

# The `bigintcalc` package

Heiko Oberdiek  
<oberdiek@uni-freiburg.de>

2007/11/11 v1.1

## Abstract

This package provides expandable arithmetic operations with big integers that can exceed  $\text{T}_{\text{E}}\text{X}$ 's number limits.

## Contents

<b>1</b>	<b>Documentation</b>	<b>2</b>
1.1	Introduction	2
1.2	Conditions	2
1.2.1	Preconditions	2
1.2.2	Postconditions	3
1.3	Error handling	3
1.4	Operations	3
1.4.1	Num	3
1.4.2	Inv, Abs, Sgn	3
1.4.3	Min, Max, Cmp	4
1.4.4	Odd	5
1.4.5	Inc, Dec, Add, Sub	5
1.4.6	Shl, Shr	5
1.4.7	Mul, Sqr, Fac, Pow	6
1.4.8	Div, Mul	6
1.5	Interface for programmers	7
<b>2</b>	<b>Implementation</b>	<b>8</b>
2.1	Reload check and package identification	8
2.2	Catcodes	9
2.3	$\varepsilon$ - $\text{T}_{\text{E}}\text{X}$ detection	9
2.4	Help macros	9
2.5	Expand number	10
2.6	Normalize expanded number	11
2.7	Num	12
2.8	Inv, Abs, Sgn	12
2.9	Cmp, Min, Max	13
2.10	Odd	15
2.11	Inc, Dec	15
2.12	Add, Sub	18
2.13	Shl, Shr	24
2.14	<code>\BIC@Tim</code>	27
2.15	Mul	29
2.16	Sqr	30
2.17	Fac	31
2.18	Pow	32
2.18.1	Help macros	34
2.18.2	Recursive calculation	35

2.19	Div	36
2.20	Mod	42
<b>3</b>	<b>Test</b>	<b>44</b>
3.1	Catcode checks for loading	44
3.2	Macro tests	46
3.2.1	Preamble with test macro definitions	46
3.2.2	Time	49
3.2.3	Test sets	50
<b>4</b>	<b>Installation</b>	<b>59</b>
4.1	Download	59
4.2	Bundle installation	59
4.3	Package installation	59
4.4	Refresh file name databases	59
4.5	Some details for the interested	60
<b>5</b>	<b>History</b>	<b>60</b>
	[2007/09/27 v1.0]	60
	[2007/11/11 v1.1]	60
<b>6</b>	<b>Index</b>	<b>60</b>

# 1 Documentation

## 1.1 Introduction

Package `bigintcalc` defines arithmetic operations that deal with big integers. Big integers can be given either as explicit integer number or as macro code that expands to an explicit number. *Big* means that there is no limit on the size of the number. Big integers may exceed  $\text{\TeX}$ 's range limitation of -2147483647 and 2147483647. Only memory issues will limit the usable range.

In opposite to package `intcalc` unexpandable command tokens are not supported, even if they are valid  $\text{\TeX}$  numbers like count registers or commands created by `\chardef`. Nevertheless they may be used, if they are prefixed by `\number`.

Also  $\varepsilon$ - $\text{\TeX}$ 's `\numexpr` expressions are not supported directly in the manner of package `intcalc`. However they can be given if `\the\numexpr` or `\number\numexpr` are used.

The operations have the form of macros that take one or two integers as parameter and return the integer result. The macro name is a three letter operation name prefixed by the package name, e.g. `\bigintcalcAdd{10}{43}` returns 53.

The macros are fully expandable, exactly two expansion steps generate the result. Therefore the operations may be used nearly everywhere in  $\text{\TeX}$ , even inside `\csname`, file names, or other expandable contexts.

## 1.2 Conditions

### 1.2.1 Preconditions

- Arguments can be anything that expands to a number that consists of optional signs and digits.
- The arguments and return values must be sound. Zero as divisor or factorials of negative numbers will cause errors.

### 1.2.2 Postconditions

Additional properties of the macros apart from calculating a correct result (of course ☺):

- The macros are fully expandable. Thus they can be used inside `\edef`, `\csname`, for example.
- Furthermore exactly two expansion steps calculate the result.
- The number consists of one optional minus sign and one or more digits. The first digit is larger than zero for numbers that consists of more than one digit.

In short, the number format is exactly the same as `\number` generates, but without its range limitation. And the tokens (minus sign, digits) have cat-code 12 (other).

- Call by value is simulated. First the arguments are converted to numbers. Then these numbers are used in the calculations.

Remember that arguments may contain expensive macros or  $\varepsilon$ -TeX expressions. This strategy avoids multiple evaluations of such arguments.

## 1.3 Error handling

Some errors are detected by the macros, example: division by zero. In this cases an undefined control sequence is called and causes a TeX error message, example: `\BigIntCalcError:DivisionByZero`. The name of the control sequence contains the reason for the error. The TeX error may be ignored. Then the operation returns zero as result. Because the macros are supposed to work in expandible contexts. An traditional error message, however, is not expandable and would break these contexts.

## 1.4 Operations

Some definition equations below use the function `Int` that converts a real number to an integer. The number is truncated that means rounding to zero:

$$\text{Int}(x) := \begin{cases} \lfloor x \rfloor & \text{if } x \geq 0 \\ \lceil x \rceil & \text{otherwise} \end{cases}$$

### 1.4.1 Num

`\bigintcalcNum {⟨x⟩}`

Macro `\bigintcalcNum` converts its argument to a normalized integer number without unnecessary leading zeros or signs. The result matches the regular expression:

`0|-?[1-9][0-9]*`

### 1.4.2 Inv, Abs, Sgn

`\bigintcalcInv {⟨x⟩}`

Macro `\bigintcalcInv` switches the sign.

$$\text{Inv}(x) := -x$$

`\bigintcalcAbs {⟨x⟩}`

Macro `\bigintcalcAbs` returns the absolute value of integer  $\langle x \rangle$ .

$$\text{Abs}(x) := |x|$$

`\bigintcalcSgn {⟨x⟩}`

Macro `\bigintcalcSgn` encodes the sign of  $\langle x \rangle$  as number.

$$\text{Sgn}(x) := \begin{cases} -1 & \text{if } x < 0 \\ 0 & \text{if } x = 0 \\ 1 & \text{if } x > 0 \end{cases}$$

These return values can easily be distinguished by `\ifcase`:

```
\ifcase\bigintcalcSgn{<x>}
  $x=0$
\or
  $x>0$
\else
  $x<0$
\fi
```

### 1.4.3 Min, Max, Cmp

`\bigintcalcMin {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcMin` returns the smaller of the two integers.

$$\text{Min}(x, y) := \begin{cases} x & \text{if } x < y \\ y & \text{otherwise} \end{cases}$$

`\bigintcalcMax {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcMax` returns the larger of the two integers.

$$\text{Max}(x, y) := \begin{cases} x & \text{if } x > y \\ y & \text{otherwise} \end{cases}$$

`\bigintcalcCmp {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcCmp` encodes the comparison result as number:

$$\text{Cmp}(x, y) := \begin{cases} -1 & \text{if } x < y \\ 0 & \text{if } x = y \\ 1 & \text{if } x > y \end{cases}$$

These values can be distinguished by `\ifcase`:

```
\ifcase\bigintcalcCmp{<x>}{<y>}
  $x=y$
\or
  $x>y$
\else
  $x<y$
\fi
```

#### 1.4.4 Odd

`\bigintcalcOdd {⟨x⟩}`

$$\text{Odd}(x) := \begin{cases} 1 & \text{if } x \text{ is odd} \\ 0 & \text{if } x \text{ is even} \end{cases}$$

#### 1.4.5 Inc, Dec, Add, Sub

`\bigintcalcInc {⟨x⟩}`

Macro `\bigintcalcInc` increments  $\langle x \rangle$  by one.

$$\text{Inc}(x) := x + 1$$

`\bigintcalcDec {⟨x⟩}`

Macro `\bigintcalcDec` decrements  $\langle x \rangle$  by one.

$$\text{Dec}(x) := x - 1$$

`\bigintcalcAdd {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcAdd` adds the two numbers.

$$\text{Add}(x, y) := x + y$$

`\bigintcalcSub {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcSub` calculates the difference.

$$\text{Sub}(x, y) := x - y$$

#### 1.4.6 Shl, Shr

`\bigintcalcShl {⟨x⟩}`

Macro `\bigintcalcShl` implements shifting to the left that means the number is multiplied by two. The sign is preserved.

$$\text{Shl}(x) := x * 2$$

`\bigintcalcShr {⟨x⟩}`

Macro `\bigintcalcShr` implements shifting to the right. That is equivalent to an integer division by two. The sign is preserved.

$$\text{Shr}(x) := \text{Int}(x/2)$$

### 1.4.7 Mul, Sqr, Fac, Pow

`\bigintcalcMul {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcMul` calculates the product of  $\langle x \rangle$  and  $\langle y \rangle$ .

$$\text{Mul}(x, y) := x * y$$

`\bigintcalcSqr {⟨x⟩}`

Macro `\bigintcalcSqr` returns the square product.

$$\text{Sqr}(x) := x^2$$

`\bigintcalcFac {⟨x⟩}`

Macro `\bigintcalcFac` returns the factorial of  $\langle x \rangle$ . Negative numbers are not permitted.

$$\text{Fac}(x) := x! \quad \text{for } x \geq 0$$

$$(0! = 1)$$

`\bigintcalcPow Mx My`

Macro `\bigintcalcPow` calculates the value of  $\langle x \rangle$  to the power of  $\langle y \rangle$ . The error “division by zero” is thrown if  $\langle x \rangle$  is zero and  $\langle y \rangle$  is negative. permitted:

$$\text{Pow}(x, y) := \text{Int}(x^y) \quad \text{for } x \neq 0 \text{ or } y \geq 0$$

$$(0^0 = 1)$$

### 1.4.8 Div, Mod

`\bigintcalcDiv {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcDiv` performs an integer division. Argument  $\langle y \rangle$  must not be zero.

$$\text{Div}(x, y) := \text{Int}(x/y) \quad \text{for } y \neq 0$$

`\bigintcalcMod {⟨x⟩} {⟨y⟩}`

Macro `\bigintcalcMod` gets the remainder of the integer division. The sign follows the divisor  $\langle y \rangle$ . Argument  $\langle y \rangle$  must not be zero.

$$\text{Mod}(x, y) := x \% y \quad \text{for } y \neq 0$$

The result ranges:

$$-|y| < \text{Mod}(x, y) \leq 0 \quad \text{for } y < 0$$

$$0 \leq \text{Mod}(x, y) < y \quad \text{for } y \geq 0$$

## 1.5 Interface for programmers

If the programmer can ensure some more properties about the arguments of the operations, then the following macros are a little more efficient.

In general numbers must obey the following constraints:

- Plain number: digit tokens only, no command tokens.
- Non-negative. Signs are forbidden.
- Delimited by exclamation mark. Curly braces around the number are not allowed and will break the code.

`\BigIntCalcOdd  $\langle number \rangle$  !`

1/0 is returned if  $\langle number \rangle$  is odd/even.

`\BigIntCalcInc  $\langle number \rangle$  !`

Incrementation.

`\BigIntCalcDec  $\langle number \rangle$  !`

Decrementation, positive number without zero.

`\BigIntCalcAdd  $\langle number A \rangle$  !  $\langle number B \rangle$  !`

Addition,  $A \geq B$ .

`\BigIntCalcSub  $\langle number A \rangle$  !  $\langle number B \rangle$  !`

Subtraction,  $A \geq B$ .

`\BigIntCalcShl  $\langle number \rangle$  !`

Left shift (multiplication with two).

`\BigIntCalcShr  $\langle number \rangle$  !`

Right shift (integer division by two).

`\BigIntCalcMul  $\langle number A \rangle$  !  $\langle number B \rangle$  !`

Multiplication,  $A \geq B$ .

`\BigIntCalcDiv  $\langle number A \rangle$  !  $\langle number B \rangle$  !`

Division operation.

`\BigIntCalcMod  $\langle number A \rangle$  !  $\langle number B \rangle$  !`

Modulo operation.

## 2 Implementation

```
1 <*package>
```

### 2.1 Reload check and package identification

Reload check, especially if the package is not used with L<sup>A</sup>T<sub>E</sub>X.

```
2 \begingroup
3 \catcode44 12 % ,
4 \catcode45 12 % -
5 \catcode46 12 % .
6 \catcode58 12 % :
7 \catcode64 11 % @
8 \expandafter\let\expandafter\x\csname ver@bigintcalc.sty\endcsname
9 \ifcase 0%
10 \ifx\x\relax % plain
11 \else
12 \ifx\x\empty % LaTeX
13 \else
14 1%
15 \fi
16 \fi
17 \else
18 \catcode35 6 % #
19 \catcode123 1 % {
20 \catcode125 2 % }
21 \expandafter\ifx\csname PackageInfo\endcsname\relax
22 \def\x#1#2{%
23 \immediate\write-1{Package #1 Info: #2.}%
24 }%
25 \else
26 \def\x#1#2{\PackageInfo{#1}{#2, stopped}}%
27 \fi
28 \x{bigintcalc}{The package is already loaded}%
29 \endgroup
30 \expandafter\endinput
31 \fi
32 \endgroup
```

Package identification:

```
33 \begingroup
34 \catcode35 6 % #
35 \catcode40 12 % (
36 \catcode41 12 % )
37 \catcode44 12 % ,
38 \catcode45 12 % -
39 \catcode46 12 % .
40 \catcode47 12 % /
41 \catcode58 12 % :
42 \catcode64 11 % @
43 \catcode123 1 % {
44 \catcode125 2 % }
45 \expandafter\ifx\csname ProvidesPackage\endcsname\relax
46 \def\x#1#2#3[#4]{\endgroup
47 \immediate\write-1{Package: #3 #4}%
48 \xdef#1{#4}%
49 }%
50 \else
51 \def\x#1#2[#3]{\endgroup
52 #2[#3]}%
53 \ifx#1\relax
54 \xdef#1{#3}%
55 \fi
56 }%
```



```

57 \fi
58 \expandafter\x\csname ver@bigintcalc.sty\endcsname
59 \ProvidesPackage{bigintcalc}%
60 [2007/11/11 v1.1 Expandable big integer calculations (H0)]

```

## 2.2 Catcodes

```

61 \begingroup
62 \catcode123 1 % {
63 \catcode125 2 % }
64 \def\x{\endgroup
65 \expandafter\edef\csname BIC@AtEnd\endcsname{%
66 \catcode35 \the\catcode35\relax
67 \catcode64 \the\catcode64\relax
68 \catcode123 \the\catcode123\relax
69 \catcode125 \the\catcode125\relax
70 }%
71 }%
72 \x
73 \catcode35 6 % #
74 \catcode64 11 % @
75 \catcode123 1 % {
76 \catcode125 2 % }
77 \def\TMP@EnsureCode#1#2{%
78 \edef\BIC@AtEnd{%
79 \BIC@AtEnd
80 \catcode#1 \the\catcode#1\relax
81 }%
82 \catcode#1 #2\relax
83 }
84 \TMP@EnsureCode{33}{12}% !
85 \TMP@EnsureCode{36}{14}% $ (comment!)
86 \TMP@EnsureCode{38}{14}% & (comment!)
87 \TMP@EnsureCode{40}{12}% (
88 \TMP@EnsureCode{41}{12}% )
89 \TMP@EnsureCode{42}{12}% *
90 \TMP@EnsureCode{43}{12}% +
91 \TMP@EnsureCode{45}{12}% -
92 \TMP@EnsureCode{46}{12}% .
93 \TMP@EnsureCode{47}{12}% /
94 \TMP@EnsureCode{58}{11}% : (letter!)
95 \TMP@EnsureCode{60}{12}% <
96 \TMP@EnsureCode{61}{12}% =
97 \TMP@EnsureCode{62}{12}% >
98 \TMP@EnsureCode{63}{14}% ? (comment!)
99 \begingroup\expandafter\expandafter\expandafter\endgroup
100 \expandafter\ifx\csname BIC@TestMode\endcsname\relax
101 \else
102 \catcode63=9 % ? (ignore)
103 \fi
104 ? \let\BIC@@TestMode\BIC@TestMode

```

## 2.3 $\varepsilon$ -TeX detection

```

105 \begingroup\expandafter\expandafter\expandafter\endgroup
106 \expandafter\ifx\csname numexpr\endcsname\relax
107 \catcode36=9 % $ (ignore)
108 \else
109 \catcode38=9 % & (ignore)
110 \fi

```

## 2.4 Help macros

\BIC@Fi

```

111 \let\BIC@Fi\fi

\BIC@AfterFi

112 \def\BIC@AfterFi#1#2\BIC@Fi{\fi#1}%

\BIC@AfterFiFi

113 \def\BIC@AfterFiFi#1#2\BIC@Fi{\fi\fi#1}%

\BIC@AfterFiFiFi

114 \def\BIC@AfterFiFiFi#1#2\BIC@Fi{\fi\fi\fi#1}%

\BIC@Space

115 \begingroup
116 \def\x#1{\endgroup
117 \let\BIC@Space= #1%
118 }%
119 \x{ }

```

## 2.5 Expand number

```

120 \begingroup\expandafter\expandafter\expandafter\endgroup
121 \expandafter\ifx\csname RequirePackage\endcsname\relax
122 \input pdftexcmds.sty\relax
123 \else
124 \RequirePackage{pdftexcmds}[2007/11/11]%
125 \fi

126 \begingroup\expandafter\expandafter\expandafter\endgroup
127 \expandafter\ifx\csname pdf@escapehex\endcsname\relax

\BIC@Expand

128 \def\BIC@Expand#1{%
129 \romannumeral0%
130 \BIC@@Expand#1!\@nil{}}%
131 }%

\BIC@@Expand

132 \def\BIC@@Expand#1#2\@nil#3{%
133 \expandafter\ifcat\noexpand#1\relax
134 \expandafter\@firstoftwo
135 \else
136 \expandafter\@secondoftwo
137 \fi
138 {%
139 \expandafter\BIC@@Expand#1#2\@nil{#3}%
140 }{%
141 \ifx#1!%
142 \expandafter\@firstoftwo
143 \else
144 \expandafter\@secondoftwo
145 \fi
146 { #3}{%
147 \BIC@@Expand#2\@nil{#3#1}%
148 }%
149 }%
150 }%

\@firstoftwo

151 \expandafter\ifx\csname @firstoftwo\endcsname\relax
152 \long\def\@firstoftwo#1#2{#1}%
153 \fi

```

\@secondoftwo

```
154 \expandafter\ifx\csname @secondoftwo\endcsname\relax
155   \long\def\@secondoftwo#1#2{#2}%
156   \fi

157 \else
```

\BIC@Expand

```
158 \def\BIC@Expand#1{%
159   \romannumeral0\expandafter\expandafter\expandafter\BIC@Space
160   \pdf@unescapehex{%
161     \expandafter\expandafter\expandafter
162     \BIC@StripHexSpace\pdf@escapehex{#1}20\@nil
163   }%
164 }%
```

\BIC@StripHexSpace

```
165 \def\BIC@StripHexSpace#120#2\@nil{%
166   #1%
167   \ifx\#2\%
168   \else
169     \BIC@AfterFi{%
170       \BIC@StripHexSpace#2\@nil
171     }%
172   \BIC@Fi
173 }%

174 \fi
```

## 2.6 Normalize expanded number

\BIC@Normalize #1: result sign

#2: first token of number

```
175 \def\BIC@Normalize#1#2{%
176   \ifx#2-%
177     \ifx\#1\%
178       \BIC@AfterFiFi{%
179         \BIC@Normalize-%
180       }%
181     \else
182       \BIC@AfterFiFi{%
183         \BIC@Normalize{}%
184       }%
185     \fi
186   \else
187     \ifx#2+%
188       \BIC@AfterFiFi{%
189         \BIC@Normalize{#1}%
190       }%
191     \else
192       \ifx#20%
193         \BIC@AfterFiFiFi{%
194           \BIC@NormalizeZero{#1}%
195         }%
196       \else
197         \BIC@AfterFiFiFi{%
198           \BIC@NormalizeDigits#1#2%
199         }%
200       \fi
201     \fi
202   \BIC@Fi
203 }
```

\BIC@NormalizeZero

```
204 \def\BIC@NormalizeZero#1#2{%
205   \ifx#2!%
206     \BIC@AfterFi{ 0}%
207   \else
208     \ifx#20%
209       \BIC@AfterFiFi{%
210         \BIC@NormalizeZero{#1}%
211       }%
212     \else
213       \BIC@AfterFiFi{%
214         \BIC@NormalizeDigits#1#2%
215       }%
216     \fi
217   \BIC@Fi
218 }
```

\BIC@NormalizeDigits

```
219 \def\BIC@NormalizeDigits#1!{ #1}
```

## 2.7 Num

\bigintcalcNum

```
220 \def\bigintcalcNum#1{%
221   \romannumeral0%
222   \expandafter\expandafter\expandafter\BIC@Normalize
223   \expandafter\expandafter\expandafter{%
224     \expandafter\expandafter\expandafter}%
225   \BIC@Expand{#1}!%
226 }
```

## 2.8 Inv, Abs, Sgn

\bigintcalcInv

```
227 \def\bigintcalcInv#1{%
228   \romannumeral0\expandafter\expandafter\expandafter\BIC@Space
229   \bigintcalcNum{-#1}%
230 }
```

\bigintcalcAbs

```
231 \def\bigintcalcAbs#1{%
232   \romannumeral0%
233   \expandafter\expandafter\expandafter\BIC@Abs
234   \bigintcalcNum{#1}%
235 }
```

\BIC@Abs

```
236 \def\BIC@Abs#1{%
237   \ifx#1-%
238     \expandafter\BIC@Space
239   \else
240     \expandafter\BIC@Space
241     \expandafter#1%
242   \fi
243 }
```

\bigintcalcSgn

```
244 \def\bigintcalcSgn#1{%
245   \number
246   \expandafter\expandafter\expandafter\BIC@Sgn
```

```

247 \bigintcalcNum{#1}! %
248 }

```

\BIC@Sgn

```

249 \def\BIC@Sgn#1#2!{%
250 \ifx#1-%
251 -1%
252 \else
253 \ifx#10%
254 0%
255 \else
256 1%
257 \fi
258 \fi
259 }

```

## 2.9 Cmp, Min, Max

\bigintcalcCmp

```

260 \def\bigintcalcCmp#1#2{%
261 \number
262 \expandafter\expandafter\expandafter\BIC@Cmp
263 \bigintcalcNum{#2}!{#1}%
264 }

```

\BIC@Cmp

```

265 \def\BIC@Cmp#1!#2{%
266 \expandafter\expandafter\expandafter\BIC@@Cmp
267 \bigintcalcNum{#2}!#1!%
268 }

```

\BIC@@Cmp

```

269 \def\BIC@@Cmp#1#2!#3#4!{%
270 \ifx#1-%
271 \ifx#3-%
272 \BIC@AfterFiFi{%
273 \BIC@@Cmp#4!#2!%
274 }%
275 \else
276 \BIC@AfterFiFi{%
277 -1 %
278 }%
279 \fi
280 \else
281 \ifx#3-%
282 \BIC@AfterFiFi{%
283 1 %
284 }%
285 \else
286 \BIC@AfterFiFi{%
287 \BIC@CmpLength#1#2!#3#4!#1#2!#3#4!%
288 }%
289 \fi
290 \BIC@Fi
291 }

```

\BIC@PosCmp

```

292 \def\BIC@PosCmp#1!#2!{%
293 \BIC@CmpLength#1!#2!#1!#2!%
294 }

```

\BIC@CmpLength

```
295 \def\BIC@CmpLength#1#2!#3#4!{%
296   \ifx\#2\%
297     \ifx\#4\%
298       \BIC@AfterFiFi\BIC@CmpDiff
299     \else
300       \BIC@AfterFiFi{%
301         \BIC@CmpResult{-1}%
302       }%
303     \fi
304   \else
305     \ifx\#4\%
306       \BIC@AfterFiFi{%
307         \BIC@CmpResult1%
308       }%
309     \else
310       \BIC@AfterFiFi{%
311         \BIC@CmpLength#2!#4!%
312       }%
313     \fi
314   \BIC@Fi
315 }
```

\BIC@CmpResult

```
316 \def\BIC@CmpResult#1#2!#3!{#1 }
```

\BIC@CmpDiff

```
317 \def\BIC@CmpDiff#1#2!#3#4!{%
318   \ifnum#1<#3 %
319     \BIC@AfterFi{%
320       -1 %
321     }%
322   \else
323     \ifnum#1>#3 %
324       \BIC@AfterFiFi{%
325         1 %
326       }%
327     \else
328       \ifx\#2\%
329         \BIC@AfterFiFiFi{%
330           0 %
331         }%
332       \else
333         \BIC@AfterFiFiFi{%
334           \BIC@CmpDiff#2!#4!%
335         }%
336       \fi
337     \fi
338   \BIC@Fi
339 }
```

\bigintcalcMin

```
340 \def\bigintcalcMin#1{%
341   \romannumeral0%
342   \expandafter\expandafter\expandafter\BIC@MinMax
343   \bigintcalcNum{#1}!-!%
344 }
```

\bigintcalcMax

```
345 \def\bigintcalcMax#1{%
346   \romannumeral0%
```

```

347 \expandafter\expandafter\expandafter\BIC@MinMax
348 \bigintcalcNum{#1}!!%
349 }

\BIC@MinMax #1:  $x$ 
#2: sign for comparison
#3:  $y$ 
350 \def\BIC@MinMax#1!#2!#3{%
351 \expandafter\expandafter\expandafter\BIC@@MinMax
352 \bigintcalcNum{#3}!#1!#2!%
353 }

\BIC@@MinMax #1:  $y$ 
#2:  $x$ 
#3: sign for comparison
354 \def\BIC@@MinMax#1!#2!#3!{%
355 \ifnum\BIC@@Cmp#1!#2!=#31 %
356 \BIC@AfterFi{ #1}%
357 \else
358 \BIC@AfterFi{ #2}%
359 \BIC@Fi
360 }

```

## 2.10 Odd

```

\bigintcalcOdd
361 \def\bigintcalcOdd#1{%
362 \romannumeral0%
363 \expandafter\expandafter\expandafter\BIC@Odd
364 \bigintcalcAbs{#1}!%
365 }

\BigIntCalcOdd
366 \def\BigIntCalcOdd#1!{%
367 \romannumeral0%
368 \BIC@Odd#1!%
369 }

\BIC@Odd #1:  $x$ 
370 \def\BIC@Odd#1#2{%
371 \ifx#2!%
372 \ifodd#1 %
373 \BIC@AfterFiFi{ 1}%
374 \else
375 \BIC@AfterFiFi{ 0}%
376 \fi
377 \else
378 \expandafter\BIC@Odd\expandafter#2%
379 \BIC@Fi
380 }

```

## 2.11 Inc, Dec

```

\bigintcalcInc
381 \def\bigintcalcInc#1{%
382 \romannumeral0%
383 \expandafter\expandafter\expandafter\BIC@IncSwitch
384 \bigintcalcNum{#1}!%
385 }

```

\BIC@IncSwitch

```
386 \def\BIC@IncSwitch#1#2!{%
387   \ifcase\BIC@@Cmp#1#2!-1!%
388     \BIC@AfterFi{ 0}%
389   \or
390     \BIC@AfterFi{%
391       \BIC@Inc#1#2!{%}%
392     }%
393   \else
394     \BIC@AfterFi{%
395       \expandafter-\romannumeral0%
396       \BIC@Dec#2!{%}%
397     }%
398   \BIC@Fi
399 }
```

\bigintcalcDec

```
400 \def\bigintcalcDec#1{%
401   \romannumeral0%
402   \expandafter\expandafter\expandafter\BIC@DecSwitch
403   \bigintcalcNum{#1}!%
404 }
```

\BIC@DecSwitch

```
405 \def\BIC@DecSwitch#1#2!{%
406   \ifcase\BIC@Sgn#1#2! %
407     \BIC@AfterFi{ -1}%
408   \or
409     \BIC@AfterFi{%
410       \BIC@Dec#1#2!{%}%
411     }%
412   \else
413     \BIC@AfterFi{%
414       \expandafter-\romannumeral0%
415       \BIC@Inc#2!{%}%
416     }%
417   \BIC@Fi
418 }
```

\BigIntCalcInc

```
419 \def\BigIntCalcInc#1!{%
420   \romannumeral0\BIC@Inc#1!{%}%
421 }
```

\BigIntCalcDec

```
422 \def\BigIntCalcDec#1!{%
423   \romannumeral0\BIC@Dec#1!{%}%
424 }
```

\BIC@Inc

```
425 \def\BIC@Inc#1#2!#3{%
426   \ifx\#2\%
427     \BIC@AfterFi{%
428       \BIC@@Inc1#1#3!{%}%
429     }%
430   \else
431     \BIC@AfterFi{%
432       \BIC@Inc#2!{#1#3}%
433     }%
434   \BIC@Fi
435 }
```



\BIC@@Inc

```
436 \def\BIC@@Inc#1#2#3!#4{%
437   \ifcase#1 %
438     \ifx\\#3\\%
439       \BIC@AfterFiFi{ #2#4}%
440     \else
441       \BIC@AfterFiFi{%
442         \BIC@@Inc0#3!{#2#4}%
443       }%
444     \fi
445   \else
446     \ifnum#2<9 %
447       \BIC@AfterFiFi{%
448 &       \expandafter\BIC@@@Inc\the\numexpr#2+1\relax
449 $       \expandafter\expandafter\expandafter\BIC@@@Inc
450 $       \ifcase#2 \expandafter1%
451 $       \or\expandafter2%
452 $       \or\expandafter3%
453 $       \or\expandafter4%
454 $       \or\expandafter5%
455 $       \or\expandafter6%
456 $       \or\expandafter7%
457 $       \or\expandafter8%
458 $       \or\expandafter9%
459 $?     \else\BigIntCalcError:ThisCannotHappen%
460 $       \fi
461       0#3!{#4}%
462     }%
463   \else
464     \BIC@AfterFiFi{%
465       \BIC@@@Inc01#3!{#4}%
466     }%
467   \fi
468 \BIC@Fi
469 }
```

\BIC@@@Inc

```
470 \def\BIC@@@Inc#1#2#3!#4{%
471   \ifx\\#3\\%
472     \ifnum#2=1 %
473       \BIC@AfterFiFi{ 1#1#4}%
474     \else
475       \BIC@AfterFiFi{ #1#4}%
476     \fi
477   \else
478     \BIC@AfterFi{%
479       \BIC@@Inc#2#3!{#1#4}%
480     }%
481   \BIC@Fi
482 }
```

\BIC@Dec

```
483 \def\BIC@Dec#1#2!#3{%
484   \ifx\\#2\\%
485     \BIC@AfterFi{%
486       \BIC@@Dec1#1#3!{ }%
487     }%
488   \else
489     \BIC@AfterFi{%
490       \BIC@Dec#2!{#1#3}%
491     }%
492   \BIC@Fi
```

```

493 }

\BIC@@Dec

494 \def\BIC@@Dec#1#2#3!#4{%
495   \ifcase#1 %
496     \ifx\#3\%
497       \BIC@AfterFiFi{ #2#4}%
498     \else
499       \BIC@AfterFiFi{%
500         \BIC@@Dec0#3!{#2#4}%
501       }%
502     \fi
503   \else
504     \ifnum#2>0 %
505       \BIC@AfterFiFi{%
506 &         \expandafter\BIC@@Dec\the\numexpr#2-1\relax
507 $         \expandafter\expandafter\expandafter\BIC@@Dec
508 $         \ifcase#2
509 $?         \BigIntCalcError:ThisCannotHappen%
510 $         \or\expandafter0%
511 $         \or\expandafter1%
512 $         \or\expandafter2%
513 $         \or\expandafter3%
514 $         \or\expandafter4%
515 $         \or\expandafter5%
516 $         \or\expandafter6%
517 $         \or\expandafter7%
518 $         \or\expandafter8%
519 $?         \else\BigIntCalcError:ThisCannotHappen%
520 $         \fi
521         0#3!{#4}%
522       }%
523     \else
524       \BIC@AfterFiFi{%
525         \BIC@@Dec91#3!{#4}%
526       }%
527     \fi
528   \BIC@Fi
529 }

\BIC@@@Dec

530 \def\BIC@@@Dec#1#2#3!#4{%
531   \ifx\#3\%
532     \ifcase#1 %
533       \ifx\#4\%
534         \BIC@AfterFiFiFi{ 0}%
535       \else
536         \BIC@AfterFiFiFi{ #4}%
537       \fi
538     \else
539       \BIC@AfterFiFi{ #1#4}%
540     \fi
541   \else
542     \BIC@AfterFi{%
543       \BIC@@Dec#2#3!{#1#4}%
544     }%
545   \BIC@Fi
546 }

```

## 2.12 Add, Sub

\bigintcalcAdd

```

547 \def\bigintcalcAdd#1{%
548   \romannumeral0%
549   \expandafter\expandafter\expandafter\BIC@Add
550   \bigintcalcNum{#1}!%
551 }

```

\BIC@Add

```

552 \def\BIC@Add#1!#2{%
553   \expandafter\expandafter\expandafter
554   \BIC@AddSwitch\bigintcalcNum{#2}!#1!%
555 }

```

\bigintcalcSub

```

556 \def\bigintcalcSub#1#2{%
557   \romannumeral0%
558   \expandafter\expandafter\expandafter\BIC@Add
559   \bigintcalcNum{-#2}!{#1}%
560 }

```

\BIC@AddSwitch Decision table for \BIC@AddSwitch.

$x < 0$	$y < 0$	$-x > -y$	–	$\text{Add}(-x, -y)$
		else		$\text{Add}(-y, -x)$
	else	$-x > y$	–	$\text{Sub}(-x, y)$
		$-x = y$		0
else		else	+	$\text{Sub}(y, -x)$
	$y < 0$	$x > -y$	+	$\text{Sub}(x, -y)$
		$x = -y$		0
		else	–	$\text{Sub}(-y, x)$
	else	$x > y$	+	$\text{Add}(x, y)$
		else		$\text{Add}(y, x)$

```

561 \def\BIC@AddSwitch#1#2!#3#4!{%
562   \ifx#1-% x < 0
563     \ifx#3-% y < 0
564       \expandafter-\romannumeral0%
565       \ifnum\BIC@PosCmp#2!#4!=1 % -x > -y
566         \BIC@AfterFiFiFi{%
567           \BIC@AddXY#2!#4!!!%
568         }%
569       \else % -x <= -y
570         \BIC@AfterFiFiFi{%
571           \BIC@AddXY#4!#2!!!%
572         }%
573       \fi
574     \else % y >= 0
575       \ifcase\BIC@PosCmp#2!#3#4!% -x = y
576         \BIC@AfterFiFiFi{ 0}%
577       \or % -x > y
578         \expandafter-\romannumeral0%
579         \BIC@AfterFiFiFi{%
580           \BIC@SubXY#2!#3#4!!!%
581         }%
582       \else % -x <= y
583         \BIC@AfterFiFiFi{%
584           \BIC@SubXY#3#4!#2!!!%
585         }%
586       \fi
587     \fi
588   \else % x >= 0
589     \ifx#3-% y < 0

```

```

590     \ifcase\BIC@PosCmp#1#2!#4!% x = -y
591     \BIC@AfterFiFiFi{ 0}%
592     \or % x > -y
593     \BIC@AfterFiFiFi{%
594     \BIC@SubXY#1#2!#4!!!%
595     }%
596     \else % x <= -y
597     \expandafter-\romannumeral0%
598     \BIC@AfterFiFiFi{%
599     \BIC@SubXY#4!#1#2!!!%
600     }%
601     \fi
602     \else % y >= 0
603     \ifnum\BIC@PosCmp#1#2!#3#4!=1 % x > y
604     \BIC@AfterFiFiFi{%
605     \BIC@AddXY#1#2!#3#4!!!%
606     }%
607     \else % x <= y
608     \BIC@AfterFiFiFi{%
609     \BIC@AddXY#3#4!#1#2!!!%
610     }%
611     \fi
612     \fi
613     \BIC@Fi
614 }

\BigIntCalcAdd

615 \def\BigIntCalcAdd#1!#2!{%
616     \romannumeral0\BIC@AddXY#1!#2!!!%
617 }

\BigIntCalcSub

618 \def\BigIntCalcSub#1!#2!{%
619     \romannumeral0\BIC@SubXY#1!#2!!!%
620 }

\BIC@AddXY

621 \def\BIC@AddXY#1#2!#3#4!#5!#6!{%
622     \ifx\#2\%
623     \ifx\#3\%
624     \BIC@AfterFiFiFi{%
625     \BIC@DoAdd0!#1#5!#60!%
626     }%
627     \else
628     \BIC@AfterFiFiFi{%
629     \BIC@DoAdd0!#1#5!#3#6!%
630     }%
631     \fi
632     \else
633     \ifx\#4\%
634     \ifx\#3\%
635     \BIC@AfterFiFiFi{%
636     \BIC@AddXY#2!{}!#1#5!#60!%
637     }%
638     \else
639     \BIC@AfterFiFiFi{%
640     \BIC@AddXY#2!{}!#1#5!#3#6!%
641     }%
642     \fi
643     \else
644     \BIC@AfterFiFiFi{%
645     \BIC@AddXY#2!#4!#1#5!#3#6!%

```

```

646     }%
647     \fi
648     \BIC@Fi
649 }

\BIC@DoAdd #1: carry
#2: reverted result
#3#4: reverted  $x$ 
#5#6: reverted  $y$ 
650 \def\BIC@DoAdd#1#2!#3#4!#5#6!{%
651     \ifx\#4\%
652         \BIC@AfterFi{%
653             & \expandafter\BIC@Space
654             & \the\numexpr#1+#3+#5\relax#2%
655             $ \expandafter\expandafter\expandafter\BIC@AddResult
656             $ \BIC@AddDigit#1#3#5#2%
657         }%
658     \else
659         \BIC@AfterFi{%
660             \expandafter\expandafter\expandafter\BIC@DoAdd
661             \BIC@AddDigit#1#3#5#2!#4!#6!%
662         }%
663     \BIC@Fi
664 }

\BIC@AddResult
665 $ \def\BIC@AddResult#1{%
666 $ \ifx#10%
667 $ \expandafter\BIC@Space
668 $ \else
669 $ \expandafter\BIC@Space\expandafter#1%
670 $ \fi
671 $ }%

\BIC@AddDigit #1: carry
#2: digit of  $x$ 
#3: digit of  $y$ 
672 \def\BIC@AddDigit#1#2#3{%
673     \romannumeral0%
674 & \expandafter\BIC@@AddDigit\the\numexpr#1+#2+#3!%
675 $ \expandafter\BIC@@AddDigit\number%
676 $ \csname
677 $ BIC@AddCarry%
678 $ \ifcase#1 %
679 $ #2%
680 $ \else
681 $ \ifcase#2 1\or2\or3\or4\or5\or6\or7\or8\or9\or10\fi
682 $ \fi
683 $ \endcsname#3!%
684 }

\BIC@@AddDigit
685 \def\BIC@@AddDigit#1!{%
686     \ifnum#1<10 %
687         \BIC@AfterFi{ 0#1}%
688     \else
689         \BIC@AfterFi{ #1}%
690     \BIC@Fi
691 }

\BIC@AddCarry0
692 $ \expandafter\def\csname BIC@AddCarry0\endcsname#1{#1}%

```

\BIC@AddCarry10

```
693 $ \expandafter\def\csname BIC@AddCarry10\endcsname#1{#1}%
```

\BIC@AddCarry[1-9]

```
694 $ \def\BIC@Temp#1#2{%
695 $   \expandafter\def\csname BIC@AddCarry#1\endcsname##1{%
696 $     \ifcase##1 #1\or
697 $       #2%
698 $?   \else\BigIntCalcError:ThisCannotHappen%
699 $     \fi
700 $   }%
701 $ }%
702 $ \BIC@Temp 0{1\or2\or3\or4\or5\or6\or7\or8\or9}%
703 $ \BIC@Temp 1{2\or3\or4\or5\or6\or7\or8\or9\or10}%
704 $ \BIC@Temp 2{3\or4\or5\or6\or7\or8\or9\or10\or11}%
705 $ \BIC@Temp 3{4\or5\or6\or7\or8\or9\or10\or11\or12}%
706 $ \BIC@Temp 4{5\or6\or7\or8\or9\or10\or11\or12\or13}%
707 $ \BIC@Temp 5{6\or7\or8\or9\or10\or11\or12\or13\or14}%
708 $ \BIC@Temp 6{7\or8\or9\or10\or11\or12\or13\or14\or15}%
709 $ \BIC@Temp 7{8\or9\or10\or11\or12\or13\or14\or15\or16}%
710 $ \BIC@Temp 8{9\or10\or11\or12\or13\or14\or15\or16\or17}%
711 $ \BIC@Temp 9{10\or11\or12\or13\or14\or15\or16\or17\or18}%
```

\BIC@SubXY Preconditions:

- $x > y$ ,  $x \geq 0$ , and  $y \geq 0$
- $\text{digits}(x) = \text{digits}(y)$

```
712 \def\BIC@SubXY#1#2!#3#4!#5!#6!{%
713   \ifx\#2\%
714     \ifx\#3\%
715       \BIC@AfterFiFi{%
716         \BIC@DoSub0!#1#5!#60!%
717       }%
718     \else
719       \BIC@AfterFiFi{%
720         \BIC@DoSub0!#1#5!#3#6!%
721       }%
722     \fi
723   \else
724     \ifx\#4\%
725       \ifx\#3\%
726         \BIC@AfterFiFiFi{%
727           \BIC@SubXY#2!#1#5!#60!%
728         }%
729       \else
730         \BIC@AfterFiFiFi{%
731           \BIC@SubXY#2!#1#5!#3#6!%
732         }%
733       \fi
734     \else
735       \BIC@AfterFiFiFi{%
736         \BIC@SubXY#2!#4!#1#5!#3#6!%
737       }%
738     \fi
739   \BIC@Fi
740 }
```

\BIC@DoSub #1: carry

#2: reverted result

#3#4: reverted x

#5#6: reverted y

```

741 \def\BIC@DoSub#1#2!#3#4!#5#6!{%
742   \ifx\#4\%
743     \BIC@AfterFi{%
744       \expandafter\expandafter\expandafter\BIC@SubResult
745       \BIC@SubDigit#1#3#5#2%
746     }%
747   \else
748     \BIC@AfterFi{%
749       \expandafter\expandafter\expandafter\BIC@DoSub
750       \BIC@SubDigit#1#3#5#2!#4!#6!%
751     }%
752   \BIC@Fi
753 }

```

\BIC@SubResult

```

754 \def\BIC@SubResult#1{%
755   \ifx#10%
756     \expandafter\BIC@SubResult
757   \else
758     \expandafter\BIC@Space\expandafter#1%
759   \fi
760 }

```

\BIC@SubDigit #1: carry

#2: digit of  $x$

#3: digit of  $y$

```

761 \def\BIC@SubDigit#1#2#3{%
762   \romannumeral0%
763 & \expandafter\BIC@@SubDigit\the\numexpr#2-#3-#1!%
764 $ \expandafter\BIC@@AddDigit\number
765 $   \csname
766 $     BIC@SubCarry%
767 $     \ifcase#1 %
768 $       #3%
769 $     \else
770 $       \ifcase#3 1\or2\or3\or4\or5\or6\or7\or8\or9\or10\fi
771 $     \fi
772 $   \endcsname#2!%
773 }

```

\BIC@@SubDigit

```

774 & \def\BIC@@SubDigit#1!{%
775 &   \ifnum#1<0 %
776 &     \BIC@AfterFi{%
777 &       \expandafter\BIC@Space
778 &       \expandafter1\the\numexpr#1+10\relax
779 &     }%
780 &   \else
781 &     \BIC@AfterFi{ 0#1}%
782 &   \BIC@Fi
783 & }%

```

\BIC@SubCarry0

```

784 $ \expandafter\def\csname BIC@SubCarry0\endcsname#1{#1}%

```

\BIC@SubCarry10

```

785 $ \expandafter\def\csname BIC@SubCarry10\endcsname#1{1#1}%

```

\BIC@SubCarry[1-9]

```

786 $ \def\BIC@Temp#1#2{%
787 $   \expandafter\def\csname BIC@SubCarry#1\endcsname##1{%

```

```

788 $ \ifcase##1 #2%
789 $? \else\BigIntCalcError:ThisCannotHappen%
790 $ \fi
791 $ }%
792 $ }%
793 $ \BIC@Temp 1{19\or0\or1\or2\or3\or4\or5\or6\or7\or8}%
794 $ \BIC@Temp 2{18\or19\or0\or1\or2\or3\or4\or5\or6\or7}%
795 $ \BIC@Temp 3{17\or18\or19\or0\or1\or2\or3\or4\or5\or6}%
796 $ \BIC@Temp 4{16\or17\or18\or19\or0\or1\or2\or3\or4\or5}%
797 $ \BIC@Temp 5{15\or16\or17\or18\or19\or0\or1\or2\or3\or4}%
798 $ \BIC@Temp 6{14\or15\or16\or17\or18\or19\or0\or1\or2\or3}%
799 $ \BIC@Temp 7{13\or14\or15\or16\or17\or18\or19\or0\or1\or2}%
800 $ \BIC@Temp 8{12\or13\or14\or15\or16\or17\or18\or19\or0\or1}%
801 $ \BIC@Temp 9{11\or12\or13\or14\or15\or16\or17\or18\or19\or0}%

```

## 2.13 Shl, Shr

\bigintcalcShl

```

802 \def\bigintcalcShl#1{%
803 \romannumeral0%
804 \expandafter\expandafter\expandafter\BIC@Shl
805 \bigintcalcNum{#1}!%
806 }

```

\BIC@Shl

```

807 \def\BIC@Shl#1#2!{%
808 \ifx#1-%
809 \BIC@AfterFi{%
810 \expandafter-\romannumeral0%
811 & \BIC@@Shl#2!!%
812 $ \BIC@AddXY#2!#2!!!%
813 }%
814 \else
815 \BIC@AfterFi{%
816 & \BIC@@Shl#1#2!!%
817 $ \BIC@AddXY#1#2!#1#2!!!%
818 }%
819 \BIC@Fi
820 }

```

\BigIntCalcShl

```

821 \def\BigIntCalcShl#1!{%
822 \romannumeral0%
823 & \BIC@@Shl#1!!%
824 $ \BIC@AddXY#1!#1!!!%
825 }

```

\BIC@@Shl

```

826 & \def\BIC@@Shl#1#2!{%
827 & \ifx\#2\%
828 & \BIC@AfterFi{%
829 & \BIC@@@Shl0!#1%
830 & }%
831 & \else
832 & \BIC@AfterFi{%
833 & \BIC@@Shl#2!#1%
834 & }%
835 & \BIC@Fi
836 & }%

```



```

\BIC@@@Shl #1: carry
#2: result
#3#4: reverted number
837 & \def\BIC@@@Shl#1#2!#3#4!{%
838 & \ifx\#4\%
839 & \BIC@AfterFi{%
840 & \expandafter\BIC@Space
841 & \the\numexpr#3*2+#1\relax#2%
842 & }%
843 & \else
844 & \BIC@AfterFi{%
845 & \expandafter\BIC@@@Shl\the\numexpr#3*2+#1!#2!#4!%
846 & }%
847 & \BIC@Fi
848 & }%

\BIC@@@Shl
849 & \def\BIC@@@Shl#1!{%
850 & \ifnum#1<10 %
851 & \BIC@AfterFi{%
852 & \BIC@@Shl0#1%
853 & }%
854 & \else
855 & \BIC@AfterFi{%
856 & \BIC@@Shl#1%
857 & }%
858 & \BIC@Fi
859 & }%

\bigintcalcShr
860 \def\bigintcalcShr#1{%
861 \romannumeral0%
862 \expandafter\expandafter\expandafter\BIC@Shr
863 \bigintcalcNum{#1}!%
864 }

\BIC@Shr
865 \def\BIC@Shr#1#2!{%
866 \ifx#1-%
867 \expandafter-\romannumeral0%
868 \BIC@AfterFi{%
869 \BIC@@Shr#2!%
870 }%
871 \else
872 \BIC@AfterFi{%
873 \BIC@@Shr#1#2!%
874 }%
875 \BIC@Fi
876 }

\BigIntCalcShr
877 \def\BigIntCalcShr#1!{%
878 \romannumeral0%
879 \BIC@@Shr#1!%
880 }

\BIC@@Shr
881 \def\BIC@@Shr#1#2!{%
882 \ifcase#1 %
883 \BIC@AfterFi{ 0}%
884 \or

```

```

885     \ifx\|#2\%
886     \BIC@AfterFiFi{ 0}%
887     \else
888     \BIC@AfterFiFi{%
889     \BIC@@@Shr#1#2!!%
890     }%
891     \fi
892     \else
893     \BIC@AfterFiFi{%
894     \BIC@@@Shr0#1#2!!%
895     }%
896     \BIC@Fi
897 }

\BIC@@@Shr #1: carry
#2#3: number
#4: result

898 \def\BIC@@@Shr#1#2#3!#4!{%
899     \ifx\|#3\%
900     \ifodd#1#2 %
901     \BIC@AfterFiFi{%
902     & \expandafter\BIC@ShrResult\the\numexpr(#1#2-1)/2\relax
903     $ \expandafter\expandafter\expandafter\BIC@ShrResult
904     $ \csname BIC@ShrDigit#1#2\endcsname
905     #4!%
906     }%
907     \else
908     \BIC@AfterFiFi{%
909     & \expandafter\BIC@ShrResult\the\numexpr#1#2/2\relax
910     $ \expandafter\expandafter\expandafter\BIC@ShrResult
911     $ \csname BIC@ShrDigit#1#2\endcsname
912     #4!%
913     }%
914     \fi
915     \else
916     \ifodd#1#2 %
917     \BIC@AfterFiFi{%
918     & \expandafter\BIC@@@Shr\the\numexpr(#1#2-1)/2\relax1%
919     $ \expandafter\expandafter\expandafter\BIC@@@Shr
920     $ \csname BIC@ShrDigit#1#2\endcsname
921     #3!#4!%
922     }%
923     \else
924     \BIC@AfterFiFi{%
925     & \expandafter\BIC@@@Shr\the\numexpr#1#2/2\relax0%
926     $ \expandafter\expandafter\expandafter\BIC@@@Shr
927     $ \csname BIC@ShrDigit#1#2\endcsname
928     #3!#4!%
929     }%
930     \fi
931     \BIC@Fi
932 }

\BIC@ShrResult

933 & \def\BIC@ShrResult#1#2!{ #2#1}%
934 $ \def\BIC@ShrResult#1#2#3!{ #3#1}%

\BIC@@@Shr #1: new digit
#2: carry
#3: remaining number
#4: result

935 \def\BIC@@@Shr#1#2#3!#4!{%

```

```

936 \BIC@@@Shr#2#3!#4#1!%
937 }

```

\BIC@ShrDigit[00-19]

```

938 $ \def\BIC@Temp#1#2#3#4{%
939 $ \expandafter\def\csname BIC@ShrDigit#1#2\endcsname{#3#4}%
940 $ }%
941 $ \BIC@Temp 0000%
942 $ \BIC@Temp 0101%
943 $ \BIC@Temp 0210%
944 $ \BIC@Temp 0311%
945 $ \BIC@Temp 0420%
946 $ \BIC@Temp 0521%
947 $ \BIC@Temp 0630%
948 $ \BIC@Temp 0731%
949 $ \BIC@Temp 0840%
950 $ \BIC@Temp 0941%
951 $ \BIC@Temp 1050%
952 $ \BIC@Temp 1151%
953 $ \BIC@Temp 1260%
954 $ \BIC@Temp 1361%
955 $ \BIC@Temp 1470%
956 $ \BIC@Temp 1571%
957 $ \BIC@Temp 1680%
958 $ \BIC@Temp 1781%
959 $ \BIC@Temp 1890%
960 $ \BIC@Temp 1991%

```

## 2.14 \BIC@Tim

\BIC@Tim Macro \BIC@Tim implements “Number *times* digit”.

#1: plain number without sign  
#2: digit

\BIC@@Tim #1#2: number

#3: reverted number

```

961 \def\BIC@@Tim#1#2!{%
962 \ifx\#2\%
963 \BIC@AfterFi{%
964 \BIC@ProcessTim0!#1%
965 }%
966 \else
967 \BIC@AfterFi{%
968 \BIC@@Tim#2!#1%
969 }%
970 \BIC@Fi
971 }

```

\BIC@ProcessTim #1: carry

#2: result

#3#4: reverted number

#5: digit

```

972 \def\BIC@ProcessTim#1#2!#3#4!#5{%
973 \ifx\#4\%
974 \BIC@AfterFi{%
975 \expandafter\BIC@Space
976 & \the\numexpr#3*#5+#1\relax
977 $ \romannumeral0\BIC@TimDigit#3#5#1%
978 #2%
979 }%
980 \else

```

```

981     \BIC@AfterFi{%
982     \expandafter\BIC@@ProcessTim
983 &     \the\numexpr#3*#5+#1%
984 $     \romannumeral0\BIC@TimDigit#3#5#1%
985     !#2!#4!#5%
986     }%
987 \BIC@Fi
988 }

\BIC@@ProcessTim #1#2: carry?, new digit
#3: new number
#4: old number
#5: digit
989 \def\BIC@@ProcessTim#1#2!{%
990     \ifx\#2\%
991     \BIC@AfterFi{%
992     \BIC@ProcessTim0#1%
993     }%
994 \else
995     \BIC@AfterFi{%
996     \BIC@ProcessTim#1#2%
997     }%
998 \BIC@Fi
999 }

\BIC@TimDigit #1: digit 0–9
#2: digit 3–9
#3: carry 0–9
1000 $ \def\BIC@TimDigit#1#2#3{%
1001 $     \ifcase#1 % 0
1002 $     \BIC@AfterFi{ #3}%
1003 $     \or % 1
1004 $     \BIC@AfterFi{%
1005 $         \expandafter\BIC@Space
1006 $         \number\csname BIC@AddCarry#2\endcsname#3 %
1007 $     }%
1008 $     \else
1009 $     \ifcase#3 %
1010 $     \BIC@AfterFiFi{%
1011 $         \expandafter\BIC@Space
1012 $         \number\csname BIC@MulDigit#2\endcsname#1 %
1013 $     }%
1014 $     \else
1015 $     \BIC@AfterFiFi{%
1016 $         \expandafter\BIC@Space
1017 $         \romannumeral0%
1018 $         \expandafter\BIC@AddXY
1019 $         \number\csname BIC@MulDigit#2\endcsname#1!%
1020 $         #3!!!%
1021 $     }%
1022 $     \fi
1023 $     \BIC@Fi
1024 $ }%

\BIC@MulDigit[3–9]
1025 $ \def\BIC@Temp#1#2{%
1026 $     \expandafter\def\csname BIC@MulDigit#1\endcsname##1{%
1027 $         \ifcase##1 0%
1028 $         \or ##1%
1029 $         \or ##2%
1030 $     }%
1031 $     \else\BigIntCalcError:ThisCannotHappen%
1032 $     \fi

```

```

1032 $ }%
1033 $ }%
1034 $ \BIC@Temp 3{6\or9\or12\or15\or18\or21\or24\or27}%
1035 $ \BIC@Temp 4{8\or12\or16\or20\or24\or28\or32\or36}%
1036 $ \BIC@Temp 5{10\or15\or20\or25\or30\or35\or40\or45}%
1037 $ \BIC@Temp 6{12\or18\or24\or30\or36\or42\or48\or54}%
1038 $ \BIC@Temp 7{14\or21\or28\or35\or42\or49\or56\or63}%
1039 $ \BIC@Temp 8{16\or24\or32\or40\or48\or56\or64\or72}%
1040 $ \BIC@Temp 9{18\or27\or36\or45\or54\or63\or72\or81}%

```

## 2.15 Mul

\bigintcalcMul

```

1041 \def\bigintcalcMul#1#2{%
1042   \romannumeral0%
1043   \expandafter\expandafter\expandafter\BIC@Mul
1044   \bigintcalcNum{#1}!{#2}%
1045 }

```

\BIC@Mul

```

1046 \def\BIC@Mul#1!#2{%
1047   \expandafter\expandafter\expandafter\BIC@MulSwitch
1048   \bigintcalcNum{#2}!#1!%
1049 }

```

\BIC@MulSwitch Decision table for \BIC@MulSwitch.

$x = 0$	0			
$x > 0$	$y = 0$	0		
	$y > 0$	$x > y$	+	$\text{Mul}(x, y)$
		else		$\text{Mul}(y, x)$
	$y < 0$	$x > -y$	-	$\text{Mul}(x, -y)$
		else		$\text{Mul}(-y, x)$
$x < 0$	$y = 0$	0		
	$y > 0$	$-x > y$	-	$\text{Mul}(-x, y)$
		else		$\text{Mul}(y, -x)$
	$y < 0$	$-x > -y$	+	$\text{Mul}(-x, -y)$
		else		$\text{Mul}(-y, -x)$

```

1050 \def\BIC@MulSwitch#1#2!#3#4!{%
1051   \ifcase\BIC@Sgn#1#2! % x = 0
1052     \BIC@AfterFi{ 0}%
1053   \or % x > 0
1054     \ifcase\BIC@Sgn#3#4! % y = 0
1055       \BIC@AfterFiFi{ 0}%
1056     \or % y > 0
1057       \ifnum\BIC@PosCmp#1#2!#3#4!=1 % x > y
1058         \BIC@AfterFiFiFi{%
1059           \BIC@ProcessMul0!#1#2!#3#4!%
1060         }%
1061       \else % x <= y
1062         \BIC@AfterFiFiFi{%
1063           \BIC@ProcessMul0!#3#4!#1#2!%
1064         }%
1065       \fi
1066     \else % y < 0
1067       \expandafter-\romannumeral0%
1068       \ifnum\BIC@PosCmp#1#2!#4!=1 % x > -y
1069         \BIC@AfterFiFiFi{%
1070           \BIC@ProcessMul0!#1#2!#4!%
1071         }%

```

```

1072     \else % x <= -y
1073         \BIC@AfterFiFiFi{%
1074             \BIC@ProcessMul0!#4!#1#2!%
1075         }%
1076     \fi
1077 \fi
1078 \else % x < 0
1079     \ifcase\BIC@Sgn#3#4! % y = 0
1080         \BIC@AfterFiFiFi{ 0}%
1081     \or % y > 0
1082         \expandafter-\romannumeral0%
1083         \ifnum\BIC@PosCmp#2!#3#4!=1 % -x > y
1084             \BIC@AfterFiFiFi{%
1085                 \BIC@ProcessMul0!#2!#3#4!%
1086             }%
1087         \else % -x <= y
1088             \BIC@AfterFiFiFi{%
1089                 \BIC@ProcessMul0!#3#4!#2!%
1090             }%
1091         \fi
1092     \else % y < 0
1093         \ifnum\BIC@PosCmp#2!#4!=1 % -x > -y
1094             \BIC@AfterFiFiFi{%
1095                 \BIC@ProcessMul0!#2!#4!%
1096             }%
1097         \else % -x <= -y
1098             \BIC@AfterFiFiFi{%
1099                 \BIC@ProcessMul0!#4!#2!%
1100             }%
1101         \fi
1102     \fi
1103 \BIC@Fi
1104 }

```

\BigIntCalcMul

```

1105 \def\BigIntCalcMul#1!#2!{%
1106     \romannumeral0%
1107     \BIC@ProcessMul0!#1!#2!%
1108 }

```

\BIC@ProcessMul

```

#1: result
#2: number  $x$ 
#3#4: number  $y$ 
1109 \def\BIC@ProcessMul#1!#2!#3#4!{%
1110     \ifx\#4\%
1111         \BIC@AfterFiFi{%
1112             \expandafter\expandafter\expandafter\BIC@Space
1113             \bigintcalcAdd{\BIC@Tim#2!#3}{#10}%
1114         }%
1115     \else
1116         \BIC@AfterFiFi{%
1117             \expandafter\expandafter\expandafter\BIC@ProcessMul
1118             \bigintcalcAdd{\BIC@Tim#2!#3}{#10}!#2!#4!%
1119         }%
1120     \BIC@Fi
1121 }

```

## 2.16 Sqr

\bigintcalcSqr

```

1122 \def\bigintcalcSqr#1{%
1123     \romannumeral0%

```

```

1124 \expandafter\expandafter\expandafter\BIC@Sqr
1125 \bigintcalcNum{#1}!%
1126 }

```

\BIC@Sqr

```

1127 \def\BIC@Sqr#1{%
1128   \ifx#1-%
1129     \expandafter\BIC@@Sqr
1130   \else
1131     \expandafter\BIC@@Sqr\expandafter#1%
1132   \fi
1133 }

```

\BIC@@Sqr

```

1134 \def\BIC@@Sqr#1!{%
1135   \BIC@ProcessMul0!#1!#1!%
1136 }

```

## 2.17 Fac

\bigintcalcFac

```

1137 \def\bigintcalcFac#1{%
1138   \romannumeral0%
1139   \expandafter\expandafter\expandafter\BIC@Fac
1140   \bigintcalcNum{#1}!%
1141 }

```

\BIC@Fac

```

1142 \def\BIC@Fac#1#2!{%
1143   \ifx#1-%
1144     \BIC@AfterFi{ 0\BigIntCalcError:FacNegative}%
1145   \else
1146     \ifnum\BIC@PosCmp#1#2!13!<0 %
1147       \ifcase#1#2 %
1148         \BIC@AfterFiFiFi{ 1}% 0!
1149         \or\BIC@AfterFiFiFi{ 1}% 1!
1150         \or\BIC@AfterFiFiFi{ 2}% 2!
1151         \or\BIC@AfterFiFiFi{ 6}% 3!
1152         \or\BIC@AfterFiFiFi{ 24}% 4!
1153         \or\BIC@AfterFiFiFi{ 120}% 5!
1154         \or\BIC@AfterFiFiFi{ 720}% 6!
1155         \or\BIC@AfterFiFiFi{ 5040}% 7!
1156         \or\BIC@AfterFiFiFi{ 40320}% 8!
1157         \or\BIC@AfterFiFiFi{ 362880}% 9!
1158         \or\BIC@AfterFiFiFi{ 3628800}% 10!
1159         \or\BIC@AfterFiFiFi{ 39916800}% 11!
1160         \or\BIC@AfterFiFiFi{ 479001600}% 12!
1161       ? \else\BigIntCalcError:ThisCannotHappen%
1162       \fi
1163     \else
1164       \BIC@AfterFiFiFi{%
1165         \BIC@ProcessFac#1#2!479001600!%
1166       }%
1167     \fi
1168   \BIC@Fi
1169 }

```

\BIC@ProcessFac #1:  $n$

#2: result

```

1170 \def\BIC@ProcessFac#1!#2!{%
1171   \ifnum\BIC@PosCmp#1!12!=0 %

```

```

1172     \BIC@AfterFi{ #2}%
1173 \else
1174     \BIC@AfterFi{%
1175         \expandafter\BIC@@ProcessFac
1176         \romannumeral0\BIC@ProcessMul0!#2!#1!%
1177         !#1!%
1178     }%
1179 \BIC@Fi
1180 }

```

```

\BIC@@ProcessFac #1: result
#2:  $n$ 
1181 \def\BIC@@ProcessFac#1!#2!{%
1182     \expandafter\BIC@ProcessFac
1183     \romannumeral0\BIC@Dec#2!{%}%
1184     !#1!%
1185 }

```

## 2.18 Pow

```

\bigintcalcPow #1: basis
#2: power
1186 \def\bigintcalcPow#1{%
1187     \romannumeral0%
1188     \expandafter\expandafter\expandafter\BIC@Pow
1189     \bigintcalcNum{#1}!%
1190 }

\BIC@Pow #1: basis
#2: power
1191 \def\BIC@Pow#1!#2{%
1192     \expandafter\expandafter\expandafter\BIC@PowSwitch
1193     \bigintcalcNum{#2}!#1!%
1194 }

\BIC@PowSwitch #1#2: power  $y$ 
#3#4: basis  $x$ 
Decision table for \BIC@PowSwitch.

```

$y = 0$	1		
$y = 1$	$x$		
$y = 2$	$x < 0$	$\text{Mul}(-x, -x)$	
	else	$\text{Mul}(x, x)$	
$y < 0$	$x = 0$	DivisionByZero	
	$x = 1$	1	
	$x = -1$	ifodd( $y$ )	-1
		else	1
	else ( $ x  > 1$ )	0	
$y > 2$	$x = 0$	0	
	$x = 1$	1	
	$x = -1$	ifodd( $y$ )	-1
		else	1
	$x < -1$ ( $x < 0$ )	ifodd( $y$ )	$-\text{Pow}(-x, y)$
		else	$\text{Pow}(-x, y)$
	else ( $x > 1$ )	$\text{Pow}(x, y)$	

```

1195 \def\BIC@PowSwitch#1#2!#3#4!{%
1196     \ifcase\ifx\\#2\\%
1197         \ifx#100 %  $y = 0$ 
1198         \else\ifx#111 %  $y = 1$ 

```



```

1199         \else\ifx#122 % y = 2
1200         \else4 % y > 2
1201         \fi\fi\fi
1202     \else
1203         \ifx#1-3 % y < 0
1204         \else4 % y > 2
1205         \fi
1206     \fi
1207     \BIC@AfterFi{ 1}% y = 0
1208 \or % y = 1
1209     \BIC@AfterFi{ #3#4}%
1210 \or % y = 2
1211     \ifx#3-% x < 0
1212         \BIC@AfterFiFi{%
1213             \BIC@ProcessMul0!#4!#4!%
1214         }%
1215     \else % x >= 0
1216         \BIC@AfterFiFi{%
1217             \BIC@ProcessMul0!#3#4!#3#4!%
1218         }%
1219     \fi
1220 \or % y < 0
1221     \ifcase\ifx\#4\%
1222         \ifx#300 % x = 0
1223         \else\ifx#311 % x = 1
1224         \else3 % x > 1
1225         \fi\fi
1226     \else
1227         \ifcase\BIC@MinusOne#3#4! %
1228             3 % |x| > 1
1229         \or
1230             2 % x = -1
1231 ?         \else\BigIntCalcError:ThisCannotHappen%
1232         \fi
1233     \fi
1234     \BIC@AfterFiFi{ 0}\BigIntCalcError:DivisionByZero}% x = 0
1235 \or % x = 1
1236     \BIC@AfterFiFi{ 1}% x = 1
1237 \or % x = -1
1238     \ifcase\BIC@ModTwo#2! % even(y)
1239         \BIC@AfterFiFiFi{ 1}%
1240     \or % odd(y)
1241         \BIC@AfterFiFiFi{ -1}%
1242 ?     \else\BigIntCalcError:ThisCannotHappen%
1243     \fi
1244 \or % |x| > 1
1245     \BIC@AfterFiFi{ 0}%
1246 ?     \else\BigIntCalcError:ThisCannotHappen%
1247     \fi
1248 \or % y > 2
1249     \ifcase\ifx\#4\%
1250         \ifx#300 % x = 0
1251         \else\ifx#311 % x = 1
1252         \else4 % x > 1
1253         \fi\fi
1254     \else
1255         \ifx#3-%
1256             \ifcase\BIC@MinusOne#3#4! %
1257                 3 % x < -1
1258             \else
1259                 2 % x = -1
1260             \fi

```

```

1261         \else
1262         4 % x > 1
1263         \fi
1264     \fi
1265     \BIC@AfterFiFi{ 0}% x = 0
1266     \or % x = 1
1267     \BIC@AfterFiFi{ 1}% x = 1
1268     \or % x = -1
1269     \ifcase\BIC@ModTwo#1#2! % even(y)
1270     \BIC@AfterFiFiFi{ 1}%
1271     \or % odd(y)
1272     \BIC@AfterFiFiFi{ -1}%
1273 ?     \else\BigIntCalcError:ThisCannotHappen%
1274     \fi
1275     \or % x < -1
1276     \ifcase\BIC@ModTwo#1#2! % even(y)
1277     \BIC@AfterFiFiFi{%
1278     \BIC@PowRec#4!#1#2!1!%
1279     }%
1280     \or % odd(y)
1281     \expandafter-\romannumeral0%
1282     \BIC@AfterFiFiFi{%
1283     \BIC@PowRec#4!#1#2!1!%
1284     }%
1285 ?     \else\BigIntCalcError:ThisCannotHappen%
1286     \fi
1287     \or % x > 1
1288     \BIC@AfterFiFi{%
1289     \BIC@PowRec#3#4!#1#2!1!%
1290     }%
1291 ?     \else\BigIntCalcError:ThisCannotHappen%
1292     \fi
1293 ? \else\BigIntCalcError:ThisCannotHappen%
1294 \BIC@Fi
1295 }

```

### 2.18.1 Help macros

**\BIC@ModTwo** Macro \BIC@ModTwo expects a number without sign and returns digit 1 or 0 if the number is odd or even.

```

1296 \def\BIC@ModTwo#1#2!{%
1297   \ifx\#2\%
1298     \ifodd#1 %
1299     \BIC@AfterFiFi1%
1300   \else
1301     \BIC@AfterFiFi0%
1302   \fi
1303 \else
1304   \BIC@AfterFi{%
1305   \BIC@ModTwo#2!%
1306   }%
1307 \BIC@Fi
1308 }

```

**\BIC@MinusOne** Macro \BIC@MinusOne expects a number and returns digit 1 if the number equals minus one and returns 0 otherwise.

```

1309 \def\BIC@MinusOne#1#2!{%
1310   \ifx#1-%
1311   \BIC@@MinusOne#2!%
1312 \else
1313   0%
1314 \fi

```

```
1315 }
```

```
\BIC@@MinusOne
```

```
1316 \def\BIC@@MinusOne#1#2!{%
1317   \ifx#11%
1318     \ifx\|#2\|%
1319       1%
1320     \else
1321       0%
1322     \fi
1323   \else
1324     0%
1325   \fi
1326 }
```

## 2.18.2 Recursive calculation

```
\BIC@PowRec      Pow(x, y) {
                  PowRec(x, y, 1)
                  }
                  PowRec(x, y, r) {
                    if y == 1 then
                      return r
                    else
                      ifodd y then
                        return PowRec(x*x, y div 2, r*x) % y div 2 = (y-1)/2
                      else
                        return PowRec(x*x, y div 2, r)
                      fi
                    fi
                  }
                  #1: x (basis)
                  #2#3: y (power)
                  #4: r (result)
1327 \def\BIC@PowRec#1!#2#3!#4!{%
1328   \ifcase\ifx#21\ifx\|#3\|0 \else1 \fi\else1 \fi % y = 1
1329     \ifnum\BIC@PosCmp#1!#4!=1 % x > r
1330       \BIC@AfterFiFi{%
1331         \BIC@ProcessMul0!#1!#4!%
1332       }%
1333     \else
1334       \BIC@AfterFiFi{%
1335         \BIC@ProcessMul0!#4!#1!%
1336       }%
1337     \fi
1338   \or
1339     \ifcase\BIC@ModTwo#2#3! % even(y)
1340       \BIC@AfterFiFi{%
1341         \expandafter\BIC@@PowRec\romannumeral0%
1342         \BIC@@Shr#2#3!%
1343         !#1!#4!%
1344       }%
1345     \or % odd(y)
1346       \ifnum\BIC@PosCmp#1!#4!=1 % x > r
1347         \BIC@AfterFiFiFi{%
1348           \expandafter\BIC@@@PowRec\romannumeral0%
1349           \BIC@ProcessMul0!#1!#4!%
1350           !#1!#2#3!%
1351         }%
1352       \else
1353         \BIC@AfterFiFiFi{%
1354           \expandafter\BIC@@@PowRec\romannumeral0%
```

```

1355         \BIC@ProcessMul0!#1!#4!%
1356         !#1!#2#3!%
1357     }%
1358     \fi
1359 ?   \else\BigIntCalcError:ThisCannotHappen%
1360     \fi
1361 ?   \else\BigIntCalcError:ThisCannotHappen%
1362     \BIC@Fi
1363 }

```

```

\BIC@@PowRec #1:  $y/2$ 
#2:  $x$ 
#3: new  $r$  ( $r$  or  $r * x$ )
1364 \def\BIC@@PowRec#1!#2!#3!{%
1365     \expandafter\BIC@PowRec\romannumeral0%
1366     \BIC@ProcessMul0!#2!#2!%
1367     !#1!#3!%
1368 }

```

```

\BIC@@@PowRec #1:  $r * x$  #2:  $x$  #3:  $y$ 
1369 \def\BIC@@@PowRec#1!#2!#3!{%
1370     \expandafter\BIC@@PowRec\romannumeral0%
1371     \BIC@@Shr#3!%
1372     !#2!#1!%
1373 }

```

## 2.19 Div

```

\bigintcalcDiv #1:  $x$ 
#2:  $y$  (divisor)
1374 \def\bigintcalcDiv#1{%
1375     \romannumeral0%
1376     \expandafter\expandafter\expandafter\BIC@Div
1377     \bigintcalcNum{#1}!%
1378 }

```

```

\BIC@Div #1:  $x$ 
#2:  $y$ 
1379 \def\BIC@Div#1!#2{%
1380     \expandafter\expandafter\expandafter\BIC@DivSwitchSign
1381     \bigintcalcNum{#2}!#1!%
1382 }

```

```

\BigIntCalcDiv
1383 \def\BigIntCalcDiv#1!#2!{%
1384     \romannumeral0%
1385     \BIC@DivSwitchSign#2!#1!%
1386 }

```

\BIC@DivSwitchSign Decision table for \BIC@DivSwitchSign.

$y = 0$	DivisionByZero	
$y > 0$	$x = 0$	0
	$x > 0$	DivSwitch(+, $x, y$ )
	$x < 0$	DivSwitch(−, $-x, y$ )
$y < 0$	$x = 0$	0
	$x > 0$	DivSwitch(−, $x, -y$ )
	$x < 0$	DivSwitch(+, $-x, -y$ )

```

#1:  $y$  (divisor)
#2:  $x$ 
1387 \def\BIC@DivSwitchSign#1#2!#3#4!{%
1388   \ifcase\BIC@Sgn#1#2! %  $y = 0$ 
1389     \BIC@AfterFi{ 0\BigIntCalcError:DivisionByZero}%
1390   \or %  $y > 0$ 
1391     \ifcase\BIC@Sgn#3#4! %  $x = 0$ 
1392       \BIC@AfterFiFi{ 0}%
1393     \or %  $x > 0$ 
1394       \BIC@AfterFiFi{%
1395         \BIC@DivSwitch{ }#3#4!#1#2!%
1396       }%
1397     \else %  $x < 0$ 
1398       \BIC@AfterFiFi{%
1399         \BIC@DivSwitch{-#4!#1#2!%
1400       }%
1401     \fi
1402   \else %  $y < 0$ 
1403     \ifcase\BIC@Sgn#3#4! %  $x = 0$ 
1404       \BIC@AfterFiFi{ 0}%
1405     \or %  $x > 0$ 
1406       \BIC@AfterFiFi{%
1407         \BIC@DivSwitch{-#3#4!#2!%
1408       }%
1409     \else %  $x < 0$ 
1410       \BIC@AfterFiFi{%
1411         \BIC@DivSwitch{ }#4!#2!%
1412       }%
1413     \fi
1414   \BIC@Fi
1415 }

```

\BIC@DivSwitch Decision table for \BIC@DivSwitch.

$y = x$	sign 1	
$y > x$	0	
$y < x$	$y = 1$	sign $x$
	$y = 2$	sign Shr( $x$ )
	$y = 4$	sign Shr(Shr( $x$ ))
	else	sign ProcessDiv( $x, y$ )

```

#1: sign
#2:  $x$ 
#3#4:  $y$  ( $y \neq 0$ )
1416 \def\BIC@DivSwitch#1#2!#3#4!{%
1417   \ifcase\BIC@PosCmp#3#4!#2!%  $y = x$ 
1418     \BIC@AfterFi{ #1}%
1419   \or %  $y > x$ 
1420     \BIC@AfterFi{ 0}%
1421   \else %  $y < x$ 
1422     \ifx\#1\%
1423       \else
1424         \expandafter-\romannumeral0%
1425       \fi
1426     \ifcase\ifx\#4\%
1427       \ifx#310 %  $y = 1$ 
1428       \else\ifx#321 %  $y = 2$ 
1429       \else\ifx#342 %  $y = 4$ 
1430       \else3 %  $y > 2$ 
1431       \fi\fi\fi
1432     \else
1433       3 %  $y > 2$ 

```

```

1434         \fi
1435         \BIC@AfterFiFi{ #2}% y = 1
1436     \or % y = 2
1437         \BIC@AfterFiFi{%
1438             \BIC@Shr#2!%
1439         }%
1440     \or % y = 4
1441         \BIC@AfterFiFi{%
1442             \expandafter\BIC@Shr\romannumeral0%
1443             \BIC@Shr#2!%
1444         }%
1445     \or % y > 2
1446         \BIC@AfterFiFi{%
1447             \BIC@DivStartX#2!#3#4!!!%
1448         }%
1449 ? \else\BigIntCalcError:ThisCannotHappen%
1450     \fi
1451 \BIC@Fi
1452 }

\BIC@ProcessDiv #1#2:  $x$ 
#3#4:  $y$ 
#5: collect first digits of  $x$ 
#6: corresponding digits of  $y$ 
1453 \def\BIC@DivStartX#1#2!#3#4!#5!#6!{%
1454     \ifx\#4\%
1455         \BIC@AfterFi{%
1456             \BIC@DivStartYii#6#3#4!{#5#1}#2=!%
1457         }%
1458     \else
1459         \BIC@AfterFi{%
1460             \BIC@DivStartX#2!#4!#5#1!#6#3!%
1461         }%
1462     \BIC@Fi
1463 }

\BIC@DivStartYii #1:  $y$ 
#2:  $x, =$ 
1464 \def\BIC@DivStartYii#1!{%
1465     \expandafter\BIC@DivStartYiv\romannumeral0%
1466     \BIC@Shl#1!%
1467     !#1!%
1468 }

\BIC@DivStartYiv #1:  $2y$ 
#2:  $y$ 
#3:  $x, =$ 
1469 \def\BIC@DivStartYiv#1!{%
1470     \expandafter\BIC@DivStartYvi\romannumeral0%
1471     \BIC@Shl#1!%
1472     !#1!%
1473 }

\BIC@DivStartYvi #1:  $4y$ 
#2:  $2y$ 
#3:  $y$ 
#4:  $x, =$ 
1474 \def\BIC@DivStartYvi#1!#2!{%
1475     \expandafter\BIC@DivStartYviii\romannumeral0%
1476     \BIC@AddXY#1!#2!!!%
1477     !#1!#2!%
1478 }

```

```

\BIC@DivStartYviii #1: 6y
                   #2: 4y
                   #3: 2y
                   #4: y
                   #5: x, =
1479 \def\BIC@DivStartYviii#1!#2!{%
1480   \expandafter\BIC@DivStart\romannumeral0%
1481   \BIC@Shl#2!%
1482   !#1!#2!%
1483 }

\BIC@DivStart #1: 8y
              #2: 6y
              #3: 4y
              #4: 2y
              #5: y
              #6: x, =
1484 \def\BIC@DivStart#1!#2!#3!#4!#5!#6!{%
1485   \BIC@ProcessDiv#6!!#5!#4!#3!#2!#1!=%
1486 }

\BIC@ProcessDiv #1#2#3: x, =
                #4: result
                #5: y
                #6: 2y
                #7: 4y
                #8: 6y
                #9: 8y
1487 \def\BIC@ProcessDiv#1#2#3!#4!#5!{%
1488   \ifcase\BIC@PosCmp#5!#1!% y = #1
1489     \ifx#2=%
1490       \BIC@AfterFiFi{\BIC@DivCleanup{#41}}%
1491     \else
1492       \BIC@AfterFiFi{%
1493         \BIC@ProcessDiv#2#3!#41!#5!%
1494       }%
1495     \fi
1496   \or % y > #1
1497     \ifx#2=%
1498       \BIC@AfterFiFi{\BIC@DivCleanup{#40}}%
1499     \else
1500       \ifx\#4\%
1501         \BIC@AfterFiFiFi{%
1502           \BIC@ProcessDiv{#1#2}#3!#5!%
1503         }%
1504       \else
1505         \BIC@AfterFiFiFi{%
1506           \BIC@ProcessDiv{#1#2}#3!#40!#5!%
1507         }%
1508       \fi
1509     \fi
1510   \else % y < #1
1511     \BIC@AfterFi{%
1512       \BIC@@ProcessDiv{#1}#2#3!#4!#5!%
1513     }%
1514   \BIC@Fi
1515 }

\BIC@DivCleanup #1: result
                #2: garbage
1516 \def\BIC@DivCleanup#1#2={ #1}%

```

```

\BIC@@ProcessDiv
1517 \def\BIC@@ProcessDiv#1#2#3!#4!#5!#6!#7!{%
1518 \ifcase\BIC@PosCmp#7!#1!% 4y = #1
1519 \ifx#2=%
1520 \BIC@AfterFiFi{\BIC@DivCleanup{#44}}}%
1521 \else
1522 \BIC@AfterFiFi{%
1523 \BIC@ProcessDiv#2#3!#44!#5!#6!#7!%
1524 }%
1525 \fi
1526 \or % 4y > #1
1527 \ifcase\BIC@PosCmp#6!#1!% 2y = #1
1528 \ifx#2=%
1529 \BIC@AfterFiFiFi{\BIC@DivCleanup{#42}}}%
1530 \else
1531 \BIC@AfterFiFiFi{%
1532 \BIC@ProcessDiv#2#3!#42!#5!#6!#7!%
1533 }%
1534 \fi
1535 \or % 2y > #1
1536 \ifx#2=%
1537 \BIC@AfterFiFiFi{\BIC@DivCleanup{#41}}}%
1538 \else
1539 \BIC@AfterFiFiFi{%
1540 \BIC@DivSub#1!#5!#2#3!#41!#5!#6!#7!%
1541 }%
1542 \fi
1543 \else % 2y < #1
1544 \BIC@AfterFiFi{%
1545 \expandafter\BIC@ProcessDivII\romannumeral0%
1546 \BIC@SubXY#1!#6!!!%
1547 !#2#3!#4!#5!23%
1548 #6!#7!%
1549 }%
1550 \fi
1551 \else % 4y < #1
1552 \BIC@AfterFiFi{%
1553 \BIC@@@ProcessDiv{#1}#2#3!#4!#5!#6!#7!%
1554 }%
1555 \BIC@Fi
1556 }

```

\BIC@DivSub Next token group: #1-#2 and next digit #3.

```

1557 \def\BIC@DivSub#1!#2!#3{%
1558 \expandafter\BIC@ProcessDiv\expandafter{%
1559 \romannumeral0%
1560 \BIC@SubXY#1!#2!!!%
1561 #3%
1562 }%
1563 }

```

\BIC@ProcessDivII #1:  $x' - 2y$   
#2#3: remaining  $x$ , =  
#4: result  
#5:  $y$   
#6: first possible result digit  
#7: second possible result digit

```

1564 \def\BIC@ProcessDivII#1!#2#3!#4!#5!#6#7{%
1565 \ifcase\BIC@PosCmp#5!#1!% y = #1
1566 \ifx#2=%
1567 \BIC@AfterFiFi{\BIC@DivCleanup{#4#7}}}%
1568 \else

```



```

1569     \BIC@AfterFiFi{%
1570     \BIC@ProcessDiv#2#3!#4#7!#5!%
1571     }%
1572     \fi
1573 \or % y > #1
1574     \ifx#2=%
1575     \BIC@AfterFiFi{\BIC@DivCleanup{#4#6}}%
1576     \else
1577     \BIC@AfterFiFi{%
1578     \BIC@ProcessDiv{#1#2}#3!#4#6!#5!%
1579     }%
1580     \fi
1581 \else % y < #1
1582     \ifx#2=%
1583     \BIC@AfterFiFi{\BIC@DivCleanup{#4#7}}%
1584     \else
1585     \BIC@AfterFiFi{%
1586     \BIC@DivSub#1!#5!#2#3!#4#7!#5!%
1587     }%
1588     \fi
1589 \BIC@Fi
1590 }

```

```

\BIC@ProcessDivIV #1#2#3:  $x, =, x > 4y$ 
#4: result
#5:  $y$ 
#6:  $2y$ 
#7:  $4y$ 
#8:  $6y$ 
#9:  $8y$ 

1591 \def\BIC@@@ProcessDiv#1#2#3!#4!#5!#6!#7!#8!#9!{%
1592 \ifcase\BIC@PosCmp#8!#1!% 6y = #1
1593     \ifx#2=%
1594     \BIC@AfterFiFi{\BIC@DivCleanup{#46}}%
1595     \else
1596     \BIC@AfterFiFi{%
1597     \BIC@ProcessDiv#2#3!#46!#5!#6!#7!#8!#9!%
1598     }%
1599     \fi
1600 \or % 6y > #1
1601     \BIC@AfterFi{%
1602     \expandafter\BIC@ProcessDivII\romannumeral0%
1603     \BIC@SubXY#1!#7!!!%
1604     !#2#3!#4!#5!45%
1605     #6!#7!#8!#9!%
1606     }%
1607 \else % 6y < #1
1608     \ifcase\BIC@PosCmp#9!#1!% 8y = #1
1609     \ifx#2=%
1610     \BIC@AfterFiFiFi{\BIC@DivCleanup{#48}}%
1611     \else
1612     \BIC@AfterFiFiFi{%
1613     \BIC@ProcessDiv#2#3!#48!#5!#6!#7!#8!#9!%
1614     }%
1615     \fi
1616 \or % 8y > #1
1617     \BIC@AfterFiFi{%
1618     \expandafter\BIC@ProcessDivII\romannumeral0%
1619     \BIC@SubXY#1!#8!!!%
1620     !#2#3!#4!#5!67%
1621     #6!#7!#8!#9!%
1622     }%

```

```

1623     \else % 8y < #1
1624         \BIC@AfterFiFi{%
1625             \expandafter\BIC@ProcessDivII\romannumeral0%
1626             \BIC@SubXY#1!#9!!!%
1627             !#2#3!#4!#5!89%
1628             #6!#7!#8!#9!%
1629         }%
1630     \fi
1631 \BIC@Fi
1632 }

```

## 2.20 Mod

```

\bigintcalcMod #1: x
#2: y
1633 \def\bigintcalcMod#1{%
1634     \romannumeral0%
1635     \expandafter\expandafter\expandafter\BIC@Mod
1636     \bigintcalcNum{#1}!%
1637 }

\BIC@Mod #1: x
#2: y
1638 \def\BIC@Mod#1!#2{%
1639     \expandafter\expandafter\expandafter\BIC@ModSwitchSign
1640     \bigintcalcNum{#2}!#1!%
1641 }

\BigIntCalcMod
1642 \def\BigIntCalcMod#1!#2!{%
1643     \romannumeral0%
1644     \BIC@ModSwitchSign#2!#1!%
1645 }

```

\BIC@ModSwitchSign Decision table for \BIC@ModSwitchSign.

$y = 0$	DivisionByZero	
$y > 0$	$x = 0$	0
	else	ModSwitch(+, $x, y$ )
$y < 0$	ModSwitch(-, $-x, -y$ )	

```

#1#2: y
#3#4: x
1646 \def\BIC@ModSwitchSign#1#2!#3#4!{%
1647     \ifcase\ifx\#2\%
1648         \ifx#100 % y = 0
1649         \else1 % y > 0
1650         \fi
1651     \else
1652         \ifx#1-2 % y < 0
1653         \else1 % y > 0
1654         \fi
1655     \fi
1656     \BIC@AfterFi{ 0\BigIntCalcError:DivisionByZero}%
1657 \or % y > 0
1658     \ifcase\ifx\#4\%
1659         \ifx#300 \else1 \fi\else1 \fi % x = 0
1660     \else
1661         \BIC@AfterFiFi{%
1662             \BIC@ModSwitch{#3#4!#1#2!%
1663         }%

```

```

1664 \fi
1665 \else % y < 0
1666 \ifcase\ifx\#4\%
1667 \ifx#300 % x = 0
1668 \else1 % x > 0
1669 \fi
1670 \else
1671 \ifx#3-2 % x < 0
1672 \else1 % x > 0
1673 \fi
1674 \fi
1675 \BIC@AfterFiFi{ 0}%
1676 \or % x > 0
1677 \BIC@AfterFiFi{%
1678 \BIC@ModSwitch--#3#4!#2!%
1679 }%
1680 \else % x < 0
1681 \BIC@AfterFiFi{%
1682 \BIC@ModSwitch-#4!#2!%
1683 }%
1684 \fi
1685 \BIC@Fi
1686 }

```

\BIC@ModSwitch Decision table for \BIC@ModSwitch.

$y = 1$	0	
$y = 2$	ifodd( $x$ )	sign 1
	else	0
$y > 2$	$x < 0$	$z \leftarrow x - (x/y) * y; \quad (z < 0) ? z + y : z$
	$x > 0$	$x - (x/y) * y$

#1: sign

#2#3:  $x$

#4#5:  $y$

```

1687 \def\BIC@ModSwitch#1#2#3!#4#5!{%
1688 \ifcase\ifx\#5\%
1689 \ifx#410 % y = 1
1690 \else\ifx#421 % y = 2
1691 \else2 % y > 2
1692 \fi\fi
1693 \else2 % y > 2
1694 \fi
1695 \BIC@AfterFi{ 0}% y = 1
1696 \or % y = 2
1697 \ifcase\BIC@ModTwo#2#3! % even(x)
1698 \BIC@AfterFiFi{ 0}%
1699 \or % odd(x)
1700 \BIC@AfterFiFi{ #11}%
1701 ? \else\BigIntCalcError:ThisCannotHappen%
1702 \fi
1703 \or % y > 2
1704 \ifx\#1\%
1705 \else
1706 \expandafter\BIC@Space\romannumeral0%
1707 \expandafter\BIC@ModMinus\romannumeral0%
1708 \fi
1709 \ifx#2-% x < 0
1710 \BIC@AfterFiFi{%
1711 \expandafter\expandafter\expandafter\BIC@ModX
1712 \bigintcalcSub{#2#3}{%
1713 \bigintcalcMul{#4#5}{\bigintcalcDiv{#2#3}{#4#5}}}%

```

```

1714         }!#4#5!%
1715     }%
1716     \else % x > 0
1717         \BIC@AfterFiFi{%
1718             \expandafter\expandafter\expandafter\BIC@Space
1719             \bigintcalcSub{#2#3}{%
1720                 \bigintcalcMul{#4#5}{\bigintcalcDiv{#2#3}{#4#5}}%
1721             }%
1722         }%
1723     \fi
1724 ? \else\BigIntCalcError:ThisCannotHappen%
1725     \BIC@Fi
1726 }

\BIC@ModMinus

1727 \def\BIC@ModMinus#1{%
1728     \ifx#10%
1729         \BIC@AfterFi{ 0}%
1730     \else
1731         \BIC@AfterFi{ -#1}%
1732     \BIC@Fi
1733 }

\BIC@ModX #1#2: z
#3: x
1734 \def\BIC@ModX#1#2!#3!{%
1735     \ifx#1-% z < 0
1736         \BIC@AfterFi{%
1737             \expandafter\BIC@Space\romannumeral0%
1738             \BIC@SubXY#3!#2!!!%
1739         }%
1740     \else % z >= 0
1741         \BIC@AfterFi{ #1#2}%
1742     \BIC@Fi
1743 }

1744 \BIC@AtEnd
1745 </package>

```

### 3 Test

#### 3.1 Catcode checks for loading

```

1746 <*test1>
1747 \catcode'\{=1 %
1748 \catcode'\}=2 %
1749 \catcode'\#=6 %
1750 \catcode'\@=11 %
1751 \expandafter\ifx\csname count@\endcsname\relax
1752     \countdef\count@=255 %
1753 \fi
1754 \expandafter\ifx\csname @gobble\endcsname\relax
1755     \long\def\@gobble#1{}%
1756 \fi
1757 \expandafter\ifx\csname @firstofone\endcsname\relax
1758     \long\def\@firstofone#1{#1}%
1759 \fi
1760 \expandafter\ifx\csname loop\endcsname\relax
1761     \expandafter\@firstofone
1762 \else
1763     \expandafter\@gobble

```

```

1764 \fi
1765 {%
1766   \def\loop#1\repeat{%
1767     \def\body{#1}%
1768     \iterate
1769   }%
1770   \def\iterate{%
1771     \body
1772     \let\next\iterate
1773   \else
1774     \let\next\relax
1775   \fi
1776   \next
1777 }%
1778 \let\repeat=\fi
1779 }%
1780 \def\RestoreCatcodes{}
1781 \count@=0 %
1782 \loop
1783   \edef\RestoreCatcodes{%
1784     \RestoreCatcodes
1785     \catcode\the\count@=\the\catcode\count@\relax
1786   }%
1787 \ifnum\count@<255 %
1788   \advance\count@ 1 %
1789 \repeat
1790
1791 \def\RangeCatcodeInvalid#1#2{%
1792   \count@=#1\relax
1793   \loop
1794     \catcode\count@=15 %
1795   \ifnum\count@<#2\relax
1796     \advance\count@ 1 %
1797   \repeat
1798 }
1799 \expandafter\ifx\csname LoadCommand\endcsname\relax
1800   \def\LoadCommand{\input bigintcalc.sty\relax}%
1801 \fi
1802 \def\Test{%
1803   \RangeCatcodeInvalid{0}{47}%
1804   \RangeCatcodeInvalid{58}{64}%
1805   \RangeCatcodeInvalid{91}{96}%
1806   \RangeCatcodeInvalid{123}{255}%
1807   \catcode'\@=12 %
1808   \catcode'\@=0 %
1809   \catcode'\{=1 %
1810   \catcode'\}=2 %
1811   \catcode'\#=6 %
1812   \catcode'\[=12 %
1813   \catcode'\]=12 %
1814   \catcode'\%=14 %
1815   \catcode'\ =10 %
1816   \catcode13=5 %
1817   \LoadCommand
1818   \RestoreCatcodes
1819 }
1820 \Test
1821 \csname @@end\endcsname
1822 \end
1823 </test1>

```

## 3.2 Macro tests

### 3.2.1 Preamble with test macro definitions

```
1824 <*test2>
1825 \NeedsTeXFormat{LaTeX2e}
1826 \nofiles
1827 \documentclass{article}
1828 <noetex> \let \SavedNumexpr \numexpr
1829 <noetex> \let \numexpr \UNDEFINED
1830 \makeatletter
1831 \chardef \BIC@TestMode=1 %
1832 \makeatother
1833 \usepackage{bigintcalc}[2007/11/11]
1834 <noetex> \let \numexpr \SavedNumexpr
1835 \usepackage{qstest}
1836 \IncludeTests{*}
1837 \LogTests{log}{*}{*}
1838 \newcommand*{\TestSpaceAtEnd}[1]{%
1839 <noetex> \let \SavedNumexpr \numexpr
1840 <noetex> \let \numexpr \UNDEFINED
1841 \edef\resultA{#1}%
1842 \edef\resultB{#1 }%
1843 <noetex> \let \numexpr \SavedNumexpr
1844 \Expect*{\resultA\space}*{\resultB}%
1845 }
1846 \newcommand*{\TestResult}[2]{%
1847 <noetex> \let \SavedNumexpr \numexpr
1848 <noetex> \let \numexpr \UNDEFINED
1849 \edef\result{#1}%
1850 <noetex> \let \numexpr \SavedNumexpr
1851 \Expect*{\result}{#2}%
1852 }
1853 \newcommand*{\TestResultTwoExpansions}[2]{%
1854 <*noetex>
1855 \begingroup
1856 \let \numexpr \UNDEFINED
1857 \expandafter\expandafter\expandafter
1858 \endgroup
1859 </noetex>
1860 \expandafter\expandafter\expandafter\Expect
1861 \expandafter\expandafter\expandafter{#1}{#2}%
1862 }
1863 \newcount\TestCount
1864 <etex> \newcommand*{\TestArg}[1]{\numexpr#1\relax}
1865 <noetex> \newcommand*{\TestArg}[1]{#1}
1866 \newcommand*{\TestTeXDivide}[2]{%
1867 \TestCount=\TestArg{#1}\relax
1868 \divide\TestCount by \TestArg{#2}\relax
1869 \Expect*{\bigintcalcDiv{#1}{#2}}*{\the\TestCount}%
1870 }
1871 \newcommand*{\Test}[2]{%
1872 \TestResult{#1}{#2}%
1873 \TestResultTwoExpansions{#1}{#2}%
1874 \TestSpaceAtEnd{#1}%
1875 }
1876 \newcommand*{\TestExch}[2]{\Test{#2}{#1}}
1877 \newcommand*{\TestInv}[2]{%
1878 \Test{\bigintcalcInv{#1}}{#2}%
1879 }
1880 \newcommand*{\TestAbs}[2]{%
1881 \Test{\bigintcalcAbs{#1}}{#2}%
1882 }
```

```

1883 \newcommand*{\TestSgn}[2]{%
1884   \Test{\bigintcalcSgn{#1}}{#2}%
1885 }
1886 \newcommand*{\TestMin}[3]{%
1887   \Test{\bigintcalcMin{#1}{#2}}{#3}%
1888 }
1889 \newcommand*{\TestMax}[3]{%
1890   \Test{\bigintcalcMax{#1}{#2}}{#3}%
1891 }
1892 \newcommand*{\TestCmp}[3]{%
1893   \Test{\bigintcalcCmp{#1}{#2}}{#3}%
1894 }
1895 \newcommand*{\TestOdd}[2]{%
1896   \Test{\bigintcalcOdd{#1}}{#2}%
1897   \edef\x{%
1898     \noexpand\Test{%
1899       \noexpand\BigIntCalcOdd
1900       \bigintcalcAbs{#1}!%
1901     }{#2}%
1902   }%
1903   \x
1904 }
1905 \newcommand*{\TestInc}[2]{%
1906   \Test{\bigintcalcInc{#1}}{#2}%
1907   \ifnum\bigintcalcSgn{#1}>-1 %
1908     \edef\x{%
1909       \noexpand\Test{%
1910         \noexpand\BigIntCalcInc\bigintcalcNum{#1}!%
1911       }{#2}%
1912     }%
1913     \x
1914   \fi
1915 }
1916 \newcommand*{\TestDec}[2]{%
1917   \Test{\bigintcalcDec{#1}}{#2}%
1918   \ifnum\bigintcalcSgn{#1}>0 %
1919     \edef\x{%
1920       \noexpand\Test{%
1921         \noexpand\BigIntCalcDec\bigintcalcNum{#1}!%
1922       }{#2}%
1923     }%
1924     \x
1925   \fi
1926 }
1927 \newcommand*{\TestAdd}[3]{%
1928   \Test{\bigintcalcAdd{#1}{#2}}{#3}%
1929   \ifnum\bigintcalcSgn{#1}>0 %
1930     \ifnum\bigintcalcSgn{#2}> 0 %
1931       \ifnum\bigintcalcCmp{#1}{#2}>0 %
1932         \edef\x{%
1933           \noexpand\Test{%
1934             \noexpand\BigIntCalcAdd
1935             \bigintcalcNum{#1}!\bigintcalcNum{#2}!%
1936           }{#3}%
1937         }%
1938         \x
1939       \else
1940         \edef\x{%
1941           \noexpand\Test{%
1942             \noexpand\BigIntCalcAdd
1943             \bigintcalcNum{#2}!\bigintcalcNum{#1}!%
1944           }{#3}%

```

```

1945         }%
1946         \x
1947     \fi
1948 \fi
1949 \fi
1950 }
1951 \newcommand*{\TestSub}[3]{%
1952   \Test{\bigintcalcSub{#1}{#2}}{#3}%
1953   \ifnum\bigintcalcSgn{#1}>0 %
1954     \ifnum\bigintcalcSgn{#2}> 0 %
1955       \ifnum\bigintcalcCmp{#1}{#2}>0 %
1956         \edef\x{%
1957           \noexpand\Test{%
1958             \noexpand\BigIntCalcSub
1959             \bigintcalcNum{#1}!\bigintcalcNum{#2}!%
1960           }{#3}%
1961         }%
1962         \x
1963       \fi
1964     \fi
1965   \fi
1966 }
1967 \newcommand*{\TestShl}[2]{%
1968   \Test{\bigintcalcShl{#1}}{#2}%
1969   \edef\x{%
1970     \noexpand\Test{%
1971       \noexpand\BigIntCalcShl\bigintcalcAbs{#1}!%
1972     }{\bigintcalcAbs{#2}}}%
1973   }%
1974   \x
1975 }
1976 \newcommand*{\TestShr}[2]{%
1977   \Test{\bigintcalcShr{#1}}{#2}%
1978   \edef\x{%
1979     \noexpand\Test{%
1980       \noexpand\BigIntCalcShr\bigintcalcAbs{#1}!%
1981     }{\bigintcalcAbs{#2}}}%
1982   }%
1983   \x
1984 }
1985 \newcommand*{\TestMul}[3]{%
1986   \Test{\bigintcalcMul{#1}{#2}}{#3}%
1987   \edef\x{%
1988     \noexpand\Test{%
1989       \noexpand\BigIntCalcMul
1990       \bigintcalcAbs{#1}!\bigintcalcAbs{#2}!%
1991     }{\bigintcalcAbs{#3}}}%
1992   }%
1993   \x
1994 }
1995 \newcommand*{\TestSqr}[2]{%
1996   \Test{\bigintcalcSqr{#1}}{#2}%
1997 }
1998 \newcommand*{\TestFac}[2]{%
1999   \expandafter\TestExch\expandafter{%
2000     \the\numexpr#2%
2001   }{\bigintcalcFac{#1}}%
2002 }
2003 \newcommand*{\TestFacBig}[2]{%
2004   \Test{\bigintcalcFac{#1}}{#2}%
2005 }
2006 \newcommand*{\TestPow}[3]{%

```



```

2007 \Test{\bigintcalcPow{#1}{#2}}{#3}%
2008 }
2009 \newcommand*{\TestDiv}[3]{%
2010 \Test{\bigintcalcDiv{#1}{#2}}{#3}%
2011 \TestTeXDivide{#1}{#2}%
2012 }
2013 \newcommand*{\TestDivBig}[3]{%
2014 \Test{\bigintcalcDiv{#1}{#2}}{#3}%
2015 \edef\x{%
2016 \noexpand\Test{%
2017 \noexpand\BigIntCalcDiv\bigintcalcAbs{#1}!\bigintcalcAbs{#2}!%
2018 }\bigintcalcAbs{#3}}%
2019 }%
2020 }
2021 \newcommand*{\TestMod}[3]{%
2022 \Test{\bigintcalcMod{#1}{#2}}{#3}%
2023 \ifcase\ifcase\bigintcalcSgn{#1} 0%
2024 \or
2025 \ifcase\bigintcalcSgn{#2} 1%
2026 \or 0%
2027 \else 1%
2028 \fi
2029 \else
2030 \ifcase\bigintcalcSgn{#2} 1%
2031 \or 1%
2032 \else 0%
2033 \fi
2034 \fi\relax
2035 \edef\x{%
2036 \noexpand\Test{%
2037 \noexpand\BigIntCalcMod
2038 \bigintcalcAbs{#1}!\bigintcalcAbs{#2}!%
2039 }\bigintcalcAbs{#3}}%
2040 }%
2041 \x
2042 \fi
2043 }

```

### 3.2.2 Time

```

2044 \beginingroup\expandafter\expandafter\expandafter\endgroup
2045 \expandafter\ifx\cename pdfresettimer\endcename\relax
2046 \else
2047 \makeatletter
2048 \newcount\SummaryTime
2049 \newcount\TestTime
2050 \SummaryTime=\z@
2051 \newcommand*{\PrintTime}[2]{%
2052 \typeout{%
2053 [Time #1: \strip@pt\dimexpr\number#2sp\relax\space s]%
2054 }%
2055 }%
2056 \newcommand*{\StartTime}[1]{%
2057 \renewcommand*{\TimeDescription}{#1}%
2058 \pdfresettimer
2059 }%
2060 \newcommand*{\TimeDescription}{}%
2061 \newcommand*{\StopTime}{%
2062 \TestTime=\pdfelapsedtime
2063 \global\advance\SummaryTime\TestTime
2064 \PrintTime\TimeDescription\TestTime
2065 }%
2066 \let\saved@qstest\qstest
2067 \let\saved@endqstest\endqstest

```

```

2068 \def\qstest#1#2{%
2069     \saved@qstest{#1}{#2}%
2070     \StartTime{#1}%
2071 }%
2072 \def\endqstest{%
2073     \StopTime
2074     \saved@endqstest
2075 }%
2076 \AtEndDocument{%
2077     \PrintTime{summary}\SummaryTime
2078 }%
2079 \makeatother
2080 \fi

```

### 3.2.3 Test sets

```

2081 \makeatletter
2082
2083 \begin{qstest}{inv}{inv}%
2084     \TestInv{0}{0}%
2085     \TestInv{1}{-1}%
2086     \TestInv{-1}{1}%
2087     \TestInv{10}{-10}%
2088     \TestInv{-10}{10}%
2089     \TestInv{2147483647}{-2147483647}%
2090     \TestInv{-2147483647}{2147483647}%
2091     \TestInv{12345678901234567890}{-12345678901234567890}%
2092     \TestInv{-12345678901234567890}{12345678901234567890}%
2093     \TestInv{ 0 }{0}%
2094     \TestInv{ 1 }{-1}%
2095     \TestInv{--1}{-1}%
2096     \TestInv{\number\z@}{0}%
2097     \TestInv{\ifx\relax\relax1\fi}{-1}%
2098     \TestInv{\ifx\relax\relax-\fi\ifx234\else1\fi}{1}%
2099 \end{qstest}
2100
2101 \begin{qstest}{abs}{abs}%
2102     \TestAbs{0}{0}%
2103     \TestAbs{1}{1}%
2104     \TestAbs{-1}{1}%
2105     \TestAbs{10}{10}%
2106     \TestAbs{-10}{10}%
2107     \TestAbs{2147483647}{2147483647}%
2108     \TestAbs{-2147483647}{2147483647}%
2109     \TestAbs{12345678901234567890}{12345678901234567890}%
2110     \TestAbs{-12345678901234567890}{12345678901234567890}%
2111     \TestAbs{ 0 }{0}%
2112     \TestAbs{ 1 }{1}%
2113     \TestAbs{--1}{1}%
2114     \TestAbs{-++1}{1}%
2115     \TestAbs{00000000000}{0}%
2116     \TestAbs{00000001000}{1000}%
2117     \TestAbs{\ifx\relax\relax 0\else 1\fi}{0}%
2118 \end{qstest}
2119
2120 \begin{qstest}{sign}{sign}%
2121     \TestSgn{0}{0}%
2122     \TestSgn{1}{1}%
2123     \TestSgn{-1}{-1}%
2124     \TestSgn{10}{1}%
2125     \TestSgn{-10}{-1}%
2126     \TestSgn{2147483647}{1}%
2127     \TestSgn{-2147483647}{-1}%
2128     \TestSgn{12345678901234567890}{1}%

```

```

2129 \TestSgn{-12345678901234567890}{-1}%
2130 \TestSgn{ 0 }{0}%
2131 \TestSgn{ 2 }{1}%
2132 \TestSgn{ -2 }{-1}%
2133 \TestSgn{--2}{1}%
2134 \TestSgn{\number\z@}{0}%
2135 \TestSgn{\number\@ne}{1}%
2136 \TestSgn{\number\m@ne}{-1}%
2137 \TestSgn{%
2138   -++\number\z@\number\z@
2139   \iftrue1\fi\iftrue2\fi\iftrue3\fi
2140 }{1}%
2141 \end{qstest}
2142
2143 \begin{qstest}{min}{min}%
2144 \TestMin{0}{1}{0}%
2145 \TestMin{1}{0}{0}%
2146 \TestMin{-10}{-20}{-20}%
2147 \TestMin{ 1 }{ 2 }{1}%
2148 \TestMin{ 2 }{ 1 }{1}%
2149 \TestMin{1}{1}{1}%
2150 \TestMin{\number\z@}{\number\@ne}{0}%
2151 \TestMin{\number\@ne}{\number\m@ne}{-1}%
2152 \end{qstest}
2153
2154 \begin{qstest}{max}{max}%
2155 \TestMax{0}{1}{1}%
2156 \TestMax{1}{0}{1}%
2157 \TestMax{-10}{-20}{-10}%
2158 \TestMax{ 1 }{ 2 }{2}%
2159 \TestMax{ 2 }{ 1 }{2}%
2160 \TestMax{1}{1}{1}%
2161 \TestMax{\number\z@}{\number\@ne}{1}%
2162 \TestMax{\number\@ne}{\number\m@ne}{1}%
2163 \end{qstest}
2164
2165 \begin{qstest}{cmp}{cmp}%
2166 \TestCmp{0}{0}{0}%
2167 \TestCmp{-21}{17}{-1}%
2168 \TestCmp{3}{4}{-1}%
2169 \TestCmp{-10}{-10}{0}%
2170 \TestCmp{-10}{-11}{1}%
2171 \TestCmp{100}{5}{1}%
2172 \TestCmp{9}{10}{-1}%
2173 \TestCmp{10}{9}{1}%
2174 \TestCmp{ 3 }{ 3 }{0}%
2175 \TestCmp{-9}{-10}{1}%
2176 \TestCmp{-10}{-9}{-1}%
2177 \TestCmp{-3}{-3}{0}%
2178 \TestCmp{0}{-2}{1}%
2179 \TestCmp{0}{2}{-1}%
2180 \TestCmp{2}{0}{1}%
2181 \TestCmp{-2}{0}{-1}%
2182 \TestCmp{12}{11}{1}%
2183 \TestCmp{11}{12}{-1}%
2184 \TestCmp{2147483647}{-2147483647}{1}%
2185 \TestCmp{-2147483647}{2147483647}{-1}%
2186 \TestCmp{2147483647}{2147483647}{0}%
2187 \TestCmp{\number\z@}{\number\@ne}{-1}%
2188 \TestCmp{\number\@ne}{\number\m@ne}{1}%
2189 \TestCmp{ 4 }{ 5 }{-1}%
2190 \TestCmp{ -3 }{ -7 }{1}%

```

```

2191 \end{qstest}
2192
2193 \begin{qstest}{odd}{odd}
2194 \tracingmacros=1
2195 \TestOdd{0}{0}%
2196 \TestOdd{1}{1}%
2197 \TestOdd{2}{0}%
2198 \TestOdd{3}{1}%
2199 \TestOdd{14}{0}%
2200 \TestOdd{15}{1}%
2201 \TestOdd{12345678901234567896}{0}%
2202 \TestOdd{12345678901234567897}{1}%
2203 \end{qstest}
2204
2205 \begin{qstest}{inc}{inc}%
2206 \TestInc{0}{1}%
2207 \TestInc{1}{2}%
2208 \TestInc{-1}{0}%
2209 \TestInc{10}{11}%
2210 \TestInc{-10}{-9}%
2211 \TestInc{ 3 }{4}%
2212 \TestInc{999}{1000}%
2213 \TestInc{-1000}{-999}%
2214 \TestInc{129}{130}%
2215 \TestInc{2147483646}{2147483647}%
2216 \TestInc{-2147483647}{-2147483646}%
2217 \TestInc{12345678901234567890}{12345678901234567891}%
2218 \TestInc{9999999999999999999}{10000000000000000000}%
2219 \TestInc{-12345678901234567891}{-12345678901234567890}%
2220 \TestInc{-10000000000000000000}{-9999999999999999999}%
2221 \end{qstest}
2222
2223 \begin{qstest}{dec}{dec}%
2224 \TestDec{0}{-1}%
2225 \TestDec{1}{0}%
2226 \TestDec{-1}{-2}%
2227 \TestDec{10}{9}%
2228 \TestDec{-10}{-11}%
2229 \TestDec{1000}{999}%
2230 \TestDec{-999}{-1000}%
2231 \TestDec{130}{129}%
2232 \TestDec{2147483647}{2147483646}%
2233 \TestDec{-2147483646}{-2147483647}%
2234 \TestDec{12345678901234567891}{12345678901234567890}%
2235 \TestDec{10000000000000000000}{9999999999999999999}%
2236 \TestDec{-12345678901234567890}{-12345678901234567891}%
2237 \TestDec{-9999999999999999999}{-10000000000000000000}%
2238 \end{qstest}
2239
2240 \begin{qstest}{add}{add}%
2241 \TestAdd{0}{0}{0}%
2242 \TestAdd{1}{0}{1}%
2243 \TestAdd{0}{1}{1}%
2244 \TestAdd{1}{2}{3}%
2245 \TestAdd{-1}{-1}{-2}%
2246 \TestAdd{2147483646}{1}{2147483647}%
2247 \TestAdd{-2147483647}{2147483647}{0}%
2248 \TestAdd{20}{-5}{15}%
2249 \TestAdd{-4}{-1}{-5}%
2250 \TestAdd{-1}{-4}{-5}%
2251 \TestAdd{-4}{1}{-3}%
2252 \TestAdd{-1}{4}{3}%

```

```

2253 \TestAdd{4}{-1}{3}%
2254 \TestAdd{1}{-4}{-3}%
2255 \TestAdd{-4}{-1}{-5}%
2256 \TestAdd{-1}{-4}{-5}%
2257 \TestAdd{ -4 }{ -1 }{-5}%
2258 \TestAdd{ -1 }{ -4 }{-5}%
2259 \TestAdd{ -4 }{ 1 }{-3}%
2260 \TestAdd{ -1 }{ 4 }{3}%
2261 \TestAdd{ 4 }{ -1 }{3}%
2262 \TestAdd{ 1 }{ -4 }{-3}%
2263 \TestAdd{ -4 }{ -1 }{-5}%
2264 \TestAdd{ -1 }{ -4 }{-5}%
2265 \TestAdd{876543210}{111111111}{987654321}%
2266 \TestAdd{999999999}{2}{1000000001}%
2267 \end{qstest}
2268
2269 \begin{qstest}{sub}{sub}
2270 \TestSub{0}{0}{0}%
2271 \TestSub{1}{0}{1}%
2272 \TestSub{1}{2}{-1}%
2273 \TestSub{-1}{-1}{0}%
2274 \TestSub{2147483646}{-1}{2147483647}%
2275 \TestSub{-2147483647}{-2147483647}{0}%
2276 \TestSub{-4}{-1}{-3}%
2277 \TestSub{-1}{-4}{3}%
2278 \TestSub{-4}{1}{-5}%
2279 \TestSub{-1}{4}{-5}%
2280 \TestSub{4}{-1}{5}%
2281 \TestSub{1}{-4}{5}%
2282 \TestSub{-4}{-1}{-3}%
2283 \TestSub{-1}{-4}{3}%
2284 \TestSub{ -4 }{ -1 }{-3}%
2285 \TestSub{ -1 }{ -4 }{3}%
2286 \TestSub{ -4 }{ 1 }{-5}%
2287 \TestSub{ -1 }{ 4 }{-5}%
2288 \TestSub{ 4 }{ -1 }{5}%
2289 \TestSub{ 1 }{ -4 }{5}%
2290 \TestSub{ -4 }{ -1 }{-3}%
2291 \TestSub{ -1 }{ -4 }{3}%
2292 \TestSub{1000000000}{2}{999999998}%
2293 \TestSub{987654321}{111111111}{876543210}%
2294 \end{qstest}
2295
2296 \begin{qstest}{shl}{shl}
2297 \TestShl{0}{0}%
2298 \TestShl{1}{2}%
2299 \TestShl{2}{4}%
2300 \TestShl{5621}{11242}%
2301 \TestShl{1073741823}{2147483646}%
2302 \end{qstest}
2303
2304 \begin{qstest}{shr}{shr}
2305 \TestShr{0}{0}%
2306 \TestShr{1}{0}%
2307 \TestShr{2}{1}%
2308 \TestShr{3}{1}%
2309 \TestShr{4}{2}%
2310 \TestShr{5}{2}%
2311 \TestShr{6}{3}%
2312 \TestShr{7}{3}%
2313 \TestShr{8}{4}%
2314 \TestShr{9}{4}%

```

```

2315 \TestShr{10}{5}%
2316 \TestShr{11}{5}%
2317 \TestShr{12}{6}%
2318 \TestShr{13}{6}%
2319 \TestShr{14}{7}%
2320 \TestShr{15}{7}%
2321 \TestShr{16}{8}%
2322 \TestShr{17}{8}%
2323 \TestShr{18}{9}%
2324 \TestShr{19}{9}%
2325 \TestShr{20}{10}%
2326 \TestShr{21}{10}%
2327 \TestShr{22}{11}%
2328 \TestShr{11241}{5620}%
2329 \TestShr{73054202}{36527101}%
2330 \TestShr{2147483646}{1073741823}%
2331 \end{qstest}
2332
2333 \begin{qstest}{mul}{mul}
2334 \TestMul{0}{0}{0}%
2335 \TestMul{1}{0}{0}%
2336 \TestMul{0}{1}{0}%
2337 \TestMul{1}{1}{1}%
2338 \TestMul{3}{1}{3}%
2339 \TestMul{1}{-3}{-3}%
2340 \TestMul{-4}{-5}{20}%
2341 \TestMul{3}{7}{21}%
2342 \TestMul{7}{3}{21}%
2343 \TestMul{3}{-7}{-21}%
2344 \TestMul{7}{-3}{-21}%
2345 \TestMul{-3}{7}{-21}%
2346 \TestMul{-7}{3}{-21}%
2347 \TestMul{-3}{-7}{21}%
2348 \TestMul{-7}{-3}{21}%
2349 \TestMul{12}{11}{132}%
2350 \TestMul{999}{333}{332667}%
2351 \TestMul{1000}{4321}{4321000}%
2352 \TestMul{12345}{173955}{2147474475}%
2353 \TestMul{1073741823}{2}{2147483646}%
2354 \TestMul{2}{1073741823}{2147483646}%
2355 \TestMul{-1073741823}{2}{-2147483646}%
2356 \TestMul{2}{-1073741823}{-2147483646}%
2357 \TestMul{6706022400}{13}{87178291200}%
2358 \end{qstest}
2359
2360 \begin{qstest}{sqr}{sqr}
2361 \TestSqr{0}{0}%
2362 \TestSqr{1}{1}%
2363 \TestSqr{2}{4}%
2364 \TestSqr{3}{9}%
2365 \TestSqr{4}{16}%
2366 \TestSqr{9}{81}%
2367 \TestSqr{10}{100}%
2368 \TestSqr{46340}{2147395600}%
2369 \TestSqr{-1}{1}%
2370 \TestSqr{-2}{4}%
2371 \TestSqr{-46340}{2147395600}%
2372 \end{qstest}
2373
2374 \begin{qstest}{fac}{fac}
2375 \TestFac{0}{1}%
2376 \TestFac{1}{1}%

```

```

2377 \TestFac{2}{2}%
2378 \TestFac{3}{2*3}%
2379 \TestFac{4}{2*3*4}%
2380 \TestFac{5}{2*3*4*5}%
2381 \TestFac{6}{2*3*4*5*6}%
2382 \TestFac{7}{2*3*4*5*6*7}%
2383 \TestFac{8}{2*3*4*5*6*7*8}%
2384 \TestFac{9}{2*3*4*5*6*7*8*9}%
2385 \TestFac{10}{2*3*4*5*6*7*8*9*10}%
2386 \TestFac{11}{2*3*4*5*6*7*8*9*10*11}%
2387 \TestFac{12}{2*3*4*5*6*7*8*9*10*11*12}%
2388 \TestFacBig{13}{6227020800}%
2389 \TestFacBig{14}{87178291200}%
2390 \TestFacBig{15}{1307674368000}%
2391 \TestFacBig{16}{20922789888000}%
2392 \TestFacBig{17}{355687428096000}%
2393 \TestFacBig{18}{6402373705728000}%
2394 \TestFacBig{19}{121645100408832000}%
2395 \TestFacBig{20}{2432902008176640000}%
2396 \TestFacBig{21}{51090942171709440000}%
2397 \TestFacBig{22}{112400072777607680000}%
2398 \end{qstest}
2399
2400 \begin{qstest}{pow}{pow}
2401 \TestPow{-2}{0}{1}%
2402 \TestPow{-1}{0}{1}%
2403 \TestPow{0}{0}{1}%
2404 \TestPow{1}{0}{1}%
2405 \TestPow{2}{0}{1}%
2406 \TestPow{3}{0}{1}%
2407 \TestPow{-2}{1}{-2}%
2408 \TestPow{-1}{1}{-1}%
2409 \TestPow{1}{1}{1}%
2410 \TestPow{2}{1}{2}%
2411 \TestPow{3}{1}{3}%
2412 \TestPow{-2}{2}{4}%
2413 \TestPow{-1}{2}{1}%
2414 \TestPow{0}{2}{0}%
2415 \TestPow{1}{2}{1}%
2416 \TestPow{2}{2}{4}%
2417 \TestPow{3}{2}{9}%
2418 \TestPow{0}{1}{0}%
2419 \TestPow{1}{-2}{1}%
2420 \TestPow{1}{-1}{1}%
2421 \TestPow{-1}{-2}{1}%
2422 \TestPow{-1}{-1}{-1}%
2423 \TestPow{-1}{3}{-1}%
2424 \TestPow{-1}{4}{1}%
2425 \TestPow{-2}{-1}{0}%
2426 \TestPow{-2}{-2}{0}%
2427 \TestPow{2}{3}{8}%
2428 \TestPow{2}{4}{16}%
2429 \TestPow{2}{5}{32}%
2430 \TestPow{2}{6}{64}%
2431 \TestPow{2}{7}{128}%
2432 \TestPow{2}{8}{256}%
2433 \TestPow{2}{9}{512}%
2434 \TestPow{2}{10}{1024}%
2435 \TestPow{-2}{3}{-8}%
2436 \TestPow{-2}{4}{16}%
2437 \TestPow{-2}{5}{-32}%
2438 \TestPow{-2}{6}{64}%

```

```

2439 \TestPow{-2}{7}{-128}%
2440 \TestPow{-2}{8}{256}%
2441 \TestPow{-2}{9}{-512}%
2442 \TestPow{-2}{10}{1024}%
2443 \TestPow{3}{3}{27}%
2444 \TestPow{3}{4}{81}%
2445 \TestPow{3}{5}{243}%
2446 \TestPow{-3}{3}{-27}%
2447 \TestPow{-3}{4}{81}%
2448 \TestPow{-3}{5}{-243}%
2449 \TestPow{2}{30}{1073741824}%
2450 \TestPow{-3}{19}{-1162261467}%
2451 \TestPow{5}{13}{1220703125}%
2452 \TestPow{-7}{11}{-1977326743}%
2453 \end{qstest}
2454
2455 \begin{qstest}{div}{div}
2456 \TestDiv{1}{1}{1}%
2457 \TestDiv{2}{1}{2}%
2458 \TestDiv{-2}{1}{-2}%
2459 \TestDiv{2}{-1}{-2}%
2460 \TestDiv{-2}{-1}{2}%
2461 \TestDiv{15}{2}{7}%
2462 \TestDiv{-16}{2}{-8}%
2463 \TestDiv{1}{2}{0}%
2464 \TestDiv{1}{3}{0}%
2465 \TestDiv{2}{3}{0}%
2466 \TestDiv{-2}{3}{0}%
2467 \TestDiv{2}{-3}{0}%
2468 \TestDiv{-2}{-3}{0}%
2469 \TestDiv{13}{3}{4}%
2470 \TestDiv{-13}{-3}{4}%
2471 \TestDiv{-13}{3}{-4}%
2472 \TestDiv{-6}{5}{-1}%
2473 \TestDiv{-5}{5}{-1}%
2474 \TestDiv{-4}{5}{0}%
2475 \TestDiv{-3}{5}{0}%
2476 \TestDiv{-2}{5}{0}%
2477 \TestDiv{-1}{5}{0}%
2478 \TestDiv{0}{5}{0}%
2479 \TestDiv{1}{5}{0}%
2480 \TestDiv{2}{5}{0}%
2481 \TestDiv{3}{5}{0}%
2482 \TestDiv{4}{5}{0}%
2483 \TestDiv{5}{5}{1}%
2484 \TestDiv{6}{5}{1}%
2485 \TestDiv{-5}{4}{-1}%
2486 \TestDiv{-4}{4}{-1}%
2487 \TestDiv{-3}{4}{0}%
2488 \TestDiv{-2}{4}{0}%
2489 \TestDiv{-1}{4}{0}%
2490 \TestDiv{0}{4}{0}%
2491 \TestDiv{1}{4}{0}%
2492 \TestDiv{2}{4}{0}%
2493 \TestDiv{3}{4}{0}%
2494 \TestDiv{4}{4}{1}%
2495 \TestDiv{5}{4}{1}%
2496 \TestDiv{12345}{678}{18}%
2497 \TestDiv{32372}{5952}{5}%
2498 \TestDiv{284271294}{18162}{15651}%
2499 \TestDiv{217652429}{12561}{17327}%
2500 \TestDiv{462028434}{5439}{84947}%

```



```

2501 \TestDiv{2147483647}{1000}{2147483}%
2502 \TestDiv{2147483647}{-1000}{-2147483}%
2503 \TestDiv{-2147483647}{1000}{-2147483}%
2504 \TestDiv{-2147483647}{-1000}{2147483}%
2505 \TestDiv{0}{3}{0}%
2506 \TestDiv{1}{3}{0}%
2507 \TestDiv{2}{3}{0}%
2508 \TestDiv{3}{3}{1}%
2509 \TestDiv{4}{3}{1}%
2510 \TestDiv{5}{3}{1}%
2511 \TestDiv{6}{3}{2}%
2512 \TestDiv{7}{3}{2}%
2513 \TestDiv{8}{3}{2}%
2514 \TestDiv{9}{3}{3}%
2515 \TestDiv{10}{3}{3}%
2516 \TestDiv{11}{3}{3}%
2517 \TestDiv{12}{3}{4}%
2518 \TestDiv{13}{3}{4}%
2519 \TestDiv{14}{3}{4}%
2520 \TestDiv{15}{3}{5}%
2521 \TestDiv{16}{3}{5}%
2522 \TestDiv{17}{3}{5}%
2523 \TestDiv{18}{3}{6}%
2524 \TestDiv{19}{3}{6}%
2525 \TestDiv{20}{3}{6}%
2526 \TestDiv{21}{3}{7}%
2527 \TestDiv{22}{3}{7}%
2528 \TestDiv{23}{3}{7}%
2529 \TestDiv{24}{3}{8}%
2530 \TestDiv{25}{3}{8}%
2531 \TestDiv{26}{3}{8}%
2532 \TestDiv{27}{3}{9}%
2533 \TestDiv{28}{3}{9}%
2534 \TestDiv{29}{3}{9}%
2535 \TestDiv{30}{3}{10}%
2536 \TestDiv{31}{3}{10}%
2537 \TestDivBig{17363436332507}{24702}{702916214}%
2538 \end{qstest}
2539
2540 \begin{qstest}{mod}{mod}
2541 \TestMod{-6}{5}{4}%
2542 \TestMod{-5}{5}{0}%
2543 \TestMod{-4}{5}{1}%
2544 \TestMod{-3}{5}{2}%
2545 \TestMod{-2}{5}{3}%
2546 \TestMod{-1}{5}{4}%
2547 \TestMod{0}{5}{0}%
2548 \TestMod{1}{5}{1}%
2549 \TestMod{2}{5}{2}%
2550 \TestMod{3}{5}{3}%
2551 \TestMod{4}{5}{4}%
2552 \TestMod{5}{5}{0}%
2553 \TestMod{6}{5}{1}%
2554 \TestMod{-5}{4}{3}%
2555 \TestMod{-4}{4}{0}%
2556 \TestMod{-3}{4}{1}%
2557 \TestMod{-2}{4}{2}%
2558 \TestMod{-1}{4}{3}%
2559 \TestMod{0}{4}{0}%
2560 \TestMod{1}{4}{1}%
2561 \TestMod{2}{4}{2}%
2562 \TestMod{3}{4}{3}%

```

```

2563 \TestMod{4}{4}{0}%
2564 \TestMod{5}{4}{1}%
2565 \TestMod{-6}{-5}{-1}%
2566 \TestMod{-5}{-5}{0}%
2567 \TestMod{-4}{-5}{-4}%
2568 \TestMod{-3}{-5}{-3}%
2569 \TestMod{-2}{-5}{-2}%
2570 \TestMod{-1}{-5}{-1}%
2571 \TestMod{0}{-5}{0}%
2572 \TestMod{1}{-5}{-4}%
2573 \TestMod{2}{-5}{-3}%
2574 \TestMod{3}{-5}{-2}%
2575 \TestMod{4}{-5}{-1}%
2576 \TestMod{5}{-5}{0}%
2577 \TestMod{6}{-5}{-4}%
2578 \TestMod{-5}{-4}{-1}%
2579 \TestMod{-4}{-4}{0}%
2580 \TestMod{-3}{-4}{-3}%
2581 \TestMod{-2}{-4}{-2}%
2582 \TestMod{-1}{-4}{-1}%
2583 \TestMod{0}{-4}{0}%
2584 \TestMod{1}{-4}{-3}%
2585 \TestMod{2}{-4}{-2}%
2586 \TestMod{3}{-4}{-1}%
2587 \TestMod{4}{-4}{0}%
2588 \TestMod{5}{-4}{-3}%
2589 \TestMod{2147483647}{1000}{647}%
2590 \TestMod{2147483647}{-1000}{-353}%
2591 \TestMod{-2147483647}{1000}{353}%
2592 \TestMod{-2147483647}{-1000}{-647}%
2593 \TestMod{ 0 }{ 4 }{0}%
2594 \TestMod{ 1 }{ 4 }{1}%
2595 \TestMod{ -1 }{ 4 }{3}%
2596 \TestMod{ 0 }{ -4 }{0}%
2597 \TestMod{ 1 }{ -4 }{-3}%
2598 \TestMod{ -1 }{ -4 }{-1}%
2599 \TestMod{18362}{25}{12}%
2600 \end{qstest}
2601
2602 \newcommand*{\TestError}[2]{%
2603   \begingroup
2604     \expandafter\def\csname BigIntCalcError:#1\endcsname{%
2605       \Expect*{#2}{0}%
2606       \expandafter\def\csname BigIntCalcError:#1\endcsname{ERROR}%
2607       \Expect*{#2}{OERROR}%
2608     \endgroup
2609 }
2610 \begin{qstest}{error}{error}
2611   \TestError{FacNegative}{\bigintcalcFac{-1}}%
2612   \TestError{FacNegative}{\bigintcalcFac{-2147483647}}%
2613   \TestError{DivisionByZero}{\bigintcalcPow{0}{-1}}%
2614   \TestError{DivisionByZero}{\bigintcalcDiv{1}{0}}%
2615   \TestError{DivisionByZero}{\bigintcalcMod{1}{0}}%
2616 \end{qstest}
2617
2618 \begin{document}
2619 \end{document}
2620 </test2>

```

## 4 Installation

### 4.1 Download

**Package.** This package is available on CTAN<sup>1</sup>:

[CTAN:macros/latex/contrib/oberdiek/bigintcalc.dtx](#) The source file.

[CTAN:macros/latex/contrib/oberdiek/bigintcalc.pdf](#) Documentation.

**Bundle.** All the packages of the bundle ‘oberdiek’ are also available in a TDS compliant ZIP archive. There the packages are already unpacked and the documentation files are generated. The files and directories obey the TDS standard.

[CTAN:install/macros/latex/contrib/oberdiek.tds.zip](#)

TDS refers to the standard “A Directory Structure for T<sub>E</sub>X Files” ([CTAN:tds/tds.pdf](#)). Directories with `texmf` in their name are usually organized this way.

### 4.2 Bundle installation

**Unpacking.** Unpack the `oberdiek.tds.zip` in the TDS tree (also known as `texmf` tree) of your choice. Example (linux):

```
unzip oberdiek.tds.zip -d ~/texmf
```

**Script installation.** Check the directory `TDS:scripts/oberdiek/` for scripts that need further installation steps. Package `attachfile2` comes with the Perl script `pdfatfi.pl` that should be installed in such a way that it can be called as `pdfatfi`. Example (linux):

```
chmod +x scripts/oberdiek/pdfatfi.pl
cp scripts/oberdiek/pdfatfi.pl /usr/local/bin/
```

### 4.3 Package installation

**Unpacking.** The `.dtx` file is a self-extracting `docstrip` archive. The files are extracted by running the `.dtx` through plain-T<sub>E</sub>X:

```
tex bigintcalc.dtx
```

**TDS.** Now the different files must be moved into the different directories in your installation TDS tree (also known as `texmf` tree):

<code>bigintcalc.sty</code>	→ <code>tex/generic/oberdiek/bigintcalc.sty</code>
<code>bigintcalc.pdf</code>	→ <code>doc/latex/oberdiek/bigintcalc.pdf</code>
<code>test/bigintcalc-test1.tex</code>	→ <code>doc/latex/oberdiek/test/bigintcalc-test1.tex</code>
<code>test/bigintcalc-test2.tex</code>	→ <code>doc/latex/oberdiek/test/bigintcalc-test2.tex</code>
<code>test/bigintcalc-test3.tex</code>	→ <code>doc/latex/oberdiek/test/bigintcalc-test3.tex</code>
<code>bigintcalc.dtx</code>	→ <code>source/latex/oberdiek/bigintcalc.dtx</code>

If you have a `docstrip.cfg` that configures and enables `docstrip`’s TDS installing feature, then some files can already be in the right place, see the documentation of `docstrip`.

### 4.4 Refresh file name databases

If your T<sub>E</sub>X distribution (teT<sub>E</sub>X, miK<sub>T</sub>E<sub>X</sub>, ...) relies on file name databases, you must refresh these. For example, teT<sub>E</sub>X users run `texhash` or `mktextlsr`.

---

<sup>1</sup><http://ftp.ctan.org/tex-archive/>

## 4.5 Some details for the interested

**Attached source.** The PDF documentation on CTAN also includes the `.dtx` source file. It can be extracted by AcrobatReader 6 or higher. Another option is `pdftk`, e.g. unpack the file into the current directory:

```
pdftk bigintcalc.pdf unpack_files output .
```

**Unpacking with L<sup>A</sup>T<sub>E</sub>X.** The `.dtx` chooses its action depending on the format:

**plain-T<sub>E</sub>X:** Run `docstrip` and extract the files.

**L<sup>A</sup>T<sub>E</sub>X:** Generate the documentation.

If you insist on using L<sup>A</sup>T<sub>E</sub>X for `docstrip` (really, `docstrip` does not need L<sup>A</sup>T<sub>E</sub>X), then inform the autodetect routine about your intention:

```
latex \let\install=y\input{bigintcalc.dtx}
```

Do not forget to quote the argument according to the demands of your shell.

**Generating the documentation.** You can use both the `.dtx` or the `.drv` to generate the documentation. The process can be configured by the configuration file `ltxdoc.cfg`. For instance, put this line into this file, if you want to have A4 as paper format:

```
\PassOptionsToClass{a4paper}{article}
```

An example follows how to generate the documentation with pdfL<sup>A</sup>T<sub>E</sub>X:

```
pdflatex bigintcalc.dtx
makeindex -s gind.ist bigintcalc.idx
pdflatex bigintcalc.dtx
makeindex -s gind.ist bigintcalc.idx
pdflatex bigintcalc.dtx
```

## 5 History

[2007/09/27 v1.0]

- First version.

[2007/11/11 v1.1]

- Use of package `pdfdoccmds` for L<sup>A</sup>T<sub>E</sub>X support.

## 6 Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in roman refer to the code lines where the entry is used.

Symbols	
<code>\#</code> .....	1749, 1811
<code>\%</code> .....	1814
<code>\@</code> .....	1750, 1807
<code>\@firstofone</code> .....	1758, 1761
<code>\@firstoftwo</code> .....	134, 142, <u>151</u>
<code>\@gobble</code> .....	1755, 1763
<code>\@ne</code> .....	2135,
	2150, 2151, 2161, 2162, 2187, 2188
<code>\@nil</code> .	130, 132, 139, 147, 162, 165, 170
<code>\@secondoftwo</code> .....	136, 144, <u>154</u>
<code>\[</code> .....	1812
<code>\%</code> .....	167, 177, 296, 297, 305, 328, 426,
	438, 471, 484, 496, 531, 533,
	622, 623, 633, 634, 651, 713,
	714, 724, 725, 742, 827, 838,
	885, 899, 962, 973, 990, 1110,
	1196, 1221, 1249, 1297, 1318,

	1328, 1422, 1426, 1454, 1500, 1647, 1658, 1666, 1688, 1704, 1808		1116, 1144, 1172, 1174, 1207, 1209, 1304, 1389, 1418, 1420, 1455, 1459, 1511, 1552, 1601, 1656, 1695, 1729, 1731, 1736, 1741
\{	1747, 1809		
\}	1748, 1810		
\]	1813	\BIC@AfterFiFi	113, 178, 182, 188, 209, 213, 272, 276, 282, 286, 298, 300, 306, 310, 324, 373, 375, 439, 441, 447, 464, 473, 475, 497, 499, 505, 524, 539, 624, 628, 644, 715, 719, 735, 886, 888, 901, 908, 917, 924, 1010, 1015, 1055, 1080, 1164, 1212, 1216, 1234, 1236, 1245, 1265, 1267, 1288, 1299, 1301, 1330, 1334, 1340, 1392, 1394, 1398, 1404, 1406, 1410, 1435, 1437, 1441, 1446, 1490, 1492, 1498, 1520, 1522, 1544, 1567, 1569, 1575, 1577, 1583, 1585, 1594, 1596, 1617, 1624, 1659, 1661, 1675, 1677, 1681, 1698, 1700, 1710, 1717
\_	1815	\BIC@AfterFiFiFi	114, 193, 197, 329, 333, 534, 536, 566, 570, 576, 579, 583, 591, 593, 598, 604, 608, 635, 639, 726, 730, 1058, 1062, 1069, 1073, 1084, 1088, 1094, 1098, 1148, 1149, 1150, 1151, 1152, 1153, 1154, 1155, 1156, 1157, 1158, 1159, 1160, 1239, 1241, 1270, 1272, 1277, 1282, 1347, 1353, 1501, 1505, 1529, 1531, 1537, 1539, 1610, 1612
<b>A</b>		\BIC@AtEnd	78, 79, 1744
\advance	1788, 1796, 2063	\BIC@Cmp	262, 265
\AtEndDocument	2076	\BIC@CmpDiff	298, 317
<b>B</b>		\BIC@CmpLength	287, 293, 295
\begin	2083, 2101, 2120, 2143, 2154, 2165, 2193, 2205, 2223, 2240, 2269, 2296, 2304, 2333, 2360, 2374, 2400, 2455, 2540, 2610, 2618	\BIC@CmpResult	301, 307, 316
\BIC@@@Shl	845, 849	\BIC@Dec	396, 410, 423, 483, 1183
\BIC@@@Shr	918, 919, 925, 926, 935	\BIC@DecSwitch	402, 405
\BIC@@@Dec	506, 507, 525, 530	\BIC@Div	1376, 1379
\BIC@@@Inc	448, 449, 465, 470	\BIC@DivCleanup	1490, 1498, 1516, 1520, 1529, 1537, 1567, 1575, 1583, 1594, 1610
\BIC@@@PowRec	1348, 1354, 1369	\BIC@DivStart	1480, 1484
\BIC@@@ProcessDiv	1553, 1591	\BIC@DivStartX	1447, 1453, 1460
\BIC@@@Shl	829, 837, 852, 856	\BIC@DivStartYii	1456, 1464
\BIC@@@Shr	889, 894, 898, 936	\BIC@DivStartYiv	1465, 1469
\BIC@@AddDigit	674, 675, 685, 764	\BIC@DivStartYvi	1470, 1474
\BIC@@Cmp	266, 269, 355, 387	\BIC@DivStartYviii	1475, 1479
\BIC@@Dec	486, 494, 543	\BIC@DivSub	1540, 1557, 1586
\BIC@@Expand	130, 132	\BIC@DivSwitch	1395, 1399, 1407, 1411, 1416
\BIC@@Inc	428, 436, 479	\BIC@DivSwitchSign	1380, 1385, 1387
\BIC@@MinMax	351, 354	\BIC@DoAdd	625, 629, 650
\BIC@@MinusOne	1311, 1316	\BIC@DoSub	716, 720, 741
\BIC@@PowRec	1341, 1364, 1370	\BIC@Expand	128, 158, 225
\BIC@@ProcessDiv	1512, 1517	\BIC@Fac	1139, 1142
\BIC@@ProcessFac	1175, 1181	\BIC@Fi	111, 112, 113, 114, 172, 202, 217, 290, 314, 338, 359, 379, 398, 417, 434, 468, 481, 492, 528, 545, 613, 648,
\BIC@@ProcessTim	982, 989		
\BIC@@Shl	811, 816, 823, 826		
\BIC@@Shr	869, 873, 879, 881, 1342, 1371, 1438, 1442, 1443		
\BIC@@Sqr	1129, 1131, 1134		
\BIC@@SubDigit	763, 774		
\BIC@@TestMode	104		
\BIC@@Tim	961		
\BIC@Abs	233, 236		
\BIC@Add	549, 552, 558		
\BIC@AddCarry0	692		
\BIC@AddCarry10	693		
\BIC@AddCarry[1-9]	694		
\BIC@AddDigit	656, 661, 672		
\BIC@AddResult	655, 665		
\BIC@AddSwitch	554, 561		
\BIC@AddXY	567, 571, 605, 609, 616, 621, 812, 817, 824, 1018, 1476		
\BIC@AfterFi	112, 169, 206, 319, 356, 358, 388, 390, 394, 407, 409, 413, 427, 431, 478, 485, 489, 542, 652, 659, 687, 689, 743, 748, 776, 781, 809, 815, 828, 832, 839, 844, 851, 855, 868, 872, 883, 893, 963, 967, 974, 981, 991, 995, 1002, 1004, 1052, 1111,		

663, 690, 739, 752, 782, 819, 835, 847, 858, 875, 896, 931, 970, 987, 998, 1023, 1103, 1120, 1168, 1179, 1294, 1307, 1362, 1414, 1451, 1462, 1514, 1555, 1589, 1631, 1685, 1725, 1732, 1742	\BIC@SubXY . . . . .
	. 580, 584, 594, 599, 619, <u>712</u> , 1546, 1560, 1603, 1619, 1626, 1738
\BIC@Inc . . . . . 391, 415, 420, <u>425</u>	\BIC@Temp . . . . . 694, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 786, 793, 794, 795, 796, 797, 798, 799, 800, 801, 938, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 1025, 1034, 1035, 1036, 1037, 1038, 1039, 1040
\BIC@IncSwitch . . . . . 383, <u>386</u>	\BIC@TestMode . . . . . 104, 1831
\BIC@MinMax . . . . . 342, 347, <u>350</u>	\BIC@Tim . . . . . 961, 1113, 1118
\BIC@MinusOne . . . . . 1227, 1256, <u>1309</u>	\BIC@TimDigit . . . . . 977, 984, <u>1000</u>
\BIC@Mod . . . . . 1635, <u>1638</u>	\bigintcalcAbs . . 4, <u>231</u> , 364, 1881, 1900, 1971, 1972, 1980, 1981, 1990, 1991, 2017, 2018, 2038, 2039
\BIC@ModMinus . . . . . 1707, <u>1727</u>	\BigIntCalcAdd . . . 7, <u>615</u> , 1934, 1942
\BIC@ModSwitch . 1662, 1678, 1682, <u>1687</u>	\bigintcalcAdd 5, <u>547</u> , 1113, 1118, 1928
\BIC@ModSwitchSign . . 1639, 1644, <u>1646</u>	\bigintcalcCmp 4, <u>260</u> , 1893, 1931, 1955
\BIC@ModTwo . . . . .	\BigIntCalcDec . . . . . 7, <u>422</u> , 1921
1238, 1269, 1276, <u>1296</u> , 1339, 1697	\bigintcalcDec . . . . . 5, <u>400</u> , 1917
\BIC@ModX . . . . . 1711, <u>1734</u>	\BigIntCalcDiv . . . . . 7, <u>1383</u> , 2017
\BIC@Mul . . . . . 1043, <u>1046</u>	\bigintcalcDiv . . . . . 6, <u>1374</u> , 1713, 1720, 1869, 2010, 2014, 2614
\BIC@MulDigit[3-9] . . . . . <u>1025</u>	\BigIntCalcError . . . . . 459, 509, 519, 698, 789, 1030, 1144, 1161, 1231, 1234, 1242, 1246, 1273, 1285, 1291, 1293, 1359, 1361, 1389, 1449, 1656, 1701, 1724
\BIC@MulSwitch . . . . . 1047, <u>1050</u>	\bigintcalcFac . . . . .
\BIC@Normalize . . . . . <u>175</u> , 222	. . 6, <u>1137</u> , 2001, 2004, 2611, 2612
\BIC@NormalizeDigits . . 198, 214, <u>219</u>	\BigIntCalcInc . . . . . 7, <u>419</u> , 1910
\BIC@NormalizeZero . . . . . 194, <u>204</u>	\bigintcalcInc . . . . . 5, <u>381</u> , 1906
\BIC@Odd . . . . . 363, 368, <u>370</u>	\bigintcalcInv . . . . . 3, <u>227</u> , 1878
\BIC@PosCmp . . . . 292, 565, 575, 590, 603, 1057, 1068, 1083, 1093, 1146, 1171, 1329, 1346, 1417, 1488, 1518, 1527, 1565, 1592, 1608	\bigintcalcMax . . . . . 4, <u>345</u> , 1890
\BIC@Pow . . . . . 1188, <u>1191</u>	\bigintcalcMin . . . . . 4, <u>340</u> , 1887
\BIC@PowRec 1278, 1283, 1289, <u>1327</u> , 1365	\BigIntCalcMod . . . . . 7, <u>1642</u> , 2037
\BIC@PowSwitch . . . . . 1192, <u>1195</u>	\bigintcalcMod . . . 6, <u>1633</u> , 2022, 2615
\BIC@ProcessDiv . . . . .	\BigIntCalcMul . . . . . 7, <u>1105</u> , 1989
. . . . . <u>1453</u> , 1485, <u>1487</u> , 1523, 1532, 1558, 1570, 1578, 1597, 1613	\bigintcalcMul 6, <u>1041</u> , 1713, 1720, 1986
\BIC@ProcessDivII . . . . .	\bigintcalcNum . . 3, <u>220</u> , 229, 234, 247, 263, 267, 343, 348, 352, 384, 403, 550, 554, 559, 805, 863, 1044, 1048, 1125, 1140, 1189, 1193, 1377, 1381, 1636, 1640, 1910, 1921, 1935, 1943, 1959
. . . . 1545, <u>1564</u> , 1602, 1618, 1625	\BigIntCalcOdd . . . . . 7, <u>366</u> , 1899
\BIC@ProcessDivIV . . . . . <u>1591</u>	\bigintcalcOdd . . . . . 5, <u>361</u> , 1896
\BIC@ProcessFac . . . . 1165, <u>1170</u> , 1182	\bigintcalcPow . . . 6, <u>1186</u> , 2007, 2613
\BIC@ProcessMul . 1059, 1063, 1070, 1074, 1085, 1089, 1095, 1099, 1107, <u>1109</u> , 1135, 1176, 1213, 1217, 1331, 1335, 1349, 1355, 1366	\bigintcalcSgn . . . . .
\BIC@ProcessTim . . . 964, <u>972</u> , 992, 996	4, <u>244</u> , 1884, 1907, 1918, 1929, 1930, 1953, 1954, 2023, 2025, 2030
\BIC@Sgn . . . . . 246, <u>249</u> , 406, 1051, 1054, 1079, 1388, 1391, 1403	\BigIntCalcShl . . . . . 7, <u>821</u> , 1971
\BIC@Shl . . . 804, <u>807</u> , 1466, 1471, 1481	\bigintcalcShl . . . . . 5, <u>802</u> , 1968
\BIC@Shr . . . . . 862, <u>865</u>	\BigIntCalcShr . . . . . 7, <u>877</u> , 1980
\BIC@ShrDigit[00-19] . . . . . <u>938</u>	\bigintcalcShr . . . . . 5, <u>860</u> , 1977
\BIC@ShrResult 902, 903, 909, 910, <u>933</u>	\bigintcalcSqr . . . . . 6, <u>1122</u> , 1996
\BIC@Space . . . . . <u>115</u> , 159, 228, 238, 240, 653, 667, 669, 758, 777, 840, 975, 1005, 1011, 1016, 1112, 1706, 1718, 1737	\BigIntCalcSub . . . . . 7, <u>618</u> , 1958
\BIC@Sqr . . . . . 1124, <u>1127</u>	\bigintcalcSub 5, <u>556</u> , 1712, 1719, 1952
\BIC@StripHexSpace . . . . . 162, <u>165</u>	\body . . . . . 1767, 1771
\BIC@SubCarry0 . . . . . <u>784</u>	
\BIC@SubCarry10 . . . . . <u>785</u>	
\BIC@SubCarry[1-9] . . . . . <u>786</u>	
\BIC@SubDigit . . . . . 745, 750, <u>761</u>	
\BIC@SubResult . . . . . 744, <u>754</u>	

<b>C</b>		
<code>\catcode</code>	3, 4, 5, 6, 7, 18, 19, 20, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 62, 63, 66, 67, 68, 69, 73, 74, 75, 76, 80, 82, 102, 107, 109, 1747, 1748, 1749, 1750, 1785, 1794, 1807, 1808, 1809, 1810, 1811, 1812, 1813, 1814, 1815, 1816	
<code>\chardef</code>	1831	
<code>\count@</code>	1752, 1781, 1785, 1787, 1788, 1792, 1794, 1795, 1796	
<code>\countdef</code>	1752	
<code>\csname</code>	8, 21, 45, 58, 65, 100, 106, 121, 127, 151, 154, 676, 692, 693, 695, 765, 784, 785, 787, 904, 911, 920, 927, 939, 1006, 1012, 1019, 1026, 1751, 1754, 1757, 1760, 1799, 1821, 2045, 2604, 2606	
<b>D</b>		
<code>\dimexpr</code>	2053	
<code>\divide</code>	1868	
<code>\documentclass</code>	1827	
<b>E</b>		
<code>\empty</code>	12	
<code>\end</code>	1822, 2099, 2118, 2141, 2152, 2163, 2191, 2203, 2221, 2238, 2267, 2294, 2302, 2331, 2358, 2372, 2398, 2453, 2538, 2600, 2616, 2619	
<code>\endcsname</code>	8, 21, 45, 58, 65, 100, 106, 121, 127, 151, 154, 683, 692, 693, 695, 772, 784, 785, 787, 904, 911, 920, 927, 939, 1006, 1012, 1019, 1026, 1751, 1754, 1757, 1760, 1799, 1821, 2045, 2604, 2606	
<code>\endinput</code>	30	
<code>\endqstest</code>	2067, 2072	
<code>\Expect</code>	1844, 1851, 1860, 1869, 2605, 2607	
<b>I</b>		
<code>\ifcase</code>	9, 387, 406, 437, 450, 495, 508, 532, 575, 590, 678, 681, 696, 767, 770, 788, 882, 1001, 1009, 1027, 1051, 1054, 1079, 1147, 1196, 1221, 1227, 1238, 1249, 1256, 1269, 1276, 1328, 1339, 1388, 1391, 1403, 1417, 1426, 1488, 1518, 1527, 1565, 1592, 1608, 1647, 1658, 1666, 1688, 1697, 2023, 2025, 2030	
<code>\ifcat</code>	133	
<code>\ifnum</code>	318, 323, 355, 446, 472, 504, 565, 603, 686, 775, 850, 1057, 1068, 1083, 1093, 1146, 1171, 1329, 1346, 1787, 1795, 1907, 1918, 1929, 1930, 1931, 1953, 1954, 1955	
<code>\ifodd</code>	372, 900, 916, 1298	
<code>\iftrue</code>	2139	
<code>\ifx</code>	10, 12, 21, 45, 53, 100, 106, 121, 127, 141, 151, 154, 167, 176, 177, 187, 192, 205, 208, 237, 250, 253, 270, 271, 281, 296, 297, 305, 328, 371, 426, 438, 471, 484, 496, 531, 533, 562, 563, 589, 622, 623, 633, 634, 651, 666, 713, 714, 724, 725, 742, 755, 808, 827, 838, 866, 885, 899, 962, 973, 990, 1110, 1128, 1143, 1196, 1197, 1198, 1199, 1203, 1211, 1221, 1222, 1223, 1249, 1250, 1251, 1255, 1297, 1310, 1317, 1318, 1328, 1422, 1426, 1427, 1428, 1429, 1454, 1489, 1497, 1500, 1519, 1528, 1536, 1566, 1574, 1582, 1593, 1609, 1647, 1648, 1652, 1658, 1666, 1667, 1671, 1688, 1689, 1690, 1704, 1709, 1728, 1735, 1751, 1754, 1757, 1760, 1799, 2045, 2097, 2098, 2117	
<code>\immediate</code>	23, 47	
<code>\IncludeTests</code>	1836	
<code>\input</code>	122, 1800	
<code>\iterate</code>	1768, 1770, 1772	
<b>L</b>		
<code>\LoadCommand</code>	1800, 1817	
<code>\LogTests</code>	1837	
<code>\loop</code>	1766, 1782, 1793	
<b>M</b>		
<code>\m@ne</code>	2136, 2151, 2162, 2188	
<code>\makeatletter</code>	1830, 2047, 2081	
<code>\makeatother</code>	1832, 2079	
<b>N</b>		
<code>\NeedsTeXFormat</code>	1825	
<code>\newcommand</code>	1838, 1846, 1853, 1864, 1865, 1866, 1871, 1876, 1877, 1880, 1883, 1886, 1889, 1892, 1895, 1905, 1916, 1927, 1951, 1967, 1976, 1985, 1995, 1998, 2003, 2006, 2009, 2013, 2021, 2051, 2056, 2060, 2061, 2602	
<code>\newcount</code>	1863, 2048, 2049	
<code>\next</code>	1772, 1774, 1776	
<code>\nofiles</code>	1826	
<code>\number</code>	245, 261, 675, 764, 1006, 1012, 1019, 2053, 2096, 2134, 2135, 2136, 2138, 2150, 2151, 2161, 2162, 2187, 2188	
<code>\numexpr</code>	448, 506, 654, 674, 763, 778, 841, 845, 902, 909, 918, 925, 976, 983, 1828, 1829, 1834, 1839, 1840, 1843, 1847, 1848, 1850, 1856, 1864, 2000	
<b>P</b>		
<code>\PackageInfo</code>	26	
<code>\pdf@escapehex</code>	162	
<code>\pdf@unescapehex</code>	160	

\pdfelapsedtime .....	2062	2175, 2176, 2177, 2178, 2179,
\pdfresettimer .....	2058	2180, 2181, 2182, 2183, 2184,
\PrintTime .....	2051, 2064, 2077	2185, 2186, 2187, 2188, 2189, 2190
\ProvidesPackage .....	59	\TestCount .... 1863, 1867, 1868, 1869
<b>Q</b>		\TestDec .. 1916, 2224, 2225, 2226,
\qstest .....	2066, 2068	2227, 2228, 2229, 2230, 2231,
<b>R</b>		2232, 2233, 2234, 2235, 2236, 2237
\RangeCatcodeInvalid .....		\TestDiv .....
.... 1791, 1803, 1804, 1805, 1806		2009,
\renewcommand .....	2057	2456, 2457, 2458, 2459, 2460,
\repeat .....	1766, 1778, 1789, 1797	2461, 2462, 2463, 2464, 2465,
\RequirePackage .....	124	2466, 2467, 2468, 2469, 2470,
\RestoreCatcodes 1780, 1783, 1784, 1818		2471, 2472, 2473, 2474, 2475,
\result .....	1849, 1851	2476, 2477, 2478, 2479, 2480,
\resultA .....	1841, 1844	2481, 2482, 2483, 2484, 2485,
\resultB .....	1842, 1844	2486, 2487, 2488, 2489, 2490,
\romannumeral 129, 159, 221, 228, 232,		2491, 2492, 2493, 2494, 2495,
341, 346, 362, 367, 382, 395,		2496, 2497, 2498, 2499, 2500,
401, 414, 420, 423, 548, 557,		2501, 2502, 2503, 2504, 2505,
564, 578, 597, 616, 619, 673,		2506, 2507, 2508, 2509, 2510,
762, 803, 810, 822, 861, 867,		2511, 2512, 2513, 2514, 2515,
878, 977, 984, 1017, 1042, 1067,		2516, 2517, 2518, 2519, 2520,
1082, 1106, 1123, 1138, 1176,		2521, 2522, 2523, 2524, 2525,
1183, 1187, 1281, 1341, 1348,		2526, 2527, 2528, 2529, 2530,
1354, 1365, 1370, 1375, 1384,		2531, 2532, 2533, 2534, 2535, 2536
1424, 1442, 1465, 1470, 1475,		\TestDivBig .....
1480, 1545, 1559, 1602, 1618,		2013, 2537
1625, 1634, 1643, 1706, 1707, 1737		\TestError .....
<b>S</b>		2602, 2611, 2612, 2613, 2614, 2615
\saved@endqstest .....	2067, 2074	\TestExch .....
\saved@qstest .....	2066, 2069	1876, 1999
\SavedNumexpr .....		\TestFac .....
1828, 1834, 1839, 1843, 1847, 1850		1998, 2375, 2376,
\space .....	1844, 2053	2377, 2378, 2379, 2380, 2381,
\StartTime .....	2056, 2070	2382, 2383, 2384, 2385, 2386, 2387
\StopTime .....	2061, 2073	\TestFacBig .....
\strip@pt .....	2053	. 2003, 2388, 2389, 2390, 2391,
\SummaryTime ... 2048, 2050, 2063, 2077		2392, 2393, 2394, 2395, 2396, 2397
<b>T</b>		\TestInc 1905, 2206, 2207, 2208, 2209,
\Test .....	1802, 1820, 1871, 1876,	2210, 2211, 2212, 2213, 2214,
1878, 1881, 1884, 1887, 1890,		2215, 2216, 2217, 2218, 2219, 2220
1893, 1896, 1898, 1906, 1909,		\TestInv 1877, 2084, 2085, 2086, 2087,
1917, 1920, 1928, 1933, 1941,		2088, 2089, 2090, 2091, 2092,
1952, 1957, 1968, 1970, 1977,		2093, 2094, 2095, 2096, 2097, 2098
1979, 1986, 1988, 1996, 2004,		\TestMax .....
2007, 2010, 2014, 2016, 2022, 2036		1889, 2155, 2156,
\TestAbs .....	1880,	2157, 2158, 2159, 2160, 2161, 2162
2102, 2103, 2104, 2105, 2106,		\TestMin .....
2107, 2108, 2109, 2110, 2111,		1886, 2144, 2145,
2112, 2113, 2114, 2115, 2116, 2117		2146, 2147, 2148, 2149, 2150, 2151
\TestAdd .....	1927,	\TestMod .. 2021, 2541, 2542, 2543,
2241, 2242, 2243, 2244, 2245,		2544, 2545, 2546, 2547, 2548,
2246, 2247, 2248, 2249, 2250,		2549, 2550, 2551, 2552, 2553,
2251, 2252, 2253, 2254, 2255,		2554, 2555, 2556, 2557, 2558,
2256, 2257, 2258, 2259, 2260,		2559, 2560, 2561, 2562, 2563,
2261, 2262, 2263, 2264, 2265, 2266		2564, 2565, 2566, 2567, 2568,
\TestArg .....	1864, 1865, 1867, 1868	2569, 2570, 2571, 2572, 2573,
\TestCmp 1892, 2166, 2167, 2168, 2169,		2574, 2575, 2576, 2577, 2578,
2170, 2171, 2172, 2173, 2174,		2579, 2580, 2581, 2582, 2583,
		2584, 2585, 2586, 2587, 2588,
		2589, 2590, 2591, 2592, 2593,
		2594, 2595, 2596, 2597, 2598, 2599
		\TestMul .. 1985, 2334, 2335, 2336,
		2337, 2338, 2339, 2340, 2341,
		2342, 2343, 2344, 2345, 2346,
		2347, 2348, 2349, 2350, 2351,
		2352, 2353, 2354, 2355, 2356, 2357
		\TestOdd .....
		1895, 2195, 2196,



2197, 2198, 2199, 2200, 2201, 2202	2278, 2279, 2280, 2281, 2282,
\TestPow . . . . . 2006, 2401,	2283, 2284, 2285, 2286, 2287,
2402, 2403, 2404, 2405, 2406,	2288, 2289, 2290, 2291, 2292, 2293
2407, 2408, 2409, 2410, 2411,	\TestTeXDivide . . . . . 1866, 2011
2412, 2413, 2414, 2415, 2416,	\TestTime . . . . . 2049, 2062, 2063, 2064
2417, 2418, 2419, 2420, 2421,	\the . . . . . 66, 67,
2422, 2423, 2424, 2425, 2426,	68, 69, 80, 448, 506, 654, 674,
2427, 2428, 2429, 2430, 2431,	763, 778, 841, 845, 902, 909,
2432, 2433, 2434, 2435, 2436,	918, 925, 976, 983, 1785, 1869, 2000
2437, 2438, 2439, 2440, 2441,	\TimeDescription . . . . 2057, 2060, 2064
2442, 2443, 2444, 2445, 2446,	\TMP@EnsureCode 77, 84, 85, 86, 87, 88,
2447, 2448, 2449, 2450, 2451, 2452	89, 90, 91, 92, 93, 94, 95, 96, 97, 98
\TestResult . . . . . 1846, 1872	\tracingmacros . . . . . 2194
\TestResultTwoExpansions . 1853, 1873	\typeout . . . . . 2052
\TestSgn . . . . . 1883, 2121,	
2122, 2123, 2124, 2125, 2126,	<b>U</b>
2127, 2128, 2129, 2130, 2131,	\UNDEFINED . . . . 1829, 1840, 1848, 1856
2132, 2133, 2134, 2135, 2136, 2137	\usepackage . . . . . 1833, 1835
\TestShl . . . . .	
1967, 2297, 2298, 2299, 2300, 2301	<b>W</b>
\TestShr . . . . . 1976,	\write . . . . . 23, 47
2305, 2306, 2307, 2308, 2309,	
2310, 2311, 2312, 2313, 2314,	<b>X</b>
2315, 2316, 2317, 2318, 2319,	\x . . . . . 8, 10, 12, 22, 26,
2320, 2321, 2322, 2323, 2324,	28, 46, 51, 58, 64, 72, 116, 119,
2325, 2326, 2327, 2328, 2329, 2330	1897, 1903, 1908, 1913, 1919,
\TestSpaceAtEnd . . . . . 1838, 1874	1924, 1932, 1938, 1940, 1946,
\TestSqr . . . . . 1995,	1956, 1962, 1969, 1974, 1978,
2361, 2362, 2363, 2364, 2365,	1983, 1987, 1993, 2015, 2035, 2041
2366, 2367, 2368, 2369, 2370, 2371	
\TestSub . . 1951, 2270, 2271, 2272,	<b>Z</b>
2273, 2274, 2275, 2276, 2277,	\z@ . . . . . 2050,
	2096, 2134, 2138, 2150, 2161, 2187