

# The C90 encoding for Thai

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## 1 Introduction

This file describes a font encoding for Thai, as presented in a TUGboat article [1]. The glyph names follow the Adobe Glyph List (AGL) [2] recommendations. Since most available Thai fonts neither use AGL glyph names nor follow the font encoding used here, you have to be careful in setting up a proper encoding vector. A specialty (for reasons explained below) is that three glyphs, namely `/uni0E38` (Thai character ‘sara u’), `/uni0E39` (Thai character ‘sara uu’), and `/uni0E3A` (Thai character ‘phinthu’) must appear twice in the encoding; the additional glyph indices are `0x80`, `0x81`, and `0x82`, respectively.

## 2 Ligatures

The tricky part is implementing the ligatures. TeX’s ligature mechanism only provides contextual patterns of length 2. Due to the very nature of the ETX format, ligatures aren’t grouped into classes which makes this file rather long.

Thai glyphs can be grouped functionally into base glyphs (which are spacing glyphs) and diacritics (which have zero advance width). Usually, diacritical glyphs represent either vowels or tone indicators, whereas base glyphs represent consonants – I won’t go into detail here; please read the Unicode standard [4] or any introduction into the Thai script for more information.

The general composing rules are as follows:

$$CV \xrightarrow{V} C, \quad CT \xrightarrow{T} C, \quad CVT \xrightarrow{\begin{matrix} T \\ V \end{matrix}} C, \quad Cv \xrightarrow{v} C, \quad CvT \xrightarrow{\begin{matrix} T \\ v \end{matrix}} C$$

where  $C$  represents a base consonant,  $V$  an upper vowel,  $v$  a lower vowel, and  $T$  a tone mark. The tone mark always comes last.

Sometimes you will find documents which have first the tone mark and then the vowel. In real Thai input systems, this error will be caught and fixed by reordering the characters according to the TIS-620 Thai encoding standard before any output is created. The ligatures given below are not able to handle such incorrect data, and you have to normalize it before using them.

It depends on context where the diacritics are exactly positioned; some base glyphs have overlong ascenders or descenders, making it necessary to shift the diacritics vertically and horizontally.

To complicate things, the Thai vowel ‘sara am’ (TIS-620 code point 0xD3, Unicode value U+0E33), which looks like the final nasal sign ‘nikhahit’ (0xED, U+0E4D) followed by the vowel ‘sara aa’ (0xD2, U+0E32), will be decomposed into these two glyphs for rendering. The difficulty is that we must position the tone mark of the *previous* character properly! Thus we have

$$C + SM \xrightarrow{N} C + SA, \quad C + T + SM \xrightarrow{N} C + SA$$

A last specialty (used for Sanskrit written in Thai) is that ‘sara aa’ if it follows the independent vowel letter ‘ru’ (0xC4, U+0E24) or ‘lu’ (0xC6, U+0E26) is replaced with the ‘lakkhangyao’ sign (0xE5, U+0E45).

### 3 Glyph Classes

To describe the patterns and rules we start with defining glyph classes.

*base<sub>normal</sub>* Normal base glyphs without special features.

*base<sub>desc</sub>* Base glyphs with descender.

*base<sub>deslike</sub>* These base glyphs consist of two elements which look like a normal base glyph combined with a lower vowel diacritic; the diacritic-like element will be omitted if combined with a lower vowel.

*base<sub>asc</sub>* Base glyphs with an ascender on the right side.

*base<sub>indic</sub>* The two independent vowels *ru* and *lu*.

*base<sub>sign</sub>* The sign *lakkhangyao*.

*base<sub>sara am</sub>* The vowel *sara am*.

*base<sub>sara aa</sub>* The vowel *sara aa*.

*lower* Lower vowel diacritics.

*upper<sub>vowel</sub>* Upper vowel diacritics.

*upper<sub>sign</sub>* The *nikhahit* final nasal sign.

*top* Tone marks.

Here the glyph variant classes:

*base<sub>descless</sub>* The glyphs of class *base<sub>deslike</sub>* without the lower part.

*lower<sub>low</sub>* The glyphs of class *lower* shifted downwards.

*upper<sub>vowel<sub>left</sub></sub>* The glyphs of class *upper<sub>vowel</sub>* shifted to the left.

*upper<sub>sign</sub><sub>left</sub>* The glyphs of class *upper<sub>sign</sub>* shifted to the left.  
*top<sub>left</sub>* The glyphs of class *top* shifted to the left.  
*top<sub>low</sub>* The glyphs of class *top* shifted downwards.  
*top<sub>low-left</sub>* The glyphs of class *top* shifted to the left and downwards.

## 4 Context Patterns

Using the glyph classes defined in the last section it is easy to describe the context patterns for base glyphs with diacritical signs. Surprisingly, these patterns are quite systematic. Patterns in table 1 which are marked with an asterisk do nothing and are listed for completeness only. Note that these patterns cover combinations which don't happen in the Thai script (which doesn't harm).

Table 2 covers the ligatures of the character *sara am*. Finally, table 3 describes the letters specific to Sanskrit.

## 5 T<sub>E</sub>X's Ligature Mechanism

A small introduction into the exotic variants of T<sub>E</sub>X's ligature mechanism which probably many users haven't seen before. Additionally, the documentation in the *METAFONTbook* [3] is very sparse. In the following examples METAFONT's notation is used.

The usual ligature action of two glyphs *a* and *b* is the replacement of both glyphs with another glyph *c*.

$$a b =: c$$

Another possibility is to retain the left or the right original glyph (before and after the ligature, respectively) or both.

$$a b |=: c \quad a b =:| c \quad a b |=:| c$$

The first rule creates *ac*, the second *cb*, and the last *acb*. In all three cases, the current point after applying the ligature rule is still at the first glyph of the replaced glyphs, and T<sub>E</sub>X simply restarts there to check ligatures (and kernings). A classical example is

$$f f i \rightarrow f f i \rightarrow f f i$$

To advance the current point to the right, append either *>* or *>>* (the latter is only possible if you retain both input glyphs). Here are the remaining four ligature rules.

$$a b |=:> c \quad a b =:|> c \\ a b |=:|> c \quad a b |=:|>> c$$

For Thai ligatures, the most often needed rule is *|=:* (i.e., retain the left glyph and stay at the same position before applying the next ligature rule). Note that using *|=:>* instead is not a good idea since this would prohibit kerning between the left glyph and the ligature.

<i>base</i>	<i>lower</i>	→	<i>base</i>	<i>lower</i>	*
<i>base</i>	<i>upper</i>	→	<i>base</i>	<i>upper</i>	*
<i>base</i>	<i>top</i>	→	<i>base</i>	<i>top<sub>low</sub></i>	
<i>base</i>	<i>lower</i>	<i>top</i> →	<i>base</i>	<i>lower</i>	<i>top<sub>low</sub></i>
<i>base</i>	<i>upper</i>	<i>top</i> →	<i>base</i>	<i>upper</i>	<i>top</i> *
<i>base<sub>desc</sub></i>	<i>lower</i>	→	<i>base<sub>desc</sub></i>	<i>lower<sub>low</sub></i>	
<i>base<sub>desc</sub></i>	<i>upper</i>	→	<i>base<sub>desc</sub></i>	<i>upper</i>	*
<i>base<sub>desc</sub></i>	<i>top</i>	→	<i>base<sub>desc</sub></i>	<i>top<sub>low</sub></i>	
<i>base<sub>desc</sub></i>	<i>lower</i>	<i>top</i> →	<i>base<sub>desc</sub></i>	<i>lower<sub>low</sub></i>	<i>top<sub>low</sub></i>
<i>base<sub>desc</sub></i>	<i>upper</i>	<i>top</i> →	<i>base<sub>desc</sub></i>	<i>upper</i>	<i>top</i> *
<i>base<sub>deslike</sub></i>	<i>lower</i>	→	<i>base<sub>desclless</sub></i>		
<i>base<sub>deslike</sub></i>	<i>upper</i>	→	<i>base<sub>deslike</sub></i>	<i>upper</i>	*
<i>base<sub>deslike</sub></i>	<i>top</i>	→	<i>base<sub>deslike</sub></i>	<i>top<sub>low</sub></i>	
<i>base<sub>deslike</sub></i>	<i>lower</i>	<i>top</i> →	<i>base<sub>desclless</sub></i>	<i>lower</i>	<i>top<sub>low</sub></i>
<i>base<sub>deslike</sub></i>	<i>upper</i>	<i>top</i> →	<i>base<sub>deslike</sub></i>	<i>upper</i>	<i>top</i> *
<i>base<sub>asc</sub></i>	<i>lower</i>	→	<i>base<sub>asc</sub></i>	<i>lower</i>	*
<i>base<sub>asc</sub></i>	<i>upper</i>	→	<i>base<sub>asc</sub></i>	<i>upper<sub>left</sub></i>	
<i>base<sub>asc</sub></i>	<i>top</i>	→	<i>base<sub>asc</sub></i>	<i>top<sub>low-left</sub></i>	
<i>base<sub>asc</sub></i>	<i>lower</i>	<i>top</i> →	<i>base<sub>asc</sub></i>	<i>lower</i>	<i>top<sub>low-left</sub></i>
<i>base<sub>asc</sub></i>	<i>upper</i>	<i>top</i> →	<i>base<sub>asc</sub></i>	<i>upper<sub>left</sub></i>	<i>top<sub>left</sub></i>

Table 1: Context patterns for diacritical signs. Here, *base* refers to the union of the subclasses *normal*, *indic*, *sign*, *sara am*, and *sara aa* of *base*; *upper* is the union of the subclasses *vowel* and *sign* of *upper*.

<i>base</i>	<i>base<sub>sara am</sub></i>	→	<i>base</i>	<i>upper<sub>sign</sub></i>	<i>base<sub>sara aa</sub></i>
<i>base<sub>asc</sub></i>	<i>base<sub>sara am</sub></i>	→	<i>base<sub>asc</sub></i>	<i>upper<sub>sign<sub>left</sub></sub></i>	<i>base<sub>sara aa</sub></i>
<i>base</i>	<i>top</i>	<i>base<sub>sara am</sub></i> →	<i>base</i>	<i>upper<sub>sign</sub></i>	<i>top</i> <i>base<sub>sara aa</sub></i>
<i>base<sub>asc</sub></i>	<i>top</i>	<i>base<sub>sara am</sub></i> →	<i>base<sub>asc</sub></i>	<i>upper<sub>sign<sub>left</sub></sub></i>	<i>top<sub>left</sub></i> <i>base<sub>sara aa</sub></i>

Table 2: Context patterns for *sara am*. Here, *base* denotes the union of subclasses *normal*, *desc*, and *deslike* of *base*.

$$base_{indic} \ base_{sara \ aa} \rightarrow base_{indic} \ base_{sign}$$

Table 3: Context patterns for *ru* and *lu*.

<i>base</i>	<i>top</i>	→	<i>base</i>	<i>top<sub>low</sub></i>
<i>base<sub>desc</sub></i>	<i>lower</i>	→	<i>base<sub>desc</sub></i>	<i>lower<sub>low</sub></i>
<i>base<sub>desc</sub></i>	<i>top</i>	→	<i>base<sub>desc</sub></i>	<i>top<sub>low</sub></i>
<i>base<sub>desclike</sub></i>	<i>lower</i>	→	<i>base<sub>descless</sub></i>	<i>lower</i>
<i>base<sub>desclike</sub></i>	<i>top</i>	→	<i>base<sub>desclike</sub></i>	<i>top<sub>low</sub></i>
<i>base<sub>asc</sub></i>	<i>lower</i>	→	<i>base<sub>asc</sub></i>	<i>lower<sub>left</sub></i>
<i>base<sub>asc</sub></i>	<i>upper</i>	→	<i>base<sub>asc</sub></i>	<i>upper<sub>left</sub></i>
<i>base<sub>asc</sub></i>	<i>top</i>	→	<i>base<sub>asc</sub></i>	<i>top<sub>low-left</sub></i>
<i>lower</i>	<i>top</i>	→	<i>lower</i>	<i>top<sub>low</sub></i>
<i>lower<sub>low</sub></i>	<i>top</i>	→	<i>lower<sub>low</sub></i>	<i>top<sub>low</sub></i>
<i>upper<sub>left</sub></i>	<i>top</i>	→	<i>upper<sub>left</sub></i>	<i>top<sub>left</sub></i>
<i>lower<sub>left</sub></i>	<i>top</i>	→	<i>lower<sub>left</sub></i>	<i>top<sub>low-left</sub></i>

Table 4: Ligature rules for diacritical marks.

## 6 Ligature Rules

As just explained,  $\text{T}_{\text{E}}\text{X}$  can only handle context patterns of length 2, whereas Thai needs patterns of length 3. It was an interesting challenge to find out whether the problem can be solved with  $\text{T}_{\text{E}}\text{X}$ 's somewhat restricted ligature rules – the gentle reader is invited to find a solution by herself! There won't be any difficulties in understanding ligatures afterwards.

The tables 4, 5, and 6 use the same conventions as tables 1, 2, and 3, respectively. The current point isn't increased in any of the rules.

Most of the ligature rules can be derived easily by handling the patterns sequentially (quite similar to logic puzzles found in various magazines), but at the end there remain two patterns which apparently contradict.

$$\begin{aligned}
 & \textit{base} \ \textit{lower} \ \textit{top} \rightarrow \textit{base} \ \textit{lower} \ \textit{top}_{\textit{low}} \\
 & \textit{base}_{\textit{asc}} \ \textit{lower} \ \textit{top} \rightarrow \textit{base}_{\textit{asc}} \ \textit{lower} \ \textit{top}_{\textit{low-left}}
 \end{aligned}$$

After applying ligature rules for the first two glyph classes it is necessary to handle the context '*lower top*', but depending on the previous glyph class *top* must be replaced with *top<sub>left</sub>* and *top<sub>low-left</sub>*, respectively. With a context pattern length of 3 this would be easy to solve, but  $\text{T}_{\text{E}}\text{X}$  doesn't have this feature. What to do?

The context '*base lower top*' must be distinguished from '*base<sub>asc</sub> lower top*', i.e., two different *lower* classes are needed depending on the previous character since  $\text{T}_{\text{E}}\text{X}$  is not able to forward information from one ligature cycle to the next. The idea is now to create an 'alias class', a class which behaves identically to

<i>base</i>	<i>base_sara am</i> → <i>base</i>	<i>upper_sign</i>	<i>base_sara am</i>
<i>base_asc</i>	<i>base_sara am</i> → <i>base_asc</i>	<i>upper_sign_left</i>	<i>base_sara am</i>
<i>upper_sign</i>	<i>base_sara am</i> → <i>upper_sign</i>	<i>base_sara_aa</i>	
<i>upper_sign_left</i>	<i>base_sara am</i> → <i>upper_sign_left</i>	<i>base_sara_aa</i>	
<i>top_low</i>	<i>base_sara am</i> → <i>top_low</i>	<i>top</i>	<i>base_sara am</i>
<i>top_low</i>	<i>top</i> → <i>upper_sign</i>	<i>top</i>	
<i>top</i>	<i>base_sara am</i> → <i>top</i>	<i>base_sara_aa</i>	
<i>top_low-left</i>	<i>base_sara am</i> → <i>top_low-left</i>	<i>top_left</i>	<i>base_sara am</i>
<i>top_low-left</i>	<i>top_left</i> → <i>upper_sign_left</i>	<i>top_left</i>	
<i>top_left</i>	<i>base_sara am</i> → <i>top_left</i>	<i>base_sara_aa</i>	

Table 5: Ligature rules for *sara am*.

*base\_indic base\_sara\_aa* → *base\_indic base\_sign*

Table 6: Ligature rule for *ru* and *lu*.

the original one. The glyphs in this alias class are the same, but different glyph indices and glyph names are assigned to it. A closer look to table 4 shows that *lower\_left* isn't a typo but the alias class of *lower*.

## 7 The Implementation

After solving the problem theoretically now the practical implementation. All glyph names follow the *Adobe Glyph List (AGL)* [2]. There are no predefined Adobe glyph names for Thai, so the prefix 'uni' with attached Unicode value will be used for all glyphs which are encoded in Unicode. Glyph variants are identified by an arbitrarily chosen postfix.

Here the real glyph names for the various classes. Hexadecimal values in parentheses after the glyph name give the glyph indices in the encoding vector.

*base\_normal*:

<i>uni0E01</i> (0xA1)	<i>uni0E09</i> (0xA9)
<i>uni0E02</i> (0xA2)	<i>uni0E0A</i> (0xAA)
<i>uni0E03</i> (0xA3)	<i>uni0E0B</i> (0xAB)
<i>uni0E04</i> (0xA4)	<i>uni0E0C</i> (0xAC)
<i>uni0E05</i> (0xA5)	<i>uni0E11</i> (0xB1)
<i>uni0E06</i> (0xA6)	<i>uni0E12</i> (0xB2)
<i>uni0E07</i> (0xA7)	<i>uni0E13</i> (0xB3)
<i>uni0E08</i> (0xA8)	<i>uni0E14</i> (0xB4)

uni0E15 (0xB5)	uni0E25 (0xC5)
uni0E16 (0xB6)	uni0E27 (0xC7)
uni0E17 (0xB7)	uni0E28 (0xC8)
uni0E18 (0xB8)	uni0E29 (0xC9)
uni0E19 (0xB9)	uni0E2A (0xCA)
uni0E1A (0xBA)	uni0E2B (0xCB)
uni0E1C (0xBC)	uni0E2D (0xCD)
uni0E1E (0xBE)	uni0E2E (0xCE)
uni0E20 (0xC0)	uni0E2F (0xCF)
uni0E21 (0xC1)	uni0E30 (0xD0)
uni0E22 (0xC2)	uni0E40 (0xE0)
uni0E23 (0xC3)	uni0E41 (0xE1)
<i>base_desc:</i>	
uni0E0E (0xAE)	uni0E0F (0xAF)
<i>base_desclike:</i>	
uni0E0D (0xAD)	uni0E10 (0xB0)
<i>base_indic:</i>	
uni0E24 (0xC4)	uni0E26 (0xC6)
<i>base_sign:</i>	
uni0E45 (0xE5)	
<i>base_asc:</i>	
uni0E1B (0xBB)	uni0E1F (0xBF)
uni0E1D (0xBD)	uni0E2C (0xCC)
<i>base_sara_am:</i>	
uni0E33 (0xD3)	
<i>base_sara_aa:</i>	
uni0E32 (0xD2)	
<i>base_descless:</i>	
uni0E0D.descless (0x90)	uni0E10.descless (0x9F)
<i>lower:</i>	
uni0E38 (0xD8)	uni0E3A (0xDA)
uni0E39 (0xD9)	
<i>lower_left:</i>	
uni0E38.left (0x80)	uni0E3A.left (0x82)
uni0E39.left (0x81)	

*lower<sub>low</sub>*:

uni0E38.low (0xFC)	uni0E3A.low (0xFE)
uni0E39.low (0xFD)	

*upper<sub>vowel</sub>*:

uni0E31 (0xD1)	uni0E37 (0xD7)
uni0E34 (0xD4)	uni0E47 (0xE7)
uni0E35 (0xD5)	uni0E4D (0xED)
uni0E36 (0xD6)	

*upper<sub>sign</sub>*:

uni0E4D (0xED)	
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*upper<sub>vowel<sub>left</sub></sub>*:

uni0E31.left (0x92)	uni0E37.left (0x97)
uni0E34.left (0x94)	uni0E47.left (0x93)
uni0E35.left (0x95)	uni0E4D.left (0x8F)
uni0E36.left (0x96)	

*upper<sub>sign<sub>left</sub></sub>*:

uni0E4D.left (0x8F)	
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*top*:

uni0E48 (0xE8)	uni0E4B (0xEB)
uni0E49 (0xE9)	uni0E4C (0xEC)
uni0E4A (0xEA)	

*top<sub>left</sub>*:

uni0E48.left (0x98)	uni0E4B.left (0x9B)
uni0E49.left (0x99)	uni0E4C.left (0x9C)
uni0E4A.left (0x9A)	

*top<sub>low</sub>*:

uni0E48.low (0x88)	uni0E4B.low (0x8B)
uni0E49.low (0x89)	uni0E4C.low (0x8C)
uni0E4A.low (0x8A)	

*top<sub>low-left</sub>*:

uni0E48.low_left (0x83)	uni0E4B.low_left (0x86)
uni0E49.low_left (0x84)	uni0E4C.low_left (0x87)
uni0E4A.low_left (0x85)	

Automatic processing of this document as a data file requires fontinst v 1.918 or higher.



## 8 Coding Scheme

Default `s(codingscheme) = C90_THAI_ENCODING`

## 9 Non-Thai Characters

Of the many different L<sup>A</sup>T<sub>E</sub>X encodings, OT1 supports ASCII best (and this is what most Type 1 Thai fonts have). This has two advantages: We can use the raw Thai font without specifying a new encoding (switching to OT1 will be sufficient), and it will work with plain T<sub>E</sub>X also.

We use the OT1 layout for typewriter fonts (i.e., for `cmtt`) with the exception that ‘arrowup’ and ‘arrowdown’ are replaced with ‘endash’ and ‘emdash’, and the seldom used ‘dotlessj’ with ‘quotedblleft’.

### Slot 0 ‘Gamma’

Unicode character U+0393, GREEK CAPITAL LETTER GAMMA.

### Slot 1 ‘Delta’

Unicode character U+0394, GREEK CAPITAL LETTER DELTA.

### Slot 2 ‘Theta’

Unicode character U+0398, GREEK CAPITAL LETTER THETA.

### Slot 3 ‘Lambda’

Unicode character U+039B, GREEK CAPITAL LETTER LAMDA.

### Slot 4 ‘Xi’

Unicode character U+039E, GREEK CAPITAL LETTER XI.

### Slot 5 ‘Pi’

Unicode character U+03A0, GREEK CAPITAL LETTER PI.

### Slot 6 ‘Sigma’

Unicode character U+03A3, GREEK CAPITAL LETTER SIGMA.

### Slot 7 ‘Upsilon’

Unicode character U+03D2, GREEK UPSILON WITH HOOK SYMBOL.

### Slot 8 ‘Phi’

Unicode character U+03A6, GREEK CAPITAL LETTER PHI.

### Slot 9 ‘Psi’

Unicode character U+03A8, GREEK CAPITAL LETTER PSI.

### Slot 10 ‘Omega’

Unicode character U+03A9, GREEK CAPITAL LETTER OMEGA.

### Slot 11 ‘endash’

Unicode character U+2013, EN DASH.

**Mandatory ligature** `endash * hyphen` → `emdash`

This is ‘arrowup’ in OT1 encoding.

**Slot 12 ‘emdash’**

Unicode character U+2014, EM DASH.

This is ‘arrowdown’ in OT1 encoding.

**Slot 13 ‘quotesingle’**

Unicode character U+0027, APOSTROPHE.

**Slot 14 ‘exclamdown’**

Unicode character U+00A1, INVERTED EXCLAMATION MARK.

**Slot 15 ‘questiondown’**

Unicode character U+00BF, INVERTED QUESTION MARK.

**Slot 16 ‘dotlessi’**

Unicode character U+0131, LATIN SMALL LETTER DOTLESS I.

**Slot 17 ‘quotedblleft’**

Unicode character U+201C, LEFT DOUBLE QUOTATION MARK.

This is ‘dotlessj’ in OT1 encoding.

**Slot 18 ‘grave’**

Unicode character U+0300, COMBINING GRAVE ACCENT.

**Slot 19 ‘acute’**

Unicode character U+0301, COMBINING ACUTE ACCENT.

**Slot 20 ‘caron’**

Unicode character U+030C, COMBINING CARON.

**Slot 21 ‘breve’**

Unicode character U+0306, COMBINING BREVE.

**Slot 22 ‘macron’**

Unicode character U+0304, COMBINING MACRON.

**Slot 23 ‘ring’**

Unicode character U+030A, COMBINING RING ABOVE.

**Slot 24 ‘cedilla’**

Unicode character U+0327, COMBINING CEDILLA.

**Slot 25 ‘germandbls’**

Unicode character U+00DF, LATIN SMALL LETTER SHARP S.

**Slot 26 ‘ae’**

Unicode character U+00E6, LATIN SMALL LETTER AE.

**Slot 27 ‘oe’**

Unicode character U+0153, LATIN SMALL LIGATURE OE.

**Slot 28 ‘oslash’**

Unicode character U+00F8, LATIN SMALL LETTER O WITH STROKE.

**Slot 29 ‘AE’**

Unicode character U+00C6, LATIN CAPITAL LETTER AE.

**Slot 30 ‘OE’**

Unicode character U+0152, LATIN CAPITAL LIGATURE OE.

**Slot 31 ‘Oslash’**

Unicode character U+00D8, LATIN CAPITAL LETTER O WITH STROKE.

**Slot 33 ‘exclam’**

Unicode character U+0021, EXCLAMATION MARK.

**Mandatory ligature** `exclam * quoteleft → exclamdown`

**Slot 34 ‘quotedblright’**

Unicode character U+201D, RIGHT DOUBLE QUOTATION MARK.

**Slot 35 ‘numeralsign’**

Unicode character U+0023, NUMBER SIGN.

**Slot 36 ‘dollar’**

Unicode character U+0024, DOLLAR SIGN.

**Slot 37 ‘percent’**

Unicode character U+0025, PERCENT SIGN.

**Slot 38 ‘ampersand’**

Unicode character U+0026, AMPERSAND.

**Slot 39 ‘quoteright’**

Unicode character U+2019, RIGHT SINGLE QUOTATION MARK.

**Mandatory ligature** `quoteright * quoteright → quotedblright`

**Slot 40 ‘parenleft’**

Unicode character U+0028, LEFT PARENTHESIS.

**Slot 41 ‘parenright’**

Unicode character U+0029, RIGHT PARENTHESIS.

**Slot 42 ‘asterisk’**

Unicode character U+002A, ASTERISK.

**Slot 43 ‘plus’**

Unicode character U+002B, PLUS SIGN.

**Slot 44 ‘comma’**

Unicode character U+002C, COMMA.

**Slot 45 ‘hyphen’**

Unicode character U+002D, HYPHEN-MINUS.

**Mandatory ligature** `hyphen * hyphen → endash`

**Slot 46 ‘period’**

Unicode character U+002E, FULL STOP.

**Slot 47 ‘slash’**

Unicode character U+002F, SOLIDUS.

**Slot 48 ‘zero’**  
Unicode character U+0030, DIGIT ZERO.

**Slot 49 ‘one’**  
Unicode character U+0031, DIGIT ONE.

**Slot 50 ‘two’**  
Unicode character U+0032, DIGIT TWO.

**Slot 51 ‘three’**  
Unicode character U+0033, DIGIT THREE.

**Slot 52 ‘four’**  
Unicode character U+0034, DIGIT FOUR.

**Slot 53 ‘five’**  
Unicode character U+0035, DIGIT FIVE.

**Slot 54 ‘six’**  
Unicode character U+0036, DIGIT SIX.

**Slot 55 ‘seven’**  
Unicode character U+0037, DIGIT SEVEN.

**Slot 56 ‘eight’**  
Unicode character U+0038, DIGIT EIGHT.

**Slot 57 ‘nine’**  
Unicode character U+0039, DIGIT NINE.

**Slot 58 ‘colon’**  
Unicode character U+003A, COLON.

**Slot 59 ‘semicolon’**  
Unicode character U+003B, SEMICOLON.

**Slot 60 ‘less’**  
Unicode character U+003C, LESS-THAN SIGN.

**Slot 61 ‘equal’**  
Unicode character U+003D, EQUALS SIGN.

**Slot 62 ‘greater’**  
Unicode character U+003E, GREATER-THAN SIGN.

**Slot 63 ‘question’**  
Unicode character U+003F, QUESTION MARK.  
**Mandatory ligature** `question * quoteleft → questiondown`

**Slot 64 ‘at’**  
Unicode character U+0040, COMMERCIAL AT.

**Slot 65 ‘A’**  
Unicode character U+0041, LATIN CAPITAL LETTER A.

**Slot 66 ‘B’**  
Unicode character U+0042, LATIN CAPITAL LETTER B.

**Slot 67 ‘C’**  
Unicode character U+0043, LATIN CAPITAL LETTER C.

**Slot 68 ‘D’**  
Unicode character U+0044, LATIN CAPITAL LETTER D.

**Slot 69 ‘E’**  
Unicode character U+0045, LATIN CAPITAL LETTER E.

**Slot 70 ‘F’**  
Unicode character U+0046, LATIN CAPITAL LETTER F.

**Slot 71 ‘G’**  
Unicode character U+0047, LATIN CAPITAL LETTER G.

**Slot 72 ‘H’**  
Unicode character U+0048, LATIN CAPITAL LETTER H.

**Slot 73 ‘I’**  
Unicode character U+0049, LATIN CAPITAL LETTER I.

**Slot 74 ‘J’**  
Unicode character U+004A, LATIN CAPITAL LETTER J.

**Slot 75 ‘K’**  
Unicode character U+004B, LATIN CAPITAL LETTER K.

**Slot 76 ‘L’**  
Unicode character U+004C, LATIN CAPITAL LETTER L.

**Slot 77 ‘M’**  
Unicode character U+004D, LATIN CAPITAL LETTER M.

**Slot 78 ‘N’**  
Unicode character U+004E, LATIN CAPITAL LETTER N.

**Slot 79 ‘O’**  
Unicode character U+004F, LATIN CAPITAL LETTER O.

**Slot 80 ‘P’**  
Unicode character U+0050, LATIN CAPITAL LETTER P.

**Slot 81 ‘Q’**  
Unicode character U+0051, LATIN CAPITAL LETTER Q.

**Slot 82 ‘R’**  
Unicode character U+0052, LATIN CAPITAL LETTER R.

**Slot 83 ‘S’**  
Unicode character U+0053, LATIN CAPITAL LETTER S.

**Slot 84 ‘T’**

Unicode character U+0054, LATIN CAPITAL LETTER T.

**Slot 85 ‘U’**

Unicode character U+0055, LATIN CAPITAL LETTER U.

**Slot 86 ‘V’**

Unicode character U+0056, LATIN CAPITAL LETTER V.

**Slot 87 ‘W’**

Unicode character U+0057, LATIN CAPITAL LETTER W.

**Slot 88 ‘X’**

Unicode character U+0058, LATIN CAPITAL LETTER X.

**Slot 89 ‘Y’**

Unicode character U+0059, LATIN CAPITAL LETTER Y.

**Slot 90 ‘Z’**

Unicode character U+005A, LATIN CAPITAL LETTER Z.

**Slot 91 ‘bracketleft’**

Unicode character U+005B, LEFT SQUARE BRACKET.

**Slot 92 ‘backslash’**

Unicode character U+005C, REVERSE SOLIDUS.

**Slot 93 ‘bracketright’**

Unicode character U+005D, RIGHT SQUARE BRACKET.

**Slot 94 ‘circumflex’**

Unicode character U+0302, COMBINING CIRCUMFLEX ACCENT.

**Slot 95 ‘underscore’**

Unicode character U+005F, LOW LINE.

**Slot 96 ‘quoteleft’**

Unicode character U+2018, LEFT SINGLE QUOTATION MARK.

**Mandatory ligature quoteleft \* quoteleft → quotedblleft**

**Slot 97 ‘a’**

Unicode character U+0061, LATIN SMALL LETTER A.

**Slot 98 ‘b’**

Unicode character U+0062, LATIN SMALL LETTER B.

**Slot 99 ‘c’**

Unicode character U+0063, LATIN SMALL LETTER C.

**Slot 100 ‘d’**

Unicode character U+0064, LATIN SMALL LETTER D.

**Slot 101 ‘e’**

Unicode character U+0065, LATIN SMALL LETTER E.

**Slot 102 ‘f’**

Unicode character U+0066, LATIN SMALL LETTER F.

**Slot 103 ‘g’**

Unicode character U+0067, LATIN SMALL LETTER G.

**Slot 104 ‘h’**

Unicode character U+0068, LATIN SMALL LETTER H.

**Slot 105 ‘i’**

Unicode character U+0069, LATIN SMALL LETTER I.

**Slot 106 ‘j’**

Unicode character U+006A, LATIN SMALL LETTER J.

**Slot 107 ‘k’**

Unicode character U+006B, LATIN SMALL LETTER K.

**Slot 108 ‘l’**

Unicode character U+006C, LATIN SMALL LETTER L.

**Slot 109 ‘m’**

Unicode character U+006D, LATIN SMALL LETTER M.

**Slot 110 ‘n’**

Unicode character U+006E, LATIN SMALL LETTER N.

**Slot 111 ‘o’**

Unicode character U+006F, LATIN SMALL LETTER O.

**Slot 112 ‘p’**

Unicode character U+0070, LATIN SMALL LETTER P.

**Slot 113 ‘q’**

Unicode character U+0071, LATIN SMALL LETTER Q.

**Slot 114 ‘r’**

Unicode character U+0072, LATIN SMALL LETTER R.

**Slot 115 ‘s’**

Unicode character U+0073, LATIN SMALL LETTER S.

**Slot 116 ‘t’**

Unicode character U+0074, LATIN SMALL LETTER T.

**Slot 117 ‘u’**

Unicode character U+0075, LATIN SMALL LETTER U.

**Slot 118 ‘v’**

Unicode character U+0076, LATIN SMALL LETTER V.

**Slot 119 ‘w’**

Unicode character U+0077, LATIN SMALL LETTER W.

**Slot 120 ‘x’**

Unicode character U+0078, LATIN SMALL LETTER X.

**Slot 121 ‘y’**

Unicode character U+0079, LATIN SMALL LETTER Y.

**Slot 122 ‘z’**

Unicode character U+007A, LATIN SMALL LETTER Z.

**Slot 123 ‘braceleft’**

Unicode character U+007B, LEFT CURLY BRACKET.

**Slot 124 ‘bar’**

Unicode character U+007C, VERTICAL LINE.

**Slot 125 ‘braceright’**

Unicode character U+007D, RIGHT CURLY BRACKET.

**Slot 126 ‘tilde’**

Unicode character U+0303, COMBINING TILDE.

**Slot 127 ‘dieresis’**

Unicode character U+0308, COMBINING DIAERESIS.

## 10 Thai Characters

This is TIS-620 encoding with glyph variants. The encoding presented in [1] contained two alternate glyph forms at positions 157 and 158 which have been removed meanwhile.

The number of all Thai ligature rules is quite big (464 in total). Note that vptovf will make the ligature table much more compact as it may appear here.

**Slot 128 ‘uni0E38’****Slot 129 ‘uni0E39’****Slot 130 ‘uni0E3A’****Slot 131 ‘uni0E48.low\_left’**

A glyph variant of U+0E48 (THAI CHARACTER MAI EK).

**Mandatory ligature**

uni0E48.low\_left \* uni0E33 → uni0E48.low\_left \* uni0E48.left \* uni0E33

**Mandatory ligature**

uni0E48.low\_left \* uni0E48.left → uni0E4D.left \* uni0E48.left

**Slot 132 ‘uni0E49.low\_left’**

A glyph variant of U+0E49 (THAI CHARACTER MAI THO).

**Mandatory ligature**

uni0E49.low\_left \* uni0E33 → uni0E49.low\_left \* uni0E49.left \* uni0E33

**Mandatory ligature**

uni0E49.low\_left \* uni0E49.left → uni0E4D.left \* uni0E49.left



**Slot 133 ‘uni0E4A.low\_left’**

A glyph variant of U+0E4A (THAI CHARACTER MAI TRI).

**Mandatory ligature**

uni0E4A.low\_left \* uni0E33 → uni0E4A.low\_left \* uni0E4A.left \* uni0E33

**Mandatory ligature**

uni0E4A.low\_left \* uni0E4A.left → uni0E4D.left \* uni0E4A.left

**Slot 134 ‘uni0E4B.low\_left’**

A glyph variant of U+0E4B (THAI CHARACTER MAI CHATTAWA).

**Mandatory ligature**

uni0E4B.low\_left \* uni0E33 → uni0E4B.low\_left \* uni0E4B.left \* uni0E33

**Mandatory ligature**

uni0E4B.low\_left \* uni0E4B.left → uni0E4D.left \* uni0E4B.left

**Slot 135 ‘uni0E4C.low\_left’**

A glyph variant of U+0E4C (THAI CHARACTER THANTHAKHAT).

**Mandatory ligature**

uni0E4C.low\_left \* uni0E33 → uni0E4C.low\_left \* uni0E4C.left \* uni0E33

**Mandatory ligature**

uni0E4C.low\_left \* uni0E4C.left → uni0E4D.left \* uni0E4C.left

**Slot 136 ‘uni0E48.low’**

A glyph variant of U+0E48 (THAI CHARACTER MAI EK).

**Mandatory ligature**

uni0E48.low \* uni0E33 → uni0E48.low \* uni0E48 \* uni0E33

**Mandatory ligature** uni0E48.low \* uni0E48 → uni0E4D \* uni0E48

**Slot 137 ‘uni0E49.low’**

A glyph variant of U+0E49 (THAI CHARACTER MAI THO).

**Mandatory ligature**

uni0E49.low \* uni0E33 → uni0E49.low \* uni0E49 \* uni0E33

**Mandatory ligature** uni0E49.low \* uni0E49 → uni0E4D \* uni0E49

**Slot 138 ‘uni0E4A.low’**

A glyph variant of U+0E4A (THAI CHARACTER MAI TRI).

**Mandatory ligature**

uni0E4A.low \* uni0E33 → uni0E4A.low \* uni0E4A \* uni0E33

**Mandatory ligature** uni0E4A.low \* uni0E4A → uni0E4D \* uni0E4A

**Slot 139 ‘uni0E4B.low’**

A glyph variant of U+0E4B (THAI CHARACTER MAI CHATTAWA).

**Mandatory ligature**

uni0E4B.low \* uni0E33 → uni0E4B.low \* uni0E4B \* uni0E33

**Mandatory ligature** uni0E4B.low \* uni0E4B → uni0E4D \* uni0E4B

**Slot 140 ‘uni0E4C.low’**

A glyph variant of U+0E4C (THAI CHARACTER THANTHAKHAT).

**Mandatory ligature**

uni0E4C.low \* uni0E33 → uni0E4C.low \* uni0E4C \* uni0E33

**Mandatory ligature** uni0E4C.low \* uni0E4C → uni0E4D \* uni0E4C

**Slot 143** ‘uni0E4D.left’

A glyph variant of U+0E4D (THAI CHARACTER NIKHAHIT).

**Mandatory ligature** uni0E4D.left \* uni0E33 → uni0E4D.left \* uni0E32

**Mandatory ligature**

uni0E4D.left \* uni0E48 → uni0E4D.left \* uni0E48.left

**Mandatory ligature**

uni0E4D.left \* uni0E49 → uni0E4D.left \* uni0E49.left

**Mandatory ligature**

uni0E4D.left \* uni0E4A → uni0E4D.left \* uni0E4A.left

**Mandatory ligature**

uni0E4D.left \* uni0E4B → uni0E4D.left \* uni0E4B.left

**Mandatory ligature**

uni0E4D.left \* uni0E4C → uni0E4D.left \* uni0E4C.left

**Slot 144** ‘uni0E0D.descless’

A glyph variant of U+0E0D (THAI CHARACTER YO YING).

**Slot 146** ‘uni0E31.left’

A glyph variant of U+0E31 (THAI CHARACTER MAI HAN-AKAT).

**Mandatory ligature**

uni0E31.left \* uni0E48 → uni0E31.left \* uni0E48.left

**Mandatory ligature**

uni0E31.left \* uni0E49 → uni0E31.left \* uni0E49.left

**Mandatory ligature**

uni0E31.left \* uni0E4A → uni0E31.left \* uni0E4A.left

**Mandatory ligature**

uni0E31.left \* uni0E4B → uni0E31.left \* uni0E4B.left

**Mandatory ligature**

uni0E31.left \* uni0E4C → uni0E31.left \* uni0E4C.left

**Slot 147** ‘uni0E47.left’

A glyph variant of U+0E47 (THAI CHARACTER MAITAIKHU).

**Mandatory ligature**

uni0E47.left \* uni0E48 → uni0E47.left \* uni0E48.left

**Mandatory ligature**

uni0E47.left \* uni0E49 → uni0E47.left \* uni0E49.left

**Mandatory ligature**

uni0E47.left \* uni0E4A → uni0E47.left \* uni0E4A.left

**Mandatory ligature**

uni0E47.left \* uni0E4B → uni0E47.left \* uni0E4B.left

**Mandatory ligature**

uni0E47.left \* uni0E4C → uni0E47.left \* uni0E4C.left

**Slot 148** ‘uni0E34.left’

A glyph variant of U+0E34 (THAI CHARACTER SARA I).

**Mandatory ligature**

uni0E34.left \* uni0E48 → uni0E34.left \* uni0E48.left

**Mandatory ligature**

uni0E34.left \* uni0E49 → uni0E34.left \* uni0E49.left

**Mandatory ligature**

uni0E34.left \* uni0E4A → uni0E34.left \* uni0E4A.left

**Mandatory ligature**

uni0E34.left \* uni0E4B → uni0E34.left \* uni0E4B.left

**Mandatory ligature**

uni0E34.left \* uni0E4C → uni0E34.left \* uni0E4C.left

**Slot 149 ‘uni0E35.left’**

A glyph variant of U+0E35 (THAI CHARACTER SARA II).

**Mandatory ligature**

uni0E35.left \* uni0E48 → uni0E35.left \* uni0E48.left

**Mandatory ligature**

uni0E35.left \* uni0E49 → uni0E35.left \* uni0E49.left

**Mandatory ligature**

uni0E35.left \* uni0E4A → uni0E35.left \* uni0E4A.left

**Mandatory ligature**

uni0E35.left \* uni0E4B → uni0E35.left \* uni0E4B.left

**Mandatory ligature**

uni0E35.left \* uni0E4C → uni0E35.left \* uni0E4C.left

**Slot 150 ‘uni0E36.left’**

A glyph variant of U+0E36 (THAI CHARACTER SARA UE).

**Mandatory ligature**

uni0E36.left \* uni0E48 → uni0E36.left \* uni0E48.left

**Mandatory ligature**

uni0E36.left \* uni0E49 → uni0E36.left \* uni0E49.left

**Mandatory ligature**

uni0E36.left \* uni0E4A → uni0E36.left \* uni0E4A.left

**Mandatory ligature**

uni0E36.left \* uni0E4B → uni0E36.left \* uni0E4B.left

**Mandatory ligature**

uni0E36.left \* uni0E4C → uni0E36.left \* uni0E4C.left

**Slot 151 ‘uni0E37.left’**

A glyph variant of U+0E37 (THAI CHARACTER SARA UEE).

**Mandatory ligature**

uni0E37.left \* uni0E48 → uni0E37.left \* uni0E48.left

**Mandatory ligature**

uni0E37.left \* uni0E49 → uni0E37.left \* uni0E49.left

**Mandatory ligature**

uni0E37.left \* uni0E4A → uni0E37.left \* uni0E4A.left

**Mandatory ligature**

uni0E37.left \* uni0E4B → uni0E37.left \* uni0E4B.left

**Mandatory ligature**

uni0E37.left \* uni0E4C → uni0E37.left \* uni0E4C.left

**Slot 152** ‘uni0E48.left’

A glyph variant of U+0E48 (THAI CHARACTER MAI EK).

**Mandatory ligature** uni0E48.left \* uni0E33 → uni0E48.left \* uni0E32

**Slot 153** ‘uni0E49.left’

A glyph variant of U+0E49 (THAI CHARACTER MAI THO).

**Mandatory ligature** uni0E49.left \* uni0E33 → uni0E49.left \* uni0E32

**Slot 154** ‘uni0E4A.left’

A glyph variant of U+0E4A (THAI CHARACTER MAI TRI).

**Mandatory ligature** uni0E4A.left \* uni0E33 → uni0E4A.left \* uni0E32

**Slot 155** ‘uni0E4B.left’

A glyph variant of U+0E4B (THAI CHARACTER MAI CHATTAWA).

**Mandatory ligature** uni0E4B.left \* uni0E33 → uni0E4B.left \* uni0E32

**Slot 156** ‘uni0E4C.left’

A glyph variant of U+0E4C (THAI CHARACTER THANTHAKHAT).

**Mandatory ligature** uni0E4C.left \* uni0E33 → uni0E4C.left \* uni0E32

**Slot 159** ‘uni0E10.descless’

A glyph variant of U+0E10 (THAI CHARACTER THO THAN).

**Slot 161** ‘uni0E01’

Unicode character U+0E01, THAI CHARACTER KO KAI.

**Mandatory ligature** uni0E01 \* uni0E33 → uni0E01 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E01 \* uni0E48 → uni0E01 \* uni0E48.low

**Mandatory ligature** uni0E01 \* uni0E49 → uni0E01 \* uni0E49.low

**Mandatory ligature** uni0E01 \* uni0E4A → uni0E01 \* uni0E4A.low

**Mandatory ligature** uni0E01 \* uni0E4B → uni0E01 \* uni0E4B.low

**Mandatory ligature** uni0E01 \* uni0E4C → uni0E01 \* uni0E4C.low

**Slot 162** ‘uni0E02’

Unicode character U+0E02, THAI CHARACTER KHO KHAI.

**Mandatory ligature** uni0E02 \* uni0E33 → uni0E02 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E02 \* uni0E48 → uni0E02 \* uni0E48.low

**Mandatory ligature** uni0E02 \* uni0E49 → uni0E02 \* uni0E49.low

**Mandatory ligature** uni0E02 \* uni0E4A → uni0E02 \* uni0E4A.low

**Mandatory ligature** uni0E02 \* uni0E4B → uni0E02 \* uni0E4B.low

**Mandatory ligature** uni0E02 \* uni0E4C → uni0E02 \* uni0E4C.low

**Slot 163** ‘uni0E03’

Unicode character U+0E03, THAI CHARACTER KHO KHUAT.

**Mandatory ligature** uni0E03 \* uni0E33 → uni0E03 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E03 \* uni0E48 → uni0E03 \* uni0E48.low

**Mandatory ligature** uni0E03 \* uni0E49 → uni0E03 \* uni0E49.low

**Mandatory ligature** uni0E03 \* uni0E4A → uni0E03 \* uni0E4A.low

**Mandatory ligature** uni0E03 \* uni0E4B → uni0E03 \* uni0E4B.low

**Mandatory ligature** uni0E03 \* uni0E4C → uni0E03 \* uni0E4C.low

**Slot 164 ‘uni0E04’**

Unicode character U+0E04, THAI CHARACTER KHO KHWAI.

**Mandatory ligature** uni0E04 \* uni0E33 → uni0E04 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E04 \* uni0E48 → uni0E04 \* uni0E48.low

**Mandatory ligature** uni0E04 \* uni0E49 → uni0E04 \* uni0E49.low

**Mandatory ligature** uni0E04 \* uni0E4A → uni0E04 \* uni0E4A.low

**Mandatory ligature** uni0E04 \* uni0E4B → uni0E04 \* uni0E4B.low

**Mandatory ligature** uni0E04 \* uni0E4C → uni0E04 \* uni0E4C.low

**Slot 165 ‘uni0E05’**

Unicode character U+0E05, THAI CHARACTER KHO KHON.

**Mandatory ligature** uni0E05 \* uni0E33 → uni0E05 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E05 \* uni0E48 → uni0E05 \* uni0E48.low

**Mandatory ligature** uni0E05 \* uni0E49 → uni0E05 \* uni0E49.low

**Mandatory ligature** uni0E05 \* uni0E4A → uni0E05 \* uni0E4A.low

**Mandatory ligature** uni0E05 \* uni0E4B → uni0E05 \* uni0E4B.low

**Mandatory ligature** uni0E05 \* uni0E4C → uni0E05 \* uni0E4C.low

**Slot 166 ‘uni0E06’**

Unicode character U+0E06, THAI CHARACTER KHO RAKHANG.

**Mandatory ligature** uni0E06 \* uni0E33 → uni0E06 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E06 \* uni0E48 → uni0E06 \* uni0E48.low

**Mandatory ligature** uni0E06 \* uni0E49 → uni0E06 \* uni0E49.low

**Mandatory ligature** uni0E06 \* uni0E4A → uni0E06 \* uni0E4A.low

**Mandatory ligature** uni0E06 \* uni0E4B → uni0E06 \* uni0E4B.low

**Mandatory ligature** uni0E06 \* uni0E4C → uni0E06 \* uni0E4C.low

**Slot 167 ‘uni0E07’**

Unicode character U+0E07, THAI CHARACTER NGO NGU.

**Mandatory ligature** uni0E07 \* uni0E33 → uni0E07 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E07 \* uni0E48 → uni0E07 \* uni0E48.low

**Mandatory ligature** uni0E07 \* uni0E49 → uni0E07 \* uni0E49.low

**Mandatory ligature** uni0E07 \* uni0E4A → uni0E07 \* uni0E4A.low

**Mandatory ligature** uni0E07 \* uni0E4B → uni0E07 \* uni0E4B.low

**Mandatory ligature** uni0E07 \* uni0E4C → uni0E07 \* uni0E4C.low

**Slot 168 ‘uni0E08’**

Unicode character U+0E08, THAI CHARACTER CHO CHAN.

**Mandatory ligature** uni0E08 \* uni0E33 → uni0E08 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E08 \* uni0E48 → uni0E08 \* uni0E48.low

**Mandatory ligature** uni0E08 \* uni0E49 → uni0E08 \* uni0E49.low

**Mandatory ligature** uni0E08 \* uni0E4A → uni0E08 \* uni0E4A.low

**Mandatory ligature** uni0E08 \* uni0E4B → uni0E08 \* uni0E4B.low

**Mandatory ligature** uni0E08 \* uni0E4C → uni0E08 \* uni0E4C.low

**Slot 169 ‘uni0E09’**

Unicode character U+0E09, THAI CHARACTER CHO CHING.

**Mandatory ligature** uni0E09 \* uni0E33 → uni0E09 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E09 \* uni0E48 → uni0E09 \* uni0E48.low  
**Mandatory ligature** uni0E09 \* uni0E49 → uni0E09 \* uni0E49.low  
**Mandatory ligature** uni0E09 \* uni0E4A → uni0E09 \* uni0E4A.low  
**Mandatory ligature** uni0E09 \* uni0E4B → uni0E09 \* uni0E4B.low  
**Mandatory ligature** uni0E09 \* uni0E4C → uni0E09 \* uni0E4C.low

**Slot 170 ‘uni0E0A’**

Unicode character U+0E0A, THAI CHARACTER CHO CHANG.

**Mandatory ligature** uni0E0A \* uni0E33 → uni0E0A \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E0A \* uni0E48 → uni0E0A \* uni0E48.low  
**Mandatory ligature** uni0E0A \* uni0E49 → uni0E0A \* uni0E49.low  
**Mandatory ligature** uni0E0A \* uni0E4A → uni0E0A \* uni0E4A.low  
**Mandatory ligature** uni0E0A \* uni0E4B → uni0E0A \* uni0E4B.low  
**Mandatory ligature** uni0E0A \* uni0E4C → uni0E0A \* uni0E4C.low

**Slot 171 ‘uni0E0B’**

Unicode character U+0E0B, THAI CHARACTER SO SO.

**Mandatory ligature** uni0E0B \* uni0E33 → uni0E0B \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E0B \* uni0E48 → uni0E0B \* uni0E48.low  
**Mandatory ligature** uni0E0B \* uni0E49 → uni0E0B \* uni0E49.low  
**Mandatory ligature** uni0E0B \* uni0E4A → uni0E0B \* uni0E4A.low  
**Mandatory ligature** uni0E0B \* uni0E4B → uni0E0B \* uni0E4B.low  
**Mandatory ligature** uni0E0B \* uni0E4C → uni0E0B \* uni0E4C.low

**Slot 172 ‘uni0E0C’**

Unicode character U+0E0C, THAI CHARACTER CHO CHOE.

**Mandatory ligature** uni0E0C \* uni0E33 → uni0E0C \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E0C \* uni0E48 → uni0E0C \* uni0E48.low  
**Mandatory ligature** uni0E0C \* uni0E49 → uni0E0C \* uni0E49.low  
**Mandatory ligature** uni0E0C \* uni0E4A → uni0E0C \* uni0E4A.low  
**Mandatory ligature** uni0E0C \* uni0E4B → uni0E0C \* uni0E4B.low  
**Mandatory ligature** uni0E0C \* uni0E4C → uni0E0C \* uni0E4C.low

**Slot 173 ‘uni0E0D’**

Unicode character U+0E0D, THAI CHARACTER YO YING.

**Mandatory ligature** uni0E0D \* uni0E33 → uni0E0D \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E0D \* uni0E38 → uni0E0D.descless \* uni0E38  
**Mandatory ligature** uni0E0D \* uni0E39 → uni0E0D.descless \* uni0E39  
**Mandatory ligature** uni0E0D \* uni0E3A → uni0E0D.descless \* uni0E3A  
**Mandatory ligature** uni0E0D \* uni0E48 → uni0E0D \* uni0E48.low  
**Mandatory ligature** uni0E0D \* uni0E49 → uni0E0D \* uni0E49.low  
**Mandatory ligature** uni0E0D \* uni0E4A → uni0E0D \* uni0E4A.low  
**Mandatory ligature** uni0E0D \* uni0E4B → uni0E0D \* uni0E4B.low  
**Mandatory ligature** uni0E0D \* uni0E4C → uni0E0D \* uni0E4C.low

**Slot 174 ‘uni0E0E’**

Unicode character U+0E0E, THAI CHARACTER DO CHADA.

**Mandatory ligature** uni0E0E \* uni0E33 → uni0E0E \* uni0E4D \* uni0E33

Mandatory ligature uni0E0E \* uni0E38 → uni0E0E \* uni0E38.low  
Mandatory ligature uni0E0E \* uni0E39 → uni0E0E \* uni0E39.low  
Mandatory ligature uni0E0E \* uni0E3A → uni0E0E \* uni0E3A.low  
Mandatory ligature uni0E0E \* uni0E48 → uni0E0E \* uni0E48.low  
Mandatory ligature uni0E0E \* uni0E49 → uni0E0E \* uni0E49.low  
Mandatory ligature uni0E0E \* uni0E4A → uni0E0E \* uni0E4A.low  
Mandatory ligature uni0E0E \* uni0E4B → uni0E0E \* uni0E4B.low  
Mandatory ligature uni0E0E \* uni0E4C → uni0E0E \* uni0E4C.low

**Slot 175 ‘uni0E0F’**

Unicode character U+0E0F, THAI CHARACTER TO PATAK.

Mandatory ligature uni0E0F \* uni0E33 → uni0E0F \* uni0E4D \* uni0E33  
Mandatory ligature uni0E0F \* uni0E38 → uni0E0F \* uni0E38.low  
Mandatory ligature uni0E0F \* uni0E39 → uni0E0F \* uni0E39.low  
Mandatory ligature uni0E0F \* uni0E3A → uni0E0F \* uni0E3A.low  
Mandatory ligature uni0E0F \* uni0E48 → uni0E0F \* uni0E48.low  
Mandatory ligature uni0E0F \* uni0E49 → uni0E0F \* uni0E49.low  
Mandatory ligature uni0E0F \* uni0E4A → uni0E0F \* uni0E4A.low  
Mandatory ligature uni0E0F \* uni0E4B → uni0E0F \* uni0E4B.low  
Mandatory ligature uni0E0F \* uni0E4C → uni0E0F \* uni0E4C.low

**Slot 176 ‘uni0E10’**

Unicode character U+0E10, THAI CHARACTER THO THAN.

Mandatory ligature uni0E10 \* uni0E33 → uni0E10 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E10 \* uni0E38 → uni0E10.descless \* uni0E38  
Mandatory ligature uni0E10 \* uni0E39 → uni0E10.descless \* uni0E39  
Mandatory ligature uni0E10 \* uni0E3A → uni0E10.descless \* uni0E3A  
Mandatory ligature uni0E10 \* uni0E48 → uni0E10 \* uni0E48.low  
Mandatory ligature uni0E10 \* uni0E49 → uni0E10 \* uni0E49.low  
Mandatory ligature uni0E10 \* uni0E4A → uni0E10 \* uni0E4A.low  
Mandatory ligature uni0E10 \* uni0E4B → uni0E10 \* uni0E4B.low  
Mandatory ligature uni0E10 \* uni0E4C → uni0E10 \* uni0E4C.low

**Slot 177 ‘uni0E11’**

Unicode character U+0E11, THAI CHARACTER THO NANGMONTHO.

Mandatory ligature uni0E11 \* uni0E33 → uni0E11 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E11 \* uni0E48 → uni0E11 \* uni0E48.low  
Mandatory ligature uni0E11 \* uni0E49 → uni0E11 \* uni0E49.low  
Mandatory ligature uni0E11 \* uni0E4A → uni0E11 \* uni0E4A.low  
Mandatory ligature uni0E11 \* uni0E4B → uni0E11 \* uni0E4B.low  
Mandatory ligature uni0E11 \* uni0E4C → uni0E11 \* uni0E4C.low

**Slot 178 ‘uni0E12’**

Unicode character U+0E12, THAI CHARACTER THO PHUTHAO.

Mandatory ligature uni0E12 \* uni0E33 → uni0E12 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E12 \* uni0E48 → uni0E12 \* uni0E48.low  
Mandatory ligature uni0E12 \* uni0E49 → uni0E12 \* uni0E49.low  
Mandatory ligature uni0E12 \* uni0E4A → uni0E12 \* uni0E4A.low

**Mandatory ligature** uni0E12 \* uni0E4B → uni0E12 \* uni0E4B.low  
**Mandatory ligature** uni0E12 \* uni0E4C → uni0E12 \* uni0E4C.low

**Slot 179 ‘uni0E13’**

Unicode character U+0E13, THAI CHARACTER NO NEN.

**Mandatory ligature** uni0E13 \* uni0E33 → uni0E13 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E13 \* uni0E48 → uni0E13 \* uni0E48.low  
**Mandatory ligature** uni0E13 \* uni0E49 → uni0E13 \* uni0E49.low  
**Mandatory ligature** uni0E13 \* uni0E4A → uni0E13 \* uni0E4A.low  
**Mandatory ligature** uni0E13 \* uni0E4B → uni0E13 \* uni0E4B.low  
**Mandatory ligature** uni0E13 \* uni0E4C → uni0E13 \* uni0E4C.low

**Slot 180 ‘uni0E14’**

Unicode character U+0E14, THAI CHARACTER DO DEK.

**Mandatory ligature** uni0E14 \* uni0E33 → uni0E14 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E14 \* uni0E48 → uni0E14 \* uni0E48.low  
**Mandatory ligature** uni0E14 \* uni0E49 → uni0E14 \* uni0E49.low  
**Mandatory ligature** uni0E14 \* uni0E4A → uni0E14 \* uni0E4A.low  
**Mandatory ligature** uni0E14 \* uni0E4B → uni0E14 \* uni0E4B.low  
**Mandatory ligature** uni0E14 \* uni0E4C → uni0E14 \* uni0E4C.low

**Slot 181 ‘uni0E15’**

Unicode character U+0E15, THAI CHARACTER TO TAO.

**Mandatory ligature** uni0E15 \* uni0E33 → uni0E15 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E15 \* uni0E48 → uni0E15 \* uni0E48.low  
**Mandatory ligature** uni0E15 \* uni0E49 → uni0E15 \* uni0E49.low  
**Mandatory ligature** uni0E15 \* uni0E4A → uni0E15 \* uni0E4A.low  
**Mandatory ligature** uni0E15 \* uni0E4B → uni0E15 \* uni0E4B.low  
**Mandatory ligature** uni0E15 \* uni0E4C → uni0E15 \* uni0E4C.low

**Slot 182 ‘uni0E16’**

Unicode character U+0E16, THAI CHARACTER THO THUNG.

**Mandatory ligature** uni0E16 \* uni0E33 → uni0E16 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E16 \* uni0E48 → uni0E16 \* uni0E48.low  
**Mandatory ligature** uni0E16 \* uni0E49 → uni0E16 \* uni0E49.low  
**Mandatory ligature** uni0E16 \* uni0E4A → uni0E16 \* uni0E4A.low  
**Mandatory ligature** uni0E16 \* uni0E4B → uni0E16 \* uni0E4B.low  
**Mandatory ligature** uni0E16 \* uni0E4C → uni0E16 \* uni0E4C.low

**Slot 183 ‘uni0E17’**

Unicode character U+0E17, THAI CHARACTER THO THAHAN.

**Mandatory ligature** uni0E17 \* uni0E33 → uni0E17 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E17 \* uni0E48 → uni0E17 \* uni0E48.low  
**Mandatory ligature** uni0E17 \* uni0E49 → uni0E17 \* uni0E49.low  
**Mandatory ligature** uni0E17 \* uni0E4A → uni0E17 \* uni0E4A.low  
**Mandatory ligature** uni0E17 \* uni0E4B → uni0E17 \* uni0E4B.low  
**Mandatory ligature** uni0E17 \* uni0E4C → uni0E17 \* uni0E4C.low



**Slot 184 ‘uni0E18’**

Unicode character U+0E18, THAI CHARACTER THO THONG.

**Mandatory ligature** uni0E18 \* uni0E33 → uni0E18 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E18 \* uni0E48 → uni0E18 \* uni0E48.low

**Mandatory ligature** uni0E18 \* uni0E49 → uni0E18 \* uni0E49.low

**Mandatory ligature** uni0E18 \* uni0E4A → uni0E18 \* uni0E4A.low

**Mandatory ligature** uni0E18 \* uni0E4B → uni0E18 \* uni0E4B.low

**Mandatory ligature** uni0E18 \* uni0E4C → uni0E18 \* uni0E4C.low

**Slot 185 ‘uni0E19’**

Unicode character U+0E19, THAI CHARACTER NO NU.

**Mandatory ligature** uni0E19 \* uni0E33 → uni0E19 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E19 \* uni0E48 → uni0E19 \* uni0E48.low

**Mandatory ligature** uni0E19 \* uni0E49 → uni0E19 \* uni0E49.low

**Mandatory ligature** uni0E19 \* uni0E4A → uni0E19 \* uni0E4A.low

**Mandatory ligature** uni0E19 \* uni0E4B → uni0E19 \* uni0E4B.low

**Mandatory ligature** uni0E19 \* uni0E4C → uni0E19 \* uni0E4C.low

**Slot 186 ‘uni0E1A’**

Unicode character U+0E1A, THAI CHARACTER BO BAIMAI.

**Mandatory ligature** uni0E1A \* uni0E33 → uni0E1A \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E1A \* uni0E48 → uni0E1A \* uni0E48.low

**Mandatory ligature** uni0E1A \* uni0E49 → uni0E1A \* uni0E49.low

**Mandatory ligature** uni0E1A \* uni0E4A → uni0E1A \* uni0E4A.low

**Mandatory ligature** uni0E1A \* uni0E4B → uni0E1A \* uni0E4B.low

**Mandatory ligature** uni0E1A \* uni0E4C → uni0E1A \* uni0E4C.low

**Slot 187 ‘uni0E1B’**

Unicode character U+0E1B, THAI CHARACTER PO PLA.

**Mandatory ligature** uni0E1B \* uni0E31 → uni0E1B \* uni0E31.left

**Mandatory ligature**

uni0E1B \* uni0E33 → uni0E1B \* uni0E4D.left \* uni0E33

**Mandatory ligature** uni0E1B \* uni0E34 → uni0E1B \* uni0E34.left

**Mandatory ligature** uni0E1B \* uni0E35 → uni0E1B \* uni0E35.left

**Mandatory ligature** uni0E1B \* uni0E36 → uni0E1B \* uni0E36.left

**Mandatory ligature** uni0E1B \* uni0E37 → uni0E1B \* uni0E37.left

**Mandatory ligature** uni0E1B \* uni0E38 → uni0E1B \* uni0E38.left

**Mandatory ligature** uni0E1B \* uni0E39 → uni0E1B \* uni0E39.left

**Mandatory ligature** uni0E1B \* uni0E3A → uni0E1B \* uni0E3A.left

**Mandatory ligature** uni0E1B \* uni0E47 → uni0E1B \* uni0E47.left

**Mandatory ligature** uni0E1B \* uni0E48 → uni0E1B \* uni0E48.low.left

**Mandatory ligature** uni0E1B \* uni0E49 → uni0E1B \* uni0E49.low.left

**Mandatory ligature** uni0E1B \* uni0E4A → uni0E1B \* uni0E4A.low.left

**Mandatory ligature** uni0E1B \* uni0E4B → uni0E1B \* uni0E4B.low.left

**Mandatory ligature** uni0E1B \* uni0E4C → uni0E1B \* uni0E4C.low

**Mandatory ligature** uni0E1B \* uni0E4D → uni0E1B \* uni0E4D.left

**Slot 188 ‘uni0E1C’**

Unicode character U+0E1C, THAI CHARACTER PHO PHUNG.

**Mandatory ligature** uni0E1C \* uni0E33 → uni0E1C \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E1C \* uni0E48 → uni0E1C \* uni0E48.low

**Mandatory ligature** uni0E1C \* uni0E49 → uni0E1C \* uni0E49.low

**Mandatory ligature** uni0E1C \* uni0E4A → uni0E1C \* uni0E4A.low

**Mandatory ligature** uni0E1C \* uni0E4B → uni0E1C \* uni0E4B.low

**Mandatory ligature** uni0E1C \* uni0E4C → uni0E1C \* uni0E4C.low

**Slot 189 ‘uni0E1D’**

Unicode character U+0E1D, THAI CHARACTER FO FA.

**Mandatory ligature** uni0E1D \* uni0E31 → uni0E1D \* uni0E31.left

**Mandatory ligature**

uni0E1D \* uni0E33 → uni0E1D \* uni0E4D.left \* uni0E33

**Mandatory ligature** uni0E1D \* uni0E34 → uni0E1D \* uni0E34.left

**Mandatory ligature** uni0E1D \* uni0E35 → uni0E1D \* uni0E35.left

**Mandatory ligature** uni0E1D \* uni0E36 → uni0E1D \* uni0E36.left

**Mandatory ligature** uni0E1D \* uni0E37 → uni0E1D \* uni0E37.left

**Mandatory ligature** uni0E1D \* uni0E38 → uni0E1D \* uni0E38.left

**Mandatory ligature** uni0E1D \* uni0E39 → uni0E1D \* uni0E39.left

**Mandatory ligature** uni0E1D \* uni0E3A → uni0E1D \* uni0E3A.left

**Mandatory ligature** uni0E1D \* uni0E47 → uni0E1D \* uni0E47.left

**Mandatory ligature** uni0E1D \* uni0E48 → uni0E1D \* uni0E48.low.left

**Mandatory ligature** uni0E1D \* uni0E49 → uni0E1D \* uni0E49.low.left

**Mandatory ligature** uni0E1D \* uni0E4A → uni0E1D \* uni0E4A.low.left

**Mandatory ligature** uni0E1D \* uni0E4B → uni0E1D \* uni0E4B.low.left

**Mandatory ligature** uni0E1D \* uni0E4C → uni0E1D \* uni0E4C.low

**Mandatory ligature** uni0E1D \* uni0E4D → uni0E1D \* uni0E4D.left

**Slot 190 ‘uni0E1E’**

Unicode character U+0E1E, THAI CHARACTER PHO PHAN.

**Mandatory ligature** uni0E1E \* uni0E33 → uni0E1E \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E1E \* uni0E48 → uni0E1E \* uni0E48.low

**Mandatory ligature** uni0E1E \* uni0E49 → uni0E1E \* uni0E49.low

**Mandatory ligature** uni0E1E \* uni0E4A → uni0E1E \* uni0E4A.low

**Mandatory ligature** uni0E1E \* uni0E4B → uni0E1E \* uni0E4B.low

**Mandatory ligature** uni0E1E \* uni0E4C → uni0E1E \* uni0E4C.low

**Slot 191 ‘uni0E1F’**

Unicode character U+0E1F, THAI CHARACTER FO FAN.

**Mandatory ligature** uni0E1F \* uni0E31 → uni0E1F \* uni0E31.left

**Mandatory ligature**

uni0E1F \* uni0E33 → uni0E1F \* uni0E4D.left \* uni0E33

**Mandatory ligature** uni0E1F \* uni0E34 → uni0E1F \* uni0E34.left

**Mandatory ligature** uni0E1F \* uni0E35 → uni0E1F \* uni0E35.left

**Mandatory ligature** uni0E1F \* uni0E36 → uni0E1F \* uni0E36.left

**Mandatory ligature** uni0E1F \* uni0E37 → uni0E1F \* uni0E37.left

Mandatory ligature uni0E1F \* uni0E38 → uni0E1F \* uni0E38.left  
Mandatory ligature uni0E1F \* uni0E39 → uni0E1F \* uni0E39.left  
Mandatory ligature uni0E1F \* uni0E3A → uni0E1F \* uni0E3A.left  
Mandatory ligature uni0E1F \* uni0E47 → uni0E1F \* uni0E47.left  
Mandatory ligature uni0E1F \* uni0E48 → uni0E1F \* uni0E48.low\_left  
Mandatory ligature uni0E1F \* uni0E49 → uni0E1F \* uni0E49.low\_left  
Mandatory ligature uni0E1F \* uni0E4A → uni0E1F \* uni0E4A.low\_left  
Mandatory ligature uni0E1F \* uni0E4B → uni0E1F \* uni0E4B.low\_left  
Mandatory ligature uni0E1F \* uni0E4C → uni0E1F \* uni0E4C.low  
Mandatory ligature uni0E1F \* uni0E4D → uni0E1F \* uni0E4D.left

#### Slot 192 ‘uni0E20’

Unicode character U+0E20, THAI CHARACTER PHO SAMPHAO.

Mandatory ligature uni0E20 \* uni0E33 → uni0E20 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E20 \* uni0E48 → uni0E20 \* uni0E48.low  
Mandatory ligature uni0E20 \* uni0E49 → uni0E20 \* uni0E49.low  
Mandatory ligature uni0E20 \* uni0E4A → uni0E20 \* uni0E4A.low  
Mandatory ligature uni0E20 \* uni0E4B → uni0E20 \* uni0E4B.low  
Mandatory ligature uni0E20 \* uni0E4C → uni0E20 \* uni0E4C.low

#### Slot 193 ‘uni0E21’

Unicode character U+0E21, THAI CHARACTER MO MA.

Mandatory ligature uni0E21 \* uni0E33 → uni0E21 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E21 \* uni0E48 → uni0E21 \* uni0E48.low  
Mandatory ligature uni0E21 \* uni0E49 → uni0E21 \* uni0E49.low  
Mandatory ligature uni0E21 \* uni0E4A → uni0E21 \* uni0E4A.low  
Mandatory ligature uni0E21 \* uni0E4B → uni0E21 \* uni0E4B.low  
Mandatory ligature uni0E21 \* uni0E4C → uni0E21 \* uni0E4C.low

#### Slot 194 ‘uni0E22’

Unicode character U+0E22, THAI CHARACTER YO YAK.

Mandatory ligature uni0E22 \* uni0E33 → uni0E22 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E22 \* uni0E48 → uni0E22 \* uni0E48.low  
Mandatory ligature uni0E22 \* uni0E49 → uni0E22 \* uni0E49.low  
Mandatory ligature uni0E22 \* uni0E4A → uni0E22 \* uni0E4A.low  
Mandatory ligature uni0E22 \* uni0E4B → uni0E22 \* uni0E4B.low  
Mandatory ligature uni0E22 \* uni0E4C → uni0E22 \* uni0E4C.low

#### Slot 195 ‘uni0E23’

Unicode character U+0E23, THAI CHARACTER RO RUA.

Mandatory ligature uni0E23 \* uni0E33 → uni0E23 \* uni0E4D \* uni0E33  
Mandatory ligature uni0E23 \* uni0E48 → uni0E23 \* uni0E48.low  
Mandatory ligature uni0E23 \* uni0E49 → uni0E23 \* uni0E49.low  
Mandatory ligature uni0E23 \* uni0E4A → uni0E23 \* uni0E4A.low  
Mandatory ligature uni0E23 \* uni0E4B → uni0E23 \* uni0E4B.low  
Mandatory ligature uni0E23 \* uni0E4C → uni0E23 \* uni0E4C.low

**Slot 196 ‘uni0E24’**

Unicode character U+0E24, THAI CHARACTER RU.

**Mandatory ligature** uni0E24 \* uni0E32 → uni0E24 \* uni0E45  
**Mandatory ligature** uni0E24 \* uni0E48 → uni0E24 \* uni0E48.low  
**Mandatory ligature** uni0E24 \* uni0E49 → uni0E24 \* uni0E49.low  
**Mandatory ligature** uni0E24 \* uni0E4A → uni0E24 \* uni0E4A.low  
**Mandatory ligature** uni0E24 \* uni0E4B → uni0E24 \* uni0E4B.low  
**Mandatory ligature** uni0E24 \* uni0E4C → uni0E24 \* uni0E4C.low

**Slot 197 ‘uni0E25’**

Unicode character U+0E25, THAI CHARACTER LO LING.

**Mandatory ligature** uni0E25 \* uni0E33 → uni0E25 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E25 \* uni0E48 → uni0E25 \* uni0E48.low  
**Mandatory ligature** uni0E25 \* uni0E49 → uni0E25 \* uni0E49.low  
**Mandatory ligature** uni0E25 \* uni0E4A → uni0E25 \* uni0E4A.low  
**Mandatory ligature** uni0E25 \* uni0E4B → uni0E25 \* uni0E4B.low  
**Mandatory ligature** uni0E25 \* uni0E4C → uni0E25 \* uni0E4C.low

**Slot 198 ‘uni0E26’**

Unicode character U+0E26, THAI CHARACTER LU.

**Mandatory ligature** uni0E26 \* uni0E32 → uni0E26 \* uni0E45  
**Mandatory ligature** uni0E26 \* uni0E48 → uni0E26 \* uni0E48.low  
**Mandatory ligature** uni0E26 \* uni0E49 → uni0E26 \* uni0E49.low  
**Mandatory ligature** uni0E26 \* uni0E4A → uni0E26 \* uni0E4A.low  
**Mandatory ligature** uni0E26 \* uni0E4B → uni0E26 \* uni0E4B.low  
**Mandatory ligature** uni0E26 \* uni0E4C → uni0E26 \* uni0E4C.low

**Slot 199 ‘uni0E27’**

Unicode character U+0E27, THAI CHARACTER WO WAEN.

**Mandatory ligature** uni0E27 \* uni0E33 → uni0E27 \* uni0E4D \* uni0E33  
**Mandatory ligature** uni0E27 \* uni0E48 → uni0E27 \* uni0E48.low  
**Mandatory ligature** uni0E27 \* uni0E49 → uni0E27 \* uni0E49.low  
**Mandatory ligature** uni0E27 \* uni0E4A → uni0E27 \* uni0E4A.low  
**Mandatory ligature** uni0E27 \* uni0E4B → uni0E27 \* uni0E4B.low  
**Mandatory ligature** uni0E27 \* uni0E4C → uni0E27 \* uni0E4C.low

**Slot 200 ‘uni0E28’**

Unicode character U+0E28, THAI CHARACTER SO SALA.

**Mandatory ligature** uni0E28 \* uni0E48 → uni0E28 \* uni0E48.low  
**Mandatory ligature** uni0E28 \* uni0E49 → uni0E28 \* uni0E49.low  
**Mandatory ligature** uni0E28 \* uni0E4A → uni0E28 \* uni0E4A.low  
**Mandatory ligature** uni0E28 \* uni0E4B → uni0E28 \* uni0E4B.low  
**Mandatory ligature** uni0E28 \* uni0E4C → uni0E28 \* uni0E4C.low

**Slot 201 ‘uni0E29’**

Unicode character U+0E29, THAI CHARACTER SO RUSI.

**Mandatory ligature** uni0E29 \* uni0E48 → uni0E29 \* uni0E48.low  
**Mandatory ligature** uni0E29 \* uni0E49 → uni0E29 \* uni0E49.low

**Mandatory ligature** uni0E29 \* uni0E4A → uni0E29 \* uni0E4A.low  
**Mandatory ligature** uni0E29 \* uni0E4B → uni0E29 \* uni0E4B.low  
**Mandatory ligature** uni0E29 \* uni0E4C → uni0E29 \* uni0E4C.low

**Slot 202 ‘uni0E2A’**

Unicode character U+0E2A, THAI CHARACTER SO SUA.

**Mandatory ligature** uni0E2A \* uni0E48 → uni0E2A \* uni0E48.low  
**Mandatory ligature** uni0E2A \* uni0E49 → uni0E2A \* uni0E49.low  
**Mandatory ligature** uni0E2A \* uni0E4A → uni0E2A \* uni0E4A.low  
**Mandatory ligature** uni0E2A \* uni0E4B → uni0E2A \* uni0E4B.low  
**Mandatory ligature** uni0E2A \* uni0E4C → uni0E2A \* uni0E4C.low

**Slot 203 ‘uni0E2B’**

Unicode character U+0E2B, THAI CHARACTER HO HIP.

**Mandatory ligature** uni0E2B \* uni0E48 → uni0E2B \* uni0E48.low  
**Mandatory ligature** uni0E2B \* uni0E49 → uni0E2B \* uni0E49.low  
**Mandatory ligature** uni0E2B \* uni0E4A → uni0E2B \* uni0E4A.low  
**Mandatory ligature** uni0E2B \* uni0E4B → uni0E2B \* uni0E4B.low  
**Mandatory ligature** uni0E2B \* uni0E4C → uni0E2B \* uni0E4C.low

**Slot 204 ‘uni0E2C’**

Unicode character U+0E2C, THAI CHARACTER LO CHULA.

**Mandatory ligature**

uni0E2C \* uni0E33 → uni0E2C \* uni0E4D.left \* uni0E33  
**Mandatory ligature** uni0E2C \* uni0E4A → uni0E2C \* uni0E4A.low  
**Mandatory ligature** uni0E2C \* uni0E4B → uni0E2C \* uni0E4B.low

**Slot 205 ‘uni0E2D’**

Unicode character U+0E2D, THAI CHARACTER O ANG.

**Mandatory ligature** uni0E2D \* uni0E48 → uni0E2D \* uni0E48.low  
**Mandatory ligature** uni0E2D \* uni0E49 → uni0E2D \* uni0E49.low  
**Mandatory ligature** uni0E2D \* uni0E4A → uni0E2D \* uni0E4A.low  
**Mandatory ligature** uni0E2D \* uni0E4C → uni0E2D \* uni0E4C.low

**Slot 206 ‘uni0E2E’**

Unicode character U+0E2E, THAI CHARACTER HO NOKHUK.

**Mandatory ligature** uni0E2E \* uni0E48 → uni0E2E \* uni0E48.low  
**Mandatory ligature** uni0E2E \* uni0E49 → uni0E2E \* uni0E49.low  
**Mandatory ligature** uni0E2E \* uni0E4A → uni0E2E \* uni0E4A.low  
**Mandatory ligature** uni0E2E \* uni0E4B → uni0E2E \* uni0E4B.low  
**Mandatory ligature** uni0E2E \* uni0E4C → uni0E2E \* uni0E4C.low

**Slot 207 ‘uni0E2F’**

Unicode character U+0E2F, THAI CHARACTER PAIYANNOI.

**Mandatory ligature** uni0E2F \* uni0E48 → uni0E2F \* uni0E48.low  
**Mandatory ligature** uni0E2F \* uni0E49 → uni0E2F \* uni0E49.low  
**Mandatory ligature** uni0E2F \* uni0E4A → uni0E2F \* uni0E4A.low  
**Mandatory ligature** uni0E2F \* uni0E4B → uni0E2F \* uni0E4B.low  
**Mandatory ligature** uni0E2F \* uni0E4C → uni0E2F \* uni0E4C.low

**Slot 208 ‘uni0E30’**

Unicode character U+0E30, THAI CHARACTER SARA A.

**Mandatory ligature** uni0E30 \* uni0E33 → uni0E30 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E30 \* uni0E48 → uni0E30 \* uni0E48.low

**Mandatory ligature** uni0E30 \* uni0E49 → uni0E30 \* uni0E49.low

**Mandatory ligature** uni0E30 \* uni0E4A → uni0E30 \* uni0E4A.low

**Mandatory ligature** uni0E30 \* uni0E4B → uni0E30 \* uni0E4B.low

**Mandatory ligature** uni0E30 \* uni0E4C → uni0E30 \* uni0E4C.low

**Slot 209 ‘uni0E31’**

Unicode character U+0E31, THAI CHARACTER MAI HAN-AKAT.

**Slot 210 ‘uni0E32’**

Unicode character U+0E32, THAI CHARACTER SARA AA.

**Mandatory ligature** uni0E32 \* uni0E48 → uni0E32 \* uni0E48.low

**Mandatory ligature** uni0E32 \* uni0E49 → uni0E32 \* uni0E49.low

**Mandatory ligature** uni0E32 \* uni0E4A → uni0E32 \* uni0E4A.low

**Mandatory ligature** uni0E32 \* uni0E4B → uni0E32 \* uni0E4B.low

**Mandatory ligature** uni0E32 \* uni0E4C → uni0E32 \* uni0E4C.low

**Slot 211 ‘uni0E33’**

Unicode character U+0E33, THAI CHARACTER SARA AM.

**Mandatory ligature** uni0E33 \* uni0E48 → uni0E33 \* uni0E48.low

**Mandatory ligature** uni0E33 \* uni0E49 → uni0E33 \* uni0E49.low

**Mandatory ligature** uni0E33 \* uni0E4A → uni0E33 \* uni0E4A.low

**Mandatory ligature** uni0E33 \* uni0E4B → uni0E33 \* uni0E4B.low

**Mandatory ligature** uni0E33 \* uni0E4C → uni0E33 \* uni0E4C.low

**Slot 212 ‘uni0E34’**

Unicode character U+0E34, THAI CHARACTER SARA I.

**Slot 213 ‘uni0E35’**

Unicode character U+0E35, THAI CHARACTER SARA II.

**Slot 214 ‘uni0E36’**

Unicode character U+0E36, THAI CHARACTER SARA UE.

**Slot 215 ‘uni0E37’**

Unicode character U+0E37, THAI CHARACTER SARA UEE.

**Slot 216 ‘uni0E38’**

Unicode character U+0E38, THAI CHARACTER SARA U.

**Mandatory ligature** uni0E38 \* uni0E48 → uni0E38 \* uni0E48.low

**Mandatory ligature** uni0E38 \* uni0E49 → uni0E38 \* uni0E49.low

**Mandatory ligature** uni0E38 \* uni0E4A → uni0E38 \* uni0E4A.low

**Mandatory ligature** uni0E38 \* uni0E4B → uni0E38 \* uni0E4B.low

**Mandatory ligature** uni0E38 \* uni0E4C → uni0E38 \* uni0E4C.low

**Slot 217 ‘uni0E39’**

Unicode character U+0E39, THAI CHARACTER SARA UU.

**Mandatory ligature** uni0E39 \* uni0E48 → uni0E39 \* uni0E48.low

**Mandatory ligature** uni0E39 \* uni0E49 → uni0E39 \* uni0E49.low

**Mandatory ligature** uni0E39 \* uni0E4A → uni0E39 \* uni0E4A.low

**Mandatory ligature** uni0E39 \* uni0E4B → uni0E39 \* uni0E4B.low

**Mandatory ligature** uni0E39 \* uni0E4C → uni0E39 \* uni0E4C.low

**Slot 218 ‘uni0E3A’**

Unicode character U+0E3A, THAI CHARACTER PHINTHU.

**Mandatory ligature** uni0E3A \* uni0E48 → uni0E3A \* uni0E48.low

**Mandatory ligature** uni0E3A \* uni0E49 → uni0E3A \* uni0E49.low

**Mandatory ligature** uni0E3A \* uni0E4A → uni0E3A \* uni0E4A.low

**Mandatory ligature** uni0E3A \* uni0E4B → uni0E3A \* uni0E4B.low

**Mandatory ligature** uni0E3A \* uni0E4C → uni0E3A \* uni0E4C.low

**Slot 223 ‘uni0E3F’**

Unicode character U+0E3F, THAI CURRENCY SYMBOL BAHT.

**Slot 224 ‘uni0E40’**

Unicode character U+0E40, THAI CHARACTER SARA E.

**Mandatory ligature** uni0E40 \* uni0E33 → uni0E40 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E40 \* uni0E48 → uni0E40 \* uni0E48.low

**Mandatory ligature** uni0E40 \* uni0E49 → uni0E40 \* uni0E49.low

**Mandatory ligature** uni0E40 \* uni0E4A → uni0E40 \* uni0E4A.low

**Mandatory ligature** uni0E40 \* uni0E4B → uni0E40 \* uni0E4B.low

**Mandatory ligature** uni0E40 \* uni0E4C → uni0E40 \* uni0E4C.low

**Slot 225 ‘uni0E41’**

Unicode character U+0E41, THAI CHARACTER SARA AE.

**Mandatory ligature** uni0E41 \* uni0E33 → uni0E41 \* uni0E4D \* uni0E33

**Mandatory ligature** uni0E41 \* uni0E48 → uni0E41 \* uni0E48.low

**Mandatory ligature** uni0E41 \* uni0E49 → uni0E41 \* uni0E49.low

**Mandatory ligature** uni0E41 \* uni0E4A → uni0E41 \* uni0E4A.low

**Mandatory ligature** uni0E41 \* uni0E4B → uni0E41 \* uni0E4B.low

**Mandatory ligature** uni0E41 \* uni0E4C → uni0E41 \* uni0E4C.low

**Slot 226 ‘uni0E42’**

Unicode character U+0E42, THAI CHARACTER SARA O.

**Slot 227 ‘uni0E43’**

Unicode character U+0E43, THAI CHARACTER SARA AI MAIMUAN.

**Slot 228 ‘uni0E44’**

Unicode character U+0E44, THAI CHARACTER SARA AI MAIMALAI.

**Slot 229 ‘uni0E45’**

Unicode character U+0E45, THAI CHARACTER LAKKHANGYAO.

**Slot 230** ‘uni0E46’

Unicode character U+0E46, THAI CHARACTER MAIYAMOK.

**Mandatory ligature** uni0E46 \* uni0E48 → uni0E46 \* uni0E48.low

**Mandatory ligature** uni0E46 \* uni0E49 → uni0E46 \* uni0E49.low

**Mandatory ligature** uni0E46 \* uni0E4A → uni0E46 \* uni0E4A.low

**Mandatory ligature** uni0E46 \* uni0E4B → uni0E46 \* uni0E4B.low

**Mandatory ligature** uni0E46 \* uni0E4C → uni0E46 \* uni0E4C.low

**Slot 231** ‘uni0E47’

Unicode character U+0E47, THAI CHARACTER MAITAIKHU.

**Slot 232** ‘uni0E48’

Unicode character U+0E48, THAI CHARACTER MAI EK.

**Mandatory ligature** uni0E48 \* uni0E33 → uni0E48 \* uni0E32

**Slot 233** ‘uni0E49’

Unicode character U+0E49, THAI CHARACTER MAI THO.

**Mandatory ligature** uni0E49 \* uni0E33 → uni0E49 \* uni0E32

**Slot 234** ‘uni0E4A’

Unicode character U+0E4A, THAI CHARACTER MAI TRI.

**Mandatory ligature** uni0E4A \* uni0E33 → uni0E4A \* uni0E32

**Slot 235** ‘uni0E4B’

Unicode character U+0E4B, THAI CHARACTER MAI CHATTAWA.

**Mandatory ligature** uni0E4B \* uni0E33 → uni0E4B \* uni0E32

**Slot 236** ‘uni0E4C’

Unicode character U+0E4C, THAI CHARACTER THANTHAKHAT.

**Mandatory ligature** uni0E4C \* uni0E33 → uni0E4C \* uni0E32

**Slot 237** ‘uni0E4D’

Unicode character U+0E4D, THAI CHARACTER NIKHAHIT.

**Mandatory ligature** uni0E4D \* uni0E33 → uni0E4D \* uni0E32

**Slot 238** ‘uni0E4E’

Unicode character U+0E4E, THAI CHARACTER YAMAKKAN.

**Slot 239** ‘uni0E4F’

Unicode character U+0E4F, THAI CHARACTER FONGMAN.

**Slot 240** ‘uni0E50’

Unicode character U+0E50, THAI DIGIT ZERO.

**Slot 241** ‘uni0E51’

Unicode character U+0E51, THAI DIGIT ONE.

**Slot 242** ‘uni0E52’

Unicode character U+0E52, THAI DIGIT TWO.

**Slot 243** ‘uni0E53’

Unicode character U+0E53, THAI DIGIT THREE.



**Slot 244** ‘uni0E54’

Unicode character U+0E54, THAI DIGIT FOUR.

**Slot 245** ‘uni0E55’

Unicode character U+0E55, THAI DIGIT FIVE.

**Slot 246** ‘uni0E56’

Unicode character U+0E56, THAI DIGIT SIX.

**Slot 247** ‘uni0E57’

Unicode character U+0E57, THAI DIGIT SEVEN.

**Slot 248** ‘uni0E58’

Unicode character U+0E58, THAI DIGIT EIGHT.

**Slot 249** ‘uni0E59’

Unicode character U+0E59, THAI DIGIT NINE.

**Slot 250** ‘uni0E5A’

Unicode character U+0E5A, THAI CHARACTER ANGKHANKHU.

**Slot 251** ‘uni0E5B’

Unicode character U+0E5B, THAI CHARACTER KHOMUT.

**Slot 252** ‘uni0E38.low’

A glyph variant of U+0E38 (THAI CHARACTER SARA U).

**Mandatory ligature** uni0E38.low \* uni0E48 → uni0E38.low \* uni0E48.low

**Mandatory ligature** uni0E38.low \* uni0E49 → uni0E38.low \* uni0E49.low

**Mandatory ligature** uni0E38.low \* uni0E4A → uni0E38.low \* uni0E4A.low

**Mandatory ligature** uni0E38.low \* uni0E4B → uni0E38.low \* uni0E4B.low

**Mandatory ligature** uni0E38.low \* uni0E4C → uni0E38.low \* uni0E4C.low

**Slot 253** ‘uni0E39.low’

A glyph variant of U+0E39 (THAI CHARACTER SARA UU).

**Mandatory ligature** uni0E39.low \* uni0E48 → uni0E39.low \* uni0E48.low

**Mandatory ligature** uni0E39.low \* uni0E49 → uni0E39.low \* uni0E49.low

**Mandatory ligature** uni0E39.low \* uni0E4A → uni0E39.low \* uni0E4A.low

**Mandatory ligature** uni0E39.low \* uni0E4B → uni0E39.low \* uni0E4B.low

**Mandatory ligature** uni0E39.low \* uni0E4C → uni0E39.low \* uni0E4C.low

**Slot 254** ‘uni0E3A.low’

A glyph variant of U+0E3A (THAI CHARACTER PHINTHU).

**Mandatory ligature** uni0E3A.low \* uni0E48 → uni0E3A.low \* uni0E48.low

**Mandatory ligature** uni0E3A.low \* uni0E49 → uni0E3A.low \* uni0E49.low

**Mandatory ligature** uni0E3A.low \* uni0E4A → uni0E3A.low \* uni0E4A.low

**Mandatory ligature** uni0E3A.low \* uni0E4B → uni0E3A.low \* uni0E4B.low

**Mandatory ligature** uni0E3A.low \* uni0E4C → uni0E3A.low \* uni0E4C.low

## 11 Font Dimensions

**Fontdimen 1** is *italicslant*

**Fontdimen 2** is *interword*

**Fontdimen 3** is *stretchword*

**Fontdimen 4** is *shrinkword*

**Fontdimen 5** is *xheight*

**Fontdimen 6** is *quad*

**Fontdimen 7** is *extraspacer*

## References

- [1] Werner Lemberg: *Thai Fonts*, in *TUGboat*, 21(2):113–120, June 2000. Available online in PDF format as <http://tug.org/TUGboat/Articles/tb21-2/tb671emb.pdf>.
- [2] Adobe Systems Incorporated: *Adobe Glyph List*, 2003; <http://partners.adobe.com/asn/developer/type/unicodegn.html>.
- [3] Donald E. Knuth, Duane Bibby (illustrations): *The METAFONTbook*, Addison–Wesley, 1986; ISBN 0-201-13445-4.
- [4] The Unicode Consortium (editor), *et al.*: *The Unicode Standard, Version 4.0*, Addison Wesley Longman Publisher, 2003; ISBN 0-321-18578-1. Most of the information in this book is also available online at the Unicode consortium website, at <http://www.unicode.org/versions/Unicode4.0.1>.