ADAM Speech Synthesizer

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# INSTALLATION

Before connecting the ADAM Speech Synthesizer, you should inspect the ADAM computer expansion port connector. Ensure the contacts are clean and shiny. Any oxidation on the contacts could cause the ADAM Speech Synthesizer to malfunction.

The ADAM Speech Synthesizer connects to the expansion port on the right-hand side of the ADAM computer. See Figure 1. The components on the ADAM Speech Synthesizer should be pointing up when the female edge connector on the card is mated with the male card edge on the ADAM expansion port.

**WARNING: Inserting the ADAM Speech Synthesizer upside down could cause damage to the ADAM Speech Synthesizer, your ADAM computer or both.**

You should only connect or disconnect the ADAM Speech Synthesizer with the ADAM computer powered off.

There is no external speaker connected to the ADAM Speech Synthesizer. All sound is routed through the ADAM computer.

# OPERATION

The operation of the unit is straight forward, but it is important to understand its operation so that you can use it effectively. The SPO256A-AL2 is made to speak by sending it a series of ALLOPHONES. An allophone is the smallest individual sound that the unit can speak. Words and sentences are formed by outputting a series of allophones, one after the other.

Each allophone is assigned a number and this number is loaded onto the ADAM data bus then the ALD line is pulsed low and the value is read in to the SPO256A-AL2. The LRQ line is driven high by this indicating the input buffer is full.

The SPO now commences to speak the allophone and indicates so by pushing the SBY line high. When a received allophone has been spoken the SBY and LRQ lines are pulled low.

Sound is clocked out of the unit at a rate of 3.12 MHZ determined by the onboard crystal.

Sound is filtered by an R-C network, to make the sound more "human like" and amplified by the LM386.

# PORTS

There are 3 ports you can use to communicate with the Speech Synthesizer. Those are 43h (67), 44h (68) and 45h (69).

## 43h (67) COMMAND PORT

This port is used to send a single allophone to the Speech Synthesizer to speak. In machine language this would be:

COMMAND:

OUT (43h),A ;A can be any valid allophone value from 0

;to 63.

RET

See Table 6 – Allophone Address Table for the complete allophone list and descriptions.

## 44h (68) STATUS PORT

This port is used to query the status of the Speech Synthesizer to determine if it is busy or safe to send another allophone for processing. In machine language an example would be:

STATUS:

IN A,(44h) ;get status of SPO256A-AL2

AND 1 ;check is bit 0 is set

CP 1 ;is the SPO256A-AL2 busy?

JR Z,STATUS ;yes, get status again

RET ;no, return

## 45h (69) RESET

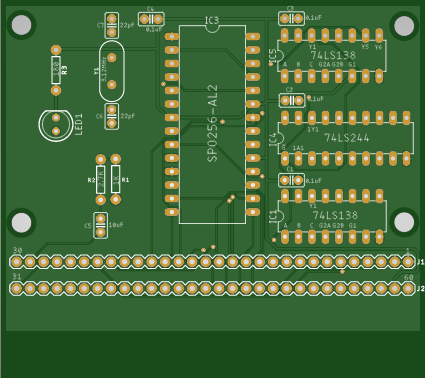
This port is used to reset the SPO256A-AL2. After the ADAM is powered on or reset the SPO256A-AL2 may be in an unknown state. This command ensures the SPO256A-AL2 is reset and ready to accept commands. This is done in machine language as follows:

RESET:

OUT (45h),N ;N can be any value between 0 and 255

RET

# PCB LAYOUT



# BILL OF MATERIALS

|  |  |  |
| --- | --- | --- |
| **QTY** | **PART** | **DESCRIPTION** |
| 2 | IC1 | 74LS138N |
|  | IC2 |  |
| 1 | IC3 | SPO256A-AL2 |
| 1 | IC4 | 74LS244 |
| **Capacitors** |  |  |
| 4 | C1 | 0.1uF ceramic capacitor |
|  | C2 |  |
|  | C3 |  |
|  | C4 |  |
| 1 | C5 | 10uF electrolytic capacitor |
| 2 | C6 | 22pF ceramic capacitor |
|  | C7 |  |
| **Resistors** |  |  |
| 1 | R1 | 1k |
| 1 | R2 | 2.7k |
| 1 | R3 | 180ohm |
| **LED** |  |  |
| 1 | LED1 | Red 5MM |
| **Crystal** |  |  |
| 1 | Y1 | 3.12MHz |
| **Edge Connector** |  |  |
| 1 | J1/J2 | 60 pin (30x2) female card edge connector |

# BASIC PROGRAMS

## SPOTEST1

This test program instructs the SPO256A-AL2 to say “Greetings Professor Falken”.

10 PRINT CHR$(12)

20 PRINT "ADAM Speech Synthesizer v1.0"

30 PRINT "2023 RE Pearson": PRINT

90 REM command ml

100 FOR x = 40000 TO 40004

110 READ a: POKE x, a

120 NEXT

125 REM reset ml

130 FOR x = 40005 TO 40009

140 READ a: POKE x, a

150 NEXT

155 REM status ml

160 FOR x = 40010 TO 40017

170 READ a: POKE x, a

180 NEXT

185 CALL 40005: FOR t = 1 TO 10000: NEXT

190 PRINT "Sending Speech Data"

200 READ c

210 IF c = 99 THEN END

220 GOSUB 1000

230 GOTO 200

1000 POKE 40001, c

1010 CALL 40000

2000 CALL 40010

2010 IF PEEK(40100) = 0 THEN 2030

2020 GOTO 2000

2030 RETURN

3000 DATA 62,0,211,67,201

3005 DATA 62,1,211,69,201

3010 DATA 219,68,230,1,50,164,156,201

3040 REM speech data

3050 DATA 36,14,19,2,13,12,44,43,2

3060 DATA 9,14,53,40,40,7,55,55,51,2

3070 DATA 40,40,26,45,41,7,7,0,11,4,99

3080 DATA 26,2,21,15,16,4,4,4,4,4,4

3110 DATA 27,1,26,35,3

3120 DATA 20,3

3130 DATA 56,6,2,55,55,3

3140 DATA 33,7,20,4,99

## SPOTEST 2

This test program first instructs the SPO256A-AL2 to speak all 58 spoken allophones, second the SPO256A-AL2 will speak the numbers 1 through 10 and finally the days of the week.

5 PRINT CHR$(12);

10 PRINT "ADAM Speech Synthesizer 1.0"

20 PRINT "2023 RE Pearson": PRINT

90 REM command ml

100 FOR x = 40000 TO 40004

110 READ a: POKE x, a

120 NEXT

125 REM reset ml

130 FOR x = 40005 TO 40009

140 READ a: POKE x, a

150 NEXT

155 REM status ml

160 FOR x = 40010 TO 40017

170 READ a: POKE x, a

180 NEXT

185 CALL 40005: FOR t = 1 TO 5000: NEXT

190 PRINT "SPO256A-AL2 Test"

200 PRINT "Allophone Test"

230 FOR i = 5 TO 63

240 PRINT "allophone "; i

245 POKE 40001, 4: CALL 40000: GOSUB 600

250 POKE 40001, i: CALL 40000: GOSUB 600

260 FOR t = 1 TO 4

270 POKE 40001, 4: CALL 40000: GOSUB 600

280 NEXT t

290 NEXT i

300 PRINT: PRINT "Numbers"

310 READ c: IF c = 99 THEN 400

320 POKE 40001, c: CALL 40000: GOSUB 600

330 GOTO 310

400 PRINT: PRINT "Days of the Week"

410 READ c: IF c = 99 THEN 480

420 POKE 40001, c: CALL 40000: GOSUB 600

430 GOTO 410

480 FOR t = 1 TO 1000: NEXT

500 PRINT: PRINT "ADAM Speech Synthesizer"

510 PRINT "Tests complete"

520 READ c: IF c = 99 THEN END

530 POKE 40001, c: CALL 40000: GOSUB 600

540 GOTO 520

600 CALL 40010: IF PEEK(40100) = 1 THEN 600

610 RETURN

3000 DATA 62,0,211,67,201

3005 DATA 62,1,211,69,201

3010 DATA 219,68,230,1,50,164,156,201

10000 DATA 4,43,60,53,2

10001 DATA 46,15,15,11,2

10002 DATA 13,31,2

10003 DATA 29,14,19,2

10004 DATA 40,40,58,2

10005 DATA 40,40,6,35,2

10006 DATA 55,55,12,12,2,41,55,2

10007 DATA 55,55,7,7,35,12,11,2

10008 DATA 20,2,13,2

10009 DATA 11,24,6,11,2

10010 DATA 13,7,7,11,4,99

10020 DATA 4,55,55,15,15,11,1,33,20,4

10021 DATA 16,15,15,11,1,33,20,4

10022 DATA 13,31,43,1,33,20,4

10023 DATA 46,7,7,11,43,1,33,20,4

10024 DATA 29,52,43,33,20,4

10025 DATA 40,39,6,1,33,20,4

10026 DATA 55,55,26,2,13,1,33,20,4,99

10030 DATA 4,26,33,1,15,16,4

10031 DATA 55,55,2,9,19,2,50,4

10032 DATA 55,55,2,12,11,2,29,29,30,2,55,55,6,43,2,51,4

10033 DATA 17,7,55,15,55,4

10034 DATA 8,30,16,2,9,45,19,19,17,4,99

# ALLOPHONE SPEECH SYNTHESIS

Introduction

The allophone speech synthesis technique provides the user with the ability to synthesize an unlimited vocabulary at a very low bit rate. Fifty-nine discrete speech sounds (called allophones) are five pauses are stored at different addresses in the SP0256 internal ROM. Each speech sound was excised from a word and analyzed using linear predictive coding (LPC). Any English word or phrase can be created by addressing the appropriate combination of allophones and pauses. Since there is a total of 64 address locations each requires a 6 bit address. Assuming that speech contains 10 to 12 sounds per second, allophone synthesis requires addressing less than 100 bits per second.

Linguistics

A few basic linguistic concepts will help you start your own library of "allophone words". (See Table 1 for the General Instrument Allophone Dictionary). First, there is no one-ta-one correspondence between written letters and speech sounds; secondly, speech sounds are acoustically different depending upon their position within a word; and lastly, the human ear may perceive the same acoustic signal differently in the context of different sounds. The first point compares to the problem that a child encounters when learning to read. Each sound in a language may be represented by more than one letter and, conversely each letter may represent more than one sound. (See the examples in Table 2.) Because of these spelling irregularities, it is necessary to think in terms of sounds, not letters, when using allophones.

The second, and equally important, point to understand, is that the acoustic signal of a speech sound may differ depending upon its position within a word. For example, the initial K sound in coop will be acoustically different from the K sound in keep and speak. The K's in coop and keep differ due to the influence of the vowels which follow them, and the final K in speak is usually not as loud as initial K's.

Finally, a listener may identify the same acoustic signal differently depending on the context in which it is perceived. Don't be surprised, therefore, if an allophone word sounds slightly different when used in various phrases.

Phonemes Of English

The sounds of a language are called phonemes, and each language has a set which is slightly different from that of other languages. Table 3 contains a chart of all the consonant phonemes of English, Table 4 all the vowel phonemes. Consonants are produced by creating an occlusion or constriction in the vocal tract which produces an aperiodic sound source. If the vocal cords are vibrating at the same time, as in the case of the voiced fricatives VV, DH, ZZ, and ZH, (See Table 5) there are two sound sources: one which is aperiodic and one which is periodic. Vowels are usually produced with a relatively open vocal tract and a periodic sound source provided by the vibrating vocal cords. They are classified according to whether the front or back of the tongue is high or low (See Table 4 whether they are long or short, and whether the lips are rounded or unrounded. In English all rounded vowels are produced in or near the back of the mouth (UW, UH, OW, AO, OR, AW). Speech sounds which have features in common behave in similar ways. For example, the voiceless stop consonants PP, TT, and KK (See Table 3) should be preceded by 50-80 msec of silence, and the voiced stop consonants BB, DD, and GG by 10-30 msec of silence.

Allophones

Phoneme is the name given to a group of similar sounds in a language. Recall that a phoneme is acoustically different depending upon its position within a word. Each of these positional variants is an allophone of the same phoneme. An allophone, therefore, is the manifestation of a phoneme in true speech signal. It is for this reason that our inventory of English speech sounds is called an allophone set.

How To Use The Allophone Set

(See Table 1 for instructions on how to create all the sample words mentioned in this section.) The allophone set (Refer to Table 5) contains two or three versions of some phonemes. It may be necessary to use one allophone of a particular phoneme for word-or-syllable-final position. A detailed set of guidelines for using the allophones is given in Table 5. Note that these are suggestions, not rules.

For example, DD2 sounds good in initial position and DD1 sounds good in final position, as in "daughter" and "collide". One of the differences between the initial and final versions of a consonant is that an initial version may be longer than the final version. Therefore, to create an initial SS. you can use two SSs instead of the usual single SS at the end of a word or syllable, as in "sister". Note that this can be done with TH, and FF, and the inherently short vowels (to be discussed below), but with no other consonants. You will want to experiment with some consonants such as str, cl) to discover which version works best in the cluster. For example, KK1 sounds good before LL as in "clown", and KK2 sounds good before WW as in "square". One allophone of a particular phoneme may sound better before or after back vowels and another before or after front vowels. KK3 sounds good before UH and KK1 sounds good before IY, as in "cookie", Some sounds (PP, BB, TT, DD, KK, GG, CH, and JH) require a brief duration of silence before them. For most of these, the silence has already been added but you may decide you want to add more. Therefore there are several pauses included in the allophone set varying from 10-200 msec. To create the final sounds in the words "letter" and "little" use the allophones ER and EL.

Remember that you must always think about how a word sounds, not how it is spelled. For example, the NG sound is represented by the letter N in "uncle". And remember that some sounds may not even be represented in words by any letters, as the YY in "computer".

As mentioned earlier there are some vowels which can be doubled to make longer versions for stressed syllables. These are the inherently short vowels I H, EH, AE, AX, AA, and UH. For example, in the word "extent" use one EH in the first syllable, which is unstressed and two EHs in the second syllable which is stressed. Of the inherently long vowels there is one, UW, which has a long and short version. The short one, UW1, sounds good after YY in computer. The long version, UW2, sounds good in monosyllabic words like "two". Included in the vowel set is a group called R-colored vowels. These are vowel + R combinations. For example, the AR in "alarm" and the OR in "score". Of the R-colored vowels there is one, ER, which has a long and short version. The short version is good for polysyllabic words with final ER sounds like "letter", and the long version is good for monosyllabic words like "fir". Om' final suggestion is that you may want to add a pause of 30-50 msec between words, when creating sentences, and a pause of 100-200 msec between clauses.

Note: Every utterance must be followed by a pause in order to make the chip stop talking the last allophone.

### TABLE 1:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **NUMBERS** |  | seventeen | SS SS EH VV TH | |
|  |  |  | NN1 PA2 PA3 TT2 | |
| zero | ZZ YR OW |  | IY NN1 |  |
| one, won | WW AX AX NN1 | eighteen | EY PA2 PA3 TT2 | |
| two, to, too | TT2 UW2 |  | IY NN1 |  |
| three | TH RR1 IY | nineteen | NN1 AY NN1 PA2 | |
| four, for, fore | FF FF OR |  | PA3 TT2 IY NN1 | |
| five | FF FF AY VV | twenty | TT2 WH EH EH | |
| six | SS SS IH IH PA3 |  | NN1 PA2 PA3 TT2 IY | |
|  | KK2 SS | thirty | TH ER2 PA2 PA3 | |
| seven | SS SS EH EH VV IH |  | TT2 IY |  |
|  | NN1 | forty | FF OR PA3 TT2 IY | |
| eight, ate | EY PA3 TT2 | fifty | FF FF IH FF FF | |
| nine | NN1 AA AY NN1 |  | PA2 PA3 TT2 IY | |
| ten | TT2 EH EH NN1 | sixty | SS SS IH PA3 KK2 | |
| eleven | IH LL EH EH VV |  | SS PA2 PA3 TT2 IY | |
|  | IH NN1 | seventy | SS SS EH VV IH | |
| twelve | TT2 WH EH EH LL |  | NN1 PA2 PA3 TT2 IY | |
|  | VV | eighty | EY PA3 TT2 IY | |
| thirteen | TH ER1 PA2 PA3 | ninety | NN1 AY NN1 PA3 | |
|  | TT2 IY NN1 |  | TT2 IY |  |
| fourteen | FF OR PA2 PA3 | hundred | HH2 AX AX NN1 | |
|  | TT2 IY NN1 |  | PA2 DD2 RR2 IH | |
| fifteen | FF IH FF PA2 PA3 |  | IH PA1 DD1 | |
|  | TT2 IY NN1 | thousand | TH AA AW ZZ TH | |
| sixteen | SS SS IH PA3 KK2 |  | PA1 PA1 NN1 DD1 | |
|  | SS PA2 PA3 TT2 IY | million | MM IH IH LL YY1 | |
|  | NN1 |  | AX NN1 |  |

|  |  |  |  |
| --- | --- | --- | --- |
| DAY OF THE WEEK | |  | EH MM PA1 BB2 |
|  |  |  | ER1 |
| Sunday | SS SS AX AX NN1 |  |  |
|  | PA2 DD2 EY | LETTERS |  |
| Monday | MM AX AX NN1 |  |  |
|  | PA2 DD2 EY | A | EY |
| Tuesday | TT2 UW2 ZZ PA2 | B | BB2 IY |
|  | DD2 EY | C | SS SS IY |
| Wednesday | WW EH EH NN1 ZZ | D | 002 IY |
|  | PA2 DD2 EY | E | IY |
| Thursday | TH ER2 ZZ PA2 | F | EH EH FF FF |
|  | DD2 EY | G | JH IY |
| Friday | FF RR2 AY PA2 | H | EY PA2 PA3 CH |
|  | DD2 EY | I | AA AY |
| Saturday | SS SS AE PA3 | J | JH EH EY |
|  | TT2 PA2 DD2 EY | K | KK1 EH EY |
|  |  | L | EH EH EL |
| MONTHS |  | M | EH EH MM |
|  |  | N | EH EH NN1 |
| January | JH AE AE NN1 | O | OW |
|  | YY2 XR lY | P | PP IY |
| February | FF EH EH PA1 | Q | KK1 YY1 UW2 |
|  | BR RR2 UW2 XR IY | R | AR |
| March | MM AR PA3 CH | S | EH EH SS SS |
| April | EY PA3 PP RR2 | T | TT2 IY |
|  | IH IH LL | U | YYl UW2 |
| May | MM EY | V | VV IY |
| June | JH UW2 NN1 | W | DD2 AX PA2 BB2 |
| July | JH UW1 LL AY |  | EL YY1 UW2 |
| August | AO AO PA2 GG2 | X | EH EH PA3 KK2 |
|  | AX SS PA3 TT1 |  | SS SS |
| September | SS SS EH PA3 PP | Y | WW AY |
|  | PA3 TT2 EH EH | Z | ZZ IY |
|  | PA1 BB2 ER1 |  |  |
| October | AA PA2 KK2 PA3 | DICTIONARY | |
|  | TT2 OW PA1 BB2 |  |  |
|  | ER1 | alarm | AX LL AR MM |
| November | NN2 OW VV EH EH | bathe | BB2 EY DH2 |
|  | MM PA1 BB2 ER1 | bather | BB2 EY DH2 ER1 |
| December | DD2 IY SS SS EH | bathing | BB2 EY DH2 IH NG |

|  |  |  |  |
| --- | --- | --- | --- |
| beer | BB2 YR | crown | KK1 RR2 AW NN1 |
| bread | BB1 RR2 EH EH PA1 | date | DD2 EY PA3 TT2 |
|  | DD1 | daughter | DD2 AO TT2 ERl |
| by | BB2 AA AY | day | DD2 EH EY |
| calendar | KK1 AE AE LL | divided | DD2 IH VV AY |
|  | EH NN1 PA2 DD2 |  | PA2 DD2 IH PA2 |
|  | ER1 |  | DD1 |
| clock | KK1 LL AA AA | emotional | IY MM OW SH AX |
|  | PA3 KK2 |  | NN1 AX EL |
| clown | KK1 LL AW NN1 | engage | EH EH PA1 NN1 |
| check | CH EH EH PA3 |  | GGI EY PA2 JH |
|  | KK2 | engagement | EH EH PA1 NN1 |
| checked | CH EH EH PA3 |  | GG1 EY PA2 JH MM |
|  | KK2 PA2 TT2 |  | EH EH NN1 PA2 |
| checker | CH EH EH PA3 |  | PA3 TT2 |
|  | KK1 ER1 | engages | EH EH PA1 NN1 |
| checkers | CH EH EH PA3 |  | GG1 EY PA2 JH IH |
|  | KK1 ER1 ZZ |  | ZZ |
| checking | CH EH EH PA3 | engaging | EH EH PA1 NN1 |
|  | KK1 IH NG |  | GG1 EY PA2 JH IH |
| checks | CH EH EH PA3 |  | NG |
|  | KK1 SS | enrage | EH NN1 RR1 EY |
| cognitive | KK3 AA AA GG3 |  | PA2 JH |
|  | NN1 IH PA3 TT2 | enraged | EH NN1 RR1 EY |
|  | IH VV |  | PA2 JH PA2 DD1 |
| collide | KK3 AX LL AY | enrages | EH NN1 RR1 EY |
|  | DD1 |  | PA2 JH IH ZZ |
| computer | KK1 AX MM PP1 | enraging | EH NN1 RR1 EY |
|  | YY1 UW1 TT2 ER |  | PA2 JH IH NG |
| cookie | KK3 UH KK1 IY | escape | EH SS SS PA3 |
| coop | KK3 UW2 PA3 PP |  | KK1 PA2 PA3 PP |
| correct | KK1 ER2 EH EH | escaped | EH SS SS PA3 |
|  | PA2 KK2 PA2 TT1 |  | KK1 PA2 PA3 PP |
| corrected | KK1 ER2 EH EH |  | PA2 TT2 |
|  | PA2 KK2 PA2 TT2 | escapes | EH SS SS PA3 KK1 |
|  | IH PA2 DDI |  | PA2 PA3 PP SS |
| correcting | KK1 ER2 EH EH | escaping | EH SS SS PA3 KK1 |
|  | PA2 KK2 PA2 TT2 |  | PA2 PA3 PP IH NG |
|  | IH NG | equal | lY PA2 PA3 KK3 |
| corrects | KK1 ER2 EH EH |  | WH AX EL |
|  | PA2 KK2 PA2 TT1 | equals | IY PA2 PA3 KK3 |
|  | SS |  | WH AX EL ZZ |

|  |  |  |  |
| --- | --- | --- | --- |
| error | EH XR OR | investigate | IH IH NN1 VV EH |
| extent | EH KK1 SS TT2 EH |  | EH SS PA2 PA3 |
|  | EH NN1 TT2 |  | TT2 IH PA1 GG1 |
| fir | FF ER2 |  | EY PA2 TT2 |
| freeze | FF FF RR1 IY ZZ | investigated | IH IH NN1 VV EH |
| freezer | FF FF RR1 IY ZZ |  | EH SS PA2 PA3 |
|  | ER1 |  | TT2 IH PA1 GG1 |
| freezers | FF FF RR1 IY ZZ |  | EY PA2 TT2 IH PA2 |
|  | ERl ZZ |  | DD1 |
| freezing | FF FF RR1 IY ZZ | investigator | IH IH NN1 VV EH |
|  | IH NG |  | EH SS PA2 PA3 |
| frozen | FF FF RR1 OW ZZ |  | TT2 IH PA1 GG1 |
|  | EH NN1 |  | EY PA2 TT2 ER1 |
|  |  | investigators | IH IH NN1 VV EH |
| gauge | GG1 EY PA2 JH |  | EH SS PA2 PA3 |
| guaged | GG1 EY PA2 JH |  | TT2 IH PA1 GG1 |
|  | PA2 DD1 |  | EY PA2 TT2 ER1 |
| guages | GG1 EY PA2 JH |  | ZZ |
|  | IH ZZ | investigates | IH IH NN1 VV EH |
| guaging | GGI EY PA2 JH |  | EH SS PA2 PA3 |
|  | IH NG |  | TT2 IH PA1 GG1 |
|  |  |  | EY PA2 TT1 SS |
| hello | HH EH LL AX OW | investigating | IH IH NN1 VV EH |
| hour | AW ER1 |  | EH SS PA2 PA3 |
|  |  |  | TT2 IH PA1 GG1 |
| infinitive | IH NN1 FF FF IH |  | EY PA2 TT2 IH NG |
|  | IH NN1 IH PA2 PA3 | key | KK1 IY |
|  | TT2 IH VV | legislate | LL EH EH PA2 |
| intrigue | IH NN1 PA3 TT2 |  | JH JH SS SS LL EY |
|  | RR2 IY PA1 GG3 |  | PA2 PA3 TT2 |
| intrigued | IH NN1 PA3 TT2 | legislated | LL EH EH PA2 |
|  | RR2 IY PA1 GG3 |  | JH JH SS SS LL EY |
|  | PA2 DD1 |  | PA2 PA3 TT2 IH DD1 |
| intrigues | IH NN1 PA3 TT2 | legislates | LL EH EH PA2 |
|  | RR2 IY PA1 GG3 |  | JH JH SS SS LL EY |
|  | ZZ |  | PA2 PA3 TT1 SS |
| intriguing | IH NN1 PA3 TT2 | legislating | LL EH EH PA2 |
|  | RR2 IY PA1 GG3 |  | JH JH SS SS LL EY |
|  | IH NG |  | PA2 PA3 TT2 IH NG |

|  |  |  |  |
| --- | --- | --- | --- |
| legislature | LL EH EH PA2 | pledging | PP LL EH EH PA3 |
|  | JH JH SS SS LL EY |  | JH IH NG |
|  | PA2 PA3 CH ER1 | plus | PP LL AX AX SS |
| letter | LL EH EH PA3 |  | SS |
|  | TT2 ER1 |  |  |
| litter | LL IH IH PA3 TT2 | ray | RR1 EH EY |
|  | ER1 | rays | RR1 EH EY ZZ |
| little | LL IH IH PA3 TT2 | ready | RR1 EH EH PA1 |
|  | EL |  | DD2 IY |
| memory | MM EH EH MM | red | RR1 EH FH PA1 |
|  | ER2 IY |  | DD1 |
| memories | MM EH EH MM | robot | RR1 OW PA2 BB2 |
|  | ER2 IY ZZ |  | AA PA3 TT2 |
| minute | MM IH NN1 IH PA3 | robots | RR1 OW PA2 BB2 |
|  | TT2 |  | AA PA3 TT1 SS |
| month | MM AX NN1 TH |  |  |
|  |  | score | SS SS PA3 KK3 OR |
| nip | NN1 IH IH PA2 | second | SS SS EH PA3 KK1 |
|  | PA3 PP |  | IH NN1 PA2 DD1 |
| nipped | NN1 IH IH PA2 | sensitive | SS SS EH EH NN1 |
|  | PA3 PP PA3 TT2 |  | SS SS IH PA2 PA3 |
| nipping | NN1 IH IH PA2 |  | TT2 IH VV |
|  | PA3 PP IH NG | sensitivity | SS SS EH EH NN1 |
| nips | NN1 IH IH PA2 |  | SS SS IH PA2 PA3 |
|  | PA3 PP SS |  | TT2 IH VV IH PA2 |
| no | NN2 AX OW |  | PA3 TT2 IY |
| physical | FF FF IH ZZ IH | sincere | SS SS IH IH NN1 |
|  | PA3 KK1 AX EL |  | SS SS YR |
| pin | PP IH IH NN1 | sincerely | SS SS IH IH NN1 |
| pinned | PP IH IH NN1 |  | SS SS YR LL IY |
|  | PA2 DDl | sincerity | SS SS IH IH NN1 |
| pinning | PP IH IH NN1 IH |  | SS SS EH EH RR1 |
|  | NG1 |  | IH PA2 PA3 TT2 IY |
| pins | PP IH IH NN1 ZZ | sister | SS SS IH IH SS |
| pledge | PP LL EH FH PA3 JH |  | PA3 TT2 ER1 |
| pledged | PP LL EH EH PA3 |  |  |
|  | JH PA2 DD1 | speak | SS SS PA3 IY PA3 |
| pledges | PP LL EH EH PA3 |  | KK2 |
|  | JH IH ZZ |  |  |

|  |  |  |  |
| --- | --- | --- | --- |
| spell | SS SS PA3 PP EH | subject (verb) | SS SS AX PA2 BB1 |
|  | EH EL |  | PA2 JH EH EH PA3 |
| spelled | SS SS PA3 PP EH |  | KK2 PA3 TT2 |
|  | EH EL PA3 DD1 | sweat | SS SS WW EH EH |
| speller | SS SS PA3 PP EH |  | PA3 TT2 |
|  | EH EL ER2 | sweated | SS SS WW EH EH |
| spellers | SS SS PA3 PP EH |  | PA3 TT2 IH PA3 |
|  | EH EL ER2 ZZ |  | DD1 |
| spelling | SS SS PA3 PP EH | sweater | SS SS WW EH EH |
|  | EH EL IH NG |  | PA3 TT2 ER1 |
| spells | SS SS PA3 PP EH | sweaters | SS SS WW EH EH |
|  | EH EL ZZ |  | PA3 TT2 ER1 ZZ |
| start | SS SS PA3 TT2 AR | sweating | SS SS WW EH EH |
|  | PA3 TT2 |  | PA3 TT2 IH NG |
| started | SS SS PA3 TT2 AR | sweats | SS SS WW EH EH |
|  | PA3 TT2 IH PA1 |  | PA3 TT2 SS |
|  | DD2 | switch | SS SS WH IH IH |
| starter | SS SS PA3 TT2 AR |  | PA3 CH |
|  | PA3 TT2 ERl | switched | SS SS WH IH IH |
| starting | SS SS PP3 TT2 AR |  | PA3 CH PA3 TT2 |
|  | PA3 TT2 IH NG | switches | SS SS WH IH IH |
| starts | SS SS PP3 TT2 AR |  | PA3 CH IH ZZ2 |
|  | PA3 TT1 SS | switching | SS SS WH IH IH |
| stop | SS SS PA3 TT1 AA |  | PA3 CH IH NG2 |
|  | AA PA3 PP | system | SS SS IH IH SS SS |
| stopped | SS SS PA3 TT1 AA |  | PA3 TT2 EH MM |
|  | AA PA3 PP PA3 TT2 | systems | SS SS I H I H SS SS |
| stopper | SS SS PA3 TT1 AA |  | PA3 TT2 EH MM ZZ |
|  | AA PA3 PP ERl | talk | TT2 AO AO PA2 |
| stopping | SS SS PA3 TT1 AA |  | KK2 |
|  | AA PA3 PP IH NG | talked | TT2 AO AO PA3 |
| stops | SS SS PA3 TT1 AA |  | KK2 PA3 TT2 |
|  | AA PA3 PP SS | talker | TT2 AO AO PA3 |
| subject (noun) | SS SS AX AX PA2 |  | KK1 ERl |
|  | BB1 PA2 JH EH PA3 | talkers | TT2 AO AO PA3 |
|  | KK2 PA3 TT2 |  | KK1 ERl ZZ |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| talking | TT2 AO AO PA3 | TABLE 2 - Examples of Spelling Irregularities | | |
|  | KK1 IH NG |  |  |  |
| talk | TT2 AO AO PA2 |  |  |  |
|  | KK2 SS |  | Same sound | Different sounds |
| thread | TH RR1 EH EH |  | represented by | represented by |
|  | PA2 DD1 |  | different letters | the same letters |
| threaded | TH RR1 EH EH | Vowels | mEAt | vEIn |
|  | PA2 DD2 IH PA2 |  | fEEt | forEIgn |
|  | DD1 |  | pEte | dEIsm |
| threader | TH RR1 EH EH |  | pEOple | dEIcer |
|  | PA2 DD2 ER1 |  | pennY | gEIsha |
| threaders | TH RR1 EH EH |  |  |  |
|  | PA2 DD2 ER1 ZZ | Consonants | SHip | althouGH |
| threading | TH RR1 EH EH |  | tenSI0n | GHastly |
|  | PA2 DD2 IH NG |  | preCIous | couGH |
| threads | TH RR1 EH EH |  | naTIon | hiccouGH |
|  | PA2 DD2 ZZ |  |  |  |
| then | DH1 EH EH NN1 |  |  |  |
| time | TT2 AA AY MM |  |  |  |
| times | TT2 AA AY MM ZZ |  |  |  |
|  |  |  |  |  |
| uncle | AX NG PA3 KK3 EL |  |  |  |
|  |  |  |  |  |
| whale | WW EY EL |  |  |  |
| whaler | WW EY LL ER1 |  |  |  |
| whalers | WW EY LL ER1 ZZ |  |  |  |
| whales | WW EY EL ZZ |  |  |  |
| whaling | WW EY LL TH NG |  |  |  |
|  |  |  |  |  |
| year | YY2 YR |  |  |  |
| yes | YY2 EH EH SS SS |  |  |  |

### TABLE 3 - CONSONANT PHONEMES OF ENGLISH

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  | **LABIO-** | **INTER-** | **ALVEO-** |  |  |  |
|  |  | **LABIAL** | **DENTAL** | **DENTAL** | **LAR** | **PALATAL** | **VELAR** | **GLOTTAL** |
| **Stops** | Voiceless | PP |  |  | TT |  | KK |  |
|  | Voiced | BB |  |  | DD |  | GG |  |
|  |  |  |  |  |  |  |  |  |
| **Fricatives** | Voiceless | WH | FF | TH | SS | SH |  | HH |
|  | Voiced |  | VV | DH | ZZ | ZH\* |  |  |
|  |  |  |  |  |  |  |  |  |
| **Affricates** | Voiceless |  |  |  |  | CH |  |  |
|  | Voiced |  |  |  |  | JH |  |  |
|  |  |  |  |  |  |  |  |  |
| **Nasals** | Voiced | MM |  |  | NN |  | NG\* |  |
|  |  |  |  |  |  |  |  |  |
| **Resonants** | Voiced | WW |  |  | RR,LL | YY |  |  |

\* These do not occur in word-initial position in English

|  |  |  |  |
| --- | --- | --- | --- |
| **Labial** | Upper and lower lips | **Palatal** | Body of tongue approximates |
|  | touch or approximate |  | palate (roof of |
|  |  |  | mouth) |
| **Labio-Dental** | Upper teeth and lower | **Velar** | Body of tongue touches |
|  | lip touch |  | Velum (posterior portion |
|  |  |  | of roof of mouth) |
| **Inter-Dental** | Tongue between teeth | **Glottal** | Glottis (opening between |
|  |  |  | vocal cords) |
| **Alveolar** | Tip of tongue touches or |  |  |
|  | approximates alveolar |  |  |
|  | ridge (just behind upper |  |  |
|  | teeth) |  |  |

### TABLE 4 - VOWEL PHONEMES OF ENGLISH

|  |  |  |  |
| --- | --- | --- | --- |
|  | **FRONT** | **CENTRAL** | **BACK** |
| **HIGH** | YR |  |  |
|  | IY |  | UW# |
|  | IH\* |  | UH\*# |
| **MID** | EY | ER | OW# |
|  | EH\* | AX\* | OY# |
|  | XR |  |  |
| **LOW** | AE\* | AW# | AO\*# |
|  |  | AY | OR# |
|  |  | AR |  |
|  |  | AA\* |  |

**\* Short Vowels**

**# Rounded Vowels**

### TABLE 5 - GUIDELINES FOR USING THE ALLOPHONES

|  |  |  |  |
| --- | --- | --- | --- |
| **Silence** |  | **Resonants** |  |
| PA1 | 10 mS before BB, DD, GG, | /WW/ | we, warrant, linguist |
|  | and JH | /RR1/ | initial position: read, |
| PA2 | 30 mS before BB, DD, GG, |  | write, x-ray |
|  | and JH | /RR2/ | initial clusters: brown, |
| PA3 | 50 mS before PP, TT, KK, |  | crane, grease |
|  | and CH, and between | /LL/ | like, hello, steel |
|  | words | /YY1/ | clusters: cute, beauty, |
| PA4 | 100 mS between clauses and |  | computer |
|  | sentences | /YY2/ | initial position: yes, yarn, |
| PA5 | 200 mS between clauses and |  | yo-yo |
|  | sentences |  |  |
|  |  | **Voiced Fricatives** |  |
| **Short Vowels** |  | /VV/ | vest, prove, even |
| \*/IH/ | sitting, stranded | /DH1/ | word-initial position: this, |
| \*/EH/ | extent, gentlemen |  | then, they |
| \*/AE/ | extract, acting | /DH2/ | word-final and between |
| \*/UH/ | cookie, full |  | vowels: bathe, bathing |
| \*/AO/ | talking, song | /ZZ/ | zoo, phase |
| \*/AX/ | lapel, instruct | /ZH/ | beige, pleasure |
| \*/AA/ | pottery, cotton |  |  |

### TABLE 5 - GUIDELINES FOR USING THE ALLOPHONES (continued)

|  |  |  |  |
| --- | --- | --- | --- |
| **R-Colored Vowels** | | **Voiced Stops** |  |
| /ER1/ | letter, furniture, interrupt | /BB1/ | final position: rib; between |
| /ER2/ | monosyllables: bird, |  | vowels: fibber, in clusters: |
|  | fern, burn |  | bleed, brown |
| /OR/ | fortune, adorn, store | /BB2/ | initial position before a |
| /AR/ | farm, alarm, garment |  | vowel: beast |
| /YR/ | hear, earring, irresponsible | /DD1/ | final position: played, end |
| /XR/ | hair, declare, stare | /DD2/ | initial position: down; clusters |
|  |  |  | drain |
|  |  | /GG1/ | before high front vowels: YR, |
|  |  |  | IY, IH, EY, EH, XR |
|  |  | /GG2/ | before high back vowels: UW, |
|  |  |  | UH, OW, OY, AX; and clusters: |
|  |  |  | green, glue |
|  |  | /GG3/ | before low vowels: AE, AW, |
|  |  |  | AY,AR,AA,AO,OR,ER; |
|  |  |  | and medial clusters : anger; |
|  |  |  | and final position: peg |

|  |  |  |  |
| --- | --- | --- | --- |
| **Voiceless Stops** | | **Affricates** |  |
| /PP/ | pleasure, ample, trip | /CH/ | church, feature |
| /TT1/ | final clusters before SS: tests | /JH/ | judge, injure |
|  | its |  |  |
| /TT2/ | all other positions: test, street | **Nasal** |  |
| /KK1/ | before front vowels: YR, IY, | /MM/ | milk, alarm, ample |
|  | IH, EV, EH, XR, AV, AE, | /NN1/ | before front and central vow- |
|  | ER, AX; initial clusters: cute, |  | els: VR, IV, IH, EV, EH, |
|  | clown, scream |  | XR, AE, ER, AX, AW, AV, |
| /KK2/ | final position: speak; final |  | UW; final clusters: earn |
|  | clusters: task | /NN2/ | before back vowels: UH, OW, |
| /KK3/ | before back vowels: UW, UH, |  | OY,OR,AR,AA |
|  | OW, OV, OR, AR, AO; initial | /NG/ | string, anger |
|  | clusters: crane, quick, clown, |  |  |
|  | scream |  |  |
|  |  | \* These allophones can be doubled. | |

### TABLE 6 – Allophone Address Table

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **DECIMAL** |  | **SAMPLE** |  | **DECIMAL** |  | **SAMPLE** |  |
| **ADDRESS** | **ALLOPHONE** | **WORD** | **DURATION** | **ADDRESS** | **ALLOPHONE** | **WORD** | **DURATION** |
| 0 | PA1 | PAUSE | 10 mS | 32 | /AW/ | Out | 370 mS |
| 1 | PA2 | PAUSE | 30 mS | 33 | /DD2/ | Do | 160 mS |
| 2 | PA3 | PAUSE | 50 mS | 34 | /GG3/ | Wig | 140 mS |
| 3 | PA4 | PAUSE | 100 mS | 35 | /VV/ | Vest | 190 mS |
| 4 | PA5 | PAUSE | 200 mS | 36 | /GG1/ | Got | 80 mS |
| 5 | /OY/ | Boy | 420 mS | 37 | /SH/ | Ship | 160 mS |
| 6 | /AY/ | Sky | 260 mS | 38 | /ZH/ | Azure | 190 mS |
| 7 | /EH/ | End | 70 mS | 39 | /RR2/ | Brain | 120 mS |
| 8 | /KK3 | Comb | 120 mS | 40 | /FF/ | Food | 150 mS |
| 9 | /PP/ | Pow | 210 mS | 41 | /KK2/ | Sky | 190 mS |
| 10 | /JH/ | Dodge | 140 mS | 42 | /KK1/ | Can't | 160 mS |
| 11 | /NN1/ | Thin | 140 mS | 43 | /ZZ/ | Zoo | 210 mS |
| 12 | /IH/ | Sit | 70 mS | 44 | /NG/ | Anchor | 220 mS |
| 13 | /TT2/ | To | 140 mS | 45 | /LL/ | Lake | 110 mS |
| 14 | /RR1/ | Rural | 170 mS | 46 | /WW/ | Wool | 180 mS |
| 15 | /AX/ | Succeed | 70 mS | 47 | /XR/ | Repair | 360 mS |
| 16 | /MM/ | Milk | 180 mS | 48 | /VH/ | Whig | 200 mS |
| 17 | /TT1/ | Part | 100 mS | 49 | /YY1/ | Yes | 130 mS |
| 18 | /DH1/ | They | 290 mS | 50 | /CH/ | Church | 190mS |
| 19 | /IY/ | See | 250 mS | 51 | /ER1/ | Fir | 160 mS |
| 20 | /EY/ | Beige | 280 mS | 52 | /ER2/ | Fir | 300 mS |
| 21 | /DD1/ | Could | 70 mS | 53 | /OW/ | Beau | 240 mS |
| 22 | /UW1/ | To | 100 mS | 54 | /DH2/ | They | 240 mS |
| 23 | /AO/ | Aught | 100 mS | 55 | /SS/ | Vest | 90 mS |
| 24 | /AA/ | Hot | 100 mS | 56 | /NN2/ | No | 190 mS |
| 25 | /YY2/ | Yes | 180 mS | 57 | /HH2/ | Hoe | 180 mS |
| 26 | /AE/ | Hat | 120 mS | 58 | /OR/ | Store | 330 mS |
| 27 | /HH1/ | He | 130 mS | 59 | /AR/ | Alarm | 290 mS |
| 28 | /BB1/ | Business | 80 mS | 60 | /YR/ | Clear | 350 mS |
| 29 | /TH/ | Thin | 180 mS | 61 | /GG2/ | Guest | 40 mS |
| 30 | /UH/ | Book | 100 mS | 62 | /EL/ | Saddle | 190 mS |
| 31 | /UW2/ | Food | 260 mS | 63 | /BB2/ | Business | 50 mS |