Analysis of Army Spare and Repair Microcircuits for Determination of Commercial Equivalents and Parts Standardization

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1.0 Introduction

The Department of Defense (DoD) faces the ever-increasing challenge of sustaining the readiness of its arsenal of advanced weaponry in an extremely dynamic period of technological progression. The problems of dimensioning manufacturing sources and material shortages (DMSMS) and technological obsolescence require a significant annual investment from the Army, Air Force, and Navy, and a growing "industry" has arisen within the Defense Community to help mitigate obsolescence problems.

For the DoD, one of the most adversely impacted areas is within microelectronics. Increased demands from the commercial sector for advanced microelectronics, coupled with declining acquisitions to meet military requirements, have driven many manufacturers away from the defense sector. Estimates of the military share of the microelectronics market now stand at less than one half of one percent. This has translated into an environment where most manufacturers are unwilling to adapt their product lines to meet the rigorous specifications of the military.

As a means to address the problems of non-availability, the use of commercial-off-the-shelf (COTS) components has been advocated. The move toward COTS was also precipitated by Defense Secretary William Perry's 29 June 1994 memo, "*Specifications & Standards - A New Way of Doing Business*," which in part mandated the DoD to "increase access to commercial state-of-the-art technology."

As the DoD migrates from a mil-spec environment to one more amenable to the use of COTS, it has become apparent that an appropriate toolset needs to be developed to assist the government designer in the selection of COTS items. Presently, the search for a candidate replacement COTS item has become a time-consuming, inefficient process. For example, the current methodology employed by the Army has led to part number proliferation that results in unnecessary labor expenditure to identify a suitable repair part. The designer must search through vendor catalogs and item data sheets until a suitable replacement is identified. This process is leading to a proliferation of microelectronic parts being used to perform specific functions within DoD weapon systems.

While the current COTS approach may be supportive of the commercialization component of Acquisition Reform (AR), it is contrary to the standardization aspects of the AR movement. The standardization of parts has been shown to be a wise strategy not only within the DoD, but also throughout the private sector. To facilitate standardization, the Defense Standardization Program (DSP) was created to "promote standardization of materiel, facilities, and engineering practices to improve military operational readiness, reduce total ownership costs, and reduce acquisition cycle time. It is also DoD policy to state requirements in performance terms, wherever practical, and to make maximum use of non-Government standards and commercial technologies, products, and practices."

2.0 Purpose

This standardization project was funded by the DSP and sponsored by the U.S. Army Aviation and Missile Command (AMCOM) Engineering Directorate. The purpose of the project was to develop a database of AMCOM-managed microelectronic items and a readily available listing of potential COTS replacement parts. The project included an analysis of the existing AMCOM Industrial Base spare and repair parts database of microcircuits to determine the feasibility of inserting commercial equivalent parts. The analysis evaluated known product attributes and performance characteristics of military spare and repair parts and compared these attributes to corresponding vendors' commercial items that are readily available. Product attributes included operating voltage, silicon manufacturing process and package outline. The outcomes of this project are a database of military microcircuit devices currently in use at AMCOM, an associated database of possible commercial equivalents, and a software interface to aid in the search and retrieval of this information.

This effort will allow the Defense Logistics Agency (DLA) and Army procurement centers to streamline the acquisition process and facilitate conversion from mil-spec to performance based specifications where determined to be feasible. By promoting standardization, the number of national stock numbers within the supply support system can also be substantially reduced. In addition, the results can be used for selection of commercial devices in the design phase of modernization efforts.

3.0 Technical Approach

The approach to executing this DoD standardization task was to utilize the U.S. Army AMCOM database of microelectronic spare and repair parts as a baseline. This database represented microelectronics used within a number of Army weapon systems, including ATACMS, Avenger, HAWK, Hellfire, Javelin, MLRS, PAC3, Patriot, and THAAD. Using the baseline database as an input to the analysis and operating on the database with existing tools, techniques, skills and experiences, a relational database was generated identifying potential commercial replacements.

The result of this task was the *AMCOM Standardization Tool for Commercially Available Microcircuits* (ASTCAM). To facilitate the widespread use of this database, an interactive software interface was developed to allow the user easy access to the information and thereby identify one or more potential replacements device. The description and use of ASTCAM will be fully explored in Section 4.0.

3.1 Design Assumptions

To understand ASTCAM and benefit fully from its use, it is important to understand the design assumptions used during its development. The microelectronic-analysis team generated a set of ground rules that were used during the research and population of the database. These ground rules included:

1. *The case design for the new device is a direct plug-in replacement.* COTS items were only included that had the same basic form and fit as the original mil-spec item.

2. *An identified substitute part is currently being manufactured.* One of the primary tasks of the AMCOM microelectronics team is to analyze the availability of all piece-parts. Microelectronic parts are considered to be obsolete when they are no longer being manufactured by an approved source. For this effort, only currently manufactured COTS items have been included as potential replacements.

2. *The functionality of the substitute part is essentially the same as the original part (i.e. timing, voltage, etc.)* The analysis to find potential replacement microcircuits focused on matching the functionality of the COTS item to that of the original mil-spec item.

3. *Temperature range is different for industrial grade and commercial grade parts.* The industry accepted temperature ranges have been used during the analysis process. These temperature ranges are as follows:

Mil-spec temperature range:	-55ºC to 125ºC
Industrial grade temperature range:	-40ºC to 85ºC
Commercial grade temperature range:	0ºC to 75ºC

4. *Any potential replacement device must be validated in the specific design application.* It is extremely important that the user of the ASTCAM system understand the tool's purpose. The goal of ASTCAM is to provide a means to quickly identify <u>potential</u> COTS equivalent microcircuits. <u>Any items identified using ASTCAM must be validated for the specific design application</u>. ASTCAM is <u>**not**</u> to be considered as a tool that will provide direct replacement parts. ASTCAM was developed in part by capturing the design expertise of electronics engineers who are experienced in military applications. As an expert system, ASTCAM provides the novice engineer or logistician an understanding of the basics of employing COTS electronics within a military application. However, ASTCAM does not replace the fundamental design engineering process. Only after a complete engineering evaluation (analysis, breadboard and test, subjecting the part to the specific environment in which the military system will operate, etc.) should the part be considered as an accepted replacement. Typically, the operating temperature range is the primary difference between the military part and the candidate industrial or commercial part. However, a complete analysis of the original part, the operating environment, and the parameters of the replacement part must be conducted.

3.2 Pros and Cons of COTS Microelectronics

As with most aspects of Acquisition Reform, the inclusion of COTS microelectronics within military system applications is not without controversy. Richard Biddle of Texas Instruments points out that the "primary driver for the use of COTS components in military applications is low initial cost." He also points out other advantages, such as proven performance in commercial applications, lighter weight, and broad initial product offerings. However, these advantages are tempered by the lack of a track record in the more extreme conditions encountered within the military. According to Biddle, "There is limited data supporting long term performance in military applications." In addition, the "obsolescence issues have not yet been resolved." With the product life cycles for commercial items being only a fraction of a life cycle for a missile, for example, the problem of non-availability appears to intensify with the COTS component.

4.0 Results

This standardization project has relied on out-of-the-box thinking to analyze and evaluate the use of available integrated circuits (I/C) in military applications. The focus in this task was to develop a database of commercial/industrial grade devices that can serve as potential substitute parts with a minimum effect on the performance on the weapon system. It is important that the military identify a means for dealing with the depletion of the microelectronic military market and implement a method into their design process in which commercial and industrial grade devices can meet military performance requirements. Candidate COTS items selected during this task were based on their feasibility to replace military grade devices with minimum performance degradation to the weapon system.

4.1 Database Development

The approach taken to accomplish this research task was to evaluate the existing AMCOM database and identify potential substitutes. The analysts identified over 5000 microelectronics components from the AMCOM spare and repair parts database that could possibly exploit COTS substitute devices. During the process, if neither industrial nor commercial parts were available, the analysts identified military parts as substitutes (if available) and included those devices in the new database. The new database identified over 15,000 piece parts that are available for consideration as substitute devices. The user is again cautioned to be aware of the ground rules that must be understood and applied before inserting the recommended devices into any military application. Without the proper engineering analysis, no attempt at replacement should be attempted.

During the analysis process, a maximum of five replacements parts were identified for satisfying each specific part number. The intent of this task was not only to provide a starting point in identifying a replacement part, but also in providing a finite number of choices. One of the problems of migrating to COTS microelectronic components is the proliferation of part numbers. This task emphasizes the importance of standardization by identifying the most promising candidate parts for the military design engineer.

Another outcome of this research effort was the determination of the number of AMCOM/Army managed items that are available per the Defense Supply System Columbus (DSSC) qualified manufacturer list (QML). The goal of the QML program is to establish and maintain a known supplier base that has successfully demonstrated that their products meet the specified performance, quality and reliability levels via the DoD product qualification program. In AMCOM's engineering evaluation process of identifying potential substitute parts, DSSC QML parts are considered as an acceptable solution to non-availability. There were 1,202 unique

DSSC part numbers in the AMCOM database, which equates to approximately 10% of the total AMCOM part numbers. These DSCC parts are identifiable based on their “5962” part number prefix. A subset of these parts is listed in Appendix A as an example of the overall database contents. A complete description of the database fields is included in Section 4.3.

4.2 ASTCAM

The software interface, *AMCOM Standardization Tool for Commercially Available Microcircuits* (ASTCAM), was designed so that the user of the new database would have quick and easy access to the replacement devices. ASTCAM was developed using standard software packages and provides a simple Windows-based interface. Figure 1 illustrates the primary user screen for ASTCAM. The information presented in the Figure 1 example is a result of a search of AMCOM part number SNJ54ABT2244J. (The information obtained as a result of this search will be used as examples when describing the different elements of the screen in Section 4.2.)

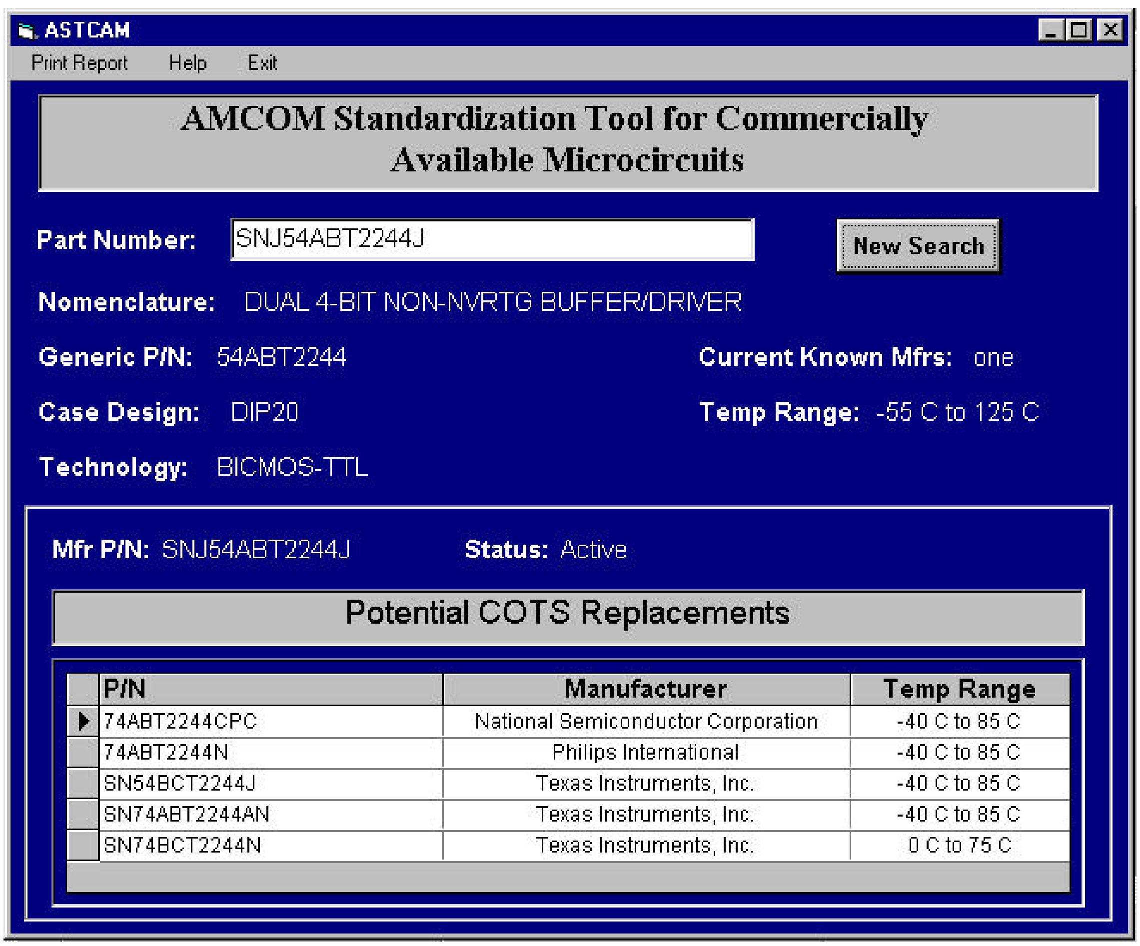

Figure 1. ASTCAM Primary User Interface Screen

The functionality of ASTCAM is straightforward. The user is to input an AMCOM part number in the Part Number box and then click on the Search button. The ASTCAM search engine then scans for the part number in the database and provides potential replacements if they exist.

The top section of the display (Figure 1) contains information regarding the searched part. The information for these attributes: Nomenclature, Generic Part Number, Case Design, Technology, Current Known Manufacturers, and Temperature, was obtained from the AMCOM master database. "Current Known Manufacturers" provides the number of manufacturers that are currently manufacturing the part. This number of manufacturers is derived from the latest AMCOM obsolescence assessment. These assessments are performed periodically by the AMCOM Engineering Directorate, typically at the request of the weapon system project office. The user should be aware that the "Current Known Manufacturers" element should be maintained on an annual basis if the data is to remain current.

The bottom section of the screen provides the manufacture's part number and the potential COTS replacements. The status of the manufacturer part number is provided. The name of the manufacturer and operating temperature range of the candidate replacement part are also provided. The manufacturer's part number was retrieved from the AMCOM master database. The remaining displayed items are a result of information obtained during the assessment. As is the case with the "Current Known Manufacturers" element, the database that contains the potential COTS replacements information should also be maintained on an annual basis if the data is to remain maintain current.

4.3 Key Definitions of Database Attributes

Figure 1 contains the seven elements of information on each user-entered item component. These elements are Part Number, Nomenclature, Generic P/N, Case Design, Technology, Current Known Manufacturers, and Temperature Range. Following are descriptions of these elements and the criteria for their inclusion in the database.

Part Number

The Part Number is to be entered by the user. The ASTCAM application is structured such that the part numbers to be entered are AMCOM part numbers. After the part number is entered, a search is performed of the ASTCAM database. The part numbers included in the ASTCAM application are those derived from the AMCOM master database of microelectronic parts. The origins of these part numbers are those contained in the parts lists of weapon systems that have had obsolescence assessments performed. The AMCOM master database lists a corresponding manufacturer part number for each AMCOM part number. There may be more than one manufacturer part number in the database for one AMCOM part number. The objective of the ASTCAM task was to find from 1 to 5 potential substitute parts for each manufacturer part number. If there are two manufacturer part numbers for one AMCOM part number, then as many as 10 potential substitute parts may be provided.

Nomenclature
The Nomenclature is the common name or description of the item referenced by the Part Number entry. The Nomenclature may be general, such as Microcircuit, or specific, such as DUAL 4-BIT NON-NVRTG BUFFER/DRIVER, which is the case in the Figure 1 example.

Generic P/N
Generic Part Number is the industry identifier for a basic manufacturer number. This identifier in most cases serves as the key numeric portion of the Part Number, while excluding all prefixes and suffixes. Again using the example in Figure 1, the generic representation of the part number is 54ABT2244, which excludes the prefix SN- and the suffix -J. "54" signifies a military device which is a device characterized for operation over the full military temperature range of -55°C to 125°C (while "74" signifies a commercial device which is characterized for operation from 0°C to 70°C). "ABT" defines the part as being in the Advanced BiCMOS Technology family. "2244" defines the particular features of the ABT part which includes that the device is an octal buffer with an equivalent output resistance of approximately 30 ohms. The complete part number is SN54ABT2244J.

Case Design
The Case Design attribute describes the basic form and fit of the electronic component. The case design typically consists of two parts: package type and pin-out. The package type in the example is DIP, which is an acronym for dual-in-line package. One definition of DIP is as follows: "The most common type IC package; circuit leads or pins extend symmetrically outward and downward from the long sides of the rectangular package body." The pin-out, or the number of component leads, in this case is 20. Other package types are Flat, Can, and PGA. Figure 2 is an illustration of case design for part number 74ABT2244CPC, the first part listed as a potential COTS replacement in Figure 1.

Technology
The Technology attribute describes the particular construction of a device. The technology in Figure 1 is BiCMOS. This type component combines elements of both bipolar and CMOS technologies onto a single chip, adding an NPN bipolar transistor output module to a core CMOS circuit structure. The result of this combination is a microcircuit that has high speed, high drive, and low power consumption.

Current Known Manufacturers
This attribute, as previously discussed, is derived from the manufacturing health assessment of each specific microelectronic component. It is important to again note that the information contained within the ASTCAM database was current and accurate at the time of database population; however, the state of manufacture is very dynamic. The database must be refreshed in order for this attribute to be of benefit to the user.

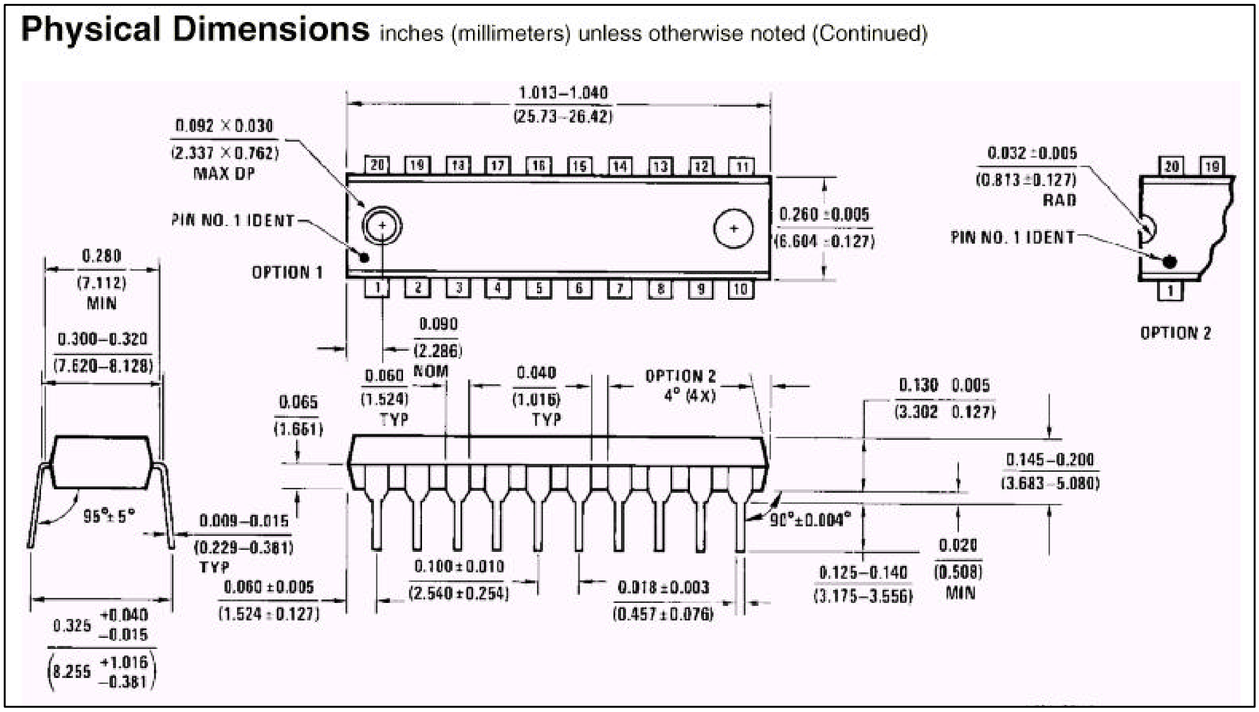

Figure 2. Case Design Illustration

Temperature Range
The temperature range for all mil-spec microelectronics is -55ºC to 125ºC. The industrial grade and commercial grade temperature ranges are -40ºC to 85ºC and 0ºC to 75ºC, respectively.

The lower section of the ASTCAM user interface screen (Figure 1) contains the results of the search. It includes the Manufacturer's Part Number and Status, along with the Part Number, Manufacturer and Temperature Range for up to five potential replacement parts. The following are descriptions of these items.

Manufacturer (Mfr) P/N
Typically, an AMCOM part is an upgrade or up-screen of a manufacturer's part; upgrading or adding parameter(s) to match the AMCOM part specifications. The manufacturer's part number displayed in ASTCAM is the vendor's representation, as called out in the vendor data book, of the AMCOM part number. There may be more than one manufacturer part number (Mfr P/N) that represents an entered Part Number. If there are multiple manufacturer part numbers, a record selector bar will appear to the right of the Status field. Click on the down arrow to view the COTS information for each Mfr P/N.

Status
The Status field describes either the state of manufacture for Manufacturer's Part Number, information signifying no information available for the searched part, or lists the type part if other than a microcircuit or semiconductor.

The status for the state of manufacture for the Manufacturer's Part Number can be Active, Discontinued, Historical, Contact Manufacturer, or Preliminary. These categories are consistent with the terminology used in Information Handling Services (IHS) CAPs, a subscription database used primarily for microelectronic evaluation. The following is a description of each of these statuses.

> An Active status denotes a part that is currently being manufactured. The definition of Active as described in IHS CAPs is: "Understood to be manufactured. The part has current documentation."
>
> A Discontinued status denotes a part that is no longer being manufactured. The definition of Discontinued as described in CAPs is: "The part is no longer made or the manufacturer is out of business."
>
> A Historical status denotes a part whose availability is unknown and the documentation pertaining to the part is dated. The definition of Historical as described in CAPs is: "Documentation is very dated. Part availability is unknown."
>
> The Contact Manufacturer status denotes a part whose availability should be determined by contacting the manufacturer. The definition for Contact Manufacturer as described in CAPs is as follows: "Documentation is dated. The part may be available, but you should contact the supplier."
>
> The Preliminary status denotes a part whose definition, according to CAPs, is "A new product. The documentation is preliminary and the availability is uncertain."

The information displayed in the status field if the manufacturer part number was not found during the assessment is Part Number Not Found and Incomplete Part Number. The descriptions of these two statuses are as follows.

> A status of Part Number Not Found denotes that the manufacturer's part number was not found when the assessment was performed. Further search for these parts would have required much more time. In addition, further searching in many cases would result in not gaining any more information.
>
> A status of Incomplete Part Number denotes a manufacturer's part number that, if a candidate substitute part is to be identified, requires more information. Typically, an Incomplete Part Number is an AMCOM part number that has been represented by its generic part number. The generic part number does not contain suffixes and/or prefixes. The suffixes and prefixes define unique part specifics such as voltage rating, lead finish, package style, etc. The suffixes and prefixes are required to identify a potential substitute part.

A status of Capacitor, Coil, Connector, Crystal, Oscillator, Relay, and Resistor may appear for the manufacturer's part number. The purpose of this task was to identify potential substitutes for microcircuits and semiconductors. However, the AMCOM database included parts other than microcircuits and semiconductors. If, after a search is performed, information for a part other than a microcircuit or semiconductor is obtained, then that type part (Capacitor, Coil, Connector, Crystal, Oscillator, Relay, and Resistor) will be displayed in the status field.

4.4 Opening and Help Screens

The user of ASTCAM will encounter two other screens during the use of this program. The opening screen, Figure 3, is displayed immediately upon entering the program. The user will have two options from this screen: either start the program or view program information.

Figure 3. ASTCAM Opening Screen

If the user chooses to view the program information, the screen illustrated in Figure 4 will be displayed. This screen presents an overview of the ASTCAM functions, along with the ability to view this final report on-line. Selection of the "Start Program" button will return the user to the primary ASTCAM screen (Figure 1).

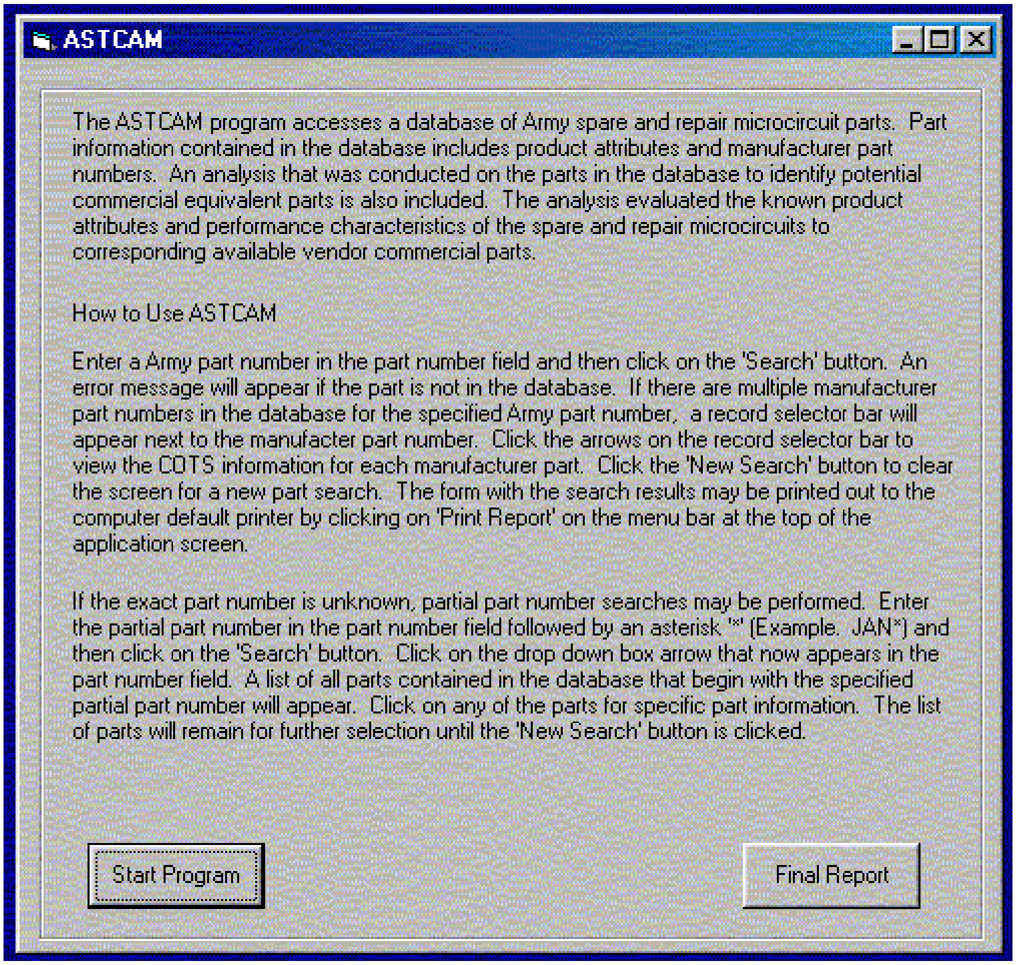

Figure 4. ASTCAM Help Screen

4.5 Recommended Use of ASTCAM

ASTCAM serves as both a database of microelectronic parts and a user interface that is not only used to search the database, but also explain the complexities of substituting COTS components for military grade parts. The logic used to develop and integrate the ASTCAM tool can provide a good education for the non-expert electronics engineer. It is recognized that the ASTCAM knowledge base may be of limited benefit to an expert electronics designer fluent in the use of commercial grade components. However, the intended use of ASTCAM is to address the needs of the non-expert, i.e. the logistician, procurement analyst, or team member who may not be aware of the intricacies of COTS and standardization.

It is anticipated that a military weapon systems project office will require replacement parts due to non-availability issues. In that scenario, an engineer could then use ASTCAM to obtain candidate replacements. Using the component shown in Figure 1 as an example, the potential replacements presented for part number SNJ54ABT2244J are 74ABT2244CPC, 74ABT2244N, SN54BCT2244J, SN74ABT2244AN, and SN74BCT2244N. To research the replacement parts, it is recommended that the engineer obtain information pertaining to the type part and the data sheets for the potential replacements.

An example of the information required for engineering analysis is contained in Appendices B-F. These appendices are provided to reinforce the understanding that replacement of a military grade part with a commercial equivalent requires detailed research and analysis. For the sake of brevity, the reports and/or data sheets contained within these appendices are **not** provided in total; instead, only the first few pages of each appear.

The information contained in Appendix B, titled "ABT Enables Optimal System Design", is a Texas Instruments report pertaining to the type part. (ABT is an acronym for advanced BiCMOS technology.) This article contains considerable information pertaining to ABT technology.

The next four appendices (C-F) are the vendor data sheets for the potential replacements. Appendix C contains the data sheets for the first part number, 74ABT2244CPC. National Semiconductor Corporation (NSC) is listed as the manufacturer for the first part number in Figure 1. NSC has sold that portion of their business to Fairchild Semiconductor Corporation (FSC). Consequently, the data sheet for part 74ABT2244CPC is from FSC.

Appendix D contains the data sheets for the second part number 74ABT2244N, which is manufactured by Philips International. Likewise, Appendix E contains the data sheets for the third and fifth parts, SN54BCT2244J and SN74BCT2244N, while Appendix F contains the data sheets for the fourth part, SN74ABT2244AN. The manufacturer for these three parts is Texas Instruments.

It is extremely important that the user understand that ASTCAM is **<u>not</u>** to be used to provide replacements directly. The engineer should perform a preliminary background assessment and report the findings and make recommendations. Afterwards, a complete engineering evaluation should be performed by the design authority. Only after a complete engineering evaluation should the part be considered a replacement.

5.0 Conclusions

The inclusion of COTS microelectronics within military applications has been a controversial aspect of Acquisition Reform. As discussed, the problems of obsolescence appear to increase with the volatility of the commercial marketplace. However, with the shrinking influence of DoD in the microelectronics industry, there seem to be few options available to the military design engineer to avoid COTS insertion.

To assist the designer and to help alleviate the potential proliferation of part numbers in an already enormous system, the DSP and AMCOM developed the ASTCAM. The results of this DOD standardization task have merit in military applications but the designer must adhere to good engineering principles and abide by the specified ground rules. The temperature range is the major difference between the military device being used and the potential commercial device being recommended. Having a database that identifies potential substitute devices and a software tool to support the designer in identifying alternate solutions will reduce the design time and thereby reduce the implementation cost. The expansion of the database will provide the designer more and quicker solutions when performing his design function.

6.0 Recommendations

As a result of this task it is recommended that the ASTCAM database and tool be made available throughout the DoD. This can be done through various means; however, delivery via the Internet would present the most appropriate option. The use of the Internet with the required level of security can allow access to the database without the problems of obsolete hardcopy, i.e. CD-ROM. By linking into the database, updates, enhancements and modifications can be made at the server level, thus serving the user community in the most efficient and cost-effective manner.

The development of ASTCAM required the capture and analysis of various levels of weapon system design expertise. As such, the model should serve as a primer to the DoD community regarding the use of COTS electronic components and standardization. To accomplish this, the ASTCAM model has been integrated into the curriculum of AMCOM's Integrated Product Development (IPD) course so that future design team members may have an understanding of these important concepts.

ASTCAM was developed to provide a proof of concept and a limited capability with its initial database of component item numbers. The ASTCAM model has been initially populated with only AMCOM-managed component items. Because of the model's unique relationship to the AMCOM sustainment process, ASTCAM has been integrated into the AMCOM microelectronic obsolescence assessment program. However, to reap the full benefits of the tool, it should continue to grow. ASTCAM should be populated with as many components from the Services as possible to become a powerful tool to not only promote standardization but also mitigate obsolescence. Regular maintenance and enhancements are encouraged.

It is also recommended that the ASTCAM model and database be integrated into the AMCOM Tech Loop process. The Tech Loop process is used to screen AMCOM procurements to determine availability, analyze for performance-based specification conversion, and determine COTS replacement potential. The ASTCAM should be integrated into this process to ensure that military-specification items are replaced by commercially available items were system requirements will allow. The use of the ASTCAM will also ensure that COTS items used as replacement spare and repair parts are standardized, thus negating the potential for parts proliferation.

It is recommended that the database of parts be refreshed on a periodic (at least annual) basis. The dynamic environment of microelectronics requires constant monitoring. In order to ensure that COTS items that are recommended for replacement are not themselves obsolete, the database must be updated.

Appendix A

Database Excerpt of DSCC Part Numbers

5962 #'s

Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
5962-3812802M2A	MICROCIRCUIT, LINEAR	5962-3812801M2A	DSCC	-55 C to 125 C	584	LCC20	
		5962-3812803M2C	DSCC	-55 C to 125 C	584	LCC20	
		5962-3812804M2C	DSCC	-55 C to 125 C	584	LCC20	
		AD584SE/883B	Analog Devices	-55 C to 125 C	584	LCC20	
		AD584TE/883B	Analog Devices	-55 C to 125 C	584	LCC20	
5962-3826703MXX	MICROCIRCUIT, DIGITAL	5962-3826701MXA	DSCC	-55 C to 125 C	28C010-200		CMOS
		AT28C010-12BC	Atmel Corporation	0 C to 75 C	28C010-200		CMOS
		AT28C010-15DM/883	Atmel Corporation	-55 C to 125 C	28C010-200		CMOS
		AT28C010-25BI	Atmel Corp.	-40 C to 85 C	28C010-200		CMOS
		KM29C010-09	Samsung Semiconductor	0 C to 75 C	28C010-200		CMOS
		KM29C010-10	Samsung Semiconductor	0 C to 75 C	28C010-200		CMOS
		KM29C010-15	Samsung Semiconductor	0 C to 75 C	28C010-200		CMOS
		X28C010DI20	Xicor, Inc.	-40 C to 85 C	28C010-200		CMOS
		X28C010DM25	Xicor, Inc.	-40 C to 85 C	28C010-200		CMOS
5962-3826707MYX	x8 EEPROM	5962-3826701MYA	DSCC	-55 C to 125 C	28C010	LCC44	CMOS
		AT28C010-12LC	Atmel Corporation	0 C to 75 C	28C010	LCC44	CMOS
		AT28C010-12LI	Atmel Corporation	-40 C to 85 C	28C010	LCC44	CMOS
		AT28C010-12LM	Atmel Corporation	-40 C to 85 C	28C010	LCC44	CMOS
		AT28C010E12LM/883	Atmel Corporation	-55 C to 125 C	28C010	LCC44	CMOS
5962-3826707MZX	x8 EEPROM	28C010ERPGB12	Space Electronics Inc.	-55 C to 125 C	28C010	FP32	CMOS
		28C010ERPGP12	Space Electronics Inc.	-55 C to 125 C	28C010	FP32	CMOS
		AT28C010-12FC	Atmel Corporation	0 C to 75 C	28C010	FP32	CMOS
		X28C010FI12	Xicor, Inc.	-40 C to 85 C	28C010	FP32	CMOS
5962-3829408MZX	MICROCIRCUIT, MEMORY	HM165664AB2/883	IDT	-55 C to 125 C	5C6408		CMOS
		HM165664AC2/883	Temic Semiconductors	-55 C to 125 C	5C6408		CMOS
		IDT7164L25TDB	Temic Semiconductors	-55 C to 125 C	5C6408		CMOS
		L7C185CMB15L	Logic Devices, Inc.	-55 C to 125 C	5C6408		CMOS
		L7C185CMB20L	Logic Devices, Inc.	-55 C to 125 C	5C6408		CMOS
5962-3829411MXX	MICROCIRCUIT, DIGITAL	HM1E65664AG2/883	Temic Semiconductors	-55 C to 125 C	7C186	DIP6/28	
		HM1E65664AQ2/883	Temic Semiconductors	-55 C to 125 C	7C186	DIP6/28	
		IDT7164L20DB	IDT	-55 C to 125 C	7C186	DIP6/28	
		IDT7164S45DB	IDT	-55 C to 125 C	7C186	DIP6/28	
		L7C185IMB20L	Logic Devices, Inc.	-55 C to 125 C	7C186	DIP6/28	
5962-3829414MYA	MICROCIRCUIT MEMORY	DPS9264G120M	Dense-Pac Microsystems, Inc.	-55 C to 125 C	7164	LCC32	
		DPS9264G150C	Dense-Pac Microsystems, Inc.	0 C to 75 C	7164	LCC32	

Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		HM4-65642/883	Harris Semiconductor	-55 C to 125 C	7164	LCC32	
		L7C185TMB15L	Logic Devices, Inc.	-55 C to 125 C	7164	LCC32	
		L7C185TMB20L	Logic Devices, Inc.	-55 C to 125 C	7164	LCC32	
5962-3848001MQA	MICROCIRCUIT, DIGITAL	Z08400-04DSE	Zilog, Inc.	0 C to 75 C	8400		MOS
		Z08400-06DSE	Zilog, Inc.	0 C to 75 C	8400		MOS
		Z08400-06PSC	Zilog, Inc.	0 C to 75 C	8400		MOS
		Z8300-1PS	Zilog, Inc.	0 C to 75 C	8400		MOS
		Z8400CM	Zilog, Inc.	-40 C to 85 C	8400		MOS
5962-3848002MQX	MICROCIRCUIT	Z08400-04PSC	Zilog, Inc.	0 C to 75 C			
		Z08400-06DSE	Zilog, Inc.	0 C to 75 C			
		Z08400-06PSC	Zilog, Inc.	0 C to 75 C			
		Z08400-08PSC	Zilog, Inc.	0 C to 75 C			
		Z8400CM	Zilog, Inc.	-40 C to 85 C			
5962-77008012A	QUAD SINGLE-SUPPLY COMPARATOR	LM139AFKB	Texas Instruments, Inc.	-55 C to 125 C	139	LCC, 20 PI	BIPOLAR
		M38510/11201B2X	DSCC	-55 C to 125 C	139	LCC, 20 PI	BIPOLAR
		PM139ARC/883	Analog Devices	-55 C to 125 C	139	LCC, 20 PI	BIPOLAR
5962-7703401UX	POSITIVE ADJUSTABLE VOLTAGE REG.	LM117-220M	Semelab PLC	-40 C to 85 C	117	SIP-TAB3	BIPOLAR
		LM317MABT	Motorola	-40 C to 85 C	117	SIP-TAB3	BIPOLAR
		LM317T	Rochester Electronics	0 C to 75 C	117	SIP-TAB3	BIPOLAR
		SDP117JDAES	Solitron Devices, Inc.	-40 C to 85 C	117	SIP-TAB3	BIPOLAR
		SDP117JDAWS	Solitron Devices, Inc.	-55 C to 125 C	117	SIP-TAB3	BIPOLAR
5962-7703403XX	MICROCIRCUIT	IP137MAHVH	Semelab PLC	-40 C to 85 C	137		BIPOLAR
		IP137MAHVH/883B	Semelab PLC	-55 C to 125 C	137		BIPOLAR
		IP137MH/883B	Semelab PLC	-55 C to 125 C	137		BIPOLAR
		LM137H	National	-40 C to 85 C	137		BIPOLAR
		LM137H	ST Microelectronics	-40 C to 85 C	137		BIPOLAR
		LM137H/883	National	-55 C to 125 C	137		BIPOLAR
		LM237H	ST Microelectronics	-40 C to 85 C	137		BIPOLAR
		LM337H	Motorola	0 C to 75 C	137		BIPOLAR
		LM337H	ST Microelectronics	0 C to 75 C	137		BIPOLAR
		LT337AH	Linear Technology Corporation	0 C to 75 C	137		BIPOLAR
5962-7703405XA	MICROCIRCUIT, LINEAR	IP117MAH	Semelab	-40 C to 85 C	117		BIPOLAR
		IP117MAH	Semelab PLC	-40 C to 85 C	117		BIPOLAR
		IP117MAH/883B	Semelab	-55 C to 125 C	117		BIPOLAR

Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		IP117MAH/883B	Semelab PLC	-55 C to 125 C	117		BIPOLAR
		IP117MH	Semelab	-40 C to 85 C	117		BIPOLAR
		LM117H	Linear Technology Corporation	-40 C to 85 C	117		BIPOLAR
		LM117H	National	-40 C to 85 C	117		BIPOLAR
		LM117H	ST Microelectronics	-40 C to 85 C	117		BIPOLAR
		LM117H/883	National	-55 C to 125 C	117		BIPOLAR
		LM117HVH	Linear Technology Corporation	-40 C to 85 C	117		BIPOLAR
		LM217LH	Motorola	-40 C to 85 C	117		BIPOLAR
		LT117AHVH	Linear Technology Corporation	-40 C to 85 C	117		BIPOLAR
5962-7802001M2X	MICROCIRCUIT	26LS32M/B2AJC	Motorola	-55 C to 125 C	26LS32	LCC20	
		5962-87616012X	DSCC	-55 C to 125 C	26LS32	LCC20	
		78020012X	DSCC	-55 C to 125 C	26LS32	LCC20	
		78020032X	DSCC	-55 C to 125 C	26LS32	LCC20	
		DS26LS32ME/883	National	-55 C to 125 C	26LS32	LCC20	
5962-7802001MEA	LINE RECEIVER	AM26LS32BDC	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		AM26LS32BDCB	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		AM26LS33AMJB	Texas Instruments, Inc.	-55 C to 125 C	26LS32	DIP16	ALS-TTL
		AM26LS33DC	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		AM26LS33MN	Philips International	-40 C to 85 C	26LS32	DIP16	ALS-TTL
5962-7802001MEA	LINE RECEIVER	DS26LS32ACN	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
(cont.)		DS26LS32ACN/A+	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
		DS26LS32CJ/A+	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
		DS26LS32CN	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
5962-7802001MEX	LINE RECEIVER	AM26LS32BDC	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		AM26LS32BDCB	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		DS26LS32ACN	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
		DS26LS32CJ/A+	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
		DS26LS32CN	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
5962-7802001MFX	LINE RECEIVER	26LS32/BFAJC	Motorola	-55 C to 125 C	26LS32	FP16	ALS-TTL
		5962-7802001MFA	DSCC	-55 C to 125 C	26LS32	FP16	ALS-TTL
		5962-8761601FX	DSCC	-55 C to 125 C	26LS32	FP16	ALS-TTL
		7802003FX	DSCC	-55 C to 125 C	26LS32	FP16	ALS-TTL
		AM26LS32FM	Advanced Micro Devices	-55 C to 125 C	26LS32	FP16	ALS-TTL
		AM26LS33AMWB	Texas Instruments, Inc.	-55 C to 125 C	26LS32	FP16	ALS-TTL
		AM26LS33FM	Advanced Micro Devices	-55 C to 125 C	26LS32	FP16	ALS-TTL
		DS26LS32MW/883	National	-55 C to 125 C	26LS32	FP16	ALS-TTL

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Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
5962-7802002MEX	MICROCIRCUIT, LINEAR	AM26LS32ACN	Texas Instruments, Inc.	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		AM26LS32AMJ	Texas Instruments, Inc.	-40 C to 85 C	26LS33	DIP/16	ALS-TTL
		AM26LS32BDC	Advanced Micro Devices	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		AM26LS32BDCB	Advanced Micro Devices	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		AM26LS32BDM	Advanced Micro Devices	-55 C to 125 C	26LS33	DIP/16	ALS-TTL
		AM26LS32DC	Advanced Micro Devices	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		AM26LS33ACN	Texas Instruments, Inc.	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		AM26LS33DC	Advanced Micro Devices	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		AM26LS33MN	Philips International	-40 C to 85 C	26LS33	DIP/16	ALS-TTL
		AM26LS33MN	Philips Semiconductors	-40 C to 85 C	26LS33	DIP/16	ALS-TTL
		DS26LS32ACN	National	0 C to 75 C	26LS33	DIP/16	ALS-TTL
		DS26LS32MJ/A+	National	-40 C to 85 C	26LS33	DIP/16	ALS-TTL
5962-7802003M2X		26LS32M/B2AJC	Motorola	-55 C to 125 C	26LS32	LCC20	
		5962-7802004M2A	DSCC	-55 C to 125 C	26LS32	LCC20	
		5962-7802006Q2A	DSCC	-55 C to 125 C	26LS32	LCC20	
		5962-87616012X	DSCC	-55 C to 125 C	26LS32	LCC20	
		DS26LS32ME/883	National	-55 C to 125 C	26LS32	LCC20	
5962-7802003MEX		AM26LS32BDC	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		AM26LS32BDCB	Advanced Micro Devices	0 C to 75 C	26LS32	DIP16	ALS-TTL
		AM26LS32BDM	Advanced Micro Devices	-55 C to 125 C	26LS32	DIP16	ALS-TTL
		AM26LS33MN	Philips Semiconductors	-40 C to 85 C	26LS32	DIP16	ALS-TTL
		DS26LS32ACN	National	0 C to 75 C	26LS32	DIP16	ALS-TTL
5962-7802004M2X	MICROCIRCUIT, LINEAR, QUAD	26LS32M/B2AJC	Motorola	-55 C to 125 C	26LS33	LCC20	
		5962-7802005M2A	DSCC	-55 C to 125 C	26LS33	LCC20	
		78020022X	DSCC	-55 C to 125 C	26LS33	LCC20	
		78020042X	DSCC	-55 C to 125 C	26LS33	LCC20	
		DS26LS32ME/883	National	-55 C to 125 C	26LS33	LCC20	
5962-7802004MEX	MICROCIRCUIT, LINEAR,QUAD	AM26LS32ACN	Texas Instruments, Inc.	0 C to 75 C	26LS33A		ALS-TTL
		AM26LS32BDC	Advanced Micro Devices	0 C to 75 C	26LS33A		ALS-TTL
		AM26LS32BPC	Advanced Micro Devices	0 C to 75 C	26LS33A		ALS-TTL
		AM26LS33AMJB	Texas Instruments, Inc.	-55 C to 125 C	26LS33A		ALS-TTL
		AM26LS33MN	Philips International	-40 C to 85 C	26LS33A		ALS-TTL
		DS26LS32ACN	National	0 C to 75 C	26LS33A		ALS-TTL
		DS26LS33MJ/883	National	-55 C to 125 C	26LS33A		ALS-TTL
5962-7802005M2X	MICROCIRCUIT, LINEAR, QUAD	26LS32M/B2AJC	Motorola	-55 C to 125 C	26F32	LCC20	RECEIVER
		5962-7802003M2A	DSCC	-55 C to 125 C	26F32	LCC20	RECEIVER

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Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		5962-7802004M2A	DSCC	-55 C to 125 C	26F32	LCC20	RECEIVER
		5962-87616012A	DSCC	-55 C to 125 C	26F32	LCC20	RECEIVER
		DS26LS32ME/883	National	-55 C to 125 C	26F32	LCC20	RECEIVER
5962-7802005MEX	MICROCIRCUIT	5962-7802005MEA	DSCC	-55 C to 125 C	320C5050	DIP16	ALS-TTL
		5962-7802005VEA	DSCC	-55 C to 125 C	320C5050	DIP16	ALS-TTL
5962-7802301M2X	MICROCIRCUIT, LINEAR, QUAD	26LS31M/B2CJC	Motorola	-55 C to 125 C	26LS31,26L5	LCC20	
		5962-7802301Q2A	DSCC	-55 C to 125 C	26LS31,26L5	LCC20	
		78023012X	DSCC	-55 C to 125 C	26LS31,26L5	LCC20	
		DS26LS31MJE/883	National	-55 C to 125 C	26LS31,26L5	LCC20	
5962-7802301MEA	LINE DRIVER	AM26LS31CN	Texas Instruments, Inc.	0 C to 75 C	26LS31	DIP16	BIPOLAR
		AM26LS31DC	Advanced Micro Devices	0 C to 75 C	26LS31	DIP16	BIPOLAR
		AM26LS31DCB	Advanced Micro Devices	0 C to 75 C	26LS31	DIP16	BIPOLAR
		AM26LS31DM	Advanced Micro Devices	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		AM26LS31PCD	Motorola	0 C to 75 C	26LS31	DIP16	BIPOLAR
		DS26LS31MJ/883	National	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		MC75174BP	Motorola	-40 C to 85 C	26LS31	DIP16	BIPOLAR
5962-7802301MEX		AM26LS31CN	Texas Instruments, Inc.	0 C to 75 C	26LS31	DIP16	BIPOLAR
		AM26LS31DC	Advanced Micro Devices	0 C to 75 C	26LS31	DIP16	BIPOLAR
		AM26LS31DCB	Advanced Micro Devices	0 C to 75 C	26LS31	DIP16	BIPOLAR
		AM26LS31DM	Advanced Micro Devices	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		DS26LS31MJ/883	National	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS1-26C31RH-Q	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS1-26C31RH-T	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS1-26CT31RH8	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS1-26CT31RH-Q	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS1-26CT31RH-T	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS9-26C31RH-Q	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS9-26C31RH-T	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS9-26CT31RH8	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS9-26CT31RH-Q	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		HS9-26CT31RH-T	Harris Semiconductor	-55 C to 125 C	26LS31	DIP16	BIPOLAR
		MC3487N	Rochester Electronics	0 C to 75 C	26LS31	DIP16	BIPOLAR
		MC75174BP	Motorola	-40 C to 85 C	26LS31	DIP16	BIPOLAR
5962-7802301MFA		26LS31/BFAJC	Motorola	-55 C to 125 C	26LS31	FP16	BIPOLAR
		5962-7802301MFA	DSCC	-55 C to 125 C	26LS31	FP16	BIPOLAR
		5962-7802301VFA	DSCC	-55 C to 125 C	26LS31	FP16	BIPOLAR

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Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		AM26LS31FM	Advanced Micro Devices	-55 C to 125 C	26LS31	FP16	BIPOLAR
5962-7802301MFX	MICROCIRCUIT, LINEAR,QUAD	26LS31/BFAJC	Motorola	-55 C to 125 C	26LS31	FP16	BIPOLAR
		5962-7802301MFA	DSCC	-55 C to 125 C	26LS31	FP16	BIPOLAR
		5962-7802301VFA	DSCC	-55 C to 125 C	26LS31	FP16	BIPOLAR
		AM26LS31CN	Texas Instruments, Inc.	0 C to 75 C	26LS31	FP16	BIPOLAR
		AM26LS31DC	Advanced Micro Devices	0 C to 75 C	26LS31	FP16	BIPOLAR
		AM26LS31DCB	Advanced Micro Devices	0 C to 75 C	26LS31	FP16	BIPOLAR
		AM26LS31FM	Advanced Micro Devices	-55 C to 125 C	26LS31	FP16	BIPOLAR
		AM26LS31PCD	Motorola	0 C to 75 C	26LS31	FP16	BIPOLAR
		DS26LS31MW/883	National	-55 C to 125 C	26LS31	FP16	BIPOLAR
		MC75174BP	Motorola	-40 C to 85 C	26LS31	FP16	BIPOLAR
5962-7802302MFA	MICROCIRCUIT	5962-7802302MFA	DSCC	-55 C to 125 C	14606T114	SOP16	F-TTL
		5962-7802302VFA	DSCC	-55 C to 125 C	14606T114	SOP16	F-TTL
5962-8501601YX	INTERRUPT CONTROLLER	CA82C59A10CD	Tundra Semiconductor Corp.	0 C to 75 C	82C59	DIP28	CMOS
		CA82C59A10CP	Tundra Semiconductor Corp.	0 C to 75 C	82C59	DIP28	CMOS
		CP82C59A12	Harris Semiconductor	0 C to 75 C	82C59	DIP28	CMOS
		MD82C59A12/B	Harris Semiconductor	-55 C to 125 C	82C59	DIP28	CMOS
		MD82C59A5/B	Harris Semiconductor	-55 C to 125 C	82C59	DIP28	CMOS
5962-8506401MQX	8-BIT MICROCONTROLLER	80C31BH16/BQA	Philips Semiconductors	-55 C to 125 C	80C31	DIP40	CMOS
		80C51BH16/BQA	Philips Semiconductors	-55 C to 125 C	80C31	DIP40	CMOS
		AD80C31	Temic Semiconductors	-40 C to 85 C	80C31	DIP40	CMOS
		AT89C51-12DM/883	Philips Semiconductors	-55 C to 125 C	80C31	DIP40	CMOS
		MD80C31BH/B	Atmel Corporation	-55 C to 125 C	80C31	DIP40	CMOS
5962-85127013X	A/D CONVERTER	5962-9169003M3X	DSCC	-55 C to 125 C	574	LCC28	
		AD574AJE	Analog Devices	0 C to 75 C	574	LCC28	
		AD574AKE	Analog Devices	0 C to 75 C	574	LCC28	
		AD574ASE/883B	Analog Devices	-55 C to 125 C	574	LCC28	
		AD574ATE/883B	Analog Devices	-55 C to 125 C	574	LCC28	
5962-8512701XX	MICROCIRCUIT, ANALOG-TO-DIGITAL CONV.	AD574AJD	Analog Devices	0 C to 75 C	574	DIP28	
		AD574AJN	Analog Devices	0 C to 75 C	574	DIP28	
		AD574AKN	Maxim Integrated Products	0 C to 75 C	574	DIP28	
		AD574AUD/883B	Analog Devices	-55 C to 125 C	574	DIP28	
		HI1-574AJD5	Harris Semiconductor	0 C to 75 C	574	DIP28	
		HI1-574AKD5	Harris Semiconductor	0 C to 75 C	574	DIP28	
		HI1-574ASD2	Harris Semiconductor	-40 C to 85 C	574	DIP28	

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Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		LT574AJNW	Linear Technology Corporation	0 C to 75 C	574	DIP28	
5962-85131013A	MICROCIRCUIT, LINEAR, CMOS	5962-85131073X	DSCC	-55 C to 125 C	0546		
		AD7506SE/883B	Analog Devices	-55 C to 125 C	0546		
		AD7506TE	Analog Devices	-40 C to 85 C	0546		
		AD7506TE/883B	Analog Devices	-55 C to 125 C	0546		
5962-85131023	8-CHANNEL ANALOG MULTIPLEXER	5962-85131023X	DSCC	-55 C to 125 C		LLCC28	CMOS
		5962-85131083X	DSCC	-55 C to 125 C		LLCC28	CMOS
		AD7507SE/883B	Analog Devices	-55 C to 125 C		LLCC28	CMOS
		AD7507TE	Analog Devices	-40 C to 85 C		LLCC28	CMOS
		AD7507TE/883B	Analog Devices	-55 C to 125 C		LLCC28	CMOS
5962-85131073X	MULTIPLEXER	5962-85131013X	DSCC	-55 C to 125 C		LLCC28	CMOS
		5962-85131073X	DSCC	-55 C to 125 C		LLCC28	CMOS
		AD7506SE/883B	Analog Devices	-55 C to 125 C		LLCC28	CMOS
		AD7506TE	Analog Devices	-40 C to 85 C		LLCC28	CMOS
		AD7506TE/883B	Analog Devices	-55 C to 125 C		LLCC28	CMOS
5962-85131083X	IC DIFF 8-CHANNEL MULTIPLEXER	5962-85131023X	DSCC	-55 C to 125 C	507	LLCC28	CMOS
		5962-85131083X	DSCC	-55 C to 125 C	507	LLCC28	CMOS
		AD7507SE/883B	Analog Devices	-55 C to 125 C	507	LLCC28	CMOS
		AD7507TE	Analog Devices	-40 C to 85 C	507	LLCC28	CMOS
		AD7507TE/883B	Analog Devices	-55 C to 125 C	507	LLCC28	CMOS
5962-8515301CX	J-K-TYPE FLIP-FLOP	M54HC73F1R	ST Microelectronics	-40 C to 85 C	54HC73	DIP14	HC-CMOS
		M74HC73B1R	ST Microelectronics	-40 C to 85 C	54HC73	DIP14	HC-CMOS
		M74HC73P	Mitsubishi Electronics America Inc.	-40 C to 85 C	54HC73	DIP14	HC-CMOS
		SN74HC73N	Texas Instruments, Inc.	-40 C to 85 C	54HC73	DIP14	HC-CMOS
		TC74HC73AP	Toshiba Electronic Components Inc	-40 C to 85 C	54HC73	DIP14	HC-CMOS
5962-8515509RA	MICROCIRCUITS, MEMORY,BIP	PAL16L8-5PC	Vantis Corp.	0 C to 75 C	16L8	DIP3/20	
		PAL16L8-7DC	Vantis Corp.	0 C to 75 C	16L8	DIP3/20	
		PAL16L8A2MJ	Texas Instruments, Inc.	-40 C to 85 C	16L8	DIP3/20	
		PAL16L8DMJ/883B	Advanced Micro Devices	-55 C to 125 C	16L8	DIP3/20	
		TIBPAL16L8-10MJB	Texas Instruments, Inc.	-55 C to 125 C	16L8	DIP3/20	
5962-85155212A	FUSE PROGRAMMABLE PLD	PAL16R8A2MFKB	Texas Instruments, Inc.	-55 C to 125 C		LLCC20	TTL
		PAL16R8AMFKB	Texas Instruments, Inc.	-55 C to 125 C		LLCC20	TTL

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Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		PAL16R8DML/883B	Advanced Micro Devices	-55 C to 125 C		LLCC20	TTL
		TIBPAL16R8-15MFKB	Texas Instruments, Inc.	-55 C to 125 C		LLCC20	TTL
		TIBPAL16R8-30MFKB	Texas Instruments, Inc.	-55 C to 125 C		LLCC20	TTL
5962-8550101CX	HEX INVERTER	CD40106BCN	Fairchild Semiconductor	-40 C to 85 C	40106	DIP14	CMOS
		CD40106BF3A	Texas Instruments, Inc.	-55 C to 125 C	40106	DIP14	CMOS
		CD40106BMJ/883	National	-55 C to 125 C	40106	DIP14	CMOS
		MM54C14J/883	National	-55 C to 125 C	40106	DIP14	CMOS
		MM54C914J/883	National	-55 C to 125 C	40106	DIP14	CMOS
5962-8551401PX	MICROCIRCUIT, 5V REF	ADREF02AQ/883B	Analog Devices	-55 C to 125 C	02	DIP 8	
		ADREF02Q/883B	Analog Devices	-55 C to 125 C	02	DIP 8	
		MAX675CPA	Maxim Integrated Products	0 C to 75 C	02	DIP 8	
		MC1404P5	Motorola	0 C to 75 C	02	DIP 8	
		REF02AJ8/883	Linear Technology Corporation	-55 C to 125 C	02	DIP 8	
		REF02AZ/883	Maxim Integrated Products	-55 C to 125 C	02	DIP 8	
		REF02CJ8	Linear Technology Corporation	0 C to 75 C	02	DIP 8	
5962-8552507YA	MICROCIRCUITS, DIGITAL, 8K X 8 CMOS	HM465664AG2/883	Temic Semiconductors	-55 C to 125 C	7164		
		HM465664AQ2/883	Temic Semiconductors	-55 C to 125 C	7164		
		L7C185TMB15L	Logic Devices, Inc.	-55 C to 125 C	7164		
		L7C185TMB20L	Logic Devices, Inc.	-55 C to 125 C	7164		
		L7C185TMB25L	Logic Devices, Inc.	-55 C to 125 C	7164		
5962-8552801RX	BUS ARBITER	CP82C89	Harris Semiconductor	0 C to 75 C	82C89	DIP20	CMOS
		ID82C89	Harris Semiconductor	0 C to 75 C	82C89	DIP20	CMOS
		ID82C89/+	Harris Semiconductor	0 C to 75 C	82C89	DIP20	CMOS
		MD82C89/B	Harris Semiconductor	-55 C to 125 C	82C89	DIP20	CMOS
5962-8603202XX	MICROCIRCUITS, DIGITAL, HCMOS,32	MC68020RC16	Motorola	0 C to 75 C	68020-16,680	PGA 114	CMOS
		MC68020RC20E	Motorola	-40 C to 85 C	68020-16,680	PGA 114	CMOS
		MC68020RC33	Motorola	0 C to 75 C	68020-16,680	PGA 114	CMOS
		MC68020RP16E	Motorola	-40 C to 85 C	68020-16,680	PGA 114	CMOS
		MC68020RP25E	Motorola	-40 C to 85 C	68020-16,680	PGA 114	CMOS
		WC32P020	White Microelectronics	-40 C to 85 C	68020-16,680	PGA 114	CMOS
5962-8605801VX	OCTAL DARLINGTON DRIVER	JAN2801J	Linfinity Microelectronics, Inc.	-40 C to 85 C	2803	DIP18	BIPOLAR
		JAN2802J	Linfinity Microelectronics, Inc.	-40 C to 85 C	2803	DIP18	BIPOLAR
		SG2801J	Linfinity Microelectronics, Inc.	-40 C to 85 C	2803	DIP18	BIPOLAR

5962 #'s

Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		SG2801J/883B	Linfinity Microelectronics, Inc.	-55 C to 125 C	2803	DIP18	BIPOLAR
		ULN2801A	ST Microelectronics	-40 C to 85 C	2803	DIP18	BIPOLAR
5962-8606101EX	2-INPUT DIGITAL MULTIPLEXER	CD54HC157F	Texas Instruments, Inc.	-40 C to 85 C	54HC157	DIP16	HC-CMOS
		CD54HC157F3A	Texas Instruments, Inc.	-55 C to 125 C	54HC157	DIP16	HC-CMOS
		GD54HC157J	LG Semicon	-40 C to 85 C	54HC157	DIP16	HC-CMOS
		GD74HC157	LG Semicon	-40 C to 85 C	54HC157	DIP16	HC-CMOS
		SNJ54HC157J	Texas Instruments, Inc.	-55 C to 125 C	54HC157	DIP16	HC-CMOS
5962-8606301XX	MICROCIRCUIT, MEMORY, DI	AT27C256R20DM/883	Atmel Corporation	-55 C to 125 C	27C256	DIP6/28	
		AT27HC256R70DM/883	Atmel Corporation	-55 C to 125 C	27C256	DIP6/28	
		CY27C256A120WMB	Cypress Semiconductor	-55 C to 125 C	27C256	DIP6/28	
		CY27C256A150WMB	Cypress Semiconductor	-55 C to 125 C	27C256	DIP6/28	
		WS27C256L20DMB	Wagerscale Integration, Inc.	-55 C to 125 C	27C256	DIP6/28	
5962-8607001EX	MICROCIRCUIT, DIGITAL, BIPOLAR,A	5962-8607001EA	DSCC	-55 C to 125 C	54F148		F-TTL
		5962-8607001EX	DSCC	-55 C to 125 C	54F148		F-TTL
		74F148PC	Fairchild Semiconductor	0 C to 75 C	54F148		F-TTL
		74F148PC	National	0 C to 75 C	54F148		F-TTL
		MC54F148J	Motorola	-40 C to 85 C	54F148		F-TTL
		MC74F148N	Motorola	0 C to 75 C	54F148		F-TTL
		N74F148N	Philips Semiconductors	0 C to 75 C	54F148		F-TTL
5962-8607101CA	SINGLE 8-BIT SHIFT REGISTER	54F164ADMQB	National	-55 C to 125 C	54F164	DIP14	F-TTL
		74F164APC	Fairchild Semiconductor	0 C to 75 C	54F164	DIP14	F-TTL
		74F164APC	National	0 C to 75 C	54F164	DIP14	F-TTL
		I74F164N	Philips Semiconductors	-40 C to 85 C	54F164	DIP14	F-TTL
		N74F164N	Philips Semiconductors	0 C to 75 C	54F164	DIP14	F-TTL
5962-8607401RX	MICROCIRCUIT, DIGITAL, SINGLE 8	5962-8607401RX	DSCC	-55 C to 125 C	54F322		F-TTL
		74F322PC	Fairchild Semiconductor	0 C to 75 C	54F322		F-TTL
		74F322PC	National	0 C to 75 C	54F322		F-TTL
		N74F322N-B	Philips International	0 C to 75 C	54F322		F-TTL
5962-8670402PX	PULSE WIDTH MODULATOR	CS2844N8	Cherry Semiconductor Inc.	-40 C to 85 C	1843	DIP8	BIPOLAR
		CS2845N8	Cherry Semiconductor Inc.	-40 C to 85 C	1843	DIP8	BIPOLAR
		IP1842AJ	Semelab	-40 C to 85 C	1843	DIP8	BIPOLAR
		IP1842AJ	Semelab PLC	-40 C to 85 C	1843	DIP8	BIPOLAR
		IP1842J	Semelab	-40 C to 85 C	1843	DIP8	BIPOLAR

5962 #'s

Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		IP1844AJ	Semelab PLC	-40 C to 85 C	1843	DIP8	BIPOLAR
		IP3845J	Semelab	0 C to 75 C	1843	DIP8	BIPOLAR
		KA3842B	Samsung Semiconductor	0 C to 75 C	1843	DIP8	BIPOLAR
5962-8670402PX		LT1241MJ8/883	Linear Technology Corporation	-55 C to 125 C	1843	DIP8	BIPOLAR
(cont.)							
5962-8670701RX	MICROCIRCUIT, DIGITAL,OCTAL	5962-8670701RA	DSCC	-55 C to 125 C	2965		BIPOLAR
		5962-8670701RX	DSCC	-55 C to 125 C	2965		BIPOLAR
		AM2965PC	Advanced Micro Devices	0 C to 75 C	2965		BIPOLAR
5962-8671101XX	MICROCIRCUIT, FIXED VOLTAGE REF.	AD589JH	Analog Devices	0 C to 75 C	113	SIP	BIPOLAR
		AD589SH/883B	Analog Devices	-55 C to 125 C	113	SIP	BIPOLAR
		AS5010GN	ALPH Industries Inc	0 C to 75 C	113	SIP	BIPOLAR
		AS5010HN	ALPH Industries Inc	0 C to 75 C	113	SIP	BIPOLAR
		LM185H1.2/883	Linear Technology Corporation	-55 C to 125 C	113	SIP	BIPOLAR
5962-8671603EX	MICROCIRCUIT, ANALOG SW	5962-8671601EA	DSCC	-55 C to 125 C	201	DIP 16	
		CWB201CP	Calogic Corp.	0 C to 75 C	201	DIP 16	
		DG201AAK/883	Vishay/Siliconix Inc.	-55 C to 125 C	201	DIP 16	
		DG201ABK	Harris Semiconductor	-40 C to 85 C	201	DIP 16	
		DG201ABK	Maxim Integrated Products	-40 C to 85 C	201	DIP 16	
5962-8672101EX		AM26LS30DC	Advanced Micro Devices	0 C to 75 C	26LS30	DIP16	ALS-TTL
		AM26LS30DC	Motorola	-40 C to 85 C	26LS30	DIP16	ALS-TTL
		AM26LS30DCB	Advanced Micro Devices	0 C to 75 C	26LS30	DIP16	ALS-TTL
		AM26LS30PC	Advanced Micro Devices	0 C to 75 C	26LS30	DIP16	ALS-TTL
		AM26LS30PC	Motorola	-40 C to 85 C	26LS30	DIP16	ALS-TTL
		DS3691N	National	0 C to 75 C	26LS30	DIP16	ALS-TTL
5962-8672302RA	MICROCIRCUIT, DIGITAL,BIP	AM2946DC	Advanced Micro Devices	0 C to 75 C	2946	DIP/20	
		AM2946DCB	Advanced Micro Devices	0 C to 75 C	2946	DIP/20	
		AM2946DM	Advanced Micro Devices	-55 C to 125 C	2946	DIP/20	
		AM2946DMB	Advanced Micro Devices	-55 C to 125 C	2946	DIP/20	
		AM2946PC	Advanced Micro Devices	0 C to 75 C	2946	DIP/20	
5962-8672601EX	MICROCIRCUITS, DIGITAL,BIPOLAR	5962-8672601EX	DSCC	-55 C to 125 C	9301		S-TTL
5962-8681901E	HEX INVERTER	M54HC4049F1R	ST Microelectronics	-40 C to 85 C	54HC4049	DIP16	HC-CMOS
		M74HC4049B1R	ST Microelectronics	-40 C to 85 C	54HC4049	DIP16	HC-CMOS
		M74HC4049BP	Mitsubishi Electronics America Inc.	-40 C to 85 C	54HC4049	DIP16	HC-CMOS

Original Part Number	DESCRIPTION	Substitute Part Number	Substitute Manufacturer	Temperature Range	GENERIC	CASE DESIGN	TECH.
		MM74HC4049N	Fairchild Semiconductor	-40 C to 85 C	54HC4049	DIP16	HC-CMOS
		TC74HC4049AP	Toshiba Electronic Components Inc	-40 C to 85 C	54HC4049	DIP16	HC-CMOS
5962-8682001EX	HEX HIGH-TO-LOW LEVEL SHIFTER	M54HC4050F1R	ST Microelectronics	-40 C to 85 C	54HC4050	DIP16	HC-CMOS
		M74HC4050B1R	ST Microelectronics	-40 C to 85 C	54HC4050	DIP16	HC-CMOS
		M74HC4050BP	Mitsubishi Electronics America Inc.	-40 C to 85 C	54HC4050	DIP16	HC-CMOS
		MM74HC4050N	National	-40 C to 85 C	54HC4050	DIP16	HC-CMOS
		TC74HC4050AP	Toshiba Electronic Components Inc	-40 C to 85 C	54HC4050	DIP16	HC-CMOS
5962-8683101CX	QUAD 2-INPUT NAND GATE	54VHCT00J/883	National	-55 C to 125 C	54HCT00	DIP14	HCT-CMOS
		74VHCT00AN	Fairchild Semiconductor	-40 C to 85 C	54HCT00	DIP14	HCT-CMOS
		74VHCT00N	National	-40 C to 85 C	54HCT00	DIP14	HCT-CMOS
		CD54HCT00F3A	Texas Instruments, Inc.	-55 C to 125 C	54HCT00	DIP14	HCT-CMOS
		GD54HCT00J	LG Semicon	-40 C to 85 C	54HCT00	DIP14	HCT-CMOS
5962-8684501PX		5962-8684501PX	DSCC	-55 C to 125 C	1016	DIP 8	
		5962-9234701MPA	DSCC	-55 C to 125 C	1016	DIP 8	
		LT1016CJ	Linear Technology Corporation	0 C to 75 C	1016	DIP 8	
		LT1016CN	Linear Technology Corporation	0 C to 75 C	1016	DIP 8	
		LT1116CN8	Linear Technology Corporation	0 C to 75 C	1016	DIP 8	
5962-8684701EX	MONOSTABLE MULTIVIBRATOR	CD74HC123EX	Texas Instruments, Inc.	-40 C to 85 C	54HC123	DIP16	HC-CMOS
		M54HC123AF1R	ST Microelectronics	-40 C to 85 C	54HC123	DIP16	HC-CMOS
		M54HC123F1R	ST Microelectronics	-40 C to 85 C	54HC123	DIP16	HC-CMOS
		M74HC123AB1R	ST Microelectronics	-40 C to 85 C	54HC123	DIP16	HC-CMOS
		MM74HC123AN	Fairchild Semiconductor	-40 C to 85 C	54HC123	DIP16	HC-CMOS

Appendix B

ABT Enables Optimal System Design

ABT Enables Optimal System Design

SCBA001A
March 1997

TEXAS INSTRUMENTS

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Introduction

As operating frequencies of microprocessors increase, the time allotted for memory access, arithmetic computation, or similar operations decreases. With this in mind, a new series of Advanced Bus-Interface Logic (ABIL) products developed with Texas Instruments (TI) submicron Advanced BiCMOS Technology (ABT) process assumes a prominent role as the key high-performance logic needed in today's workstation, personal and portable computer, and telecom systems. The goal of this family of products is to provide system designers a bus-interface solution combining high-drive capability, low power consumption, signal integrity, and propagation delays small enough to appear transparent with respect to overall system performance. Fine-pitch package options simplify layout, reduce required board space, and decrease overall system costs. Novel circuit-design techniques add value over competitive solutions.

Trends Important for Today's System Designer

Modern system designers face many complex challenges in meeting their design goals. The trends toward (need for) faster cycle times, lower power consumption, smaller footprints, greater reliability, and lower total system cost combine to put ever-increasing pressure on today's system designer.

The need for faster cycle time traditionally has been addressed by the microprocessor manufacturer. Clock and microprocessor frequencies have increased steadily with each succeeding product generation. The most advanced RISC processors in development are touting frequencies of about 200 MHz. For production systems, it is not unusual for processors to run on the order of 50 MHz and above. Increasing clock and microprocessor frequencies are now beginning to put pressure on surrounding memory and logic to make greater contributions in reducing overall system cycle times and improving overall system performance.

Higher-performance systems require the designer to focus on total system power requirements. Faster systems traditionally require more power, which often means more costly solutions. Power costs money to supply, and heat buildup due to this power costs money to remove. Also, excess power consumption adversely affects reliability due to the increase in the junction temperature of the silicon components. Lower-power devices reduce requirements for larger power supplies and high-cost cooling techniques, and could lead to smaller system packaging.

Occurring in parallel with demands for increased system performance and reduced system power consumption is demand to house systems in smaller cases, boxes, chassis, and cabinets. This miniaturization requires that each system component be optimally laid out in silicon, packaged, and mounted on the printed-circuit board (PCB).

Speed, power, size, cost, and reliability are all parameters by which system and end-equipment success are measured. Semiconductor manufacturers must be sensitive to these parameters and be able to provide well-defined and well-designed products to meet these needs.

Advanced Bus-Interface Logic (ABIL) as the System Bus Interface

Semiconductor vendors are required by system design houses to provide new products that are faster, consume less power, exist in smaller packages, and present a lower relative cost than their predecessors. Since the early 1970s, many different logic-product technologies have attempted to meet these demands.

Early logic-product technologies often forced the system designer to make tradeoffs. As shown in Figure 1, speed and power were the most typical design goals traded off. Solutions such as Schottky or HCMOS, respectively, offered high speed at the expense of low power or low power at the expense of high speed. In a typical system application, this logic technology is used between only a few system blocks, such as a simple 8-MHz processor, a slow 256K DRAM, and a local TTL bus. Their functional role was little more than small-scale integration (SSI) or medium-scale integration (MSI). Despite these shortcomings, early logic technologies thrived because they were inexpensive and readily available.

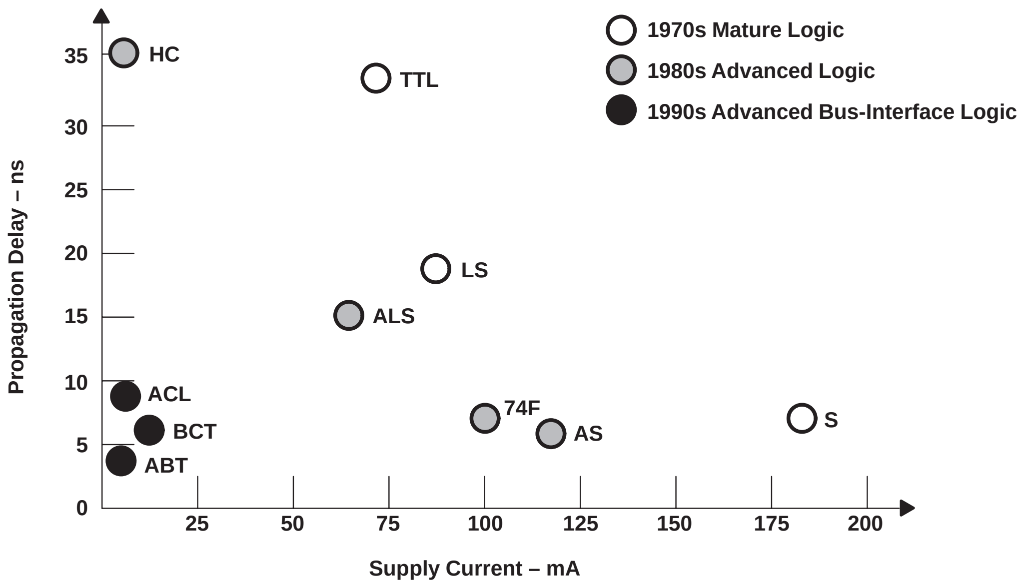


Figure 1. ABT Assumes Optimal Position

Cycle-time requirements for interface logic vary as a function of microprocessor and clock speed. In an 8-MHz system, the total system cycle available for completion of all operations is 250 ns. This can be roughly budgeted into 160 ns for the memory access, 45 ns for processor setup, and 45 ns for the interface logic (including signal propagation across PCB traces). With 45 ns available for interface, a forgiving, low-performance technology such as low-power Schottky or HCMOS can be utilized.

The situation changes dramatically when system speeds increase to 45 or 50 MHz. At 45 MHz, only 44 ns of total cycle time is available to complete all operations. Now, more expensive memories are needed with access times in the 20-ns range. Microprocessor setups can only be 8 ns. This leaves only 16 ns for interface and signal-trace propagation delay. The interface cycle time is a much higher percentage of the total system cycle time at 45 MHz than at 8 MHz.

As cycle-time requirements shrink, each nanosecond becomes critical in meeting the total system budget. The system designer has the option of using higher-performance memories, processors, or interface logic in squeezing additional nanoseconds out of the system delay. There is great demand for using interfacing logic to meet these budget needs because typically it is much less expensive for the designer to use than higher-performance memories or processors.

In light of decreasing total system cycle-time requirements, early logic technologies gave way to faster technologies. Significant gains made since the Schottky and HCMOS days result in products that no longer force the system designer into a tradeoff box. New-product development in the area of complex memories, processors, and ASICs has led the way for an equal, if not greater, acceleration in new-product development for advanced digital-logic products.

This development has propelled logic up from the ranks of *glue* status, used to fill in design gaps around the other major system blocks, to its new position as the system bus interface. ABIL products are now responsible for controlling the signals between the backplane buses and the other major system design blocks. They have become a major system design block in their own right, exerting significant influence over the performance of the final design.

In a modern-day system, ABIL products are likely to connect many major system design blocks, including application-specific parallel processors, 4M DRAMs, fast-cache SRAMs, and complex ASIC gate arrays/standard cells. The task of this new breed of advanced logic is to effectively transceive the address, data, and control signals of these integrated-circuit elements to and from heavily loaded TTL/CMOS/BTL system backplanes.

A wide variety of industry-standard and proprietary backplane specifications add to the difficulty of the task. At the low end of the scale, exhibiting data-transfer rates in the range of 10 to 20 Mbytes/s, are the PC-, AT-, and EISA-type buses. For midrange server and graphics-workstation applications, the 50- to 100-Mbytes/s data-transfer-rate range of Multibus II and microchannel-type buses is typical. High-end server and mainframe computer applications require the ≥ 100-Mbytes/s data-transfer rates of Futurebus+-type buses. Transceivers connecting to each of these backplanes must provide very high-drive current capability to effectively and reliably migrate signals across. ABIL products from TI uniquely address this need.

Enablers to Continuous New-Product Development

Reduction in minimum process dimension, enhanced value-added circuit design techniques, utilization of fine-pitch packaging, and incorporation of lower-power supply voltages are the most important enablers to continuous new development for logic products.

The minimum process dimension represents the width of the transistor-gate region and gives an indication of the switching speed of the transistor. In general, the smaller the minimum process dimension, the faster the transistors switch. An added advantage of reducing the minimum process dimension is the gain in gate density that can be achieved. A gain in gate density results in increased device functionality without a corresponding increase in silicon die area. Currently, state-of-the-art high-volume-production logic processes consider a 0.8-µm minimum process dimension. However, work is ongoing to prototype more advanced processes characterized by 0.6-, 0.5-, and 0.35-µm minimum process dimensions.

Enhanced value-added circuit-design techniques greatly increase the functionality of a logic device as well as improve its performance. These techniques often eliminate the need for the designer to utilize discrete components such as resistors, capacitors, and diodes because these are built into the silicon device itself. Additionally, optimizations in I/O or core circuitry can positively affect speed and power performance.

An aggressive drive exists to convert classic through-hole package approaches to totally above-board surface-mount approaches. Occurring in parallel is a drive to upgrade existing surface-mount packages with finer pin-to-pin pitches so as to minimize total package area. However, with smaller packages comes increased reliance on thermal-management techniques. The increased difficulty in removing heat from the smaller packages can preclude the use of inexpensive plastic packages. The need for ceramic or other alternatives would act to drive up design costs.

Finally, system designers are beginning to drive the semiconductor industry to move below 5 V as the baseline for power supplies. The migration to lower voltages, such as 3.3 V, enhances the reliability of advanced process technologies exhibiting minimum process dimensions of 0.6 µm or lower. The need for low-voltage memory and processor product interface, lower device-generated noise levels, lower power consumption, and increased battery life for unregulated portable systems accelerate the demand for 3.3-V logic. New 3.3-V logic opportunities will emerge as system designers continue to rely on advanced process technologies.

What Is Advanced BiCMOS Technology (ABT)?

Advanced BiCMOS Technology (ABT) is available today in products from TI to aid designers doing high-performance bus management. It is currently available in many different product options, including 8-bit octal, 16-, 18-, and 20-bit Widebus™, and 32- and 36-bit Widebus+™ versions.

At TI, ABT evolved from an earlier 1.5-µm BiCMOS process. It was designed to provide speeds equivalent to existing advanced bipolar solutions but with 90% less device power. This standard BiCMOS process introduced high-performance, lower-power, bus-interface products to the marketplace two years ahead of the nearest competitor. Since its bus-interface introduction in 1987, TI has utilized BiCMOS and advanced BiCMOS in products such as mixed-signal integrated circuits, high-performance gate arrays, high-speed cache tags, and application-specific processors such as the SuperSPARC™.

ABT employs a submicron 0.8-µm minimum process dimension. It combines elements of both bipolar and CMOS circuit/process technologies onto a single silicon chip. ABT offers the system designer the best combination of high speed, high drive, and low power consumption in the industry. As shown in Figure 1, ABT provides a performance point closer to the origin of the speed/power graph than any other logic technology available. Specifically, ABT is based on a CMOS core-circuit structure with an NPN bipolar output transistor module added. This means adding about four additional masks to the CMOS process. The current single NPN transistor output structure of ABT has been optimized for 5-V operation.

Simplified input and output stages of an ABT transceiver are shown in Figure 2. The inputs are designed to offer TTL-compatible levels with guaranteed switching between a V_{IH} minimum of 2 V and a V_{IL} maximum of 0.8 V. These inputs are implemented with CMOS circuitry; therefore, they offer characteristic high impedance for low leakage and low capacitance for minimal bus loading. The CMOS supply voltage of the input stage is dropped by diode D1 and transistor Q1, centering the threshold around 1.5 V. When inputs are in the low state, Q_r raises the voltage of source Q_p up to the rail, ensuring proper operation of the feedback stage. This stage provides about 100 mV of input hysteresis, increasing noise margins and reducing oscillations.

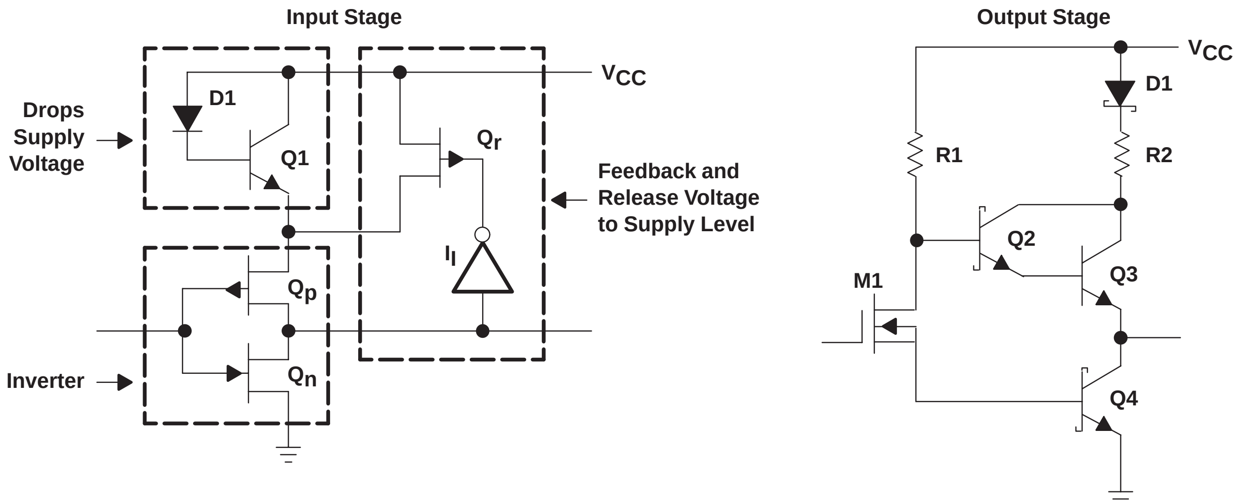


Figure 2. ABT Input/Output Circuit Structure

ABT outputs utilize bipolar circuitry to provide the high speed and drive necessary for a bus interface. A major advantage of using bipolar circuitry in the output stage is the reduced voltage swing, which lowers ground noise, improves signal integrity, and reduces dynamic power consumption. In Figure 2, M1 acts as a current switch that drives the outputs low when conducting current from R1 through to the base of Q4. The base of Q2 is pulled low, turning off the upper output. For a low-to-high output transition, M1 turns off and current through R1 charges the base of Q2. As Q2 goes high, the Darlington pair, Q2 and Q3, turns on. With its supply of base current now cut off, Q4 turns off and the output transition switches low to high. R2 limits output current in the high state and D1 is a blocking diode preventing current flow in power-down applications.

By virtue of its small minimum process geometry, tight metal pitch, and shallow junctions, ABT can provide strong output drive currents (sink currents specified at 64 mA and source currents specified at 32 mA) and low parasitic capacitances. As a result of these enhancements, internal propagation delays are very fast and very well behaved. Figure 3 shows that typical propagation delays are on the order of 2–3 ns across the operating temperature range. This excellent consistency allows ABT to be specified over the industrial temperature range of –40°C to 85°C. Figure 3 also shows that ABT performance is very well behaved across capacitive load and multiple-output switching conditions.

Maximum propagation delays for ABT are as low as 4–5 ns, depending on the device type and propagation path. Table 1 compares the data sheet maximums of several ABT 16-bit Widebus™ transceiver devices with competing FCTB/C CMOS and 74F/ALS bipolar solutions. It is clear from both Figure 3 and Table 1 that ABT is the system designer’s best choice for bus-interface applications that require consistent speed performance for many different conditions.

From a power (current) consumption standpoint, the use of bipolar in the output stage is advantageous for two reasons. First, the voltage swing is less than that of a CMOS output. The power consumed when charging or discharging internal circuit capacitances and the external load capacitance is reduced. Second, the bipolar transistors are capable of turning off more efficiently than CMOS transistors. The wasteful flow of current from V_{CC} to GND is reduced. Although bipolar does tend to have a high static power consumption, its lower dynamic power consumption allows for better overall power performance at high frequencies than either pure bipolar or CMOS. This is because the dynamic power component makes up the majority of a device’s overall power consumption.

The ABT maximum high-impedance supply currents (I_{CCZ}) range from about 50 µA for 8-bit octals to about 2–3 mA for 16-bit Widebus™ products. Maximum dynamic supply currents (I_{CCL}) range from about 30 mA for 8-bit octals to about 34 mA for 16-bit Widebus™ products. Power on demand, an enhanced circuit design improvement to the bipolar output stage on new ABT product families, reduces dynamic current consumption levels by up to 50%. High-impedance and dynamic supply-current goals for the new 32-/36-bit Widebus+™ family are 500 µA and 60 mA, respectively.

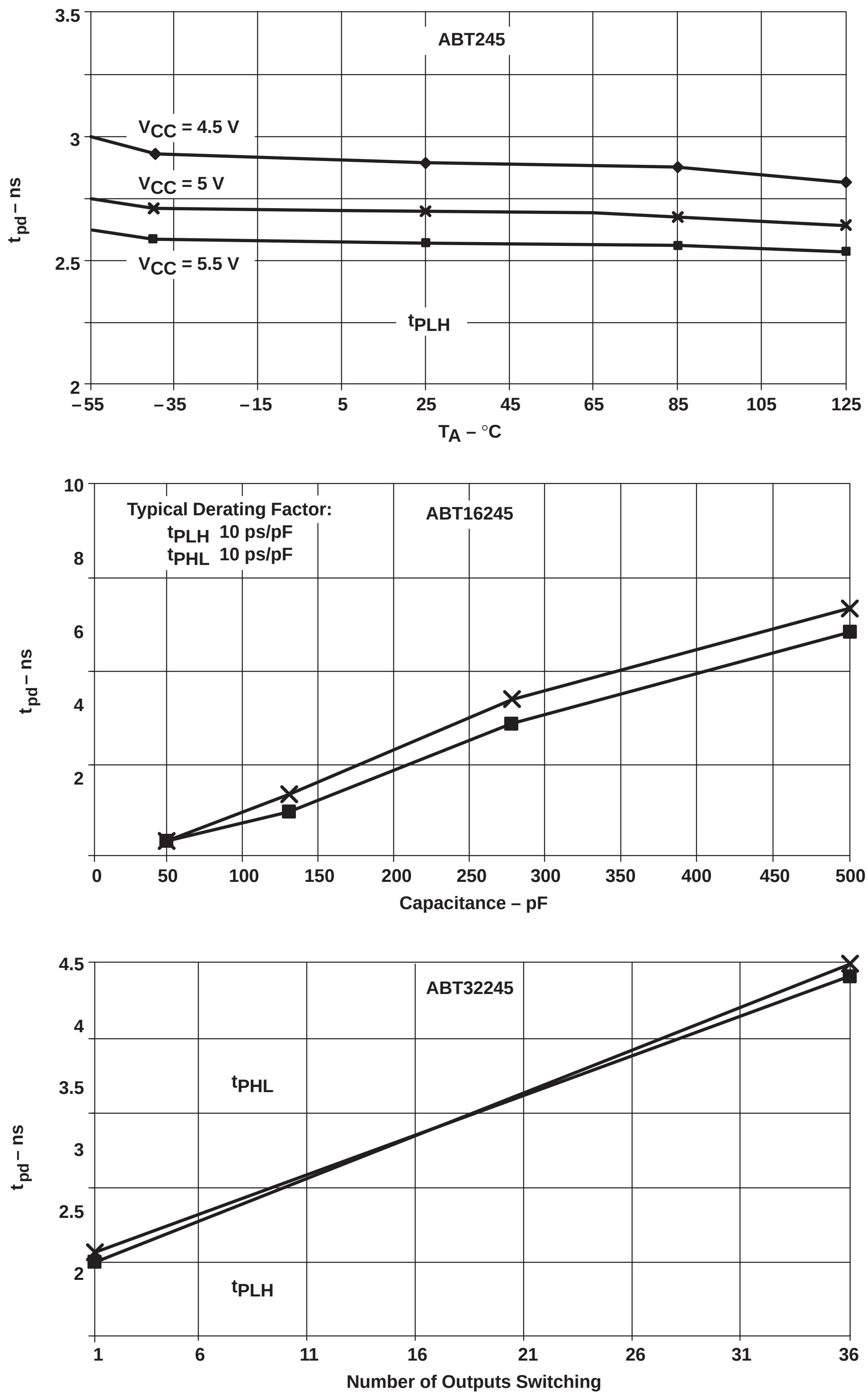
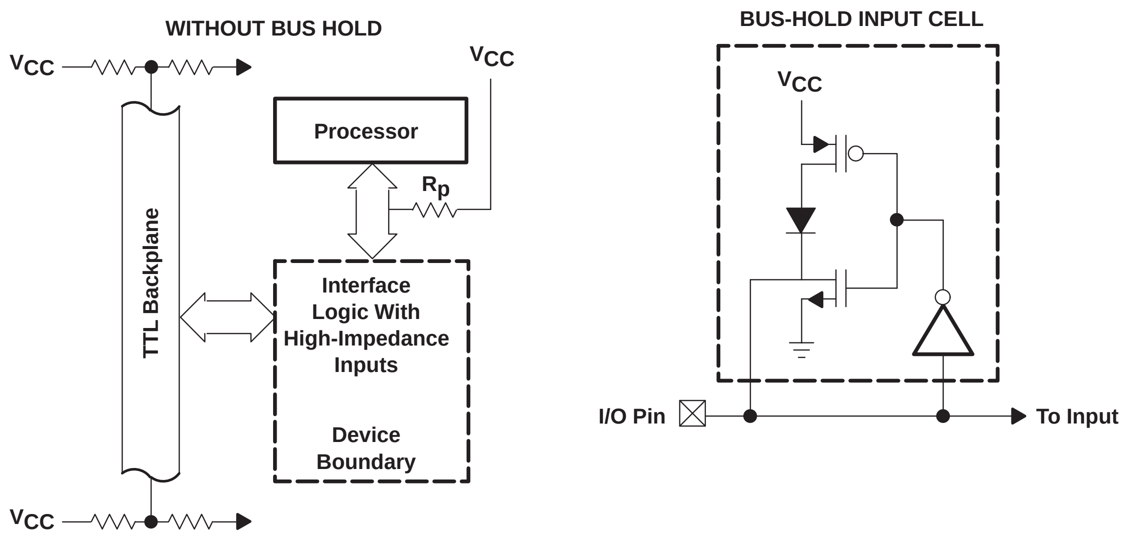


Figure 3. ABT Process Provides Consistency

Table 1. ABT Is the Speed Benchmark

REGISTERED TRANSCEIVER WITH CLKEN	ABT16952 (ns)	29FCT52C (ns)	F2952 (ns)
t_{pd} CLK to A/B	4.5	6.3	9
$t_{pd(en)}$ $\overline{OE}$ to A/B	6	7	10
$t_{pd(dis)}$ $\overline{OE}$ to A/B	5.5	6.5	9
TRANSCEIVER WITH PARITY	**ABT16657 (ns)**	**ABT657 (ns)**	**F657 (ns)**
t_{pd} A to B	4.3	5.5	8
t_{pd} A to PARITY	6.7	11.3	16
t_{pd} B to $\overline{ERR}$	6.7	15.7	22.5
REGISTERED TRANSCEIVER WITH PARITY	**ABT16833 (ns)**	**FCT833B (ns)**	**ALS29833 (ns)**
t_{pd} A to B	4.3	7	10
t_{pd} A to PARITY	6.7	10.5	15
t_{pd} CLK to $\overline{ERR}$	4.6	15	16

Bus hold, as shown in Figure 4, is another example of an enhanced, value-added circuit design technique available on new ABT product families. The bus-hold cell provides for a small holding current of 100 µA to be delivered to I/O pins configured as inputs left unused or floating. This current latches the last known input state to a valid logic level. Floating input conditions are common to CMOS backplanes or device bus-interface situations where driving entities are periodically required to be in 3 state. Bus-hold cells eliminate passive pullup (to V_{CC}) or pulldown (to GND) termination resistors necessary to prevent application problems or oscillations. External provision for these resistors by the system designer consumes board area, increases bus capacitance, contributes to bus loading, and lowers system performance. The bus-hold feature is particularly effective when offered on products with a lot of I/O capability such as 32-/36-bit Widebus+™ devices.



- Holds the last known state of the input
- Provides for ±100 µA of holding current at 0.8 V and 2 V
- Bus-hold current does not load down the driving output at valid logic levels
- Negligible impact to input/output capacitance (0.5 pF)
- Eliminates the need for external resistors on unused or floating input/output pins

Figure 4. Bus-Hold Circuit and Benefits

Appendix C

Fairchild Semiconductor

Part Number: 74ABT2244

FAIRCHILD
SEMICONDUCTOR™

May 1992
Revised November 1999

74ABT2244
Octal Buffer/Line Driver with 25Ω Series Resistors in the Outputs

General Description

The ABT2244 is an octal buffer and line driver designed to drive the capacitive inputs of MOS memory drivers, address drivers, clock drivers, and bus-oriented transmitters/receivers.

The 25Ω series resistors in the outputs reduce ringing and eliminate the need for external resistors.

Features

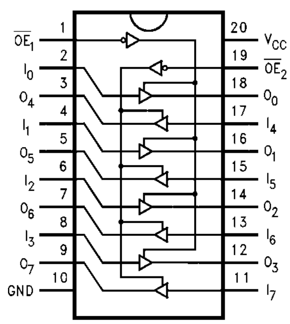
- Guaranteed latchup protection
- High impedance glitch-free bus loading during entire power up and power down cycle
- Nondestructive hot insertion capability

Ordering Code:

Order Number	Package Number	Package Description
74ABT2244CSC	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300" Wide Body
74ABT2244CSJ	M20D	20-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
74ABT2244CMSA	MSA20	20-Lead Shrink Small Outline Package (SSOP), EIAJ TYPE II, 5.3mm Wide
74ABT2244CMTC	MTC20	20-Lead Thin Shrink Small Outline Package (TSSOP), JEDEC MO-153, 4.4mm Wide
74ABT2244CPC	N20A	20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300" Wide

Devices are also available in Tape and Reel. Specify by appending the suffix letter "X" to the ordering code.

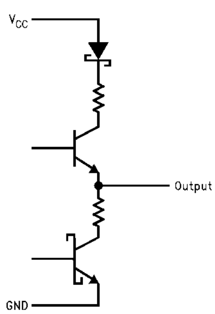
Connection Diagram



Pin Descriptions

Pin Names	Description
$\overline{OE}_1$, $\overline{OE}_2$	Output Enable Input (Active LOW)
I_0–I_7	Inputs
O_0–O_7	Outputs

Schematic of Each Output



Truth Table

$\overline{OE}_1$	I_{0-3}	O_{0-3}	$\overline{OE}_2$	I_{4-7}	O_{4-7}
H	X	Z	H	X	Z
L	H	H	L	H	H
L	L	L	L	L	L

H = HIGH Voltage Level
L = LOW Voltage Level
X = Immaterial
Z = High Impedance

Absolute Maximum Ratings (Note 1)

Storage Temperature	−65°C to +150°C
Ambient Temperature under Bias	−55°C to +125°C
Junction Temperature under Bias	−55°C to +150°C
V_{CC} Pin Potential to Ground Pin	−0.5V to +7.0V
Input Voltage (Note 2)	−0.5V to +7.0V
Input Current (Note 2)	−30 mA to +5.0 mA
Voltage Applied to Any Output	
in the Disabled or	
Power-off State	−0.5V to 5.5V
in the HIGH State	−0.5V to V_{CC}
Current Applied to Output	
in LOW State (Max)	twice the rated I_{OL} (mA)
DC Latchup Source Current	
(Across Comm Operating Range)	−300 mA
Over Voltage Latchup (I/O)	10V

Recommended Operating Conditions

Free Air Ambient Temperature	−40°C to +85°C
Supply Voltage	+4.5V to +5.5V
Minimum Input Edge Rate (ΔV/Δt)	
Data Input	50 mV/ns
Enable Input	20 mV/ns

Note 1: Absolute maximum ratings are values beyond which the device may be damaged or have its useful life impaired. Functional operation under these conditions is not implied.

DC Electrical Characteristics

Symbol	Parameter		Min	Typ	Max	Units	V_{CC}	Conditions
V_{IH}	Input HIGH Voltage		2.0			V		Recognized HIGH Signal
V_{IL}	Input LOW Voltage				0.8	V		Recognized LOW Signal
V_{CD}	Input Clamp Diode Voltage				−1.2	V	Min	I_{IN} = −18 mA
V_{OH}	Output HIGH		2.5			V	Min	I_{OH} = −3 mA
			2.0			V	Min	I_{OH} = −32 mA
V_{OL}	Output LOW Voltage				0.8	V	Min	I_{OL} = 15 mA
I_{IH}	Input HIGH Current				1 1	μA	Max	V_{IN} = 2.7V (Note 4) $V_{IN} = V_{CC}$
I_{BVI}	Input HIGH Current Breakdown Test				7	μA	Max	V_{IN} = 7.0V
I_{IL}	Input LOW Current				−1 −1	μA	Max	V_{IN} = 0.5V (Note 4) V_{IN} = 0.0V
V_{ID}	Input Leakage Test		475			V	0.0	I_{ID} = 1.9 μA All Other Pins Grounded
I_{OZH}	Output Leakage Current				10	μA	0 – 5.5V	V_{OUT} = 2.7V; $\overline{OE}$n = 2.0V
I_{OZL}	Output Leakage Current				−10	μA	0 – 5.5V	V_{OUT} = 0.5V; $\overline{OE}$n = 2.0V
I_{OS}	Output Short-Circuit Current		−100		−275	mA	Max	V_{OUT} = 0.0V
I_{CEX}	Output HIGH Leakage Current				50	μA	Max	$V_{OUT} = V_{CC}$
I_{ZZ}	Bus Drainage Test				100	μA	0.0	V_{OUT} = 5.5V; All Others GND
I_{CCH}	Power Supply Current				50	μA	Max	All Outputs HIGH
I_{CCL}	Power Supply Current				30	mA	Max	All Outputs LOW
I_{CCZ}	Power Supply Current				50	μA	Max	$\overline{OE}$n = V_{CC} All Others at V_{CC} or GND
I_{CCT}	Additional I_{CC}/Input	Outputs Enabled Outputs 3-STATE Outputs 3-STATE			2.5 2.5 50	mA mA μA	Max	$V_I = V_{CC}$ − 2.1V Enable Input $V_I = V_{CC}$ − 2.1V Data Input $V_I = V_{CC}$ − 2.1V All Others at V_{CC} or GND
I_{CCD}	Dynamic I_{CC} (Note 4)	No Load			0.1	mA/ MHz	Max	Outputs OPEN $\overline{OE}$n = GND (Note 3) One Bit Toggling, 50% Duty Cycle

Note 2: Either voltage limit or current limit is sufficient to protect inputs.

Note 3: For 8 bits toggling, I_{CCD} < 0.8 mA/MHz.

Note 4: Guaranteed, but not tested.

AC Electrical Characteristics

(SOIC and SSOP Package)

Symbol	Parameter	$T_A = +25°C$, $V_{CC} = +5V$, $C_L = 50$ pF			$T_A = -40°C$ to $+85°C$, $V_{CC} = 4.5V–5.5V$, $C_L = 50$ pF		Units
		Min	Typ	Max	Min	Max	
t_{PLH}	Propagation	1.0	2.2	3.9	1.0	3.9	ns
t_{PHL}	Delay Data to Outputs	1.0	2.9	4.4	1.0	4.4	
t_{PZH}	Output Enable	1.5	3.7	6.0	1.5	6.0	ns
t_{PZL}	Time	2.1	4.3	7.0	2.1	7.0	
t_{PHZ}	Output Disable	1.7	3.5	5.8	1.7	5.8	ns
t_{PLZ}	Time	1.7	3.7	5.8	1.7	5.8	

Capacitance

Symbol	Parameter	Typ	Units	Conditions $T_A = 25°C$
C_{IN}	Input Capacitance	5.0	pF	$V_{CC} = 0V$
C_{OUT} (Note 5)	Output Capacitance	9.0	pF	$V_{CC} = 5.0V$

Note 5: C_{OUT} is measured at frequency f = 1 MHz, per MIL-STD-883, Method 3012.

Appendix D

Philips Semiconductor

Part Number: 74ABT2244

DATA SHEET

74ABT2244

Octal buffer/line driver with 30Ω series termination resistors (3-State)

Product specification
Supersedes data of 1996 Oct 23
IC23 Data Handbook

1998 Jan 16

Philips
Semiconductors

PHILIPS

Octal buffer/line driver with 30Ω series termination resistors (3-State)

74ABT2244

FEATURES

- Octal bus interface
- 3-State buffers
- Live insertion/extraction permitted
- Outputs include series resistance of 30Ω, making external termination resistors unnecessary
- Output capability: +5mA/–32mA
- Latch-up protection exceeds 500mA per Jedec Std 17
- ESD protection exceeds 2000 V per MIL STD 883 Method 3015 and 200 V per Machine Model
- Power-up 3-State
- Same part as 74ABT244-1
- Inputs are disabled during 3-State mode

DESCRIPTION

The 74ABT2244 high-performance BiCMOS device combines low static and dynamic power dissipation with high speed.

The 74ABT2244 device is an octal buffer that is ideal for driving bus lines. The device features two Output Enables ($1\overline{OE}$, $2\overline{OE}$), each controlling four of the 3-State outputs.

The 74ABT2244 is designed with 30Ω series resistance in both the High and Low states of the output. This design reduces line noise in applications such as memory address drivers, clock drivers and bus receivers/transmitters.

The 74ABT2244 is the same as the 74ABT244-1. The part number has been changed to reflect industry standards.

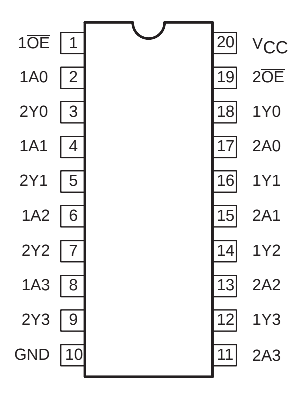
QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS T_{amb} = 25°C; GND = 0V	TYPICAL	UNIT
t_{PLH} t_{PHL}	Propagation delay An to Yn	C_L = 50pF; V_{CC} = 5V	2.8 3.9	ns
C_{IN}	Input capacitance	V_I = 0V or V_{CC}	4	pF
C_{OUT}	Output capacitance	Outputs disabled; V_O = 0V or V_{CC}	7	pF
I_{CCZ}	Total supply current	Outputs disabled; V_{CC} = 5.5V	50	μA

ORDERING INFORMATION

PACKAGES	TEMPERATURE RANGE	OUTSIDE NORTH AMERICA	NORTH AMERICA	DWG NUMBER
20-Pin Plastic DIP	–40°C to +85°C	74ABT2244 N	74ABT2244 N	SOT146-1
20-Pin plastic SO	–40°C to +85°C	74ABT2244 D	74ABT2244 D	SOT163-1
20-Pin Plastic SSOP Type II	–40°C to +85°C	74ABT2244 DB	74ABT2244 DB	SOT339-1
20-Pin Plastic TSSOP Type I	–40°C to +85°C	74ABT2244 PW	7ABT2244PW DH	SOT360-1

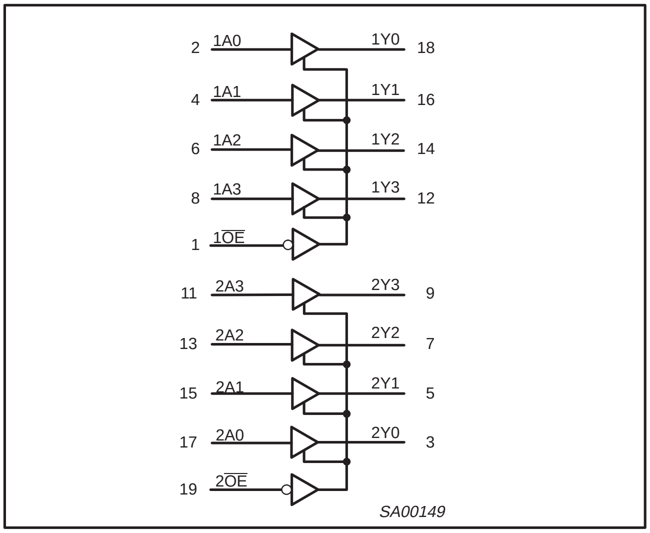
PIN CONFIGURATION



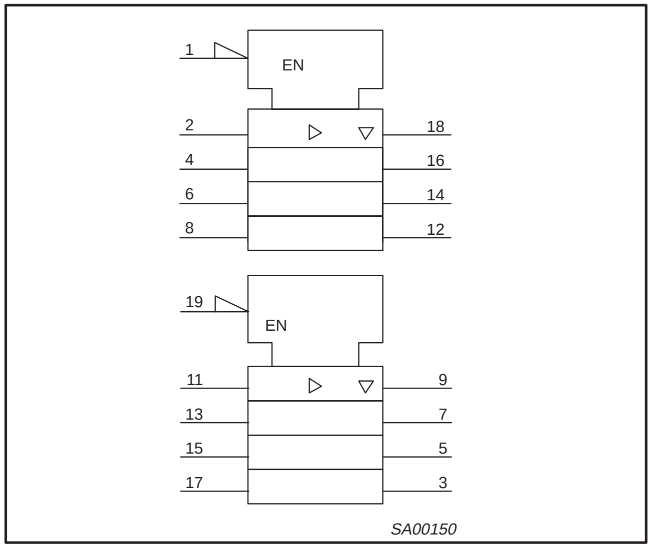
PIN DESCRIPTION

PIN NUMBER	SYMBOL	NAME AND FUNCTION
2, 4, 6, 8	1A0 – 1A3	Data inputs
11, 13, 15, 17	2A0 – 2A3	Data inputs
18, 16, 14, 12	1Y0 – 1Y3	Data outputs
9, 7, 5, 3	2Y0 – 2Y3	Data outputs
1, 19	$1\overline{OE}$, $2\overline{OE}$	Output enables
10	GND	Ground (0V)
20	V_{CC}	Positive supply voltage

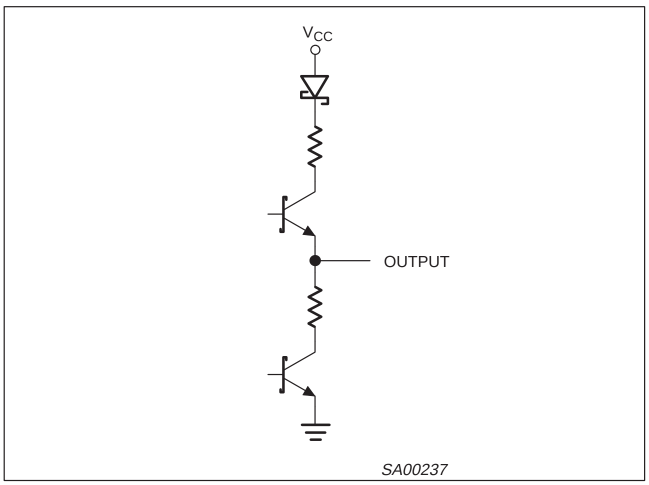
LOGIC SYMBOL



LOGIC SYMBOL (IEEE/IEC)



SCHEMATIC OF EACH OUTPUT



FUNCTION TABLE

INPUTS				OUTPUTS	
1$\overline{OE}$	1An	2$\overline{OE}$	2An	1Yn	2Yn
L	L	L	L	L	L
L	H	L	H	H	H
H	X	H	X	Z	Z

H = High voltage level
L = Low voltage level
X = Don't care
Z = High impedance "off" state

ABSOLUTE MAXIMUM RATINGS[1, 2]

SYMBOL	PARAMETER	CONDITIONS	RATING	UNIT
V_{CC}	DC supply voltage		–0.5 to +7.0	V
I_{IK}	DC input diode current	$V_I < 0$	–18	mA
V_I	DC input voltage[3]		–1.2 to +7.0	V
I_{OK}	DC output diode current	$V_O < 0$	–50	mA
V_{OUT}	DC output voltage[3]	output in Off or High state	–0.5 to +5.5	V
I_{OUT}	DC output current	output in Low state	128	mA
T_{stg}	Storage temperature range		–65 to 150	°C

NOTES:

1. Stresses beyond those listed may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
2. The performance capability of a high-performance integrated circuit in conjunction with its thermal environment can create junction temperatures which are detrimental to reliability. The maximum junction temperature of this integrated circuit should not exceed 150°C.
3. The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS		UNIT
		Min	Max	
V_{CC}	DC supply voltage	4.5	5.5	V
V_I	Input voltage	0	V_{CC}	V
V_{IH}	High-level input voltage	2.0		V
V_{IL}	Low-level Input voltage		0.8	V
I_{OH}	High-level output current		–32	mA
I_{OL}	Low-level output current		12	mA
$\Delta t/\Delta v$	Input transition rise or fall rate	0	5	ns/V
T_{amb}	Operating free-air temperature range	–40	+85	°C

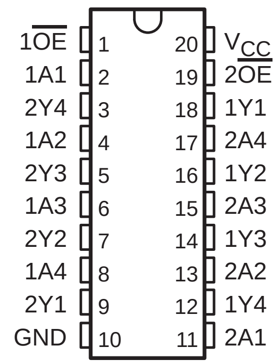
Appendix E

Texas Instruments

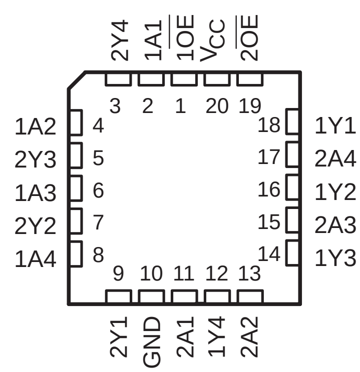
Part Numbers: SN54BCT2244 & SN74BCT2244

- **State-of-the-Art BiCMOS Design Significantly Reduces I_{CCZ}**
- **Output Ports Have Equivalent 33-Ω Series Resistors, So No External Resistors Are Required**
- **3-State Outputs Drive Bus Lines or Buffer Memory Address Registers**
- **Package Options Include Plastic Small-Outline (DW) Packages, Ceramic Chip Carriers (FK) and Flatpacks (W), andStandard Plastic and Ceramic 300-mil DIPs (J, N)**

SN54BCT2244 . . . J OR W PACKAGE
SN74BCT2244 . . . DW OR N PACKAGE
(TOP VIEW)



SN54BCT2244 . . . FK PACKAGE
(TOP VIEW)



description

These octal buffers and line drivers are designed specifically to improve both the performance and density of 3-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. Taken together with the ′BCT2240 and SN74BCT2241, these devices provide the choice of selected combinations of inverting and noninverting outputs, symmetrical active-low output-enable ($\overline{OE}$) inputs, and complementary OE and $\overline{OE}$ inputs. These devices feature high fan-out and improved fan-in.

The outputs, which are designed to source or sink up to 12 mA, include 33-Ω series resistors to reduce overshoot and undershoot.

The SN54BCT2244 is characterized for operation over the full military temperature range of –55°C to 125°C. The SN74BCT2244 is characterized for operation from 0°C to 70°C.

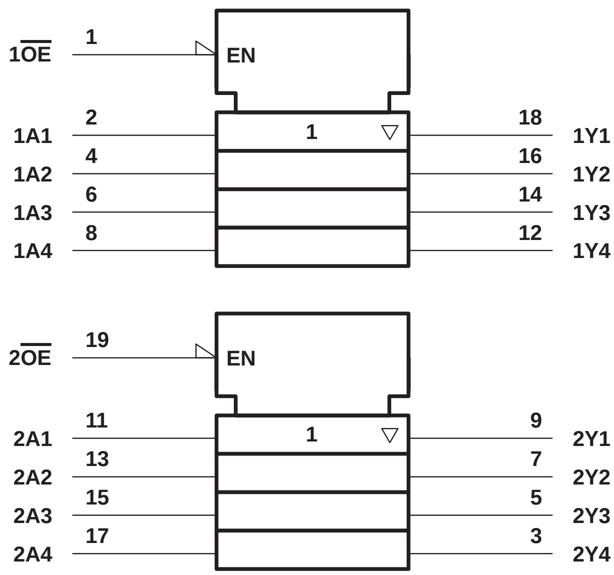
FUNCTION TABLE
(each buffer)

INPUTS		OUTPUT
$\overline{OE}$	**A**	**Y**
L	H	H
L	L	L
H	X	Z

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

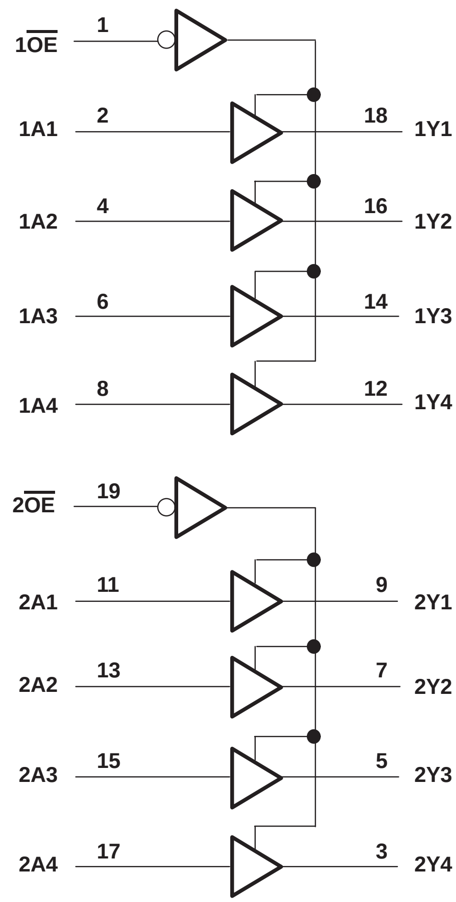
TEXAS INSTRUMENTS

logic symbol†

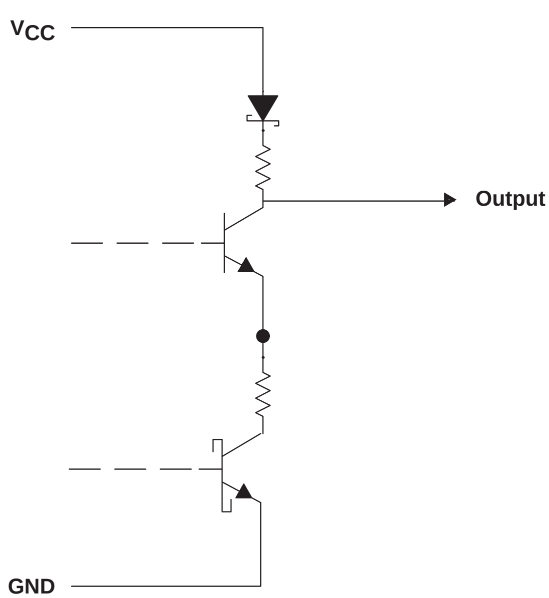


† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

logic diagram (positive logic)



schematic of Y outputs



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} . . . . – 0.5 V to 7 V
Input voltage range, V_I (see Note 1) . . . . – 0.5 V to 7 V
Voltage range applied to any output in the disabled or power-off state, V_O . . . . – 0.5 V to 5.5 V
Voltage range applied to any output in the high state, V_O . . . . – 0.5 V to V_{CC}
Input clamp current, I_{IK} . . . . –30 mA
Current into any output in the low state . . . . 24 mA
Operating free-air temperature range: SN54BCT2244 . . . . – 55°C to 125°C
SN74BCT2244 . . . . 0°C to 70°C
Storage temperature range . . . . – 65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

recommended operating conditions

		SN54BCT2244			SN74BCT2244			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.5	5	5.5	V
V_{IH}	High-level input voltage	2			2			V
V_{IL}	Low-level input voltage			0.8			0.8	V
I_{IK}	Input clamp current			–18			–18	mA
I_{OH}	High-level output current			–12			–12	mA
I_{OL}	Low-level output current			12			12	mA
T_A	Operating free-air temperature	–55		125	0		70	°C

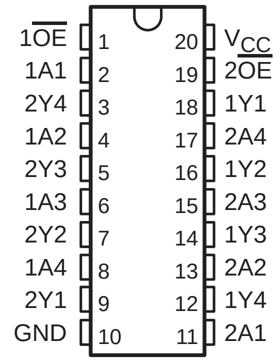
Appendix F

Texas Instruments

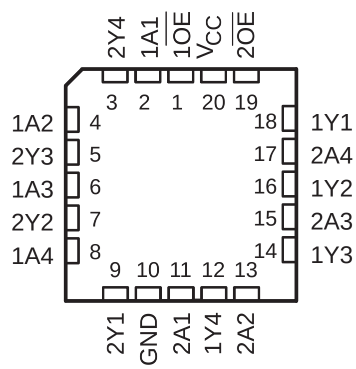
Part Number: SN74ABT2244

- **Output Ports Have Equivalent 25-Ω Series Resistors, So No External Resistors Are Required**
- **State-of-the-Art *EPIC*-II*B*™ BiCMOS Design Significantly Reduces Power Dissipation**
- **Typical V_{OLP} (Output Ground Bounce) < 1 V at V_{CC} = 5 V, T_A = 25°C**
- **Package Options Include Plastic Small-Outline (DW), Shrink Small-Outline (DB), and Thin Shrink Small-Outline (PW) Packages, Ceramic Chip Carriers (FK), and Plastic (N) and Ceramic (J) DIPs**

SN54ABT2244 . . . J PACKAGE
SN74ABT2244 . . . DB, DW, N, OR PW PACKAGE
(TOP VIEW)



SN54ABT2244 . . . FK PACKAGE
(TOP VIEW)



description

These octal buffers and line drivers are designed specifically to improve both the performance and density of 3-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. Taken together with the ′ABT2240 and ′ABT2241, these devices provide the choice of selected combinations of inverting and noninverting outputs, symmetrical active-low output-enable ($\overline{OE}$) inputs, and complementary OE and $\overline{OE}$ inputs. These devices feature high fan-out and improved fan-in.

The outputs, which are designed to sink up to 12 mA, include 25-Ω series resistors to reduce overshoot and undershoot.

To ensure the high-impedance state during power up or power down, $\overline{OE}$ should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

The SN74ABT2244 is available in TI’s shrink small-outline package (DB), which provides the same I/O pin count and functionality of standard small-outline packages in less than half the printed-circuit-board area.

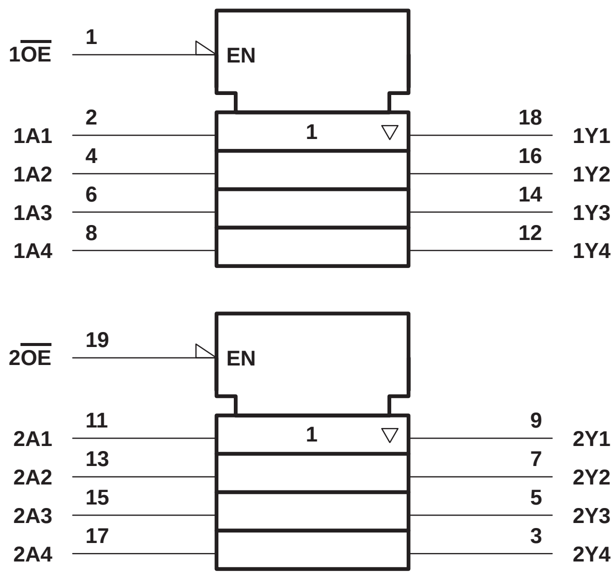
The SN54ABT2244 is characterized for operation over the full military temperature range of –55°C to 125°C. The SN74ABT2244 is characterized for operation from –40°C to 85°C.

FUNCTION TABLE
(each buffer)

INPUTS		OUTPUT
$\overline{OE}$	A	Y
L	H	H
L	L	L
H	X	Z

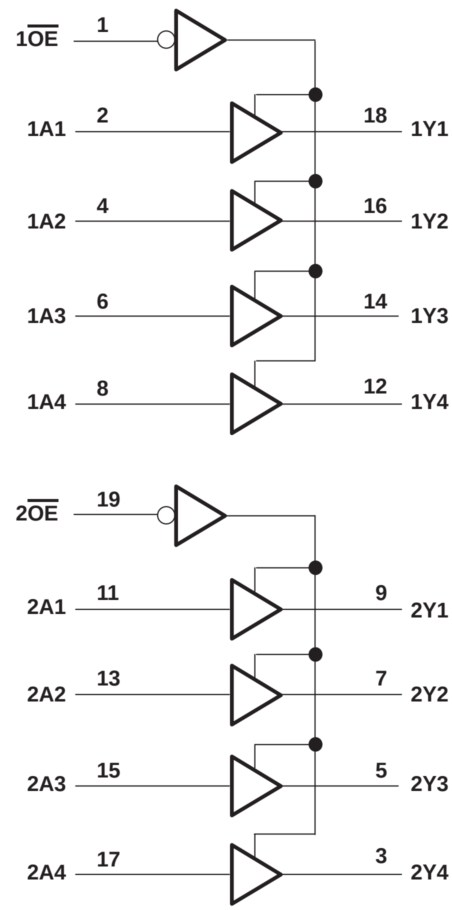
EPIC-IIB is a trademark of Texas Instruments Incorporated.

logic symbol†



† This symbol is in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.

logic diagram (positive logic)



schematic of Y outputs