answerback tone. The modulation scheme is the same for both -- DPSK (Differential Phase Shift Keying -- change of



The Office of the Future

phase). A 2400 bps modem design should conform to V.22 bis and also contain all the functionality of the 1200 bps modem. This is possible because once again the handshake is one of the few things that are different. The modulation scheme is QAM (Quadrature Amplitude Modulation -- change of phase and amplitude) of which DPSK is a subset.



V.22 bis, V.22, and Bell 212A Spectrum

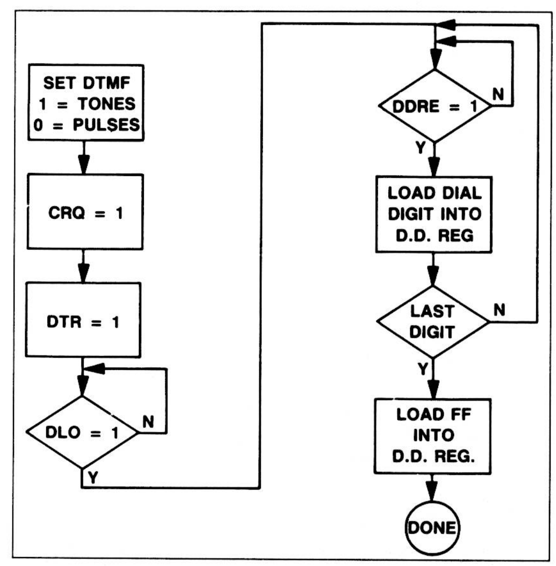
The signal processors excel in transmitting tones and also in tone detection. These two "bells and whistles" make the modem a flexible machine.

Incorporation of an auto-dialer into the modem once again takes the burden out of the hands of the design engineer. The modem does all the work by transmitting the appropriate tones at the right time. The SP can be programmed to output the DTMF tone pairs and it can also make sure that the timing is correct.

BCD				Dial Digits	Tone Pairs	
0	0	0	0	0	941	1336
0	0	0	1	1	697	1209
0	0	1	0	2	697	1336
0	0	1	1	3	697	1477
0	1	0	0	4	770	1209
0	1	0	1	5	770	1336
0	1	1	0	6	770	1477
0	1	1	1	7	852	1209
1	0	0	0	8	852	1336
1	0	0	1	9	852	1477
1	0	1	0	★	941	1209
1	0	1	1	Spare (B)	697	1633
1	1	0	0	Spare (C)	770	1633
1	1	0	1	Spare (D)	852	1633
1	1	1	0	#	941	1477
1	1	1	1	Spare (F)	941	1633

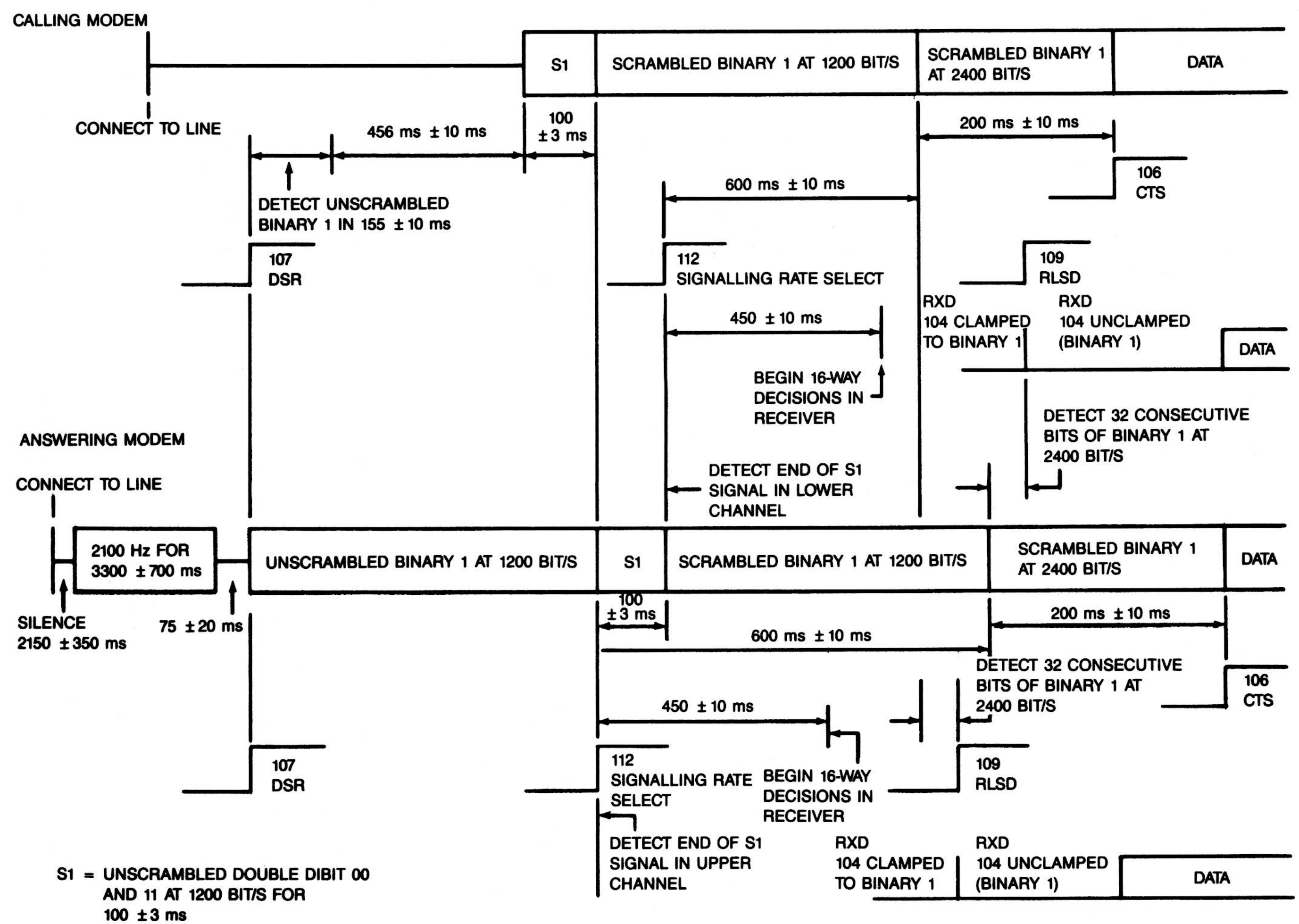
Interface Memory Signals

All the user should have to do is put the modem in auto-dial mode and load the appropriate dial digit into the dial digit register using the microprocessor bus. Since the full-duplex modem will be used over the dial-up network with a Data Access Arrangement (DAA), an option should be in the modem for it also to be able to pulse an off-hook relay for those areas which do not have touch tone lines installed.



Auto Dial Sequence Flow Diagram

Once the telephone number is dialed the next worry is the call progress signals. The signal processor can also be used to detect these signals: dial tone, ringback, and busy tone to name a few. Two ways of implementing this in the scratch memory is possible. The modem could have specific bits for the various tones, or a single bit can be given which will follow all tones in a certain bandwidth. The user would then monitor the bit to determine the duty cycle and thus the appropriate tone. Both methods report the progress tones but the second is more flexible for use as general tone detector.



V.22 bis Handshake Sequence at 2400 bps

DIAGNOSTICS

Communications sophistication can be aided with the help of modem diagnostics. In a world that is becoming network oriented the diagnostic capabilities of the modem can greatly assist in troubleshooting network problems. These problems can be a result of the transmission lines, the modem, or the communication equipment.

Some diagnostic capabilities are defined by some of the modem standards. C.C.I.T.T. V.22 bis for instance includes self test, local analog, and remote digital loopbacks as part of the modem specification. These three functions are useful to determine if the local or remote modem is having problems but that is the extent of their usefulness. To determine other network failures requires other information which the signal processor calculates and uses during normal operation.

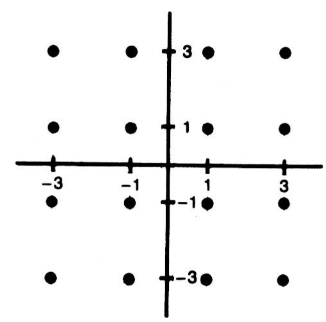
The modem must calculate various parameters to ensure accurate transmission and reception of data. Most of the parameters are associated with the telephone line characteristics. The modem receiver changes its characteristics based on the telephone line variations. These characteristics can be analyzed over a period of time to determine problems within the telephone network.

Data is manipulated in parallel form in the signal processor. Therefore, any data which is calculated can be made available to the user over the microprocessor bus. Diagnostic data is no exception. Some of the parameters which may be considered useful are equalizer tap coefficients, phase error, rotated equalizer output (received point eye pattern), decision points (ideal received data points), low pass filter output, and rotated error. If registers were allocated for diagnostic use, these parameters could be obtained in real time by entering a special code into a scratch pad location to tell the SP which of the diagnostic data to make available.

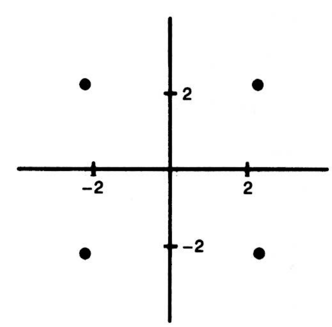
The eye pattern (rotated equalizer output) is probably the most useful diagnostic tool. It is a visual oscilloscope display which shows the received signal points as grouping of dots in the baseband signal plane. This grouping of dots is defined in the modem standards so it is a known pattern. The purpose of the eye pattern is for a modem test, production evaluation took, and indication of line disturbances. Each dot has an ideal location. The degree of spreading around each point is proportional to the severity of the line disturbance. Some of the disturbances which can be seen are white noise, phase jitter, and harmonic distortion.

Function	Access	Data Type
Scrambled Data (Imag. Reg.)	00	Real
Self Test Error Counter (Real Reg.)	00	Real
Equalizer Tap Coefficients	01-0D	Complex
Phase Error (Real Reg.)	10	Real
Rotated Equalizer Output (Received Point Eye Pattern)	11	Complex
Rotated Angle (Imag. Reg.)	12	Real
Low Pass Filter Output	40	Complex
Input Signal to Equalizer Tap Coefficients	41-4D	Complex
Decision Points (Ideal)	51	Complex
Rotated Error	52	Complex
Equalizer Output	53	Complex
Demodulator Output	56	Complex

RAM Access Codes Bank 0



V.22 bis 2400 bps Signal Constellation (Eye Pattern)



V.22, Bell 212A 1200 bps Signal Constellation (Eye Pattern)

TECHNOLOGY ADVANTAGES

Two main advantages result from using the signal processor and switched capacitor technologies: cost, and performance.

Using the SP and IA chips results in a smaller parts count not only as a result of a three chip set, but the microprocessor bus interface requires very little interface circuitry. If the creative programming is done so that the 2400 bps modem includes the functions of the 1200 bps mode, then the chips could be designed in such a way that the 1200 bps modem could have the same pin-outs and scratch pad memory bit definitions as the 2400 bps modem. The result of this would mean that the two chip sets could be interchanged with no hardware or software change. This would enable the upgradeability of many products to occur with little or no cost. Lastly, phone line costs would decrease due to the higher data rate and fewer errors as a result of the adaptive equalizer.

The second advantage, performance, is directly related to the type of equalization used in the modem. Equalization is a technique used to compensate for distortions present on a communication channel. Equalizers add loss or delay to signals in inverse proportion to the channel characteristics. The signal response curve is then relatively flat and can be amplified to regain its original form. The following is a brief description of some of the equalization techniques which can be utilized.

Compromise -- Parameters are permanently set to counteract the average distortions which characterize a communication channel.

Manual -- Tap coefficients (also called weights or parameters) are loaded manually into an equalizer. They will remain the same until a new set of values is loaded.

Preset -- The equalizer makes use of a special sequence of pulses (also called a training sequence) sent across a channel prior to the transmission of data to automatically adjust the tap coefficients.

Adaptive -- The equalizer automatically adjusts the weights during the transmission of data.

Hybrid -- Combination of Preset and Adaptive. The coefficients are adjusted automatically from the training sequence and the incoming data. Another name for this type of equalization is automatic adaptive.

Compromise equalization is not the most desirable. It is only an attempt to compensate for the expected average phone line characteristics. If you use the telephone much, you notice even with your own ears that the lines can change considerably from call to call. Error free data is therefore an impossibility. To increase the chances of error free transmission, an equalizer which will change it's characteristics for any given line is very desirable. Automatic adaptive equalization (defined in V.22 bis) does just that. The result--better performance.

Adaptive equalization is implemented digitally. Since the signal processor is good at handling data and doing real time operations and calculations very quickly, automatic adaptive equalization should be a part of any signal processor modem. This is the edge which gives the modem that almost error free communications required in today's equipment.

The V.22 bis modem contains all the functions necessary to create a flexible modem subsystem. Its ease of interface, faster data rate, excellent performance, and numerous other features enable it to be used in most of the present and upcoming data communication applications.

CHANGING TRENDS OF MODEM IC'S

AL MOUTON

MOS TELECOM PLANNING MANAGER

MOTOROLA INC.
AUSTIN TEXAS

The modem market is faced with major technolgy changes being brought about by the deregulation of the telephone industry, large sales of personel computers and a general demand for more cost effective data communication solutions.

The standard 300 to 9600 bps Bell and CCITT specified modems, as depicted in the block diagram in figure 1, are experiancing changes coming about from the development of new LSI semiconductors that are greatly reducing the cost, size and complexity of these types of modems.

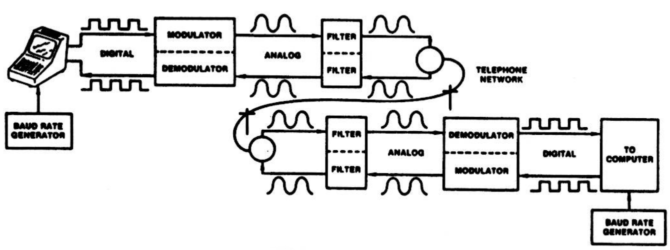


FIGURE 1

A variety of new high speed Limited Distance Modems (LDM) are also being developed. They are Data Only Multiplexers, Data on Voice Multiplexers and Voice and Data PBX's. These products are also encouraging the development of new LSI semiconductor in response for more cost effective solutions.

One area that is greatly benefiting from the new types of data communications equipment is the office enviroment. With products like the Voice and Data PBX a communication network is possible that supports analog services and provides an inexpensive means for interconnecting word processors, CRT terminals, gateways to LAN and other office equipment. The block diagram in figure 2 illustrates the completely integrated office network.

This paper reviews the variety of medium and low speed modem IC's that Motorola is offering today and planning to introduce in the near future, along with the new high speed modem IC family that will support the new data communication services.

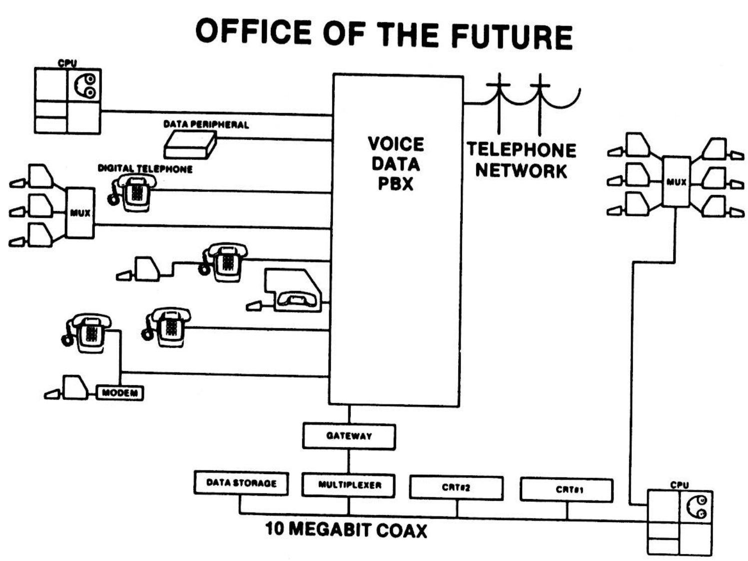


FIGURE 2