Stevens Institute of Technology
Hoboken, New Jersey

Nintendo GameBoy Advance SP Portable Amusement Link (PAL)

Final Design Report

CPE/EE 423
Group #11

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Faculty Technical Advisor
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Signed _____

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I pledge my honor that I have abided by the Stevens Honor System.

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I. Abstract

The idea of the video game dates back to the early 1970's. Its objective was to act as a source of amusement, which kept not only children busy, but also those who merely enjoyed the games. Advancements in technology have brought new game units to the market such as the Nintendo GameBoy. There have been many versions of this system with the latest being the GameBoy Advance SP. The advancements of this unit have led to the creation of components other than games that can be used on, in, or with the system. One of these advances is a TV tuner. People can now use their GameBoys to watch TV by using one of these TV Tuner components.

There are a few undesirable aspects to this TV tuner. The first is that it is not available in the United States and even if imported from another country would not work here due to the difference in TV signals. Another is that it is very bulky and unattractive. The size of it seems useless and can be minimized through a different design. Another characteristic is that the component uses an excessive amount of battery power. The purpose of the project is to improve upon this current TV tuner. Through improvement of design and efficient use of power, the TV tuner can me reduced in size and made so that it can run on alkaline or rechargeable batteries. The name of this new component will be "GameBoy Advance Portable Amusement Link (P.A.L.)." The project poses to be challenging and will use all areas of Computer Engineering and Electrical Engineering. The final product will not only be marketable, but also a desirable device for all GameBoy Advance users.

II. Introduction

In the world of high technology video gaming systems, there is always one aim, to be the smallest, fastest and have the most definition. Imagine having a hand held gaming tool that can be used for video games as well as television. If you can imagine that now imagine that it is the size of your palm. Although one video gaming system developer, Nintendo, has already provide the sleek hand held unit, no one has come to master the sleek components that can be installed into the unit. This aspect of the gaming world needs to be changed, because what is the use of a small, discrete gaming system if the other components are huge.

One component in particular that is of great importance to this kind of technology is one that can be turned into a television. This is called the TV tuner for Game Boy Advance SP, which is a Nintendo unit. The TV tuner is used like a stand that has integrated circuits that connect directly with the circuit inside the Game Boy and is used to pick up television signals for the thirteen basic channels in the United States. Through out the research that has been conducted, there was found that a few of this kind of technology exists, but with many flaws. The flaws include: the size, it is almost two times the size of the actual system and has a weight of three times the system. The power source is also another flaw; it needs standard batteries that do not last as long as the rechargeable batteries of the Game Boy. One of the major flaws is that it is non-compatible with US signals. With each flaw of the already made TV tuner, an idea was born. How about a television tuner that is smaller in size, rechargeable, and can work in the United States. That's when the idea of the senior design project, Game Boy SP Portable Amusement Link, was developed.

Looking at the disadvantages of the TV tuner that is already out, the group has come up with ideas to better the product. The goal is to build a smaller, lighter, and more cost efficient TV tuner for the Game Boy. With this in mind, the

proposal is that the tuner should be no bigger than the base of the Game Boy, making it easy to fit in pockets and book bags. This smaller size is also good for discrete uses of this project, for example, watching TV in public places. The smaller the size should also cut the weight of the tuner in half, so it is not a burden to carry with the user. Along with the smaller size, the group aims to have the TV tuner use rechargeable batteries. That is so the TV tuner lasts for however long the gaming system is on. It would be futile and pricey for the consumer to have to keep buying regular batteries for the TV tuner while the gaming system is still in use, although the TV tuner can run off of standard AA batteries. This idea of using rechargeable batteries is mainly for cost efficiency of the product.

The project will be similar to the already manufactured TV tuner for the Game Boy Advance SP in the sense that it will be using the same technology and have to use the same standard of signals governed by the NTSC. There are not many ways that TV tuners can be manufactured, so the group will be using all standard parts and some new and improved parts that can aid in making the vision a reality.

II-2. DESIGN REQUIREMENTS

The teams' main goal when envisioning a project for Senior Design was to search for a design that would target each team members' skills and which would ultimately benefit their interests. The concept of designing a more modernistic TV Tuner for the GAMEBOY ADVANCED SP system was agreed upon. The GAMEBOY ADVANCED P.A.L. would be sleeker and thinner version of the third party TV Tuner already on the market. It would also differentiate in that it would be capable of receiving and decoding VHF-NTSC signal so that it would display them on the LCD panel of the GAMEBOY ADVANCED SP unit by means of inserting it into the game cartridge slot.

A) FUNCTIONAL REQUIREMENTS:

- The prototype will be able to use the GAMEBOY ADVANCED SP unit's controls to switch between stations.
- The unit will make use of the cartridge slot to be able to be hooked up to the system itself.
- It will support frequencies between 54 and 216 MHz in the very high frequency range (VHF).
- It will receive and decode **NTSC** signal to be able to display those signals unto the LCD screen.
- The unit will run on two AA alkaline batteries, so that it will not drain out battery power source of the GAMEBOY ADVANCED SP system while on the road.

B) SYSTEM PARAMETERS:

- The unit will have a resolution of 240 X 160, which is the same as the GBA screen for full screen viewing.
- The TV Tuner will provide an expected 10+ hours of continuous play using two AA alkaline batteries.
- It will be able to tune channels by using the controls on the GAMEBOY ADVANCED SP system

- The prototype is envisioned to be approximately the comparable size of the GAMEBOY ADVANCED SP unit, which is relatively 8.2cm x 8.2cm x 2.4cm.
- The TV Tuner will weigh closely 9-12 ounces without the two AA alkaline batteries.
- It will use the boot sequence supplied from a GAMEBOY ADVANCE SP game cartridge to start the TV Tuner interface.

C) DESIGN CONSTRAINTS:

- One of the earlier notions that was as of now omitted, was for the TV Tuner to be able to use the battery power source supplied by the GAMEBOY ADVANCE SP unit; The groups' opinion is that by utilizing the systems' battery power source it will drain it out more rapidly.
- The unit will be fabricated out of plastic materials to have a more cost efficient production.
- It would have to be sold for a higher price then that previously envisioned (which was, $49.99), so that there will be a higher and more suitable revenue.
- The cost of building the prototype itself will be more then that which is provided in the Senior Design budget, since models of the GAMEBOY ADVANCE SP will have to be opened and fiddled with.

Of utmost importance in the functionality of the TV tuner, is that it will be able to receive and decode VHF-NTSC signal and display them on the GAMEBOY ADVANCED SP LCD screen. The controls of the system itself would have to be used to switch in between channels, since one of the main goals is for the TV Tuner to be lighter and less bulkier then that on the market; this will be accomplished by not adding an extra set of controls unto the unit. The TV Tuner is fabricated to slot into the GAMEBOY ADVANCED SP like a regular game cartridge. One has to slot in a GAMEBOY ADVANCED SP cartridge into the Tuner for it to run, since it will use the boot sequence from it to start the TV Tuner interface. The unit will use two AA alkaline batteries, and must be able to deliver approximately 10+ hours of continuous battery power.

The GAMEBOY ADVANCED SP system is 8.2cm x 8.2cm x 2.4 cm; the unit will compliment these measurements. The third-party tuner (international version) already on the market which provides PAL signal is way too bulky, and heavy, and so uncomfortable; hence, the group wants to design a more comfortable, sleeker, and thinner design. It ultimately should be more cost efficient and should have an eye-catching fresh style. The best interest of the consumer is in mind. The group wants the consumer to be able to take full advantage of the GBA SP system, and the addition of the GBA TV Tuner P.A.L. unit is one of the best ways. Easily portable, lightweight, cost efficient, and most importantly provides extreme comfort and paramount entertainment.

II-3 System Design

The main goal of our group is to create a television tuner design that is sleek, light, cost efficient, and readily available to Gameboy owners in the North American market. The group has generated various ideas as to how to attack one or more of the set goals of our design. The group decided to utilize most of the components already installed in the GAMEBOY Advance Unit system. The basis for our project is to create a peripheral for the Gameboy Advance unit that will allow the device to receive and decode television signals and display them on the monitor of the Gameboy Advance Unit.

The prototype of our project will require the use of a Gameboy Advance Unit. The tuner module will have to be inserted into the cartridge slot of the Gameboy unit. Because of the nature of the Gameboy unit, the TV tuner module must be turned on first. After doing so the Gameboy unit may now be powered on. The TV tuner will use the boot sequence from the cartridge in order to begin the Tuner interface. The TV tuner will then display a menu of options that the user may select from. The on screen menu option will provide the user with various options. The options provided will enable the user to set and store channels, adjust brightness, color, and contrast. The controls already on the GAMEBOY would assimilate the responsibility of a remote control used for the TV tuner to switch in between channels.

The prototype will need to obtain power from an outside source other than the Gameboy Advance unit. Our design calls for the unit to use two double A alkaline batteries or supplemented by the use of an AC adapter. Attached to the prototype will be a telescoping antenna which will enable the unit to receive any local broadcast stations available. Also, a small mono type speaker will be placed within the unit to allow for sound to be projected. This speaker will also be enabled with an earphone jack with an

independent volume control toggle switch. The resolution of the decoded television signal received is based on the resolution of the Gameboy display itself. The resolution of the Gameboy Advance screen is approximately 240 X 160.

The critical components of our prototype will be the use of a specific TV tuner. There are hundreds of TV tuner cards available on the market to select from. Although, there are only a few that will meet our specific design constraints. For our prototype we have selected the use of a Philips Tuner. The Philips Tuner module, TDA6501TT, is a programmable 2-mixer, 3-oscillator and synthesizer MOPLL intended for pure 3-band tuner concepts. We chose this tuner because of its tremendous reliability as well as its seamless performance. The TDA6501TT can be readily obtained through the Philips Semiconductors website. Another critical element is the game pack connector. This connector will allow for the TV tuner to be read by the Gameboy Advance Unit. The game pack interface uses a multiplexed 16bit data bus with a 24 bit address bus. Because of this multiplexed interface method connecting a simple memory devices is not possible without some form of interface logic. Sequential access involves an initial start address followed by consecutive data reads until all data has been transferred. Random access involves an address write followed by a single data read. The game pack interface can be obtained through Nintendo, otherwise through a third party source at www.lik-sang.com.

Development of the software will have to be coded in Assembly Language. Coding in assembly will allow for every ounce of power to be utilized. Because the Gameboy Advance unit operates a 16/32bit ARM7TDMI processor our group will need to use an Integrated Development Environment that will allow to write and develop code. Although we can test our development of code an actual hardware, there are a number of Gameboy emulators out in the market that are readily available for testing purposes.

The emulator would allow for our program to be tested and allow for program bugs to be fixed quickly.

There are various design risks that are team will endure for the following semester. One such is will be trying to implement and integrate the TV tuner along side the game cartridge. Because most of the team members are rather novice in hardware design this will impose a real challenge. Another major challenge would have to be the use of Assembly code to program specific code. Although an alternate method of programming could be used, using 'C', it is not the most efficient, especially for the design of our prototype. Overall, the whole project will be a rather challenging venture most of will have to endure. A lot of information will have to be learned as well as put into actual use to make this project a success. The P.A.L. system would incorporate most of these inclinations for the betterment of the existing third party TV tuner design. These improvements would prove beneficial and complimentary to the design of the GAMEBOY ADVANCE SP system. These are the main considerations for the system design approaches that the group has thought of and concerted upon.

II-4. Financial Budget

	Qty	Unit Price	Total Price	Reference
Labor Costs				
R&D, Fabrication, Testing	5	$30/hr 8hr/wk 32 wks	$40,960	
Device Costs				
Nintendo GameBoy Advance SP	1	$99.99	$99.99	http://www.toysrus.com
Gameboy TV Tuner	1	$60.00	$60.00	http://www.project-design.com
Miscellaneous		$100.00	$100.00	
Documentation Costs				
Ink	1	$46.00	$46.00	http://www.staples.com
Paper	1	$4.75	$4.75	http://www.staples.com
Copying	100	$0.10	$10.00	Samuel C. Williams Library
Other Costs				
Internet Service	3	$34.99	$104.97	America Online
Travel Costs			$100.00	
Telephone Bills	3	$39.99	$119.97	http://www.verizonwireless.com
GRAND TOTAL:			$41,605.68	

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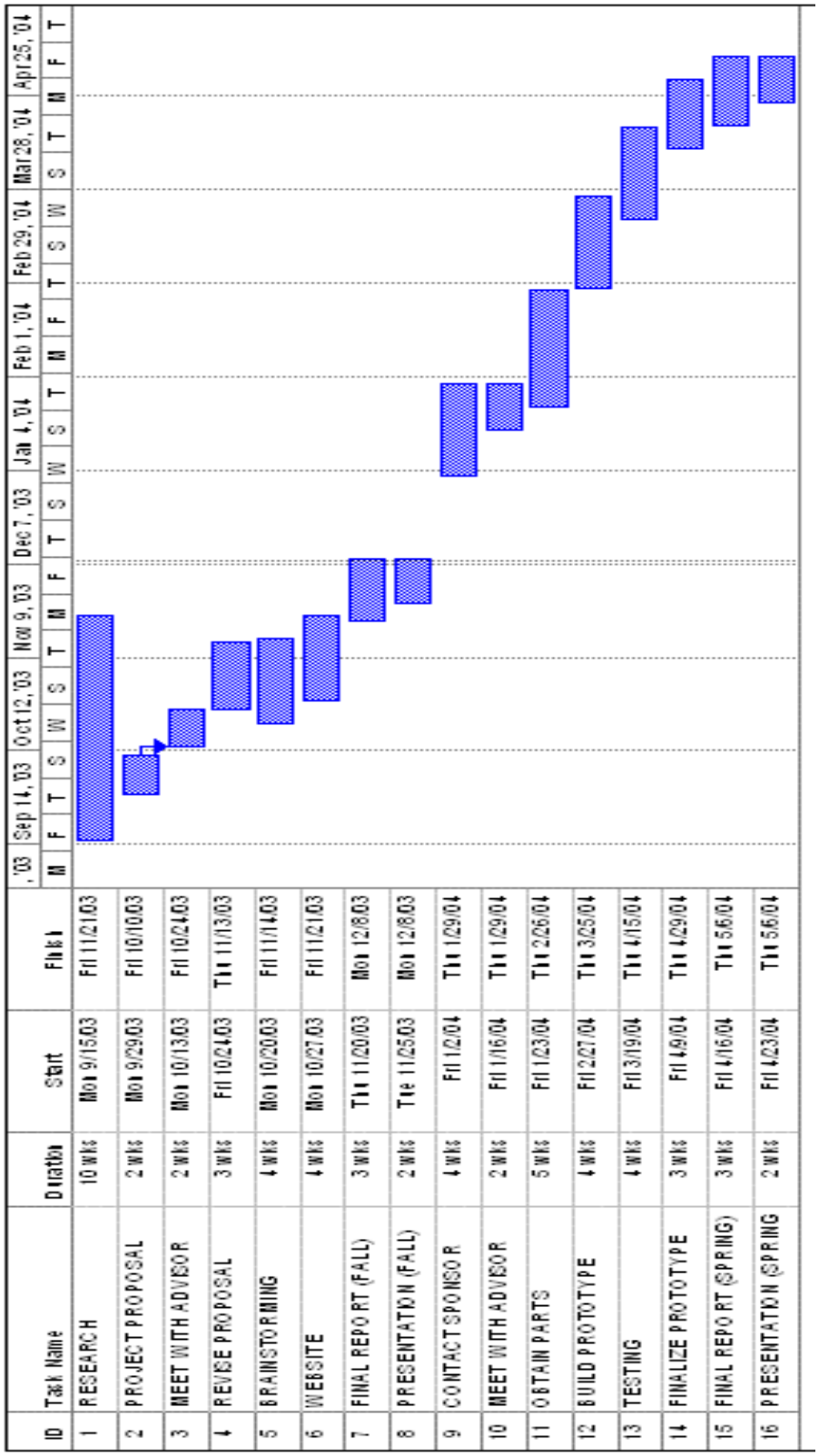
II-5. Project Schedule



ID	Task Name	Duration	Start	Finish
1	RESEARCH	10 wks	Mon 9/15/03	Fri 11/21/03
2	PROJECT PROPOSAL	2 wks	Mon 9/29/03	Fri 10/10/03
3	MEET WITH ADVISOR	2 wks	Mon 10/13/03	Fri 10/24/03
4	REVISE PROPOSAL	3 wks	Fri 10/24/03	Thu 11/13/03
5	BRAINSTORMING	4 wks	Mon 10/20/03	Fri 11/14/03
6	WEBSITE	4 wks	Mon 10/27/03	Fri 11/21/03
7	FINAL REPORT (FALL)	3 wks	Thu 11/20/03	Mon 12/8/03
8	PRESENTATION (FALL)	2 wks	Tue 11/25/03	Mon 12/8/03
9	CONTACT SPONSOR	4 wks	Fri 1/2/04	Thu 1/29/04
10	MEET WITH ADVISOR	2 wks	Fri 1/16/04	Thu 1/29/04
11	OBTAIN PARTS	5 wks	Fri 1/23/04	Thu 2/26/04
12	BUILD PROTOTYPE	4 wks	Fri 2/27/04	Thu 3/25/04
13	TESTING	4 wks	Fri 3/19/04	Thu 4/15/04
14	FINALIZE PROTOTYPE	3 wks	Fri 4/9/04	Thu 4/29/04
15	FINAL REPORT (SPRING)	3 wks	Fri 4/16/04	Thu 5/6/04
16	PRESENTATION (SPRING	2 wks	Fri 4/23/04	Thu 5/6/04

III. Summary

The Gameboy Advance Portable Amusement Link is a highly marketable product for gaming system owners. Due to the lack of improvements to the already manufactured TV tuners, our group has found a creative edge over most of the competition. Being that our group is now in the programming and design stages, our biggest problem is that of writing correct code, which has the parts interact with one another.

Once our programming is corrected and our parts are ordered properly, we plan on achieving an actual working model. The model will be in a sleek, thin plastic case that will be the size of the base of the Gameboy Advance unit. Along with the casing, our model will also come with the cartridge connector that are used to read the program from the TV tuner. This working model should be able to pick up the US television signals and show in good quality, the basic 13 channels.

As stated before, the marketability of this product is great. With the design that the group has, many gaming users would definitely purchase this component for their gaming systems. The fact that the TV tuner is one of a kind in the United States market makes the product even more marketable.

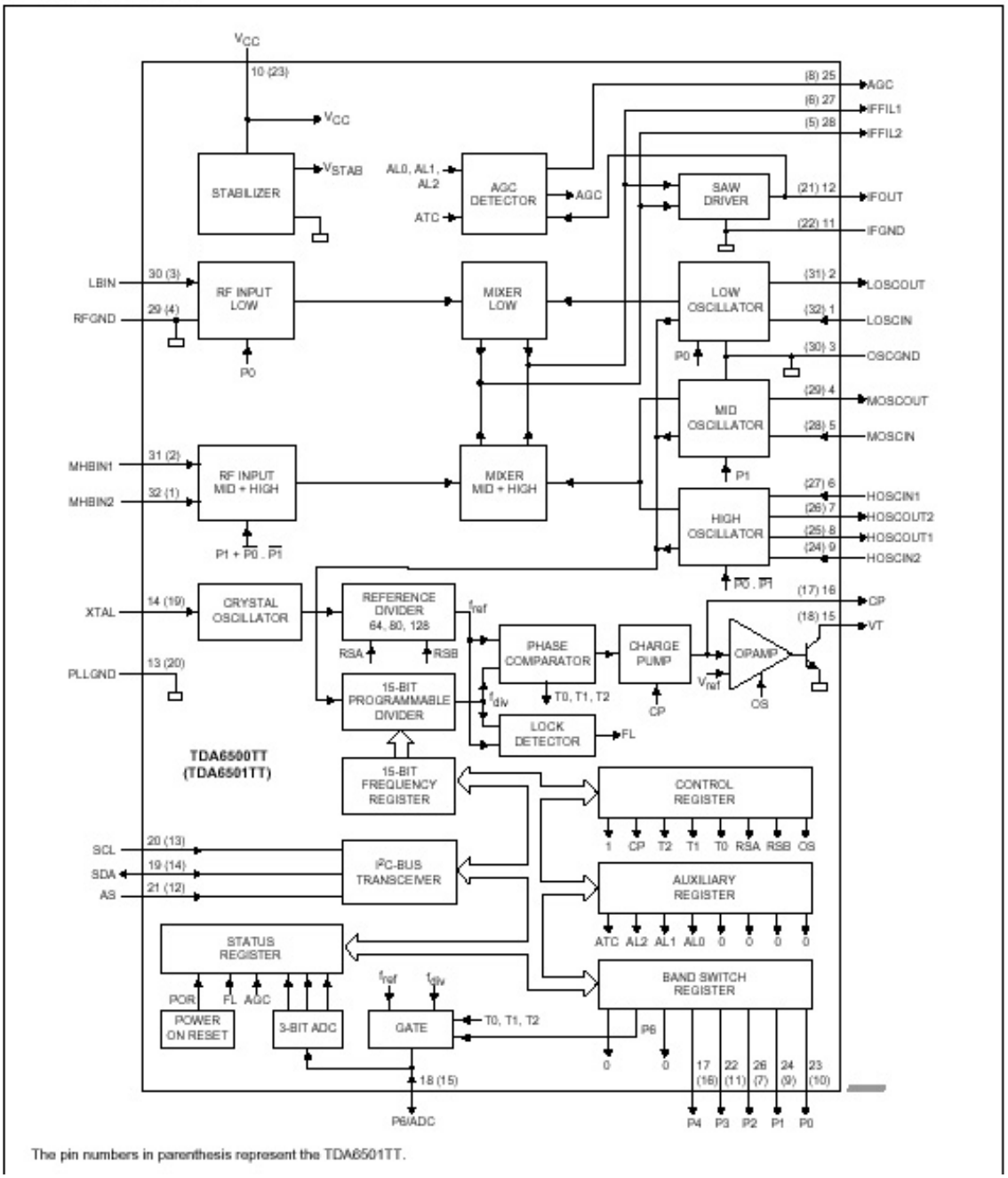
IV. References

1. **www.howthingswork.com**
2. **http://www.gameboy-advance.net/accessories/gba_tv_tuner.htm**
3. **http://www.eagb.net/advance/hr30.html**
4. **http://www.bryce-max.com.hk/GBA%20Tv%20Tuner.htm**
5. **http://www.gamesdomain.com/news/8286.html**
6. **http://www.finim.com/gba-tv_tuner.htm**
7. **http://www.success-hk.com/xg/tvtuner/tvtuner.htm**
8. **http://www3.goldenshop.com.hk/AI-trad/gba/tvturner.htm**
9. http://www.semiconductors.philips.com

Features

- Single-chip 5 V mixer/oscillator and synthesizer for TV and VCR tuners
- I²C-bus protocol compatible with 3.3 V and 5 V microcontrollers:
  - Address + 6 data bytes transmission
  - Address + 1 status byte (I²C-bus read mode)
  - Four independent I²C-bus addresses.
- Two PMOS open-drain ports with 5 mA source capability to switch high band and FM sound trap (P2 and P3)
- One PMOS open-drain port with 20 mA source capability to switch the mid band (P1)
- One PMOS open-drain port with 10 mA source capability to switch the low band (P0)
- Five step, 3-bit Analog-to-Digital Converter (ADC) and NPN open-collector general purpose port with 5 mA sinking capability (P6)
- NPN open-collector general purpose port with 5 mA sinking capability (P4)
- Internal AGC flag
- In-lock flag
- 33 V tuning voltage output
- 15-bit programmable divider
- Programmable reference divider ratio: 64, 80 or 128
- Programmable charge pump current: 60 or 280 uA
- Varicap drive disable
- Balanced mixer with a common emitter input for the low band (single input)
- Balanced mixer with a common base input for the mid and high bands (balanced input)
- 2-pin asymmetrical oscillator for the low band
- 2-pin asymmetrical oscillator for the mid band
- 4-pin symmetrical oscillator for the high band
- Frequency ranges: see Table 1
- IF preamplifier with asymmetrical 75 Ohm output impedance to drive a SAW filter (500 Ohm/40 pF)
- Wide-band AGC detector for internal tuner AGC:
  - Five programmable take-over points
  - Two programmable time constants.

5 BLOCK DIAGRAM



The pin numbers in parenthesis represent the TDA6501TT.

This is the block diagram for the Philips TDA6501TT

6 PINNING

SYMBOL	PIN		DESCRIPTION
	TDA6500TT	TDA6501TT	
LOSCIN	1	32	low band oscillator input
LOSCOUT	2	31	low band oscillator output
OSCGND	3	30	oscillator ground
MOSCOUT	4	29	mid band oscillator output
MOSCIN	5	28	mid band oscillator input
HOSCIN1	6	27	high band oscillator input
HOSCOUT2	7	26	high band oscillator output 2
HOSCOUT1	8	25	high band oscillator output 1
HOSCIN2	9	24	high band oscillator input 2
V_{CC}	10	23	supply voltage
IFGND	11	22	IF ground
IFOUT	12	21	IF output
PLLGND	13	20	digital ground
XTAL	14	19	crystal oscillator input
VT	15	18	tuning voltage output
CP	16	17	charge pump output
P4	17	16	NPN open-collector general purpose port
P6/ADC	18	15	NPN open-collector general purpose port or ADC input
SDA	19	14	serial data input and output
SCL	20	13	serial clock input
AS	21	12	address selection input
P3	22	11	PMOS open-drain general purpose port
P0	23	10	PMOS open-drain port to select low band operation
P1	24	9	PMOS open-drain port to select mid band operation
AGC	25	8	AGC output
P2	26	7	PMOS open-drain general purpose port
IFFIL1	27	6	IF filter output 1
IFFIL2	28	5	IF filter output 2
RFGND	29	4	RF ground
LBIN	30	3	low band RF input
MHBIN1	31	2	mid and high band RF input 1
MHBIN2	32	1	mid and high band RF input 2

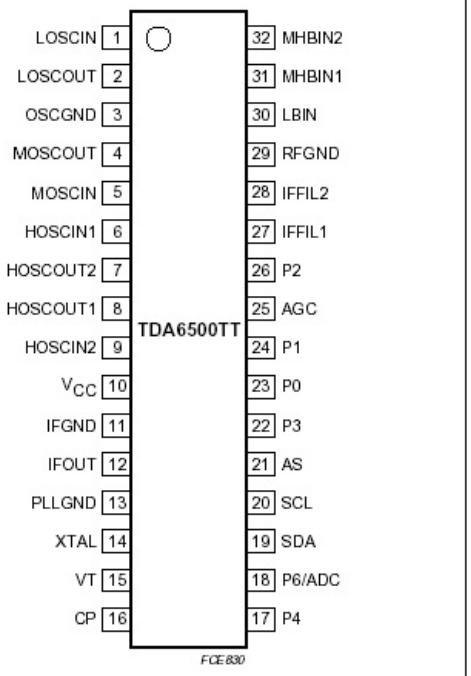


Fig.2 Pin configuration TDA6500TT.

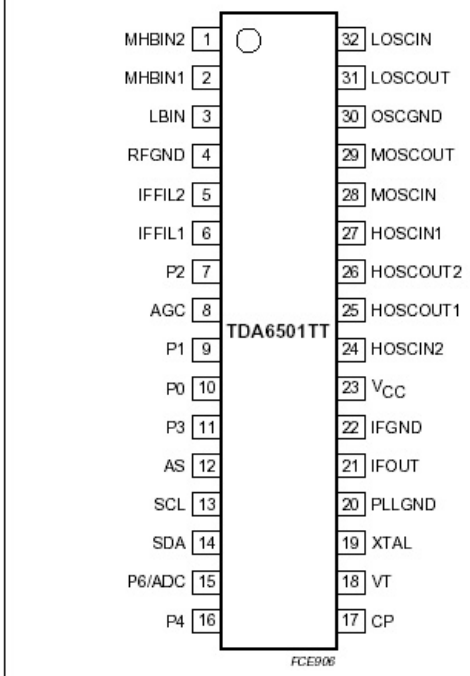
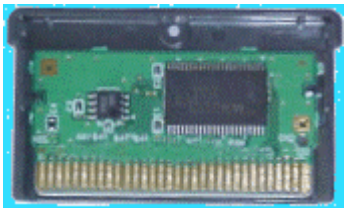
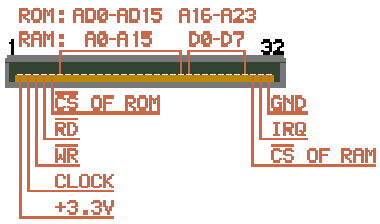
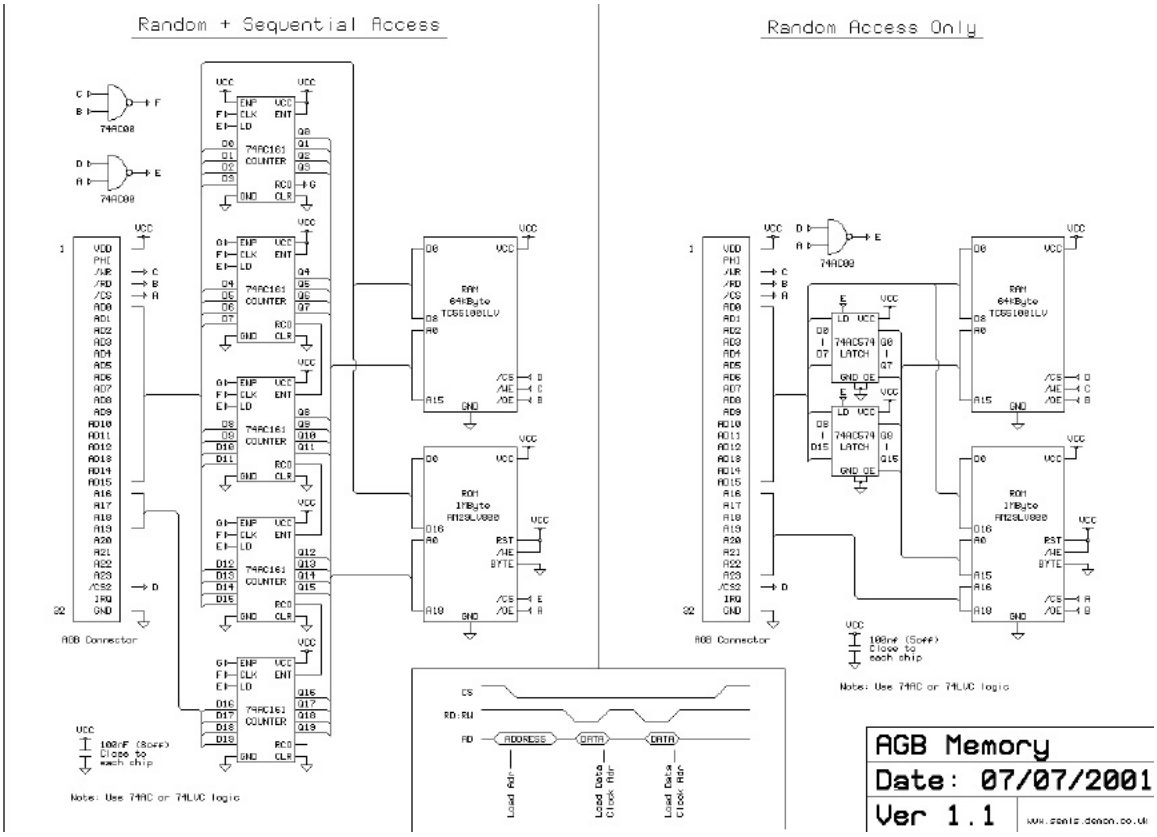


Fig.3 Pin configuration TDA6501TT.

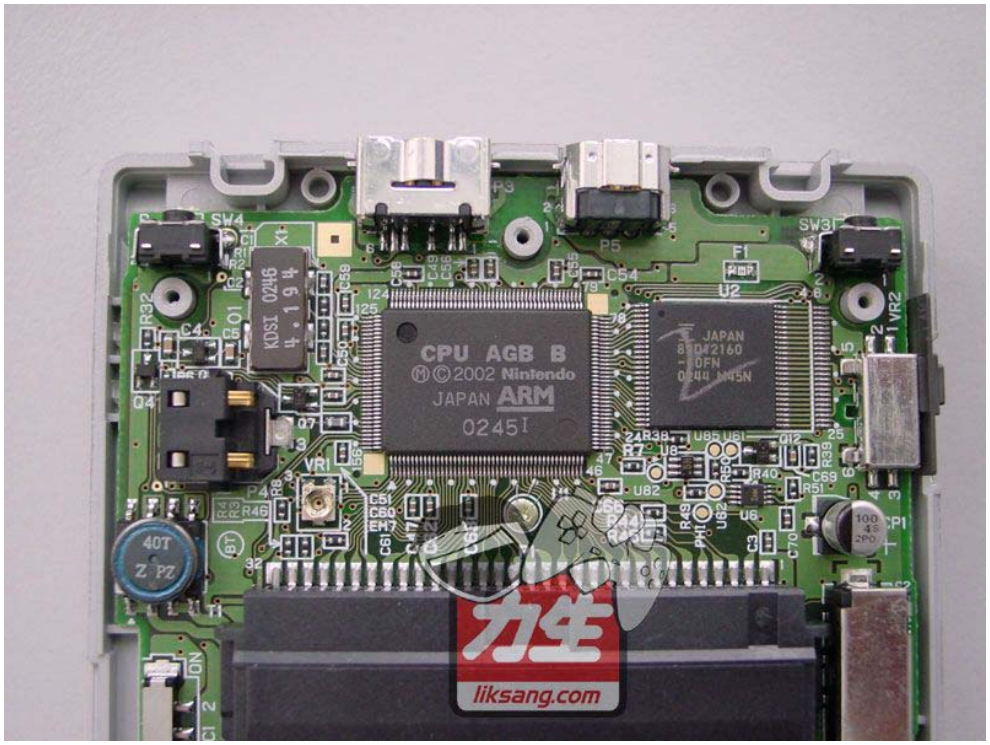


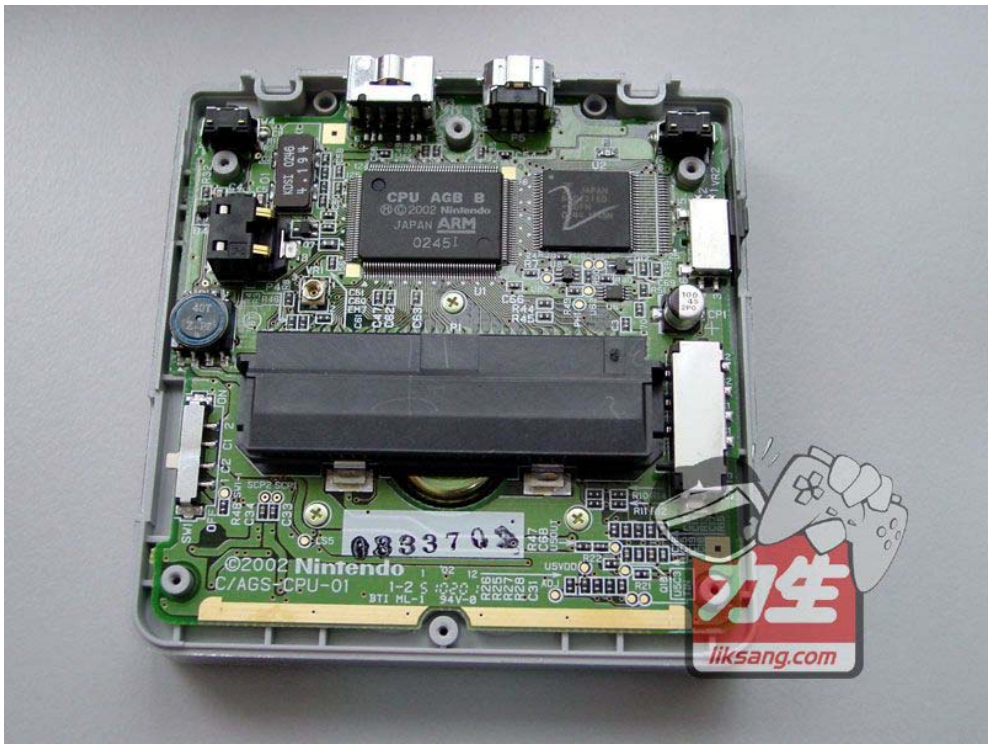
GamePack Edge Connector:





The Game pack cartridge connector sequence


CPU AGB B
©2002 Nintendo
JAPAN ARM
0245I
liksang.com


CPU AGB B
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JAPAN ARM
0245I
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C/AGS-CPU-01
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