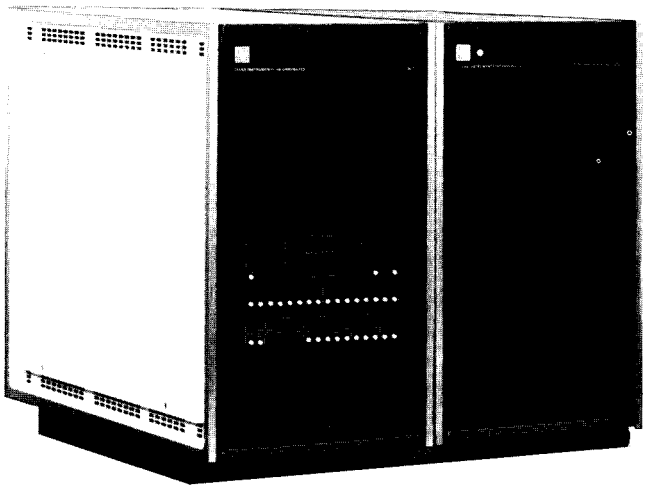
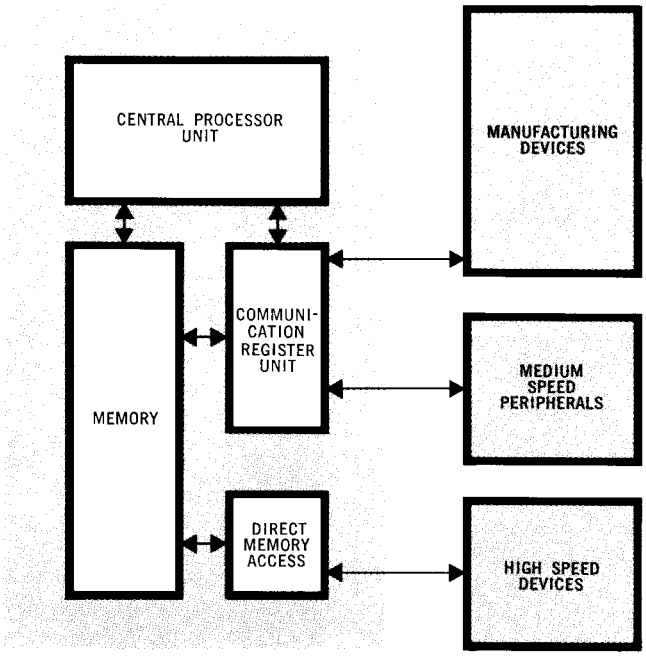
MODEL 960 "bit pusher"* process control computer

TEXAS INSTRUMENTS
INCORPORATED

MODEL 960
manufacturing & process control computer





"bit pusher"

The Texas Instruments Model 960 computer is the result of a new concept, unique in its application to the control of manufacturing systems. The hardware and software architecture was developed to handle efficiently the decisions required by discrete and continuous manufacturing operations, and to implement the necessary control response.

Unlike general purpose computers that are constrained to a fixed word length, the Model 960 is capable of varying its effective word length from 1 to 16 bits. Programming is readily accomplished with an instruction set that provides for variable length bit fields (or words) and direct manipulation of individual bits in memory and input/output.

Key features that result in the flexible and simple implementation of a system utilizing a Model 960 are:

- single instruction context switching
- inexpensive interfacing to the Communications Register Unit
- assembly language instructions relating directly to functions being controlled

unique architecture

Dual Mode operation is made possible by single instruction context switching. Two complete sets of virtual registers are included which increase efficiency in real-time multi-task applications. Powerful multiple base register addressing is provided for the programmer. Base addresses are carried for references of data, flags (single bits), procedures (instructions), and external interface positions. This simplifies the writing of procedures to control process machinery. A single procedure may re-entrantly control an entire set of similar machines operating simultaneously.

user oriented instructions

The 960 Assembly language provides user oriented instructions, allowing the manufacturing man to communicate easily to his computer the requirements for the control and monitoring of a process. Examples of user oriented instructions are: compare memory with limits, which compares a value in memory with an upper and lower limit; test input bit, set output bit or switch modes, which checks status of an external device and takes action if required. Computers usually require multiple instructions or subroutines to accomplish each of these tasks. The language contains 57 instructions, including 9 bit and bit field manipulating instructions, 19 memory-register instructions, 8 memory-memory instructions, and 21 program control instructions.

software

Complementing the versatile hardware of the Model 960 is the standard system software package containing the following major parts:

- Programming Support Monitor (PSM)
- Process Automation Monitor (PAM) which includes on-line debugging routines and floating point software
- Programming System (PS) with SAL960 (symbolic assembly language) that permits assembly on the TI 960, TI 980, or System/360. Also included is a linking relocating loader and a source maintenance routine
- Diagnostics
- Utility programs

Additional software assistance is available for the solution of specific application prcblems.

special function modules

The CRU concept provides an economical means of implementing special function hardware on plug-in modules. Included among the available functions are:

- Interval timer
- Interrupt expansion
- Pulse accumulator
- A/D converter
- D/A converter
- Fixed point multiply

Additional special function hardware assistance is available for the solution of specific application problems.

interfacing

The Communications Register Unit (CRU) provides an economical, flexible interface which accommodates application-oriented modules. These modules may be either special function modules such as interval timers, or low cost plug-in interface cards to connect external devices. These cards are available in a variety of configurations, allowing external devices to be interfaced to the computer in a few hours.

The CRU may be easily expanded to 4096 input and 4096 output lines. *Each line can be directly addressed and monitored or controlled with a single instruction.* In addition, variable bit fields (to 16 lines in length) may be directly addressed. All CRU I/O operations are based on the set/reset state of individual CRU lines. Special bit and bit field oriented machine instructions are implemented in the instruction set to operate the CRU interfaces.

The following standard plug-in CRU interface modules are available:

- TTL Interface
- Relay Contact Interface

An expandable Direct Memory Access (DMA) channel is also provided to facilitate operation of high speed devices.

peripherals

To augment the flexibility of the 960 computer, a variety of peripherals may be teamed with the CPU. Flexibility of the CRU and DMA channels available to the 960 user makes optimum utilization of the peripherals much easier than with computers with conventional architecture. The following peripherals are available:

- Card reader
- Card punch
- Teleprinter
- Paper tape reader
- Paper tape punch
- Line printer
- Magnetic tape
- Disc memory

model 960 specifications

ORGANIZATION

Directly address and manipulate individual bits, bit-fields, and words in memory and CRU

Dual mode environment, two program counters and 2 sets of 8 general purpose registers

Communication register unit directly expandable to 4096 input and 4096 output lines

Direct memory access expandable to 8 channels

Power failure protect and auto restart

Three levels of priority interrupt

MOS/ROM Microsequencer

Parallel operation

Single and double address logic

Two's complement arithmetic

32-bit instruction word

16-bit data word

PERFORMANCE

CRU burst rate of 3 million bits/second

DMAC burst rate of one million words/second, with automatic parity checking

Typical single instruction execution time:

Compare memory with limits: 8.3 to 10.7 microseconds

Transfer to supervisor mode: 4.0 microseconds

Test input bit; set output bit or switch modes; 6 microseconds

Set CRU output bit; 4.7 microseconds

MEMORY

Direct bit addressing capability throughout core memory

Direct word addressing capability throughout core memory

One microsecond cycle time

Core storage for up to 65,536 words (16 bit) in 4096 word increments

Hardware memory protect feature

Power failure protection

Memory parity logic

INSTRUCTION SET (57 INSTRUCTIONS)

9 Memory—CRU instructions (for manipulation of individual bits, bit-fields, and words)

19 Memory—register instructions

8 Memory—memory instructions

21 Program control instructions

PHYSICAL CHARACTERISTICS

Multilayer printed circuit boards (to 8 layers)

TTL/MSI circuits

MOS/LSI read only memory micro-sequencer

Modular construction

Rapid access to all modules

Self contained power supplies

Power dissipation: 420w, cooling is included

Power required: 117V ± 10%, 47 HZ to 63 HZ

Packaging is available in system desk, rack mount, and table top configurations

System desk and table top

Size:

Height:	20 inches
Width:	12 inches
Depth:	26 inches
Weight:	85 pounds

Rack Mount Size:

Height:	10.5 inches
Width:	19 inches
Depth:	24 inches
Weight:	65 pounds

ENVIRONMENTAL CHARACTERISTICS

Temperature

Operating: 0° to 50°C

Non-Operating: —40°C to +100°C

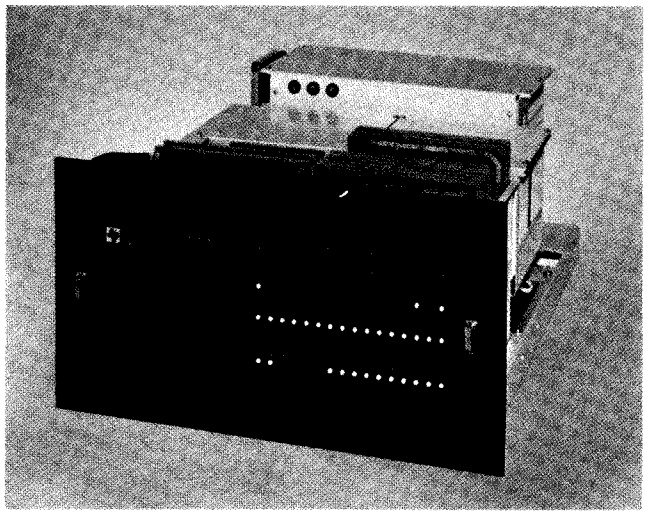
Relative humidity: 0 to 95% without condensation

Altitude: To 10,000 feet

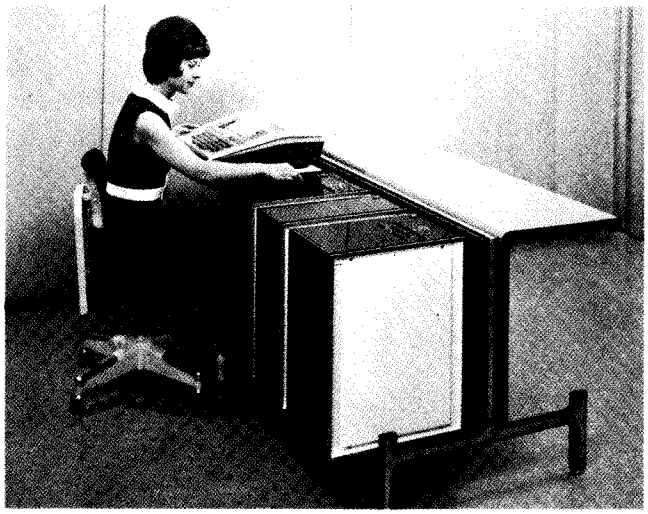
MODEL 960

"bit pusher" computer

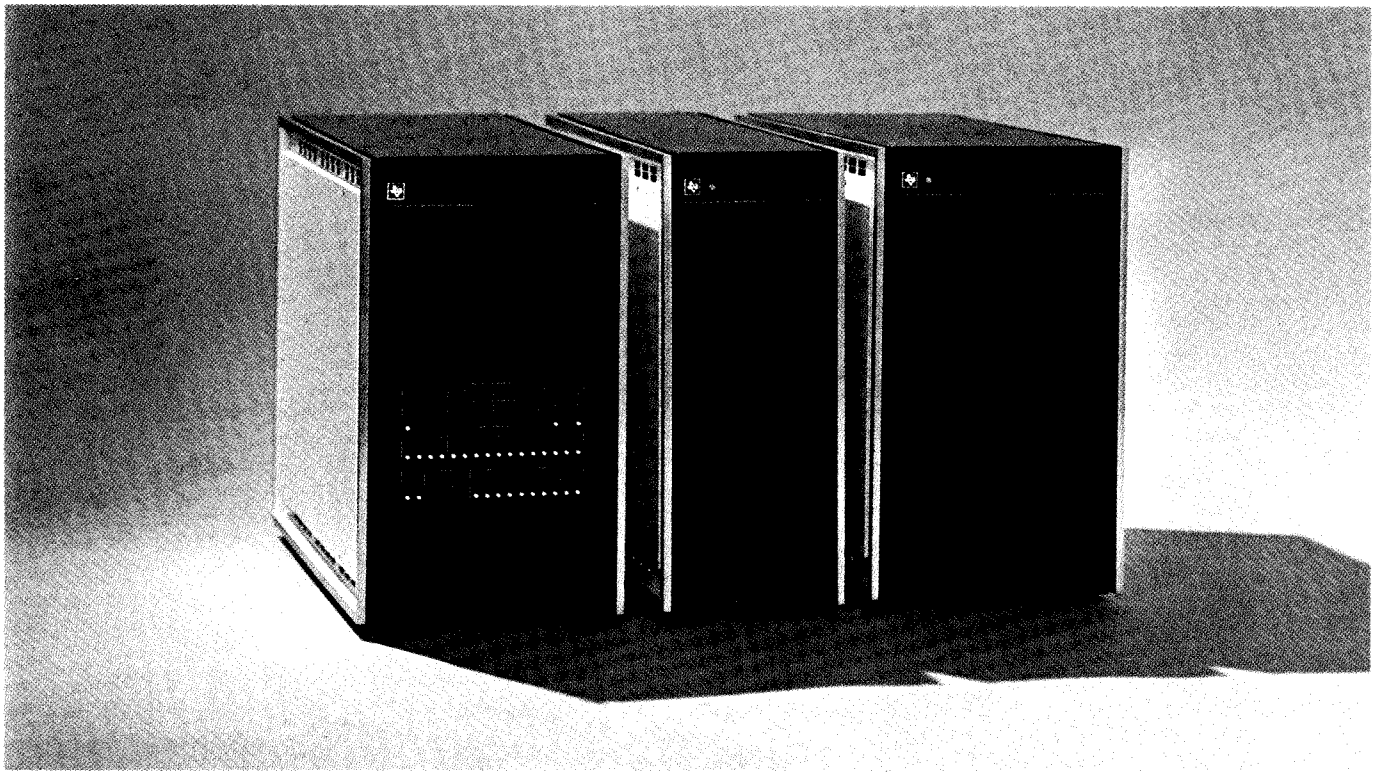
The Manufacturing Man's Computer



RACKMOUNT



SYSTEMS DESK



TABLETOP

TEXAS INSTRUMENTS
INCORPORATED
DIGITAL SYSTEMS DIVISION
P. O. BOX 66027 HOUSTON, TEXAS 77006

TECHNICAL DATA

MODEL 960
PL/3

MODEL 960 COMPUTER

Item	Description	Prerequisite Item Number	Enclosure		Purchase Price	Monthly Maintenance Charge	
			Rack Mount	Table Top		Standard(1)	Full(2)
1	Model 960 Central Processor Unit, with 4096 Word Core Memory, DMAC Bus Port, 4 Communications Register Ports, Space for Second 4K Memory Module, and 115 VAC, 50-60 Hz Power Supply	—	216101	216100 (3)	$14,500	$122.00	$162.00
2	Central Processor 4096 Word Memory, Module Expansion to 8192 Word Core Memory. (Use Item 3 for memory expansion above 8192 words)	1	246683	246683	$ 4,500	$ 16.00	$ 21.00
3	Memory Expansion Chassis, can accept up to four (4) plug-in 4096 word memory modules. Maximum number of chassis on one CPU is four (4).	1 or 2	246692	246715 (3)	$ 2,200	$ 16.00	$ 21.00
4	Memory Expansion Module, Plug-in 4096 Word Core Memory Module.	3	246683	246683	$ 4,500	$ 16.00	$ 21.00
5	DMAC Expansion Chassis, Chassis with space for DMAC Expansion Kit, including Power Supply.	1	216150	216149 (3)	$ 1,500	$ 16.00	$ 21.00
6	DMAC Expansion Kit, Wired with Space for one Line Printer, Magnetic Tape Unit and fixed Head Disc Unit Controller.	5	216694	216694	$ 2,500	$ 14.50	$ 19.50
7	Communications Register Unit, Chassis wired with space for sixteen (16) CRU Interface Modules. (Each CRU slot in the CPU can be expanded to four (4) CRU Chassis.)	1, 9, 10	216107-1	214157-1 (3)	$ 1,900	$ 12.00	$ 16.00
8	Communications Register Unit, Identical to (7) above except including Power Supply for operation of A/D and D/A Converters within this CRU.	1, 9, 10	216107-2	214157-2 (3)	$ 2,450	$ 14.50	19.50
9	CRU Expansion Card, includes CRU Expansion Logic for one (1) to four (4) CRU Chassis.	1	214095	214095	$ 90	—	—
10	CRU Expansion Cable, for connecting CRU Expansion Chassis to CRU Expansion Card. (Select as required.)						
	a. For one (1) CRU Chassis	9	216092	216092	$ 90	—	—
	b. For two (2) CRU Chassis	9	217166	217166	$ 141	—	—
	c. For three (3) or four (4) CRU Chassis	9	216094	N/A	$ 264	—	—

TEXAS INSTRUMENTS
INCORPORATED
DIGITAL SYSTEMS DIVISION
P.O. BOX 66027 HOUSTON, TEXAS 77006

MODEL 960 COMPUTER

Item	Description	Prerequisite Item Number	Enclosure		Purchase Price	Monthly Maintenance Charge	
			Rack Mount	Table Top		Standard(1)	Full(2)
11	CRU Interface Modules, (Select as required)						
	a. Data Module, 5V	(1 or 7 or 8) +(12 or 13)	214103	214103	$ 300	$ 6.00	$ 7.50
	b. Data Module, Contactor	(7 or 8) +(12 or 13)	214111	214111	$ 400	$ 10.50	$ 13.50
	c. Interval Timer Module	(1 or 7 or 8) +(12 or 13)	214114	214114	$ 500	$ 4.50	$ 6.00
	d. Interrupt Module	(1 or 7 or 8) +(12 or 13)	214087	214087	$ 300	$ 4.50	$ 6.00
	e. Multiply Module — Requires 2 CRU slots	(1 or 7 or 8)	217199	217199	$ 1,250	$ 18.50	$ 24.50
	f. Pulse Accumulator Module	(1 or 7 or 8)	217203	217203			
	g. A/D Converter Modules						
	• With 10Kohm input Z	8+(12 or 13)	217690-1	217690-1	$ 1,000	$ 14.50	$ 19.50
	• With Sample and Hold and 10 megohm input Z	8+(12 or 13)	217690-2	217690-2	$ 1,200	$ 17.50	$ 23.50
	• With Sample and Hold, 10 megohm input Z, and 8 channel Multiplexer	8+(12 or 13)	217690-3	217690-3	$ 1,600	$ 23.50	$ 31.50
	• With Sample and Hold, 10 megohm input Z, and 16 channel Multiplexer	8+(12 or 13)	217690-4	217690-4	$ 2,000	$ 29.00	$ 39.00
	h. D/A Converter Modules						
	• One Channel/Card	8+(12 or 13)	217686-1	217686-1	$ 400	$ 6.00	$ 8.00
	• Two Channels/Card	8+(12 or 13)	217686-2	217686-2	$ 700	$ 10.50	$ 13.50
	• Three Channels/Card	8+(12 or 13)	217686-3	217686-3	$ 1,000	$ 14.50	$ 19.50
12	Connector with Cover Shell, (for use with CRU Interface Module)	11	216099	216099	$ 19	—	—
13	Patch Panel, (for use with CRU Interface Module)	11	216104	216104	$ 85	—	—
14	Patch Panel Cable, Includes Twisted Pair Wire	13	216105	216105	$ 9	—	—
15	Patch Panel Cable, Includes Coax Cable	13	217602	217602		—	—
16	Patch Panel Jumper Cable, Includes Twisted Pair Wire.	13	214910	214910	$ 4.50	—	—
17	Patch Panel Shorting Plug	13	216106	216106	$ 1.55	—	—
18	Teleprinter Kit, Includes 10 cps Teletypewriter with Paper Tape Punch and Reader, Cable, Interface for CRU and Software Driver.	1	N/A	216741	$ 1,900	$ 58.00	$ 77.00

MODEL 960 COMPUTER

Item	Description	Prerequisite Item Number	Enclosure		Purchase Price	Monthly Maintenance Charge	
			Rack Mount	Table Top		Standard(1)	Full(2)
19	Teleprinter Kit, Includes 30 cps TI Silent 700/20 Electronic Data Terminal, Cable, Interface for CRU and Software Driver	1	N/A	216750 (4)	$ 3,300	$ 48.00	$ 64.00
20	High Speed Paper Tape Reader Kit, Includes 300 cps Optical Tape Reader with Spooler, Cable, Interface for CRU and Software Driver.	1, 7, or 8	216744 (5)	N/A	$ 2,800	$ 45.00	$ 60.00
21	High Speed Paper Tape Punch Kit, Includes 60 cps Paper Tape Punch, Spooler, Cable, Interface for CRU and Software Driver.	1, 7, or 8	216747 (5)	N/A	$ 3,000	$ 62.50	$ 83.00
22	Card Reader Kit, Includes 300 cpm Card Reader, Cable, Interface with Single Column Buffer, for CRU and Software Driver.	1, 7, or 8	N/A	216753 (4)	$ 4,500	$ 78.50	$104.00
23	Card Punch Kit, Includes 100 cpm Card Punch, Cable, Interface for CRU and Software Driver.	1, 7, or 8	N/A	216756 (7)	$20,300	$100.00	$133.00
24	80 Column Line Printer Kit, Includes 356 lpm Line Printer, Cable, Interface for DMAC and Software Driver.	1, 5, + 6	N/A	214909 (4)	$15,000	$ 93.00	$123.50
25	Magnetic Tape Transport, 9 Track Master Kit, includes TI 959 Transport (800 BPI, 75 ips), Cable (controller to transport), Controller for DMAC, Terminator and Software Driver.	1, 5, + 6	216795 (6)	N/A	$18,180	$243.00	$325.00
26	Magnetic Tape Transport, 9 Track Slave Kit, includes TI 959 Transport (800 BPI, 75 ips) Cable (Transport to Transport)	25	216793 (6)	N/A	$12,265	$220.00	$293.00
27	Fixed Head Disc Memory Kit, Includes Controller for DMAC, Cable, Software Driver, less Cabinet. Disc size as follows:						
	a. 114K Words	1,5,6,+30	216771-1 (5)	N/A	$23,200	$ 70.00	$ 92.50
	b. 229K Words	1,5,6,+30	216771-2 (5)	N/A	$25,600	$ 70.00	$ 92.50
	c. 334K Words	1,5,6,+30	216771-3 (5)	N/A	$31,200	$ 70.00	$ 92.50

MODEL 960 COMPUTER

Item	Description	Prerequisite Item Number	Enclosure		Purchase Price	Monthly Maintenance Charge	
			Rack Mount	Table Top		Standard(1)	Full(2)
27	Fixed Head Disc Memory Kit (cont.)						
	d. 458K Words	1,5,6,+30	216771-4 (5)	N/A	$33,100	$ 70.00	$ 92.50
	e. 573K Words	1,5,6,+30	216771-5 (5)	N/A	$43,000	$ 97.00	$129.00
	f. 688K Words	1,5,6,+30	216771-6 (5)	N/A	$45,500	$ 97.00	$129.00
	g. 802K Words	1,5,6,+30	216771-7 (5)	N/A	$48,000	$ 97.00	$129.00
	h. 917K Words	1,5,6,+30	216771-8 (5)	N/A	$50,800	$ 97.00	$129.00
28	Central Mounting Station 47"	–	N/A	216095	$ 850	–	–
29	a. Desk Top 18"	28	N/A	216098	$ 300	–	–
	b. Desk Top 30"	28	N/A	216109	$ 350	–	–
	c. Desk Top 47"	28	N/A	216104		–	–
30	Rack Mount Cabinet						
	a. 54.25 inches of mounting space	–	217250	N/A	$ 1,500	–	–
	b. 17.00 inches of mounting space	–	217267	N/A	$ 400	–	–
31	Walnut Back Panel For 47" Station	28	N/A	216114-1	$ 100	–	–

(1) Standard Maintenance – Standard Service Availability Period will be 16 consecutive hours/day, Monday through Friday between the hours of 7:00 AM and 1:00 AM, and 9 consecutive hours Saturday between the hours of 7:00 AM and 6:00 PM.

(2) Full Maintenance – Full Service Availability Period will be 24 Hours/day, Monday through Sunday.

(3) Specify if unit is to be mounted on Central Mounting Station.

(4) Rack Mount not available.

(5) Unit is rack mount only and requires rack mount cabinet. Disc System, if specified, requires separate rack mount cabinet. Item 30 b. is available for mounting paper tape reader and punch in a low cabinet compatible with central mounting station design.

(6) Includes floor standing enclosure 70 inches high X 26 inches wide X 30 inches deep.

(7) Self-contained floor standing unit.

N/A Not Applicable

Effective July 1, 1970
Supersedes PL2 Dated 6-8-70

Prices Subject to Change without Notice.
Prices are Net 30 days, FOB Stafford, Texas.