Summary of Electrical Characteristics of Some Well Known Digital Interface Standards

National Semiconductor
Application Note 216
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December 1978

Summary of Electrical Characteristics of Some Well Known Digital Interface Standards

AN-216

FORWARD

Not the least of the problems associated with the design or use of data processing equipment is the problem of providing for or, actually, interconnecting the differing types and models of equipment to form specific processing systems.

The magnitude of the problem becomes apparent when one realizes that every aspect of the electrical, mechanical and architectural format must be specified. The most common of the basic decisions confronting the engineer include:

- Type of logic (negative or positive)
- Threshold levels
- Noise immunity
- Form of transmission
  - Balanced/unbalanced, terminated/unterminated
  - Unidirectional/bidirectional, simplex/multiplexed
- Type of transmission line
- Connector type and pin out
- Bit or byte oriented
- Baud rate

If each make and/or model of equipment presented a unique interface at its I/O ports, "interface" engineering would become a major expenditure associated with the use of data processing equipment.

Fortunately, this is not the case as various interested or cognizant groups have analyzed specific recurring interface areas and recommended "official" standards around which common I/O ports could be structured. Also, the I/O specifications of some equipment with widespread popularity such as the IBM 360/370 computer and DEC minicomputer have become "defacto" standards because of the desire to provide/use equipment which interconnect to them.

Compliance with either the "official" or "defacto" standards on the part of equipment manufacturers is voluntary. However, it is obvious that much can be gained and little lost by providing equipment that offers either the "official" or "defacto" standard I/O ports.

As can be imagined, the entire subject of interface in data processing systems is complicated and confusing, particularly to those not intimately involved in the day-to-day aspects of interface engineering or management. However, at the component level the questions simplify to knowing what standards apply and what circuits or components are available to meet the standards.

This application note summarizes the important electrical characteristics of the most commonly accepted interface standards and offers recommendations on how to use National Semiconductor integrated circuits to meet those standards.

1.0 INTRODUCTION

The interface standards covered in this application note are listed in Table I. The body of the text expands upon the scope and application of each listed standard and summarizes important electrical parameters.

Table II summarizes the National Semiconductor IC's applicable to each standard.

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IM-B10M128/Printed in U.S.A.

TABLE I. COMMON LINE DRIVER/RECEIVER INTERFACE STANDARDS SUMMARY

INTERFACE AREA	APPLICATION	STANDARD	ORIGIN	COMMENTS
Data Communications Equipment (DCE*) to Data Terminal Equipment (DTE)	U.S.A. Industrial	RS232C	EIA	Unbalanced, Short Lines
		RS422	EIA	Balanced, Long Lines
		RS423	EIA	Unbalanced, RS232 Up-Grade
		RS449	EIA	System Standard Covering Use of RS422, RS423
	International	CCITT Vol. VIII V. 24	International Telephone	Similar to RS232
		CCITT No. 97 X. 26	and Telegraph Consultative	Similar to RS423
		CCITT No. 97 X. 27	Committee	Similar to RS422
	U.S.A. Military	MIL-STD-188C	D.O.D.	Unbalanced, Short Lines
		MIL-STD-188-114	D.O.D.	Similar to RS422, RS423
		MIL-STD-1397 (NTDS—Slow)	Navy	42k bits/sec
		MIL-STD-1397 (NTDS—Fast)	Navy	250k bits/sec
	U.S. Government, Non-Military	FED-STD-1020	GSA	Identical to RS423
		FED-STD-1030	GSA	Identical to RS422
Computer to Peripheral	IBM 360/370	System 360/370 Channel I/O	IBM	Unbalanced Bus
	DEC Mini-Computer	DEC Unibus®	DEC	Unbalanced Bus
Instrument to Computer	Nuclear Instrumentation	CAMAC (IEEE std. 583-1975)	NIM (AEC)	DTL/TTL Logic Levels
	Laboratory Instrumentation	488	IEEE	Unbalanced Bus
Microprocessor to Interface Devices	Microprocessor Circuits	Microbus™	National Semiconductor	Short Line; 8-Bit Parallel, Digital Transmission
Facsimile Equipment to DTE	Facsimile Transmission	RS357	EIA	Incorporates RS232
Automatic Calling Equipment to DTE	Impulse Dialing and Multi-Tone Keying	RS366	EIA	Incorporates RS232
Numerically Controlled Equipment to DTE	Numerically Controlled Equipment	RS408	EIA	Short Lines (<4 Ft.)

*Changed to "Data Circuit—Terminating Equipment"
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TABLE II. LINE DRIVER/RECEIVER INTEGRATED CIRCUIT SELECTION GUIDE FOR DIGITAL INTERFACE STANDARDS

STANDARD DESIGNATION	PART NUMBER			
	LINE DRIVER		LINE RECEIVER	
	0°C TO +70°C	−55°C TO +125°C	0°C TO +70°C	−55°C TO +125°C
U.S. Industrial Standards				
RS232C	DS1488 DS75150	Not Applicable Not Applicable	DS1489 (A) DS75154	Not Applicable Not Applicable
RS357	See RS232C			
RS366	See RS232C			
RS408	DS75453 DS75454	DS55454 DS55454	DS7820A DS75115	DS7820A DS55115
RS422	DS3691 DS26LS31 DS3487	DS1691 DS26LS31M	DS88LS120 DS26LS32 DS3486 DS26LS33 DS88C20 DS88C120	DS78LS120 DS26LS32M DS78C20 DS78C120
RS423	DS3691 DS3692	DS1691 DS1692	DS88LS120 DS88C20 DS88C120	DS78LS120 DS78C20 DS78C120
RS449	See RS422, RS423			
IEEE 488	DP8304B Transceiver	DP7304B Transceiver	DP8304B Transceiver	DP7304B Transceiver
CAMAC	See RS232C, RS422, RS423 or IEEE 488			
IBM 360/370 I/O Port	DS75123	Not Applicable	DS75124	Not Applicable
DEC Unibus®	DS36147 DS8641 Transceiver	DS16147 DS7641 Transceiver	DS8640 DS8641 Transceiver	DS7640 DS7641 Transceiver
Microbus™	DS3628 DP8228 DP8216 DP8212 DP8304B Transceiver	DS1628 DP8228M DP8216M DP8212M	DP8304B Transceiver	
Government Standards				
MIL-STD-188C	DS3691	DS1691	DS88LS120	DS78LS120
MIL-STD-188-114	DS3691	DS1691	DS88LS120	DS78LS120
FED-STD-1020	See RS423			
FED-STD-1030	See RS422			
MIL-STD-1397 (NTDS–Slow)	Use Discrete Components and/or Comparators			
MIL-STD-1397 (NTDS–Fast)	Use Discrete Components and/or Comparators			

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TABLE II. LINE DRIVER/RECEIVER INTEGRATED CIRCUIT SELECTION GUIDE FOR DIGITAL INTERFACE STANDARDS (Continued)

STANDARD DESIGNATION	PART NUMBER			
	LINE DRIVER		LINE RECEIVER	
	0°C TO +70°C	−55°C TO +125°C	0°C TO +70°C	−55°C TO +125°C
International Standards (CCITT)				
1969 White Book Vol. VIII, V. 24	See RS232C			
Circular No. 97, X. 26	See RS422			
Circular No. 97, X. 27	See RS423			

2.0 DATA TERMINAL EQUIPMENT (DTE) TO DATA COMMUNICATIONS EQUIPMENT (DCE) INTERFACE STANDARDS

2.1 Application

The DTE/DCE standards cover the electrical, mechanical and functional interface between/among terminals (i.e., teletypewriters, CRTs, etc.) and communications equipment (i.e., modems, cryptographic sets, etc.).

2.2 U.S. Industrial DTE/DCE Standards

2.2.1 EIA RS232C

The oldest and most widely known DTE/DCE standard. It provides for one-way/non-reversible, single-ended (unbalanced), non-terminated line, serial digital data transmission.

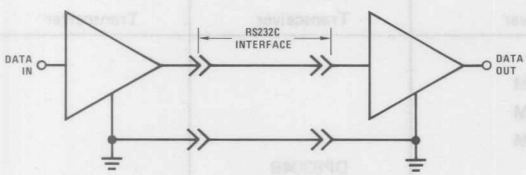

FIGURE 1. EIA RS232C Application

Important features are:

a) Positive logic (±5V min to ±15V max)
b) Fault protection
c) Slew-rate control
d) 50 feet recommended cable length and 20k bits per second data signaling rate.

2.2.2 EIA RS422, RS423

In a move to upgrade system capabilities by utilizing state-of-the-art devices and technology the EIA, in 1975, introduced 2 new specifications covering:

1) Single-ended data transmission at modulation rates up to kilobaud* (RS423)

2) Balanced data transmission at modulation rates up to 10 megabaud (RS422).

2.2.2.1 RS423

RS423 closely resembles RS232C in that it, too, specifies one-way/non-reversible, single-ended, data transmission lines. Key differences between RS423 and RS232C are:

RS423	RS232
4V to 6V Logical "1"	5V to 15V Logical "1"
−4V to −6V Logical "0"	−5V to −25V Logical "0"
100k Baud at 40 Feet	20k Baud at 50 Feet
Balanced Receiver, Referred to Driver Ground, Permitting Ground Potential Difference Between Driver and Receiver	Unbalanced Receiver

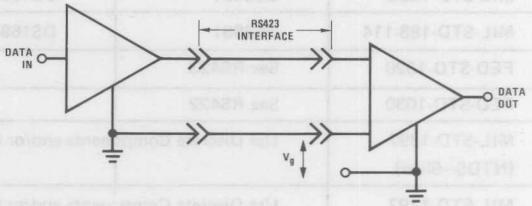

FIGURE 2. EIA RS423 Application

* Modulation rate = reciprocal of minimum pulsewidth (i.e., 20 ms pulse = 50 baud)

TABLE III. EIA RS232C SPECIFICATION SUMMARY

	PARAMETER	CONDITIONS	EIA RS232C MIN	EIA RS232C TYP	EIA RS232C MAX	UNITS
V_{OH}	Driver Output Voltage Open				25	V
V_{OL}	Circuit		−25			V
V_{OH}	Driver Output Voltage Loaded	$3\ k\Omega \leq R_L \leq 7\ k\Omega$	5		15	V
V_{OL}	Output		−15		−5	V
R_O	Driver Output Resistance Power OFF	$-2V \leq V_O \leq 2V$			300	Ω
I_{OS}	Driver Output Short-Circuit Current		−500		500	mA
	Driver Output Slew Rate					
	All Interchange Circuits				30	V/μs
	Control Circuits		6			V/ms
	Rate and Timing Circuits		6			V/ms
		% of Unit Interval	4			%
R_{IN}	Receiver Input Resistance	$3V \leq V_{IN} \leq 25V$	3000		7000	Ω
	Receiver Open Circuit Input Bias Voltage		−2		2	V
	Receiver Input Threshold					
	Output = MARK		−3			V
	Output = SPACE				3	V

TABLE IV. EIA RS423 SPECIFICATION SUMMARY

	PARAMETER	CONDITIONS	EIA RS423 MIN	EIA RS423 TYP	EIA RS423 MAX	UNITS
V_O	Driver Unloaded Output Voltage		4		6	V
$\overline{V_O}$			−4		−6	V
V_T	Driver Loaded Output Voltage	$R_L = 450\Omega$	3.6			V
$\overline{V_T}$			−3.6			V
R_S	Driver Output Resistance				50	Ω
I_{OS}	Driver Output Short-Circuit Current	$V_O = 0V$			±150	mA
	Driver Output Rise and Fall Time	Baud Rate ≤ 1k Baud			300	μs
		Baud Rate ≥ 1k Baud			30	% Unit Interval
I_{OX}	Driver Power OFF Current	$V_O = \pm 6V$			±100	μA
V_{TH}	Receiver Sensitivity	$V_{CM} \leq \pm 7V$			±200	mV
V_{CM}	Receiver Common-Mode Range				±10	V
R_{IN}	Receiver Input Resistance		4000			Ω
	Receiver Common-Mode Input Offset				±3	V

2.2.2.2 RS422

RS422 provides for balanced data transmission with unidirectional/non-reversible, terminated or non-terminated transmission lines. Important features are:

a) ±2V to ±6V driver output
b) 0.4V differential output matching
c) ±200 mV receiver input sensitivity
d) 10M baud modulation rate

2.3 International Standards

2.3.1 CCITT 1969 White Book Vol. VIII, V. 24. This standard is identical to RS232C.

2.3.2 CCITT circular No. 97 Com SPA/13, X. 26. This standard is similar to RS422 with the exception that the receiver sensitivity at the specified maximum common-mode voltage (±7V) shall be ±300 mV vs ±200 mV for RS422.

2.3.3 CCITT circular No. 97 Com SPA/13, X. 27. This standard is similar to RS423 with 2 exceptions:

a) The receiver sensitivity is as specified in paragraph X. 26, and

b) The driver output voltage is specified at a load resistance of 3.9 kΩ.

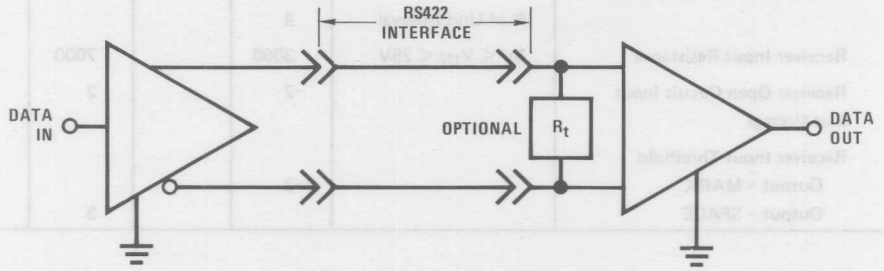

FIGURE 3. EIA RS422 Application

TABLE V. EIA RS422 SPECIFICATION SUMMARY

	PARAMETER	CONDITIONS	EIA RS422			UNITS
			MIN	TYP	MAX	
V_O	Driver Unloaded Output Voltage				6	V
$\overline{V_O}$					−6	V
V_T	Driver Loaded Output Voltage	R_T = 100Ω	2			V
$\overline{V_T}$			−2			V
R_S	Driver Output Resistance	Per Output			50	Ω
I_{OS}	Driver Output Short-Circuit Current	V_O = 0V			150	mA
	Driver Output Rise Time				10	% Unit Interval
I_{OX}	Driver Power OFF Current	$-0.25V \leq V_O \leq 6V$			±100	μA
V_{TH}	Receiver Sensitivity	V_{CM} = ±7V			200	mV
V_{CM}	Receiver Common-Mode Voltage		−10		10	V
	Receiver Input Offset		±3			V

2.4 U.S. Military Standards

2.4.1 MIL-STD-188C (Low Level)

The military equivalent to RS232C is MIL-STD-188C. Devices intended for RS232C can be applied to MIL-STD-188C by use of external wave shaping components on the driver end and input resistance and threshold tailoring on the receiver end.

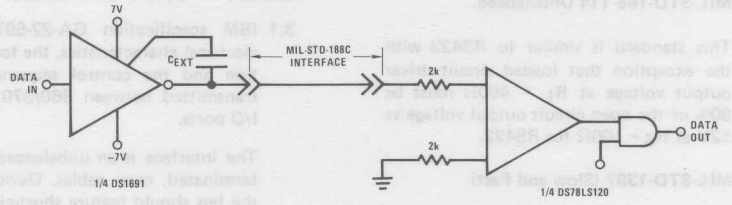

FIGURE 4. MIL-STD-188C Application

TABLE VI. MIL-STD-188C SPECIFICATION SUMMARY

PARAMETER		CONDITIONS	MIL-STD-188C LOW LEVEL LIMITS			UNITS
			MIN	TYP	MAX	
V_{OH}	Driver Output Voltage Open Circuit	(Note 1)	5		7	V
V_{OL}			−7		−5	V
R_O	Driver Output Resistance Power ON	$I_{OUT} \leq 10$ mA			100	Ω
I_{OS}	Driver Output Short-Circuit Current		−100		100	mA
	Driver Output Slew Rate					
	All Interchange Circuits	(Note 2)	5		15	% IU
	Control Circuits					
	Rate and Timing Circuits					
R_{IN}	Receiver Input Resistance	Mod Rate ≤ 200k Baud	6			Ω
	Receiver Input Threshold					
	Output = MARK	(Note 3)			100	μA
	Output = SPACE		−100			μA

Note 1: Ripple < 0.5%, V_{OH}, V_{OL} matched to within 10% of each other.

Note 2: Waveshaping required on driver output such that the signal rise or fall time is 5% to 15% of the unit interval at the applicable modulation rate.

Note 3: Balance between marking and spacing (threshold) currents actually required shall be within 10% of each other.

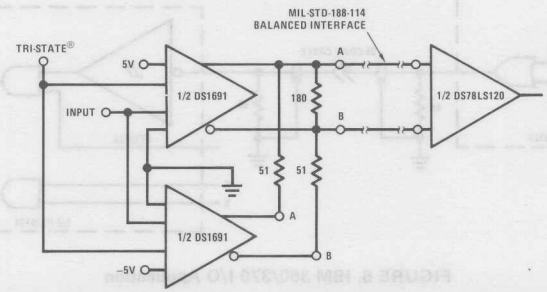

FIGURE 5. MIL-STD-188-114 (Balanced) Application

2.4.2 MIL-STD-188-114 Balanced

This standard is similar to RS422 with the exception that the driver offset voltage level is limited to ±0.4V vs ±3V allowed in RS422.

2.4.3 MIL-STD-188-114 Unbalanced.

This standard is similar to RS423 with the exception that loaded circuit driver output voltage at R_L = 450Ω must be 90% of the open circuit output voltage vs ±2V at R_S = 100Ω for RS422.

2.4.4 MIL-STD-1397 (Slow and Fast)

2.5 U.S. Government (non-military) standards FED-STD-1020 and 1030 are identical without exception to EIA RS423 and RS422, respectively.

3.0 COMPUTER TO PERIPHERAL INTERFACE STANDARDS

To date, the only standards dealing with the interface between processors and other equipment are the "defacto" standards in the form of specifications issued by IBM and DEC covering the models 360/370 I/O ports and the Unibus®, respectively.

3.1 IBM specification GA-22-6974-0 covers the electrical characteristics, the format of information and the control sequences of the data transmitted between 360/370's and up to 10 I/O ports.

The interface is an unbalanced bus using 95Ω, terminated, coax cables. Devices connected to the bus should feature short-circuit protection, hysteresis in the receivers, and open-emitter drivers. Careful attention should be paid to line lengths and quality in order to limit cable noise to less than 400 mV.

TABLE VII. MIL-STD-1397 SPECIFICATION SUMMARY

	PARAMETER	CONDITIONS	COMPARISON LIMITS (MIL-STD) 1397 (SLOW)	COMPARISON LIMITS (MIL-STD) 1397 (FAST)	UNITS
	Data Transmission Rate		42	250	k Bits/Sec
V_{OH}	Driver Output Voltage		±1.5	0	V
V_{OL}			−10 to −15.5	−3	V
I_{OH}	Driver Output Current		≥−4		mA
I_{OL}			1		mA
R_S	Driver Power OFF Impedance		≥100		kΩ
V_{IH}	Receiver Input Voltage	Fail-Safe Open Circuit	≤4.5	≤−1.1	V
V_{IL}			≥−7.5	≥−1.9	V

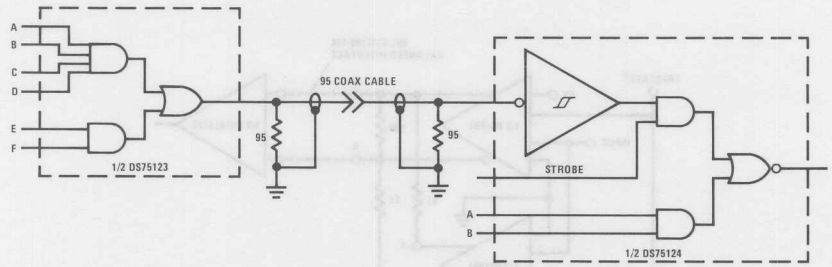

FIGURE 6. IBM 360/370 I/O Application

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TABLE VIII. IBM 360/370 SPECIFICATION SUMMARY

PARAMETER		CONDITIONS	IBM 360/370			UNITS
			MIN	TYP	MAX	
V_{OH}	Driver Output Voltage	I_{OH} = 123 mA			7	V
V_{OH}		I_{OH} = 30 μA			5.85	V
V_{OH}		I_{OH} = 59.3 mA	3.11			V
V_{OL}		I_{OL} = −240 μA			0.15	V
V_{IH}	Receiver Input Threshold				1.7	V
V_{IL}	Voltage		0.7			V
I_{IH}	Receiver Input Current	V_{IN} = 3.11V			−0.42	mA
I_{IL}		V_{IN} = 0.15V	0.24			mA
	Receiver Input Voltage Range					
V_{IN}	Power ON		−0.15		7	V
V_{IN}	Power OFF		−0.15		6	V
R_{IN}	Receiver Input Impedance	0.15V ≤ V_{IN} ≤ 3.9V	7400			Ω
I_{IN}	Receiver Input Current	V_{IN} = 0.15V			240	μA
Z_O	CABLE Impedance		83		101	Ω
R_O	CABLE Termination	P_D ≥ 390 mW	90		100	Ω
	Line Length (Specified as Noise on Signal and Ground Lines)				400	mV

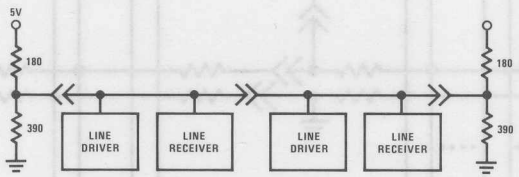

FIGURE 7. DEC Unibus® Application

TABLE IX. DEC UNIBUS ® SPECIFICATION SUMMARY

PARAMETER		CONDITIONS	DEC UNIBUS®			UNITS
			MIN	TYP	MAX	
V_{OL}	Driver Output Voltage	I_{OL} = 50 mA			0.7	V
V_O		Absolute Maximum			7	V
V_{IH}	Receiver Input Voltage		1.7			V
V_{IL}					1.3	V
I_{IH}	Receiver Input Current	V_{IN} = 4V			100	μA
I_{IL}		V_{IN} = 4V Power OFF			100	μA

3.2 DEC Unibus®

Another example of an unofficial industry standard is the interface to a number of DEC minicomputers. This interface, configured as a 120Ω double-terminated data bus is given the name Unibus®. Devices connected to the bus should feature hysteresis in the receivers and open-collector driver outputs. Cable noise should be held to less than 600 mV.

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4.0 INSTRUMENTATION TO COMPUTER INTERFACE STANDARDS

4.1 Introduction

The problem of linking instrumentation to processors to handle real-time test and measurement problems was largely a custom interface problem. Each combination of instruments demanded unique interfaces, thus inhibiting the wide spread usage of small processors to day-to-day test, measurement and control applications.

Two groups addressed the problem for specific environments. The results are:

a) IEEE 488 bus standard based upon proposals made by HP, and

b) The CAMAC system pioneered by the nuclear physics community.

4.2 IEEE 488

IEEE 488 covers the functional, mechanical and electrical interface between laboratory instrumentation (i.e., signal generators, DPM's, counters, etc.) and processors such as programmable calculators and minicomputers. Equipment with IEEE 488 I/O ports can be readily daisy chained in any combination of up to 15 equipments (including processor) spanning distances of up to 60 feet. 16 lines (3 handshake, 5 control and 8 data lines) are required.

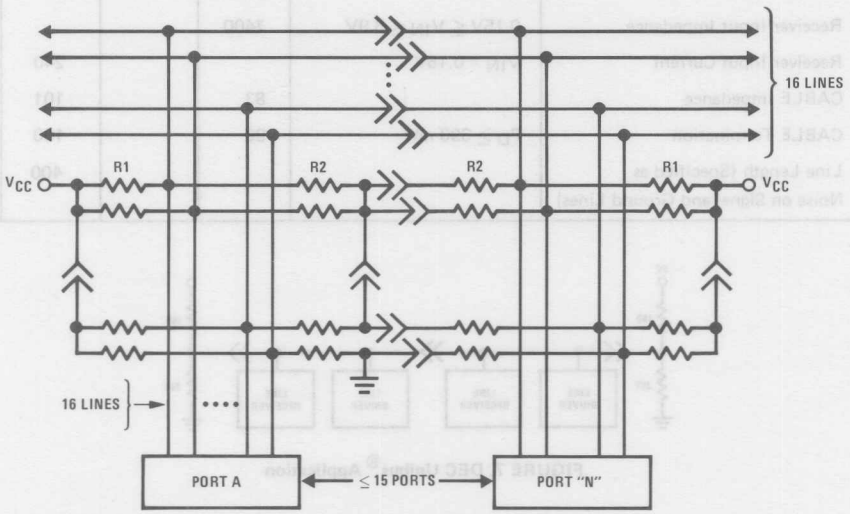


FIGURE 8. IEEE 488 Application

TABLE X. IEEE 488 SPECIFICATION SUMMARY

	PARAMETER	CONDITIONS	IEEE 488 MIN	IEEE 488 TYP	IEEE 488 MAX	UNITS
V_{OH}	Driver Output Voltage	I_{OH} = −5.2 mA	2.4			V
V_{OL}		I_{OL} = 48 mA			0.4	V
	Driver Output Current					
I_{OZ}	TRI-STATE®	V_O = 2.4V			±40	μA
I_{OH}	Open Collector	V_O = 5.25V			250	μA
V_{IH}	Receiver Input Voltage	0.4V Hysteresis Recommended	2.0			V
V_{IL}					0.8	V
I_{IH}	Receiver Input Current	V_{IN} = 2.4V			40	μA
I_{IL}		V_{IN} = 0.4V			−1.6	mA
	Receiver Clamp Current	V_{IN} = −1.5V			12	mA
R_{L1}	Termination Resistor	V_{CC} = 5V (±5%)	2850		3150	
R_{L2}		V = Gnd	5890		6510	

4.3 CAMAC

The CAMAC system is the result of efforts by those in the nuclear physics community to standardize the interface between laboratory instruments and computers before the introduction of IEEE 488.

It allows either serial or parallel interconnection of instruments via a "crate" controller.

The electrical requirements of the interfaces are compatible with DTL and TTL logic levels.

5.0 MICROPROCESSOR SYSTEMS INTERFACE STANDARDS

5.1 Microprocessor systems are bus organized systems with two types of bus requirements:

a) Minimal system: for data transfer over short distances (usually on 1 PC board), and,

b) Expanded system: for data transfer to extend the memory or computational capabilities of the system.

5.2 Minimal Systems and Microbus™

Microbus™ considers the interface between MOS/LSI microprocessors and interfacing devices in close physical proximity which communicate over 8-bit parallel unified bus systems. It specifies both the functional and electrical characteristics of the interface and is modeled after the 8060, 8080 and 8900 families of microprocessors as shown in *Figures 8, 9 and 10*.

The electrical characteristics of Microbus are shown in Table XI.

TABLE XI. MICROBUS ELECTRICAL SPECIFICATION SUMMARY

PARAMETER		DRIVER	RECEIVER		UNITS
			STANDARD	HYSTERESIS (RECOMMENDED)	
V_{OL}	Output Voltage (At 1.6 mA)	$\leq$0.4V			
V_{OH}	(At −100 μA)	$\geq$2.4V			
V_{IL}	Input Voltage		0.8	0.6	V
V_{IH}			2.0	2.0	V
	Internal Capacitive Load at 25°C	15	10	10	pF
t_r	Rise Time (Maximum)	100			ns
t_f	Fall Time (Maximum)	100			ns

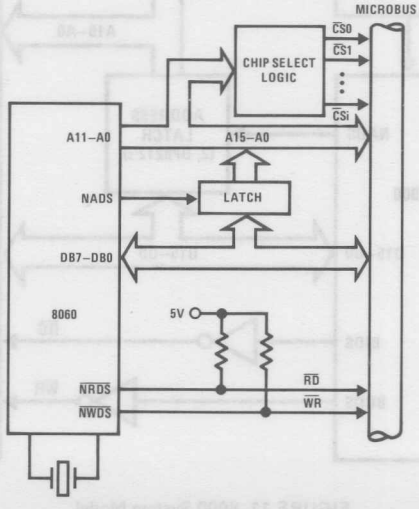


FIGURE 9. 8060 SC/MP II System Model

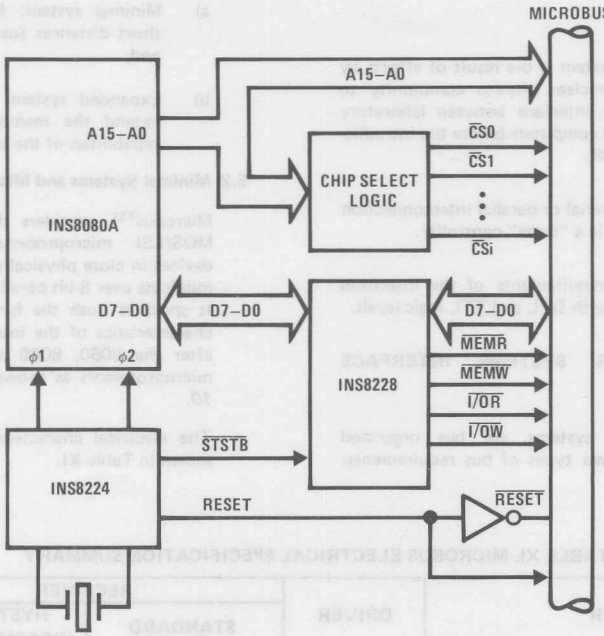


FIGURE 10. 8080 System Model for the Basic Microbus Interface

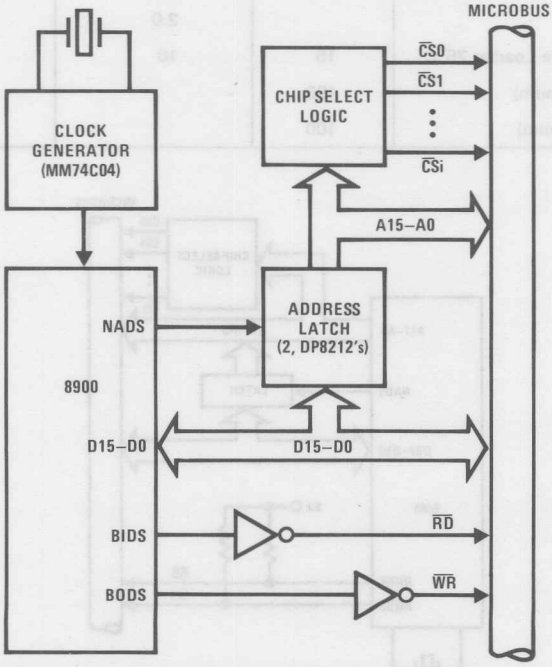


FIGURE 11. 8900 System Model

5.3 Expanded Microprocessor System Interfaces

Since the outputs of most microprocessor devices are limited to a loading of one relative to a TTL load, expanded systems will require buffers on both their address and data lines.

To date, no formal standards exist which govern this interface. However, "defacto" standards are emerging in the form of the specifications for "recommended devices" which are mentioned in the data sheets and application notes for the widely sourced microprocessor devices. Here, the answer to the question of how to provide a "standard" interface is simplified to that of proper usage of recommended devices.

Table XII summarizes the important electrical characteristics of recommended bus drivers for expanded microprocessor systems.

6.0 OTHER INTERFACE STANDARDS

Some other commonly occurring interfaces which have become standardized are:

a) Interface between facsimile terminals and voice frequency communications terminals,

b) Interface between terminals and automatic calling equipment used for data communications, and

c) Interface between numerically controlled equipment and data terminals.

6.1 EIA RS357

RS357 defines the electrical, functional and mechanical characteristics of the interface between analog facsimile equipment to be used for telephone data transmission and the data sets used for controlling/transmitting the data.

Figure 11 summarizes the functional and electrical characteristics of RS357.

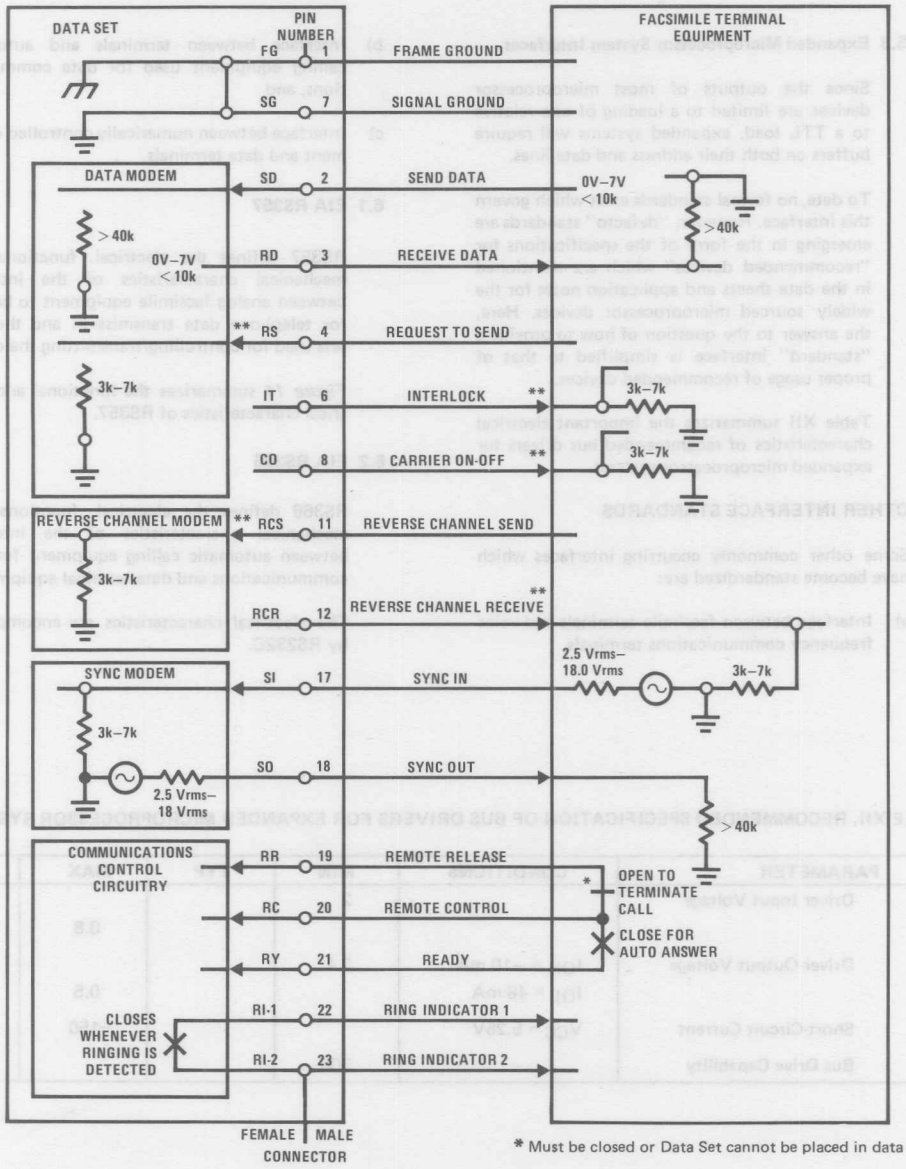
6.2 EIA RS366

RS366 defines the electrical, functional and mechanical characteristics of the interface between automatic calling equipment for data communications and data terminal equipment.

The electrical characteristics are encompassed by RS232C.

TABLE XII. RECOMMENDED SPECIFICATION OF BUS DRIVERS FOR EXPANDED MICROPROCESSOR SYSTEMS

	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{IH}	Driver Input Voltage		2			V
V_{IL}					0.8	V
V_{OH}	Driver Output Voltage	$I_{OH} = -10$ mA	2.4			V
V_{OL}		$I_{OL} = 48$ mA			0.5	V
I_{OS}	Short-Circuit Current	$V_{CC} = 5.25V$			−150	mA
C_L	Bus Drive Capability		300			pF



* Must be closed or Data Set cannot be placed in data mode

**

Receive	Sensitivity	Source
ON	3V–25V	5V–25V
OFF	3V–25V	5V–25V

FIGURE 12. Functional and Electrical Characteristics of RS357

6.3 EIA RS408

RS408 recommends the standardization of the 2 interfaces shown in *Figure 13*.

The electrical characteristics of NCE to DTE interface are, in summary, those of conventional TTL drivers (series 7400) with:

$V_{OL} \leq 0.4V$ at $I_{OL} = 48$ mA
$V_{OH} \geq 2.4V$ at $I_{OH} \leq -1.2$ mA, and
$C_L \leq 2000$ pF.

Short circuit protection should be provided.

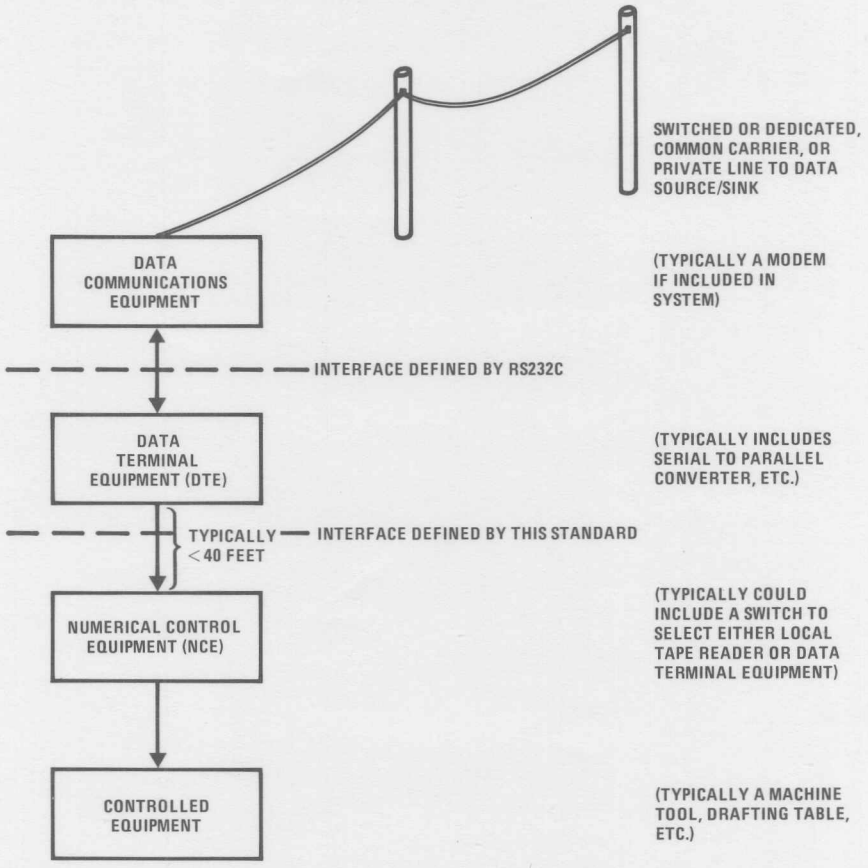
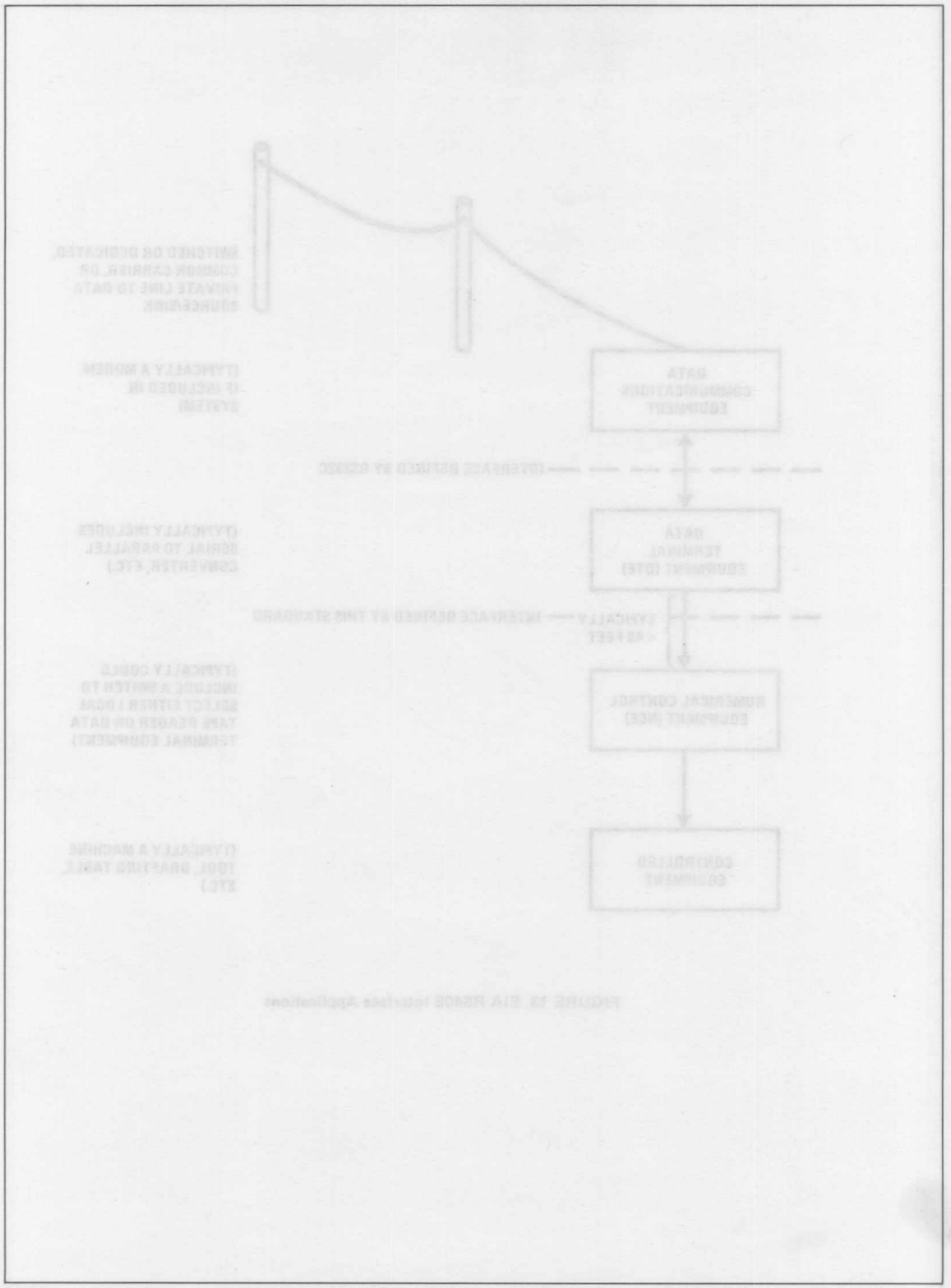


FIGURE 13. EIA RS408 Interface Applications

Summary of Electrical Characteristics of Some Well Known Digital Interface Standards

AN-216



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