

The **bigintcalc** package

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Abstract

This package provides expandable arithmetic operations with big integers that can exceed \TeX 's number limits.

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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 \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 \TeX numbers like count registers or commands created by `\chardef`. Nevertheless they may be used, if they are prefixed by `\number`.

Also ε - \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 \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 ε -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, Mul

`\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 $\langle *package \rangle$

2.1 Reload check and package identification

Reload check, especially if the package is not used with L^AT_EX.

```

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 \expandafter\ifx\csname PackageInfo\endcsname\relax
19 \def\x#1#2{%
20 \immediate\write-1{Package #1 Info: #2.}%
21 }%
22 \else
23 \def\x#1#2{\PackageInfo{#1}{#2, stopped}}%
24 \fi
25 \x{bigintcalc}{The package is already loaded}%
26 \endgroup
27 \expandafter\endinput
28 \fi
29 \endgroup

```

Package identification:

```

30 \begingroup
31 \catcode40 12 % (
32 \catcode41 12 % )
33 \catcode44 12 % ,
34 \catcode45 12 % -
35 \catcode46 12 % .
36 \catcode47 12 % /
37 \catcode58 12 % :
38 \catcode64 11 % @
39 \expandafter\ifx\csname ProvidesPackage\endcsname\relax
40 \def\x#1#2#3[#4]{\endgroup
41 \immediate\write-1{Package: #3 #4}%
42 \xdef#1{#4}%
43 }%
44 \else
45 \def\x#1#2[#3]{\endgroup
46 #2[#{#3}]%
47 \ifx#1\relax
48 \xdef#1{#3}%
49 \fi
50 }%
51 \fi
52 \expandafter\x\csname ver@bigintcalc.sty\endcsname
53 \ProvidesPackage{bigintcalc}%
54 [2007/09/27 v1.0 Expandable big integer calculations (H0)]

```


2.2 Catcodes

```

55 \expandafter\edef\csname BIC@AtEnd\endcsname{%
56   \catcode64 \the\catcode64\relax
57 }
58 \catcode64 11 % @
59 \def\TMP@EnsureCode#1#2{%
60   \edef\BIC@AtEnd{%
61     \BIC@AtEnd
62     \catcode#1 \the\catcode#1\relax
63   }%
64   \catcode#1 #2\relax
65 }
66 \TMP@EnsureCode{33}{12}% !
67 \TMP@EnsureCode{36}{14}% $ (comment!)
68 \TMP@EnsureCode{38}{14}% & (comment!)
69 \TMP@EnsureCode{40}{12}% (
70 \TMP@EnsureCode{41}{12}% )
71 \TMP@EnsureCode{42}{12}% *
72 \TMP@EnsureCode{43}{12}% +
73 \TMP@EnsureCode{45}{12}% -
74 \TMP@EnsureCode{47}{12}% /
75 \TMP@EnsureCode{58}{11}% : (letter!)
76 \TMP@EnsureCode{60}{12}% <
77 \TMP@EnsureCode{61}{12}% =
78 \TMP@EnsureCode{62}{12}% >
79 \TMP@EnsureCode{63}{14}% ? (comment!)
80 \begingroup\expandafter\expandafter\expandafter\endgroup
81 \expandafter\ifx\csname BIC@TestMode\endcsname\relax
82 \else
83   \catcode63=9 % ? (ignore)
84 \fi
85 ? \let\BIC@@TestMode\BIC@TestMode

```

2.3 ε -TeX detection

```

86 \begingroup\expandafter\expandafter\expandafter\endgroup
87 \expandafter\ifx\csname numexpr\endcsname\relax
88   \catcode36=9 % $ (ignore)
89 \else
90   \catcode38=9 % & (ignore)
91 \fi

```

2.4 Help macros

```

\BIC@Fi
92 \let\BIC@Fi\fi

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

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

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

\BIC@Space
96 \begingroup
97   \def\x#1{\endgroup
98     \let\BIC@Space= #1%
99   }%
100 \x{ }

```

2.5 Expand number

```

101 \begingroup\expandafter\expandafter\expandafter\endgroup
102 \expandafter\ifx\csname pdfescapehex\endcsname\relax

\BIC@Expand

103 \def\BIC@Expand#1{%
104   \romannumeral0%
105   \BIC@@Expand#1!\@nil{}}%
106 }%

\BIC@@Expand

107 \def\BIC@@Expand#1#2\@nil#3{%
108   \expandafter\ifcat\noexpand#1\relax
109   \expandafter\@firstoftwo
110   \else
111   \expandafter\@secondoftwo
112   \fi
113   {%
114     \expandafter\BIC@@Expand#1#2\@nil{#3}%
115   }{%
116     \ifx#1!%
117       \expandafter\@firstoftwo
118       \else
119       \expandafter\@secondoftwo
120       \fi
121       { #3}{%
122         \BIC@@Expand#2\@nil{#3#1}%
123       }%
124     }%
125   }%

\@firstoftwo

126 \expandafter\ifx\csname @firstoftwo\endcsname\relax
127   \long\def\@firstoftwo#1#2{#1}%
128   \fi

\@secondoftwo

129 \expandafter\ifx\csname @secondoftwo\endcsname\relax
130   \long\def\@secondoftwo#1#2{#2}%
131   \fi

132 \else

\BIC@Expand

133 \def\BIC@Expand#1{%
134   \pdfunescapehex{%
135     \expandafter\BIC@StripHexSpace\pdfescapehex{#1}20\@nil
136   }%
137 }%

\BIC@StripHexSpace

138 \def\BIC@StripHexSpace#120#2\@nil{%
139   #1%
140   \ifx\\#2\\%
141   \else
142     \BIC@AfterFi{%
143       \BIC@StripHexSpace#2\@nil
144     }%
145   \BIC@Fi
146   }%

147 \fi

```

2.6 Normalize expanded number

```

\BIC@Normalize #1: result sign
#2: first token of number
148 \def\BIC@Normalize#1#2{%
149   \ifx#2-%
150     \ifx\|#1\|
151       \BIC@AfterFiFi{%
152         \BIC@Normalize-%
153       }%
154     \else
155       \BIC@AfterFiFi{%
156         \BIC@Normalize{%
157       }%
158     \fi
159   \else
160     \ifx#2+%
161       \BIC@AfterFiFi{%
162         \BIC@Normalize{#1}%
163       }%
164     \else
165       \ifx#20%
166         \BIC@AfterFiFiFi{%
167           \BIC@NormalizeZero{#1}%
168         }%
169       \else
170         \BIC@AfterFiFiFi{%
171           \BIC@NormalizeDigits#1#2%
172         }%
173       \fi
174     \fi
175   \BIC@Fi
176 }

```

\BIC@NormalizeZero

```

177 \def\BIC@NormalizeZero#1#2{%
178   \ifx#2!%
179     \BIC@AfterFi{ 0}%
180   \else
181     \ifx#20%
182       \BIC@AfterFiFi{%
183         \BIC@NormalizeZero{#1}%
184       }%
185     \else
186       \BIC@AfterFiFi{%
187         \BIC@NormalizeDigits#1#2%
188       }%
189     \fi
190   \BIC@Fi
191 }

```

\BIC@NormalizeDigits

```

192 \def\BIC@NormalizeDigits#1!{ #1}

```

2.7 Num

\bigintcalcNum

```

193 \def\bigintcalcNum#1{%
194   \romannumeral0%
195   \expandafter\expandafter\expandafter\BIC@Normalize
196   \expandafter\expandafter\expandafter{%
197   \expandafter\expandafter\expandafter}%

```

```

198 \BIC@Expand{#1}!%
199 }

```

2.8 Inv, Abs, Sgn

\bigintcalcInv

```

200 \def\bigintcalcInv#1{%
201 \romannumeral0\expandafter\expandafter\expandafter\BIC@Space
202 \bigintcalcNum{-#1}%
203 }

```

\bigintcalcAbs

```

204 \def\bigintcalcAbs#1{%
205 \romannumeral0%
206 \expandafter\expandafter\expandafter\BIC@Abs
207 \bigintcalcNum{#1}%
208 }

```

\BIC@Abs

```

209 \def\BIC@Abs#1{%
210 \ifx#1-%
211 \expandafter\BIC@Space
212 \else
213 \expandafter\BIC@Space
214 \expandafter#1%
215 \fi
216 }

```

\bigintcalcSgn

```

217 \def\bigintcalcSgn#1{%
218 \number
219 \expandafter\expandafter\expandafter\BIC@Sgn
220 \bigintcalcNum{#1}! %
221 }

```

\BIC@Sgn

```

222 \def\BIC@Sgn#1#2!{%
223 \ifx#1-%
224 -1%
225 \else
226 \ifx#10%
227 0%
228 \else
229 1%
230 \fi
231 \fi
232 }

```

2.9 Cmp, Min, Max

\bigintcalcCmp

```

233 \def\bigintcalcCmp#1#2{%
234 \number
235 \expandafter\expandafter\expandafter\BIC@Cmp
236 \bigintcalcNum{#2}!{#1}%
237 }

```

\BIC@Cmp

```

238 \def\BIC@Cmp#1!#2{%
239 \expandafter\expandafter\expandafter\BIC@@Cmp

```

```

240  \bigintcalcNum{#2}!#1!%
241  }

\BIC@@Cmp
242  \def\BIC@@Cmp#1#2!#3#4!{%
243    \ifx#1-%
244      \ifx#3-%
245        \BIC@AfterFiFi{%
246          \BIC@@Cmp#4!#2!%
247        }%
248      \else
249        \BIC@AfterFiFi{%
250          -1 %
251        }%
252      \fi
253    \else
254      \ifx#3-%
255        \BIC@AfterFiFi{%
256          1 %
257        }%
258      \else
259        \BIC@AfterFiFi{%
260          \BIC@CmpLength#1#2!#3#4!#1#2!#3#4!%
261        }%
262      \fi
263    \BIC@Fi
264  }

\BIC@PosCmp
265  \def\BIC@PosCmp#1!#2!{%
266    \BIC@CmpLength#1!#2!#1!#2!%
267  }

\BIC@CmpLength
268  \def\BIC@CmpLength#1#2!#3#4!{%
269    \ifx\#2\%
270      \ifx\#4\%
271        \BIC@AfterFiFi\BIC@CmpDiff
272      \else
273        \BIC@AfterFiFi{%
274          \BIC@CmpResult{-1}%
275        }%
276      \fi
277    \else
278      \ifx\#4\%
279        \BIC@AfterFiFi{%
280          \BIC@CmpResult1%
281        }%
282      \else
283        \BIC@AfterFiFi{%
284          \BIC@CmpLength#2!#4!%
285        }%
286      \fi
287    \BIC@Fi
288  }

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

\BIC@CmpDiff
290  \def\BIC@CmpDiff#1#2!#3#4!{%

```

```

291 \ifnum#1<#3 %
292   \BIC@AfterFi{%
293     -1 %
294   }%
295 \else
296   \ifnum#1>#3 %
297     \BIC@AfterFiFi{%
298       1 %
299     }%
300   \else
301     \ifx\\#2\\%
302       \BIC@AfterFiFiFi{%
303         0 %
304       }%
305     \else
306       \BIC@AfterFiFiFi{%
307         \BIC@CmpDiff#2!#4!%
308       }%
309     \fi
310   \fi
311 \BIC@Fi
312 }

```

\bigintcalcMin

```

313 \def\bigintcalcMin#1{%
314   \romannumeral0%
315   \expandafter\expandafter\expandafter\BIC@MinMax
316   \bigintcalcNum{#1}!-!%
317 }

```

\bigintcalcMax

```

318 \def\bigintcalcMax#1{%
319   \romannumeral0%
320   \expandafter\expandafter\expandafter\BIC@MinMax
321   \bigintcalcNum{#1}!!%
322 }

```

\BIC@MinMax #1: x

#2: sign for comparison

#3: y

```

323 \def\BIC@MinMax#1!#2!#3{%
324   \expandafter\expandafter\expandafter\BIC@@MinMax
325   \bigintcalcNum{#3}!#1!#2!%
326 }

```

\BIC@@MinMax #1: y

#2: x

#3: sign for comparison

```

327 \def\BIC@@MinMax#1!#2!#3!{%
328   \ifnum\BIC@Cmp#1!#2!=#31 %
329     \BIC@AfterFi{ #1}%
330   \else
331     \BIC@AfterFi{ #2}%
332   \BIC@Fi
333 }

```

2.10 Odd

\bigintcalcOdd

```

334 \def\bigintcalcOdd#1{%
335   \romannumeral0%

```

```

336 \expandafter\expandafter\expandafter\BIC@Odd
337 \bigintcalcAbs{#1}!%
338 }

\BigIntCalcOdd

339 \def\BigIntCalcOdd#1!{%
340 \romannumeral0%
341 \BIC@Odd#1!%
342 }

\BIC@Odd #1: x

343 \def\BIC@Odd#1#2{%
344 \ifx#2!%
345 \ifodd#1 %
346 \BIC@AfterFiFi{ 1}%
347 \else
348 \BIC@AfterFiFi{ 0}%
349 \fi
350 \else
351 \expandafter\BIC@Odd\expandafter#2%
352 \BIC@Fi
353 }

```

2.11 Inc, Dec

```

\bigintcalcInc

354 \def\bigintcalcInc#1{%
355 \romannumeral0%
356 \expandafter\expandafter\expandafter\BIC@IncSwitch
357 \bigintcalcNum{#1}!%
358 }

\BIC@IncSwitch

359 \def\BIC@IncSwitch#1#2!{%
360 \ifcase\BIC@@Cmp#1#2!-1!%
361 \BIC@AfterFi{ 0}%
362 \or
363 \BIC@AfterFi{%
364 \BIC@Inc#1#2!}%
365 }%
366 \else
367 \BIC@AfterFi{%
368 \expandafter-\romannumeral0%
369 \BIC@Dec#2!}%
370 }%
371 \BIC@Fi
372 }

\bigintcalcDec

373 \def\bigintcalcDec#1{%
374 \romannumeral0%
375 \expandafter\expandafter\expandafter\BIC@DecSwitch
376 \bigintcalcNum{#1}!%
377 }

\BIC@DecSwitch

378 \def\BIC@DecSwitch#1#2!{%
379 \ifcase\BIC@Sgn#1#2! %
380 \BIC@AfterFi{ -1}%
381 \or
382 \BIC@AfterFi{%

```

```

383     \BIC@Dec#1#2!{%}%
384 }%
385 \else
386     \BIC@AfterFi{%
387     \expandafter-\romannumeral0%
388     \BIC@Inc#2!{%}%
389 }%
390 \BIC@Fi
391 }

\BigIntCalcInc
392 \def\BigIntCalcInc#1!{%
393     \romannumeral0\BIC@Inc#1!{%}%
394 }

\BigIntCalcDec
395 \def\BigIntCalcDec#1!{%
396     \romannumeral0\BIC@Dec#1!{%}%
397 }

\BIC@Inc
398 \def\BIC@Inc#1#2!#3{%
399     \ifx\#2\%
400         \BIC@AfterFi{%
401         \BIC@@Inc1#1#3!{%}%
402         }%
403     \else
404         \BIC@AfterFi{%
405         \BIC@Inc#2!{#1#3}%
406         }%
407     \BIC@Fi
408 }

\BIC@@Inc
409 \def\BIC@@Inc#1#2#3!#4{%
410     \ifcase#1 %
411         \ifx\#3\%
412             \BIC@AfterFiFi{ #2#4}%
413         \else
414             \BIC@AfterFiFi{%
415             \BIC@@Inc0#3!{#2#4}%
416             }%
417         \fi
418     \else
419         \ifnum#2<9 %
420             \BIC@AfterFiFi{%
421             & \expandafter\BIC@@Inc\the\numexpr#2+1\relax
422             $ \expandafter\expandafter\expandafter\BIC@@Inc
423             $ \ifcase#2 \expandafter1%
424             $ \or\expandafter2%
425             $ \or\expandafter3%
426             $ \or\expandafter4%
427             $ \or\expandafter5%
428             $ \or\expandafter6%
429             $ \or\expandafter7%
430             $ \or\expandafter8%
431             $ \or\expandafter9%
432             $? \else\BigIntCalcError:ThisCannotHappen%
433             $ \fi
434             0#3!{#4}%
435             }%
436         \else

```



```

437     \BIC@AfterFiFi{%
438     \BIC@@@Inc01#3!{#4}%
439     }%
440     \fi
441     \BIC@Fi
442 }

\BIC@@@Inc

443 \def\BIC@@@Inc#1#2#3!#4{%
444     \ifx\#3\%
445         \ifnum#2=1 %
446             \BIC@AfterFiFi{ 1#1#4}%
447         \else
448             \BIC@AfterFiFi{ #1#4}%
449         \fi
450     \else
451         \BIC@AfterFi{%
452             \BIC@@Inc#2#3!{#1#4}%
453         }%
454     \BIC@Fi
455 }

\BIC@Dec

456 \def\BIC@Dec#1#2!#3{%
457     \ifx\#2\%
458         \BIC@AfterFi{%
459             \BIC@@Dec1#1#3!{}%
460         }%
461     \else
462         \BIC@AfterFi{%
463             \BIC@Dec#2!{#1#3}%
464         }%
465     \BIC@Fi
466 }

\BIC@@Dec

467 \def\BIC@@Dec#1#2#3!#4{%
468     \ifcase#1 %
469         \ifx\#3\%
470             \BIC@AfterFiFi{ #2#4}%
471         \else
472             \BIC@AfterFiFi{%
473                 \BIC@@Dec0#3!{#2#4}%
474             }%
475         \fi
476     \else
477         \ifnum#2>0 %
478             \BIC@AfterFiFi{%
479 &             \expandafter\BIC@@@Dec\the\numexpr#2-1\relax
480 $             \expandafter\expandafter\expandafter\BIC@@@Dec
481 $             \ifcase#2
482 $?             \BigIntCalcError:ThisCannotHappen%
483 $             \or\expandafter0%
484 $             \or\expandafter1%
485 $             \or\expandafter2%
486 $             \or\expandafter3%
487 $             \or\expandafter4%
488 $             \or\expandafter5%
489 $             \or\expandafter6%
490 $             \or\expandafter7%
491 $             \or\expandafter8%
492 $?             \else\BigIntCalcError:ThisCannotHappen%

```

```

493 $      \fi
494      O#3!{#4}%
495      }%
496      \else
497      \BIC@AfterFiFi{%
498      \BIC@@@Dec91#3!{#4}%
499      }%
500      \fi
501 \BIC@Fi
502 }

```

\BIC@@@Dec

```

503 \def\BIC@@@Dec#1#2#3!#4{%
504   \ifx\#3\%
505     \ifcase#1 %
506       \ifx\#4\%
507         \BIC@AfterFiFiFi{ 0}%
508       \else
509         \BIC@AfterFiFiFi{ #4}%
510       \fi
511     \else
512       \BIC@AfterFiFi{ #1#4}%
513     \fi
514   \else
515     \BIC@AfterFi{%
516     \BIC@@Dec#2#3!{#1#4}%
517     }%
518 \BIC@Fi
519 }

```

2.12 Add, Sub

\bigintcalcAdd

```

520 \def\bigintcalcAdd#1{%
521   \romannumeral0%
522   \expandafter\expandafter\expandafter\BIC@Add
523   \bigintcalcNum{#1}!%
524 }

```

\BIC@Add

```

525 \def\BIC@Add#1!#2{%
526   \expandafter\expandafter\expandafter
527   \BIC@AddSwitch\bigintcalcNum{#2}!#1!%
528 }

```

\bigintcalcSub

```

529 \def\bigintcalcSub#1#2{%
530   \romannumeral0%
531   \expandafter\expandafter\expandafter\BIC@Add
532   \bigintcalcNum{-#2}!{#1}%
533 }

```

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

```

534 \def\BIC@AddSwitch#1#2!#3#4!{%
535   \ifx#1-% x < 0
536     \ifx#3-% y < 0
537       \expandafter-\romannumeral0%
538       \ifnum\BIC@PosCmp#2!#4!=1 % -x > -y
539         \BIC@AfterFiFiFi{%
540           \BIC@AddXY#2!#4!!!%
541         }%
542       \else % -x <= -y
543         \BIC@AfterFiFiFi{%
544           \BIC@AddXY#4!#2!!!%
545         }%
546       \fi
547     \else % y >= 0
548       \ifcase\BIC@PosCmp#2!#3#4!% -x = y
549         \BIC@AfterFiFiFi{ 0}%
550       \or % -x > y
551         \expandafter-\romannumeral0%
552         \BIC@AfterFiFiFi{%
553           \BIC@SubXY#2!#3#4!!!%
554         }%
555       \else % -x <= y
556         \BIC@AfterFiFiFi{%
557           \BIC@SubXY#3#4!#2!!!%
558         }%
559       \fi
560     \fi
561   \else % x >= 0
562     \ifx#3-% y < 0
563       \ifcase\BIC@PosCmp#1#2!#4!% x = -y
564         \BIC@AfterFiFiFi{ 0}%
565       \or % x > -y
566         \BIC@AfterFiFiFi{%
567           \BIC@SubXY#1#2!#4!!!%
568         }%
569       \else % x <= -y
570         \expandafter-\romannumeral0%
571         \BIC@AfterFiFiFi{%
572           \BIC@SubXY#4!#1#2!!!%
573         }%
574       \fi
575     \else % y >= 0
576       \ifnum\BIC@PosCmp#1#2!#3#4!=1 % x > y
577         \BIC@AfterFiFiFi{%
578           \BIC@AddXY#1#2!#3#4!!!%
579         }%
580       \else % x <= y
581         \BIC@AfterFiFiFi{%
582           \BIC@AddXY#3#4!#1#2!!!%
583         }%

```

```

584     \fi
585     \fi
586     \BIC@Fi
587 }

\BigIntCalcAdd

588 \def\BigIntCalcAdd#1!#2!{%
589     \romannumeral0\BIC@AddXY#1!#2!!!%
590 }

\BigIntCalcSub

591 \def\BigIntCalcSub#1!#2!{%
592     \romannumeral0\BIC@SubXY#1!#2!!!%
593 }

\BIC@AddXY

594 \def\BIC@AddXY#1#2!#3#4!#5!#6!{%
595     \ifx\#2\%
596         \ifx\#3\%
597             \BIC@AfterFiFi{%
598                 \BIC@DoAdd0!#1#5!#60!%
599             }%
600         \else
601             \BIC@AfterFiFi{%
602                 \BIC@DoAdd0!#1#5!#3#6!%
603             }%
604         \fi
605     \else
606         \ifx\#4\%
607             \ifx\#3\%
608                 \BIC@AfterFiFiFi{%
609                     \BIC@AddXY#2!{}!#1#5!#60!%
610                 }%
611             \else
612                 \BIC@AfterFiFiFi{%
613                     \BIC@AddXY#2!{}!#1#5!#3#6!%
614                 }%
615             \fi
616         \else
617             \BIC@AfterFiFi{%
618                 \BIC@AddXY#2!#4!#1#5!#3#6!%
619             }%
620         \fi
621     \BIC@Fi
622 }

\BIC@DoAdd #1: carry
#2: reverted result
#3#4: reverted  $x$ 
#5#6: reverted  $y$ 

623 \def\BIC@DoAdd#1#2!#3#4!#5#6!{%
624     \ifx\#4\%
625         \BIC@AfterFi{%
626             & \expandafter\BIC@Space
627             & \the\numexpr#1+#3+#5\relax#2%
628             $ \expandafter\expandafter\expandafter\BIC@AddResult
629             $ \BIC@AddDigit#1#3#5#2%
630         }%
631     \else
632         \BIC@AfterFi{%
633             & \expandafter\expandafter\expandafter\BIC@DoAdd
634             & \BIC@AddDigit#1#3#5#2!#4!#6!%

```

```

635     }%
636 \BIC@Fi
637 }

\BIC@AddResult

638 $ \def\BIC@AddResult#1{%
639 $ \ifx#10%
640 $ \expandafter\BIC@Space
641 $ \else
642 $ \expandafter\BIC@Space\expandafter#1%
643 $ \fi
644 $ }%

\BIC@AddDigit #1: carry
#2: digit of  $x$ 
#3: digit of  $y$ 

645 \def\BIC@AddDigit#1#2#3{%
646 \romannumeral0%
647 & \expandafter\BIC@@AddDigit\the\numexpr#1+#2+#3!%
648 $ \expandafter\BIC@@AddDigit\number%
649 $ \csname
650 $ BIC@AddCarry%
651 $ \ifcase#1 %
652 $ #2%
653 $ \else
654 $ \ifcase#2 1\or2\or3\or4\or5\or6\or7\or8\or9\or10\fi
655 $ \fi
656 $ \endcsname#3!%
657 }

\BIC@@AddDigit

658 \def\BIC@@AddDigit#1!{%
659 \ifnum#1<10 %
660 \BIC@AfterFi{ 0#1}%
661 \else
662 \BIC@AfterFi{ #1}%
663 \BIC@Fi
664 }

\BIC@AddCarry0

665 $ \expandafter\def\csname BIC@AddCarry0\endcsname#1{#1}%

\BIC@AddCarry10

666 $ \expandafter\def\csname BIC@AddCarry10\endcsname#1{#1}%

\BIC@AddCarry[1-9]

667 $ \def\BIC@Temp#1#2{%
668 $ \expandafter\def\csname BIC@AddCarry#1\endcsname##1{%
669 $ \ifcase##1 #1\or
670 $ #2%
671 $? \else\BigIntCalcError:ThisCannotHappen%
672 $ \fi
673 $ }%
674 $ }%
675 $ \BIC@Temp 0{1\or2\or3\or4\or5\or6\or7\or8\or9}%
676 $ \BIC@Temp 1{2\or3\or4\or5\or6\or7\or8\or9\or10}%
677 $ \BIC@Temp 2{3\or4\or5\or6\or7\or8\or9\or10\or11}%
678 $ \BIC@Temp 3{4\or5\or6\or7\or8\or9\or10\or11\or12}%
679 $ \BIC@Temp 4{5\or6\or7\or8\or9\or10\or11\or12\or13}%
680 $ \BIC@Temp 5{6\or7\or8\or9\or10\or11\or12\or13\or14}%
681 $ \BIC@Temp 6{7\or8\or9\or10\or11\or12\or13\or14\or15}%

```

```

682 $ \BIC@Temp 7{8\or9\or10\or11\or12\or13\or14\or15\or16}%
683 $ \BIC@Temp 8{9\or10\or11\or12\or13\or14\or15\or16\or17}%
684 $ \BIC@Temp 9{10\or11\or12\or13\or14\or15\or16\or17\or18}%

```

\BIC@SubXY Preconditions:

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

```

685 \def\BIC@SubXY#1#2!#3#4!#5!#6!{%
686   \ifx\#2\%
687     \ifx\#3\%
688       \BIC@AfterFiFi{%
689         \BIC@DoSub0!#1#5!#60!%
690       }%
691     \else
692       \BIC@AfterFiFi{%
693         \BIC@DoSub0!#1#5!#3#6!%
694       }%
695     \fi
696   \else
697     \ifx\#4\%
698       \ifx\#3\%
699         \BIC@AfterFiFiFiFi{%
700           \BIC@SubXY#2!#1#5!#60!%
701         }%
702       \else
703         \BIC@AfterFiFiFiFi{%
704           \BIC@SubXY#2!#1#5!#3#6!%
705         }%
706       \fi
707     \else
708       \BIC@AfterFiFiFi{%
709         \BIC@SubXY#2!#4!#1#5!#3#6!%
710       }%
711     \fi
712   \BIC@Fi
713 }

```

\BIC@DoSub #1: carry

#2: reverted result

#3#4: reverted x

#5#6: reverted y

```

714 \def\BIC@DoSub#1#2!#3#4!#5#6!{%
715   \ifx\#4\%
716     \BIC@AfterFi{%
717       \expandafter\expandafter\expandafter\BIC@SubResult
718       \BIC@SubDigit#1#3#5#2%
719     }%
720   \else
721     \BIC@AfterFi{%
722       \expandafter\expandafter\expandafter\BIC@DoSub
723       \BIC@SubDigit#1#3#5#2!#4!#6!%
724     }%
725   \BIC@Fi
726 }

```

\BIC@SubResult

```

727 \def\BIC@SubResult#1{%
728   \ifx#10%
729     \expandafter\BIC@SubResult
730   \else

```

```

731 \expandafter\BIC@Space\expandafter#1%
732 \fi
733 }

\BIC@SubDigit #1: carry
#2: digit of  $x$ 
#3: digit of  $y$ 

734 \def\BIC@SubDigit#1#2#3{%
735 \romannumeral0%
736 & \expandafter\BIC@@SubDigit\the\numexpr#2-#3-#1!%
737 $ \expandafter\BIC@@AddDigit\number
738 $ \csname
739 $ BIC@SubCarry%
740 $ \ifcase#1 %
741 $ #3%
742 $ \else
743 $ \ifcase#3 1\or2\or3\or4\or5\or6\or7\or8\or9\or10\fi
744 $ \fi
745 $ \endcsname#2!%
746 }

```

```

\BIC@@SubDigit

747 & \def\BIC@@SubDigit#1!{%
748 & \ifnum#1<0 %
749 & \BIC@AfterFi{%
750 & \expandafter\BIC@Space
751 & \expandafter1\the\numexpr#1+10\relax
752 & }%
753 & \else
754 & \BIC@AfterFi{ 0#1}%
755 & \BIC@Fi
756 & }%

```

```

\BIC@SubCarry0

757 $ \expandafter\def\csname BIC@SubCarry0\endcsname#1{#1}%

```

```

\BIC@SubCarry10

758 $ \expandafter\def\csname BIC@SubCarry10\endcsname#1{1#1}%

```

```

\BIC@SubCarry[1-9]

759 $ \def\BIC@Temp#1#2{%
760 $ \expandafter\def\csname BIC@SubCarry#1\endcsname##1{%
761 $ \ifcase##1 #2%
762 $? \else\BigIntCalcError:ThisCannotHappen%
763 $ \fi
764 $ }%
765 $ }%
766 $ \BIC@Temp 1{19\or0\or1\or2\or3\or4\or5\or6\or7\or8}%
767 $ \BIC@Temp 2{18\or19\or0\or1\or2\or3\or4\or5\or6\or7}%
768 $ \BIC@Temp 3{17\or18\or19\or0\or1\or2\or3\or4\or5\or6}%
769 $ \BIC@Temp 4{16\or17\or18\or19\or0\or1\or2\or3\or4\or5}%
770 $ \BIC@Temp 5{15\or16\or17\or18\or19\or0\or1\or2\or3\or4}%
771 $ \BIC@Temp 6{14\or15\or16\or17\or18\or19\or0\or1\or2\or3}%
772 $ \BIC@Temp 7{13\or14\or15\or16\or17\or18\or19\or0\or1\or2}%
773 $ \BIC@Temp 8{12\or13\or14\or15\or16\or17\or18\or19\or0\or1}%
774 $ \BIC@Temp 9{11\or12\or13\or14\or15\or16\or17\or18\or19\or0}%

```

2.13 Shl, Shr

```

\bigintcalcShl

775 \def\bigintcalcShl#1{%

```

```

776 \romannumeral0%
777 \expandafter\expandafter\expandafter\BIC@Shl
778 \bigintcalcNum{#1}!%
779 }

\BIC@Shl

780 \def\BIC@Shl#1#2!{%
781 \ifx#1-%
782 \BIC@AfterFi{%
783 \expandafter-\romannumeral0%
784 & \BIC@@Shl#2!!%
785 $ \BIC@AddXY#2!#2!!!%
786 }%
787 \else
788 \BIC@AfterFi{%
789 & \BIC@@Shl#1#2!!%
790 $ \BIC@AddXY#1#2!#1#2!!!%
791 }%
792 \BIC@Fi
793 }

\BigIntCalcShl

794 \def\BigIntCalcShl#1!{%
795 \romannumeral0%
796 & \BIC@@Shl#1!!%
797 $ \BIC@AddXY#1!#1!!!%
798 }

\BIC@@Shl

799 & \def\BIC@@Shl#1#2!{%
800 & \ifx\#2\%
801 & \BIC@AfterFi{%
802 & \BIC@@@Shl0!#1%
803 & }%
804 & \else
805 & \BIC@AfterFi{%
806 & \BIC@@Shl#2!#1%
807 & }%
808 & \BIC@Fi
809 & }%

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

810 & \def\BIC@@@Shl#1#2!#3#4!{%
811 & \ifx\#4\%
812 & \BIC@AfterFi{%
813 & \expandafter\BIC@Space
814 & \the\numexpr#3*2+#1\relax#2%
815 & }%
816 & \else
817 & \BIC@AfterFi{%
818 & \expandafter\BIC@@@Shl\the\numexpr#3*2+#1!#2!#4!%
819 & }%
820 & \BIC@Fi
821 & }%

\BIC@@@@Shl

822 & \def\BIC@@@@Shl#1!{%
823 & \ifnum#1<10 %
824 & \BIC@AfterFi{%

```



```

825 & \BIC@@@Shl0#1%
826 & }%
827 & \else
828 & \BIC@AfterFi{%
829 & \BIC@@@Shl#1%
830 & }%
831 & \BIC@Fi
832 & }%

\bigintcalcShr
833 \def\bigintcalcShr#1{%
834 \romannumeral0%
835 \expandafter\expandafter\expandafter\BIC@Shr
836 \bigintcalcNum{#1}!%
837 }

\BIC@Shr
838 \def\BIC@Shr#1#2!{%
839 \ifx#1-%
840 \expandafter-\romannumeral0%
841 \BIC@AfterFi{%
842 \BIC@@@Shr#2!%
843 }%
844 \else
845 \BIC@AfterFi{%
846 \BIC@@@Shr#1#2!%
847 }%
848 \BIC@Fi
849 }

\BigIntCalcShr
850 \def\BigIntCalcShr#1!{%
851 \romannumeral0%
852 \BIC@@@Shr#1!%
853 }

\BIC@@@Shr
854 \def\BIC@@@Shr#1#2!{%
855 \ifcase#1 %
856 \BIC@AfterFi{ 0}%
857 \or
858 \ifx\#2\%
859 \BIC@AfterFiFi{ 0}%
860 \else
861 \BIC@AfterFiFi{%
862 \BIC@@@Shr#1#2!!%
863 }%
864 \fi
865 \else
866 \BIC@AfterFi{%
867 \BIC@@@Shr0#1#2!!%
868 }%
869 \BIC@Fi
870 }

\BIC@@@Shr #1: carry
#2#3: number
#4: result
871 \def\BIC@@@Shr#1#2#3!#4!{%
872 \ifx\#3\%
873 \ifodd#1#2 %

```

```

874 \BIC@AfterFiFi{%
875 & \expandafter\BIC@ShrResult\the\numexpr(#1#2-1)/2\relax
876 $ \expandafter\expandafter\expandafter\BIC@ShrResult
877 $ \csname BIC@ShrDigit#1#2\endcsname
878 #4!%
879 }%
880 \else
881 \BIC@AfterFiFi{%
882 & \expandafter\BIC@ShrResult\the\numexpr#1#2/2\relax
883 $ \expandafter\expandafter\expandafter\BIC@ShrResult
884 $ \csname BIC@ShrDigit#1#2\endcsname
885 #4!%
886 }%
887 \fi
888 \else
889 \ifodd#1#2 %
890 \BIC@AfterFiFi{%
891 & \expandafter\BIC@@@Shr\the\numexpr(#1#2-1)/2\relax1%
892 $ \expandafter\expandafter\expandafter\BIC@@@Shr
893 $ \csname BIC@ShrDigit#1#2\endcsname
894 #3!#4!%
895 }%
896 \else
897 \BIC@AfterFiFi{%
898 & \expandafter\BIC@@@Shr\the\numexpr#1#2/2\relax0%
899 $ \expandafter\expandafter\expandafter\BIC@@@Shr
900 $ \csname BIC@ShrDigit#1#2\endcsname
901 #3!#4!%
902 }%
903 \fi
904 \BIC@Fi
905 }

```

\BIC@ShrResult

```

906 & \def\BIC@ShrResult#1#2!{ #2#1}%
907 $ \def\BIC@ShrResult#1#2#3!{ #3#1}%

```

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

```

908 \def\BIC@@@Shr#1#2#3!#4!{%
909 \BIC@@@Shr#2#3!#4#1!%
910 }

```

\BIC@ShrDigit[00-19]

```

911 $ \def\BIC@Temp#1#2#3#4{%
912 $ \expandafter\def\csname BIC@ShrDigit#1#2\endcsname{#3#4}%
913 $ }%
914 $ \BIC@Temp 0000%
915 $ \BIC@Temp 0101%
916 $ \BIC@Temp 0210%
917 $ \BIC@Temp 0311%
918 $ \BIC@Temp 0420%
919 $ \BIC@Temp 0521%
920 $ \BIC@Temp 0630%
921 $ \BIC@Temp 0731%
922 $ \BIC@Temp 0840%
923 $ \BIC@Temp 0941%
924 $ \BIC@Temp 1050%
925 $ \BIC@Temp 1151%
926 $ \BIC@Temp 1260%

```

```

927 $ \BIC@Temp 1361%
928 $ \BIC@Temp 1470%
929 $ \BIC@Temp 1571%
930 $ \BIC@Temp 1680%
931 $ \BIC@Temp 1781%
932 $ \BIC@Temp 1890%
933 $ \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
934 \def\BIC@@Tim#1#2!{%
935   \ifx\#2\%
936     \BIC@AfterFi{%
937       \BIC@ProcessTim0!#1%
938     }%
939   \else
940     \BIC@AfterFi{%
941       \BIC@@Tim#2!#1%
942     }%
943   \BIC@Fi
944 }

```

```

\BIC@ProcessTim #1: carry
#2: result
#3#4: reverted number
#5: digit
945 \def\BIC@ProcessTim#1#2!#3#4!#5{%
946   \ifx\#4\%
947     \BIC@AfterFi{%
948       \expandafter\BIC@Space
949 & \the\numexpr#3*#5+#1\relax
950 $ \romannumeral0\BIC@TimDigit#3#5#1%
951   #2%
952   }%
953   \else
954     \BIC@AfterFi{%
955       \expandafter\BIC@@ProcessTim
956 & \the\numexpr#3*#5+#1%
957 $ \romannumeral0\BIC@TimDigit#3#5#1%
958   !#2!#4!#5%
959   }%
960   \BIC@Fi
961 }

```

```

\BIC@@ProcessTim #1#2: carry?, new digit
#3: new number
#4: old number
#5: digit
962 \def\BIC@@ProcessTim#1#2!{%
963   \ifx\#2\%
964     \BIC@AfterFi{%
965       \BIC@ProcessTim0#1%
966     }%
967   \else
968     \BIC@AfterFi{%

```

```

969      \BIC@ProcessTim#1#2%
970    }%
971    \BIC@Fi
972 }

\BIC@TimDigit #1: digit 0-9
#2: digit 3-9
#3: carry 0-9

973 $ \def\BIC@TimDigit#1#2#3{%
974 $   \ifcase#1 % 0
975 $     \BIC@AfterFi{ #3}%
976 $   \or % 1
977 $     \BIC@AfterFi{%
978 $       \expandafter\BIC@Space
979 $       \number\csname BIC@AddCarry#2\endcsname#3 %
980 $     }%
981 $   \else
982 $     \ifcase#3 %
983 $       \BIC@AfterFiFi{%
984 $         \expandafter\BIC@Space
985 $         \number\csname BIC@MulDigit#2\endcsname#1 %
986 $       }%
987 $     \else
988 $       \BIC@AfterFiFi{%
989 $         \expandafter\BIC@Space
990 $         \romannumeral0%
991 $         \expandafter\BIC@AddXY
992 $         \number\csname BIC@MulDigit#2\endcsname#1!%
993 $         #3!!!%
994 $       }%
995 $     \fi
996 $   \BIC@Fi
997 $ }%

```

\BIC@MulDigit[3-9]

```

998 $ \def\BIC@Temp#1#2{%
999 $   \expandafter\def\csname BIC@MulDigit#1\endcsname##1{%
1000 $     \ifcase##1 0%
1001 $     \or ##1%
1002 $     \or ##2%
1003 $?   \else\BigIntCalcError:ThisCannotHappen%
1004 $     \fi
1005 $   }%
1006 $ }%
1007 $ \BIC@Temp 3{6\or9\or12\or15\or18\or21\or24\or27}%
1008 $ \BIC@Temp 4{8\or12\or16\or20\or24\or28\or32\or36}%
1009 $ \BIC@Temp 5{10\or15\or20\or25\or30\or35\or40\or45}%
1010 $ \BIC@Temp 6{12\or18\or24\or30\or36\or42\or48\or54}%
1011 $ \BIC@Temp 7{14\or21\or28\or35\or42\or49\or56\or63}%
1012 $ \BIC@Temp 8{16\or24\or32\or40\or48\or56\or64\or72}%
1013 $ \BIC@Temp 9{18\or27\or36\or45\or54\or63\or72\or81}%

```

2.15 Mul

\bigintcalcMul

```

1014 \def\bigintcalcMul#1#2{%
1015   \romannumeral0%
1016   \expandafter\expandafter\expandafter\BIC@Mul
1017   \bigintcalcNum{#1}!{#2}%
1018 }

```

\BIC@Mul

```

1019 \def\BIC@Mul#1!#2{%
1020   \expandafter\expandafter\expandafter\BIC@MulSwitch
1021   \bigintcalcNum{#2}!#1!%
1022 }

```

\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		$\text{Mul}(-y, -x)$

```

1023 \def\BIC@MulSwitch#1#2!#3#4!{%
1024   \ifcase\BIC@Sgn#1#2! % x = 0
1025     \BIC@AfterFi{ 0}%
1026   \or % x > 0
1027     \ifcase\BIC@Sgn#3#4! % y = 0
1028       \BIC@AfterFiFi{ 0}%
1029     \or % y > 0
1030       \ifnum\BIC@PosCmp#1#2!#3#4!=1 % x > y
1031         \BIC@AfterFiFiFi{%
1032           \BIC@ProcessMul0!#1#2!#3#4!%
1033         }%
1034       \else % x <= y
1035         \BIC@AfterFiFiFiFi{%
1036           \BIC@ProcessMul0!#3#4!#1#2!%
1037         }%
1038       \fi
1039     \else % y < 0
1040       \expandafter-\romannumeral0%
1041       \ifnum\BIC@PosCmp#1#2!#4!=1 % x > -y
1042         \BIC@AfterFiFiFiFi{%
1043           \BIC@ProcessMul0!#1#2!#4!%
1044         }%
1045       \else % x <= -y
1046         \BIC@AfterFiFiFiFiFi{%
1047           \BIC@ProcessMul0!#4!#1#2!%
1048         }%
1049       \fi
1050     \fi
1051   \else % x < 0
1052     \ifcase\BIC@Sgn#3#4! % y = 0
1053       \BIC@AfterFiFiFi{ 0}%
1054     \or % y > 0
1055       \expandafter-\romannumeral0%
1056       \ifnum\BIC@PosCmp#2!#3#4!=1 % -x > y
1057         \BIC@AfterFiFiFiFi{%
1058           \BIC@ProcessMul0!#2!#3#4!%
1059         }%
1060       \else % -x <= y
1061         \BIC@AfterFiFiFiFiFi{%
1062           \BIC@ProcessMul0!#3#4!#2!%
1063         }%

```

```

1064     \fi
1065     \else % y < 0
1066         \ifnum\BIC@PosCmp#2!#4!=1 % -x > -y
1067             \BIC@AfterFiFiFi{%
1068                 \BIC@ProcessMul0!#2!#4!%
1069             }%
1070         \else % -x <= -y
1071             \BIC@AfterFiFiFi{%
1072                 \BIC@ProcessMul0!#4!#2!%
1073             }%
1074         \fi
1075     \fi
1076 \BIC@Fi
1077 }

```

\BigIntCalcMul

```

1078 \def\BigIntCalcMul#1!#2!{%
1079     \romannumeral0%
1080     \BIC@ProcessMul0!#1!#2!%
1081 }

```

\BIC@ProcessMul

```

#1: result
#2: number x
#3#4: number y
1082 \def\BIC@ProcessMul#1!#2!#3#4!{%
1083     \ifx\#4\%
1084         \BIC@AfterFi{%
1085             \expandafter\expandafter\expandafter\BIC@Space
1086             \bigintcalcAdd{\BIC@Tim#2!#3}{#10}%
1087         }%
1088     \else
1089         \BIC@AfterFi{%
1090             \expandafter\expandafter\expandafter\BIC@ProcessMul
1091             \bigintcalcAdd{\BIC@Tim#2!#3}{#10}!#2!#4!%
1092         }%
1093     \BIC@Fi
1094 }

```

2.16 Sqr

\bigintcalcSqr

```

1095 \def\bigintcalcSqr#1{%
1096     \romannumeral0%
1097     \expandafter\expandafter\expandafter\BIC@Sqr
1098     \bigintcalcNum{#1}!%
1099 }

```

\BIC@Sqr

```

1100 \def\BIC@Sqr#1{%
1101     \ifx#1-%
1102         \expandafter\BIC@@Sqr
1103     \else
1104         \expandafter\BIC@@Sqr\expandafter#1%
1105     \fi
1106 }

```

\BIC@@Sqr

```

1107 \def\BIC@@Sqr#1!{%
1108     \BIC@ProcessMul0!#1!#1!%
1109 }

```

2.17 Fac

```

\bigintcalcFac
1110 \def\bigintcalcFac#1{%
1111   \romannumeral0%
1112   \expandafter\expandafter\expandafter\BIC@Fac
1113   \bigintcalcNum{#1}!%
1114 }

\BIC@Fac
1115 \def\BIC@Fac#1#2!{%
1116   \ifx#1-%
1117     \BIC@AfterFi{ 0\BigIntCalcError:FacNegative}%
1118   \else
1119     \ifnum\BIC@PosCmp#1#2!13!<0 %
1120       \ifcase#1#2 %
1121         \BIC@AfterFiFiFi{ 1}% 0!
1122         \or\BIC@AfterFiFiFi{ 1}% 1!
1123         \or\BIC@AfterFiFiFi{ 2}% 2!
1124         \or\BIC@AfterFiFiFi{ 6}% 3!
1125         \or\BIC@AfterFiFiFi{ 24}% 4!
1126         \or\BIC@AfterFiFiFi{ 120}% 5!
1127         \or\BIC@AfterFiFiFi{ 720}% 6!
1128         \or\BIC@AfterFiFiFi{ 5040}% 7!
1129         \or\BIC@AfterFiFiFi{ 40320}% 8!
1130         \or\BIC@AfterFiFiFi{ 362880}% 9!
1131         \or\BIC@AfterFiFiFi{ 3628800}% 10!
1132         \or\BIC@AfterFiFiFi{ 39916800}% 11!
1133         \or\BIC@AfterFiFiFi{ 479001600}% 12!
1134       ? \else\BigIntCalcError:ThisCannotHappen%
1135       \fi
1136     \else
1137       \BIC@AfterFiFi{%
1138         \BIC@ProcessFac#1#2!479001600!%
1139       }%
1140     \fi
1141   \BIC@Fi
1142 }

\BIC@ProcessFac #1: n
#2: result
1143 \def\BIC@ProcessFac#1!#2!{%
1144   \ifnum\BIC@PosCmp#1!12!=0 %
1145     \BIC@AfterFi{ #2}%
1146   \else
1147     \BIC@AfterFi{%
1148       \expandafter\BIC@@ProcessFac
1149       \romannumeral0\BIC@ProcessMul0!#2!#1!%
1150     }!#1!%
1151   }%
1152   \BIC@Fi
1153 }

\BIC@@ProcessFac #1: result
#2: n
1154 \def\BIC@@ProcessFac#1!#2!{%
1155   \expandafter\BIC@ProcessFac
1156   \romannumeral0\BIC@Dec#2!{%
1157     !#1!%
1158   }

```

2.18 Pow

```

\bigintcalcPow #1: basis
#2: power
1159 \def\bigintcalcPow#1{%
1160   \romannumeral0%
1161   \expandafter\expandafter\expandafter\BIC@Pow
1162   \bigintcalcNum{#1}!%
1163 }

\BIC@Pow #1: basis
#2: power
1164 \def\BIC@Pow#1!#2{%
1165   \expandafter\expandafter\expandafter\BIC@PowSwitch
1166   \bigintcalcNum{#2}!#1!%
1167 }

\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 ($x > 1$)	$\text{Pow}(x, y)$	

```

1168 \def\BIC@PowSwitch#1#2!#3#4!{%
1169   \ifcase\ifx\#2\%
1170     \ifx#100 %  $y = 0$ 
1171     \else\ifx#111 %  $y = 1$ 
1172     \else\ifx#122 %  $y = 2$ 
1173     \else4 %  $y > 2$ 
1174     \fi\fi\fi
1175   \else
1176     \ifx#1-3 %  $y < 0$ 
1177     \else4 %  $y > 2$ 
1178     \fi
1179   \fi
1180   \BIC@AfterFi{ 1}%  $y = 0$ 
1181 \or %  $y = 1$ 
1182   \BIC@AfterFi{ #3#4}%
1183 \or %  $y = 2$ 
1184   \ifx#3-%  $x < 0$ 
1185     \BIC@AfterFiFi{%
1186       \BIC@ProcessMul0!#4!#4!%
1187     }%
1188   \else %  $x \geq 0$ 
1189     \BIC@AfterFiFi{%
1190       \BIC@ProcessMul0!#3#4!#3#4!%

```



```

1191     }%
1192   \fi
1193 \or % y < 0
1194   \ifcase\ifx\#4\%
1195     \ifx#300 % x = 0
1196     \else\ifx#311 % x = 1
1197     \else3 % x > 1
1198     \fi\fi
1199   \else
1200     \ifcase\BIC@MinusOne#3#4! %
1201       3 % |x| > 1
1202     \or
1203       2 % x = -1
1204 ?     \else\BigIntCalcError:ThisCannotHappen%
1205     \fi
1206   \fi
1207   \BIC@AfterFiFi{ 0}\BigIntCalcError:DivisionByZero}% x = 0
1208 \or % x = 1
1209   \BIC@AfterFiFi{ 1}% x = 1
1210 \or % x = -1
1211   \ifcase\BIC@ModTwo#2! % even(y)
1212     \BIC@AfterFiFiFi{ 1}%
1213   \or % odd(y)
1214     \BIC@AfterFiFiFi{ -1}%
1215 ?   \else\BigIntCalcError:ThisCannotHappen%
1216   \fi
1217 \or % |x| > 1
1218   \BIC@AfterFiFi{ 0}%
1219 ?   \else\BigIntCalcError:ThisCannotHappen%
1220   \fi
1221 \or % y > 2
1222   \ifcase\ifx\#4\%
1223     \ifx#300 % x = 0
1224     \else\ifx#311 % x = 1
1225     \else4 % x > 1
1226     \fi\fi
1227   \else
1228     \ifx#3-%
1229       \ifcase\BIC@MinusOne#3#4! %
1230         3 % x < -1
1231       \else
1232         2 % x = -1
1233       \fi
1234     \else
1235       4 % x > 1
1236     \fi
1237   \fi
1238   \BIC@AfterFiFi{ 0}% x = 0
1239 \or % x = 1
1240   \BIC@AfterFiFi{ 1}% x = 1
1241 \or % x = -1
1242   \ifcase\BIC@ModTwo#1#2! % even(y)
1243     \BIC@AfterFiFiFi{ 1}%
1244   \or % odd(y)
1245     \BIC@AfterFiFiFi{ -1}%
1246 ?   \else\BigIntCalcError:ThisCannotHappen%
1247   \fi
1248 \or % x < -1
1249   \ifcase\BIC@ModTwo#1#2! % even(y)
1250     \BIC@AfterFiFiFi{%
1251       \BIC@PowRec#4!#1#2!1!%
1252     }%

```

```

1253     \or % odd(y)
1254     \expandafter-\romannumeral0%
1255     \BIC@AfterFiFiFi{%
1256     \BIC@PowRec#4!#1#2!1!%
1257     }%
1258 ?   \else\BigIntCalcError:ThisCannotHappen%
1259     \fi
1260     \or % x > 1
1261     \BIC@AfterFiFi{%
1262     \BIC@PowRec#3#4!#1#2!1!%
1263     }%
1264 ?   \else\BigIntCalcError:ThisCannotHappen%
1265     \fi
1266 ?   \else\BigIntCalcError:ThisCannotHappen%
1267     \BIC@Fi
1268 }

```

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.

```

1269 \def\BIC@ModTwo#1#2!{%
1270   \ifx\#2\%
1271     \ifodd#1 %
1272       \BIC@AfterFiFi1%
1273     \else
1274       \BIC@AfterFiFi0%
1275     \fi
1276   \else
1277     \BIC@AfterFi{%
1278     \BIC@ModTwo#2!%
1279     }%
1280   \BIC@Fi
1281 }

```

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

```

1282 \def\BIC@MinusOne#1#2!{%
1283   \ifx#1-%
1284     \BIC@MinusOne#2!%
1285   \else
1286     0%
1287   \fi
1288 }

```

\BIC@MinusOne

```

1289 \def\BIC@MinusOne#1#2!{%
1290   \ifx#11%
1291     \ifx\#2\%
1292       1%
1293     \else
1294       0%
1295     \fi
1296   \else
1297     0%
1298   \fi
1299 }

```

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)
1300 \def\BIC@PowRec#1!#2#3!#4!{%
1301 \ifcase\ifx#21\ifx\#3\0 \else1 \fi\else1 \fi % y = 1
1302 \ifnum\BIC@PosCmp#1!#4!=1 % x > r
1303 \BIC@AfterFiFi{%
1304 \BIC@ProcessMul0!#1!#4!%
1305 }%
1306 \else
1307 \BIC@AfterFiFi{%
1308 \BIC@ProcessMul0!#4!#1!%
1309 }%
1310 \fi
1311 \or
1312 \ifcase\BIC@ModTwo#2#3! % even(y)
1313 \BIC@AfterFiFi{%
1314 \expandafter\BIC@@PowRec\romannumeral0%
1315 \BIC@@Shr#2#3!%
1316 !#1!#4!%
1317 }%
1318 \or % odd(y)
1319 \ifnum\BIC@PosCmp#1!#4!=1 % x > r
1320 \BIC@AfterFiFiFi{%
1321 \expandafter\BIC@@@PowRec\romannumeral0%
1322 \BIC@ProcessMul0!#1!#4!%
1323 !#1!#2#3!%
1324 }%
1325 \else
1326 \BIC@AfterFiFiFi{%
1327 \expandafter\BIC@@@PowRec\romannumeral0%
1328 \BIC@ProcessMul0!#1!#4!%
1329 !#1!#2#3!%
1330 }%
1331 \fi
1332 ? \else\BigIntCalcError:ThisCannotHappen%
1333 \fi
1334 ? \else\BigIntCalcError:ThisCannotHappen%
1335 \BIC@Fi
1336 }

\BIC@@PowRec #1: y/2
#2: x
#3: new r (r or r * x)
1337 \def\BIC@@PowRec#1!#2!#3!{%
1338 \expandafter\BIC@PowRec\romannumeral0%
1339 \BIC@ProcessMul0!#2!#2!%
1340 !#1!#3!%
1341 }

```

```

\BIC@@@PowRec #1:  $r * x$  #2:  $x$  #3:  $y$ 
1342 \def\BIC@@@PowRec#1!#2!#3!{%
1343   \expandafter\BIC@@PowRec\romannumeral0%
1344   \BIC@@Shr#3!%
1345   !#2!#1!%
1346 }

```

2.19 Div

```

\bigintcalcDiv #1:  $x$ 
#2:  $y$  (divisor)
1347 \def\bigintcalcDiv#1{%
1348   \romannumeral0%
1349   \expandafter\expandafter\expandafter\BIC@Div
1350   \bigintcalcNum{#1}!%
1351 }

\BIC@Div #1:  $x$ 
#2:  $y$ 
1352 \def\BIC@Div#1!#2{%
1353   \expandafter\expandafter\expandafter\BIC@DivSwitchSign
1354   \bigintcalcNum{#2}!#1!%
1355 }

\BigIntCalcDiv
1356 \def\BigIntCalcDiv#1!#2!{%
1357   \romannumeral0%
1358   \BIC@DivSwitchSign#2!#1!%
1359 }

```

\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:  $x$ 
1360 \def\BIC@DivSwitchSign#1#2!#3#4!{%
1361   \ifcase\BIC@Sgn#1#2! %  $y = 0$ 
1362     \BIC@AfterFi{ 0\BigIntCalcError:DivisionByZero}%
1363   \or %  $y > 0$ 
1364     \ifcase\BIC@Sgn#3#4! %  $x = 0$ 
1365       \BIC@AfterFiFi{ 0}%
1366     \or %  $x > 0$ 
1367       \BIC@AfterFiFi{%
1368         \BIC@DivSwitch{ }#3#4!#1#2!%
1369       }%
1370     \else %  $x < 0$ 
1371       \BIC@AfterFiFi{%
1372         \BIC@DivSwitch-#4!#1#2!%
1373       }%
1374     \fi
1375   \else %  $y < 0$ 
1376     \ifcase\BIC@Sgn#3#4! %  $x = 0$ 
1377       \BIC@AfterFiFi{ 0}%
1378     \or %  $x > 0$ 

```

```

1379     \BIC@AfterFiFi{%
1380     \BIC@DivSwitch-#3#4!#2!%
1381     }%
1382     \else % x < 0
1383     \BIC@AfterFiFi{%
1384     \BIC@DivSwitch{ }#4!#2!%
1385     }%
1386     \fi
1387 \BIC@Fi
1388 }

```

\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 ($y \neq 0$)

```

1389 \def\BIC@DivSwitch#1#2!#3#4!{%
1390   \ifcase\BIC@PosCmp#3#4!#2!% y = x
1391     \BIC@AfterFi{ #1}%
1392   \or % y > x
1393     \BIC@AfterFi{ 0}%
1394   \else % y < x
1395     \ifx\#1\%
1396     \else
1397       \expandafter\romannumeral0%
1398     \fi
1399     \ifcase\ifx\#4\%
1400       \ifx#310 % y = 1
1401       \else\ifx#321 % y = 2
1402       \else\ifx#342 % y = 4
1403       \else3 % y > 2
1404       \fi\fi\fi
1405     \else
1406       3 % y > 2
1407     \fi
1408     \BIC@AfterFiFi{ #2}% y = 1
1409   \or % y = 2
1410     \BIC@AfterFiFi{%
1411     \BIC@@Shr#2!%
1412     }%
1413   \or % y = 4
1414     \BIC@AfterFiFi{%
1415     \expandafter\BIC@@Shr\romannumeral0%
1416     \BIC@@Shr#2!%
1417     }%
1418   \or % y > 2
1419     \BIC@AfterFiFi{%
1420     \BIC@DivStartX#2!#3#4!!!%
1421     }%
1422 ? \else\BigIntCalcError:ThisCannotHappen%
1423   \fi
1424 \BIC@Fi
1425 }

```

\BIC@ProcessDiv #1#2: x

#3#4: y

```

#5: collect first digits of  $x$ 
#6: corresponding digits of  $y$ 
1426 \def\BIC@DivStartX#1#2!#3#4!#5!#6!{%
1427   \ifx\#4\%
1428     \BIC@AfterFi{%
1429       \BIC@DivStartYii#6#3#4!{#5#1}#2=!%
1430     }%
1431   \else
1432     \BIC@AfterFi{%
1433       \BIC@DivStartX#2!#4!#5#1!#6#3!%
1434     }%
1435   \BIC@Fi
1436 }

\BIC@DivStartYii #1:  $y$ 
#2:  $x, =$ 
1437 \def\BIC@DivStartYii#1!{%
1438   \expandafter\BIC@DivStartYiv\romannumeral0%
1439   \BIC@Shl#1!%
1440   !#1!%
1441 }

\BIC@DivStartYiv #1:  $2y$ 
#2:  $y$ 
#3:  $x, =$ 
1442 \def\BIC@DivStartYiv#1!{%
1443   \expandafter\BIC@DivStartYvi\romannumeral0%
1444   \BIC@Shl#1!%
1445   !#1!%
1446 }

\BIC@DivStartYvi #1:  $4y$ 
#2:  $2y$ 
#3:  $y$ 
#4:  $x, =$ 
1447 \def\BIC@DivStartYvi#1!#2!{%
1448   \expandafter\BIC@DivStartYviii\romannumeral0%
1449   \BIC@AddXY#1!#2!!!%
1450   !#1!#2!%
1451 }

\BIC@DivStartYviii #1:  $6y$ 
#2:  $4y$ 
#3:  $2y$ 
#4:  $y$ 
#5:  $x, =$ 
1452 \def\BIC@DivStartYviii#1!#2!{%
1453   \expandafter\BIC@DivStart\romannumeral0%
1454   \BIC@Shl#2!%
1455   !#1!#2!%
1456 }

\BIC@DivStart #1:  $8y$ 
#2:  $6y$ 
#3:  $4y$ 
#4:  $2y$ 
#5:  $y$ 
#6:  $x, =$ 
1457 \def\BIC@DivStart#1!#2!#3!#4!#5!#6!{%
1458   \BIC@ProcessDiv#6!!#5!#4!#3!#2!#1!=%
1459 }

```

```

\BIC@ProcessDiv #1#2#3:  $x$ , =
#4: result
#5:  $y$ 
#6:  $2y$ 
#7:  $4y$ 
#8:  $6y$ 
#9:  $8y$ 
1460 \def\BIC@ProcessDiv#1#2#3!#4!#5!{%
1461 \ifcase\BIC@PosCmp#5!#1!%  $y = \#1$ 
1462 \ifx#2=%
1463 \BIC@AfterFiFi{\BIC@DivCleanup{#41}}}%
1464 \else
1465 \BIC@AfterFiFi{%
1466 \BIC@ProcessDiv#2#3!#41!#5!%
1467 }%
1468 \fi
1469 \or %  $y > \#1$ 
1470 \ifx#2=%
1471 \BIC@AfterFiFi{\BIC@DivCleanup{#40}}}%
1472 \else
1473 \ifx\#4\%
1474 \BIC@AfterFiFiFi{%
1475 \BIC@ProcessDiv{#1#2}#3!#5!%
1476 }%
1477 \else
1478 \BIC@AfterFiFiFi{%
1479 \BIC@ProcessDiv{#1#2}#3!#40!#5!%
1480 }%
1481 \fi
1482 \fi
1483 \else %  $y < \#1$ 
1484 \BIC@AfterFi{%
1485 \BIC@@ProcessDiv{#1}#2#3!#4!#5!%
1486 }%
1487 \BIC@Fi
1488 }

\BIC@DivCleanup #1: result
#2: garbage
1489 \def\BIC@DivCleanup#1#2={ #1}%

\BIC@@ProcessDiv
1490 \def\BIC@@ProcessDiv#1#2#3!#4!#5!#6!#7!{%
1491 \ifcase\BIC@PosCmp#7!#1!%  $4y = \#1$ 
1492 \ifx#2=%
1493 \BIC@AfterFiFi{\BIC@DivCleanup{#44}}}%
1494 \else
1495 \BIC@AfterFiFi{%
1496 \BIC@ProcessDiv#2#3!#44!#5!#6!#7!%
1497 }%
1498 \fi
1499 \or %  $4y > \#1$ 
1500 \ifcase\BIC@PosCmp#6!#1!%  $2y = \#1$ 
1501 \ifx#2=%
1502 \BIC@AfterFiFiFi{\BIC@DivCleanup{#42}}}%
1503 \else
1504 \BIC@AfterFiFiFi{%
1505 \BIC@ProcessDiv#2#3!#42!#5!#6!#7!%
1506 }%
1507 \fi
1508 \or %  $2y > \#1$ 

```

```

1509     \ifx#2=%
1510         \BIC@AfterFiFiFi{\BIC@DivCleanup{#41}}}%
1511     \else
1512         \BIC@AfterFiFiFi{%
1513             \BIC@DivSub#1!#5!#2#3!#41!#5!#6!#7!%
1514         }%
1515     \fi
1516     \else % 2y < #1
1517         \BIC@AfterFiFi{%
1518             \expandafter\BIC@ProcessDivII\romannumeral0%
1519             \BIC@SubXY#1!#6!!!%
1520             !#2#3!#4!#5!23%
1521             #6!#7!%
1522         }%
1523     \fi
1524     \else % 4y < #1
1525         \BIC@AfterFiFi{%
1526             \BIC@@@ProcessDiv{#1}#2#3!#4!#5!#6!#7!%
1527         }%
1528     \BIC@Fi
1529 }

```

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

```

1530 \def\BIC@DivSub#1!#2!#3{%
1531     \expandafter\BIC@ProcessDiv\expandafter{%
1532         \romannumeral0%
1533         \BIC@SubXY#1!#2!!!%
1534         #3%
1535     }%
1536 }

```

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

```

1537 \def\BIC@ProcessDivII#1!#2#3!#4!#5!#6#7{%
1538     \ifcase\BIC@PosCmp#5!#1!% y = #1
1539         \ifx#2=%
1540             \BIC@AfterFiFi{\BIC@DivCleanup{#4#7}}}%
1541         \else
1542             \BIC@AfterFiFi{%
1543                 \BIC@ProcessDiv#2#3!#4#7!#5!%
1544             }%
1545         \fi
1546     \or % y > #1
1547         \ifx#2=%
1548             \BIC@AfterFiFi{\BIC@DivCleanup{#4#6}}}%
1549         \else
1550             \BIC@AfterFiFi{%
1551                 \BIC@ProcessDiv{#1#2}#3!#4#6!#5!%
1552             }%
1553         \fi
1554     \else % y < #1
1555         \ifx#2=%
1556             \BIC@AfterFiFi{\BIC@DivCleanup{#4#7}}}%
1557         \else
1558             \BIC@AfterFiFi{%
1559                 \BIC@DivSub#1!#5!#2#3!#4#7!#5!%
1560             }%
1561         \fi

```



```

1562 \BIC@Fi
1563 }

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

1564 \def\BIC@@@ProcessDiv#1#2#3!#4!#5!#6!#7!#8!#9!{%
1565 \ifcase\BIC@PosCmp#8!#1!% 6y = #1
1566 \ifx#2=%
1567 \BIC@AfterFiFi{\BIC@DivCleanup{#46}}%
1568 \else
1569 \BIC@AfterFiFi{%
1570 \BIC@ProcessDiv#2#3!#46!#5!#6!#7!#8!#9!%
1571 }%
1572 \fi
1573 \or % 6y > #1
1574 \BIC@AfterFiFi{%
1575 \expandafter\BIC@ProcessDivII\romannumeral0%
1576 \BIC@SubXY#1!#7!!!%
1577 !#2#3!#4!#5!45%
1578 #6!#7!#8!#9!%
1579 }%
1580 \else % 6y < #1
1581 \ifcase\BIC@PosCmp#9!#1!% 8y = #1
1582 \ifx#2=%
1583 \BIC@AfterFiFiFi{\BIC@DivCleanup{#48}}%
1584 \else
1585 \BIC@AfterFiFiFi{%
1586 \BIC@ProcessDiv#2#3!#48!#5!#6!#7!#8!#9!%
1587 }%
1588 \fi
1589 \or % 8y > #1
1590 \BIC@AfterFiFiFi{%
1591 \expandafter\BIC@ProcessDivII\romannumeral0%
1592 \BIC@SubXY#1!#8!!!%
1593 !#2#3!#4!#5!67%
1594 #6!#7!#8!#9!%
1595 }%
1596 \else % 8y < #1
1597 \BIC@AfterFiFiFi{%
1598 \expandafter\BIC@ProcessDivII\romannumeral0%
1599 \BIC@SubXY#1!#9!!!%
1600 !#2#3!#4!#5!89%
1601 #6!#7!#8!#9!%
1602 }%
1603 \fi
1604 \BIC@Fi
1605 }

```

2.20 Mod

```

\bigintcalcMod #1:  $x$ 
#2:  $y$ 

1606 \def\bigintcalcMod#1{%
1607 \romannumeral0%
1608 \expandafter\expandafter\expandafter\BIC@Mod
1609 \bigintcalcNum{#1}!%
1610 }

```

```

\BIC@Mod #1: x
#2: y
1611 \def\BIC@Mod#1!#2!{%
1612 \expandafter\expandafter\expandafter\BIC@ModSwitchSign
1613 \bigintcalcNum{#2}!#1!%
1614 }

```

\BigIntCalcMod

```

1615 \def\BigIntCalcMod#1!#2!{%
1616 \romannumeral0%
1617 \BIC@ModSwitchSign#2!#1!%
1618 }

```

\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
1619 \def\BIC@ModSwitchSign#1#2!#3#4!{%
1620 \ifcase\ifx\#2\%
1621 \ifx#100 % y = 0
1622 \else1 % y > 0
1623 \fi
1624 \else
1625 \ifx#1-2 % y < 0
1626 \else1 % y > 0
1627 \fi
1628 \fi
1629 \BIC@AfterFi{ 0\BigIntCalcError:DivisionByZero}%
1630 \or % y > 0
1631 \ifcase\ifx\#4\%\ifx#300 \else1 \fi\else1 \fi % x = 0
1632 \BIC@AfterFiFi{ 0}%
1633 \else
1634 \BIC@AfterFiFi{%
1635 \BIC@ModSwitch{ }#3#4!#1#2!%
1636 }%
1637 \fi
1638 \else % y < 0
1639 \ifcase\ifx\#4\%
1640 \ifx#300 % x = 0
1641 \else1 % x > 0
1642 \fi
1643 \else
1644 \ifx#3-2 % x < 0
1645 \else1 % x > 0
1646 \fi
1647 \fi
1648 \BIC@AfterFiFi{ 0}%
1649 \or % x > 0
1650 \BIC@AfterFiFi{%
1651 \BIC@ModSwitch--#3#4!#2!%
1652 }%
1653 \else % x < 0
1654 \BIC@AfterFiFi{%
1655 \BIC@ModSwitch-#4!#2!%
1656 }%
1657 \fi
1658 \BIC@Fi
1659 }

```

\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

```

1660 \def\BIC@ModSwitch#1#2#3!#4#5!{%
1661   \ifcase\ifx\#5\%
1662     \ifx#410 % y = 1
1663     \else\ifx#421 % y = 2
1664     \else2 % y > 2
1665     \fi\fi
1666     \else2 % y > 2
1667     \fi
1668     \BIC@AfterFi{ 0}% y = 1
1669   \or % y = 2
1670     \ifcase\BIC@ModTwo#2#3! % even(x)
1671       \BIC@AfterFiFi{ 0}%
1672       \or % odd(x)
1673       \BIC@AfterFiFi{ #11}%
1674   ? \else\BigIntCalcError:ThisCannotHappen%
1675     \fi
1676   \or % y > 2
1677     \ifx\#1\%
1678     \else
1679       \expandafter\BIC@Space\romannumeral0%
1680       \expandafter\BIC@ModMinus\romannumeral0%
1681     \fi
1682     \ifx#2-% x < 0
1683       \BIC@AfterFiFi{%
1684         \expandafter\expandafter\expandafter\BIC@ModX
1685         \bigintcalcSub{#2#3}{%
1686           \bigintcalcMul{#4#5}{\bigintcalcDiv{#2#3}{#4#5}}%
1687         }!#4#5!%
1688       }%
1689     \else % x > 0
1690       \BIC@AfterFiFi{%
1691         \expandafter\expandafter\expandafter\BIC@Space
1692         \bigintcalcSub{#2#3}{%
1693           \bigintcalcMul{#4#5}{\bigintcalcDiv{#2#3}{#4#5}}%
1694         }%
1695       }%
1696     \fi
1697   ? \else\BigIntCalcError:ThisCannotHappen%
1698   \BIC@Fi
1699 }
```

\BIC@ModMinus

```

1700 \def\BIC@ModMinus#1{%
1701   \ifx#10%
1702     \BIC@AfterFi{ 0}%
1703   \else
1704     \BIC@AfterFi{ -#1}%
1705   \BIC@Fi
1706 }
```

\BIC@ModX #1#2: z

#3: x

```

1707 \def\BIC@ModX#1#2!#3!{%
1708   \ifx#1-% z < 0
1709     \BIC@AfterFi{%
1710       \expandafter\BIC@Space\romannumeral0%
1711       \BIC@SubXY#3!#2!!!%
1712     }%
1713   \else % z >= 0
1714     \BIC@AfterFi{ #1#2}%
1715   \BIC@Fi
1716 }

1717 \BIC@AtEnd
1718 \</package>

```

3 Test

3.1 Catcode checks for loading

```

1719 <*test1>
1720 \catcode'\@=11 %
1721 \def\RestoreCatcodes{}
1722 \count@=0 %
1723 \loop
1724   \edef\RestoreCatcodes{%
1725     \RestoreCatcodes
1726     \catcode\the\count@=\the\catcode\count@\relax
1727   }%
1728 \ifnum\count@<255 %
1729   \advance\count@\@ne
1730 \repeat
1731
1732 \def\RangeCatcodeInvalid#1#2{%
1733   \count@=#1\relax
1734   \loop
1735     \catcode\count@=15 %
1736     \ifnum\count@<#2\relax
1737       \advance\count@\@ne
1738     \repeat
1739 }
1740 \def\Test{%
1741   \RangeCatcodeInvalid{0}{47}%
1742   \RangeCatcodeInvalid{58}{64}%
1743   \RangeCatcodeInvalid{91}{96}%
1744   \RangeCatcodeInvalid{123}{255}%
1745   \catcode'\@=12 %
1746   \catcode'\=0 %
1747   \catcode'\{=1 %
1748   \catcode'\}=2 %
1749   \catcode'\#=6 %
1750   \catcode'\[=12 %
1751   \catcode'\]=12 %
1752   \catcode'\%=14 %
1753   \catcode'\ =10 %
1754   \catcode13=5 %
1755   \input bigintcalc.sty\relax
1756   \RestoreCatcodes
1757 }
1758 \Test
1759 \csname @@end\endcsname
1760 \end
1761 </test1>

```

3.2 Macro tests

3.2.1 Preamble with test macro definitions

```
1762 <*test2>
1763 \NeedsTeXFormat{LaTeX2e}
1764 \nofiles
1765 \documentclass{article}
1766 <noetex> \let\SavedNumexpr\numexpr
1767 <noetex> \let\numexpr\UNDEFINED
1768 \makeatletter
1769 \chardef\BIC@TestMode=1 %
1770 \makeatother
1771 \usepackage{bigintcalc}[2007/09/27]
1772 <noetex> \let\numexpr\SavedNumexpr
1773 \usepackage{qstest}
1774 \IncludeTests{*}
1775 \LogTests{log}{*}{*}
1776 \newcommand*{\TestSpaceAtEnd}[1]{%
1777 <noetex> \let\SavedNumexpr\numexpr
1778 <noetex> \let\numexpr\UNDEFINED
1779 \edef\resultA{#1}%
1780 \edef\resultB{#1 }%
1781 <noetex> \let\numexpr\SavedNumexpr
1782 \Expect*{\resultA\space}*{\resultB}%
1783 }
1784 \newcommand*{\TestResult}[2]{%
1785 <noetex> \let\SavedNumexpr\numexpr
1786 <noetex> \let\numexpr\UNDEFINED
1787 \edef\result{#1}%
1788 <noetex> \let\numexpr\SavedNumexpr
1789 \Expect*{\result}{#2}%
1790 }
1791 \newcommand*{\TestResultTwoExpansions}[2]{%
1792 <*noetex>
1793 \begingroup
1794 \let\numexpr\UNDEFINED
1795 \expandafter\expandafter\expandafter
1796 \endgroup
1797 </noetex>
1798 \expandafter\expandafter\expandafter\Expect
1799 \expandafter\expandafter\expandafter{#1}{#2}%
1800 }
1801 \newcount\TestCount
1802 <etex> \newcommand*{\TestArg}[1]{\numexpr#1\relax}
1803 <noetex> \newcommand*{\TestArg}[1]{#1}
1804 \newcommand*{\TestTeXDivide}[2]{%
1805 \TestCount=\TestArg{#1}\relax
1806 \divide\TestCount by \TestArg{#2}\relax
1807 \Expect*{\bigintcalcDiv{#1}{#2}}*{\the\TestCount}%
1808 }
1809 \newcommand*{\Test}[2]{%
1810 \TestResult{#1}{#2}%
1811 \TestResultTwoExpansions{#1}{#2}%
1812 \TestSpaceAtEnd{#1}%
1813 }
1814 \newcommand*{\TestExch}[2]{\Test{#2}{#1}}
1815 \newcommand*{\TestInv}[2]{%
1816 \Test{\bigintcalcInv{#1}}{#2}%
1817 }
1818 \newcommand*{\TestAbs}[2]{%
1819 \Test{\bigintcalcAbs{#1}}{#2}%
1820 }
```

```

1821 \newcommand*\TestSgn}[2]{%
1822   \Test{\bigintcalcSgn{#1}}{#2}%
1823 }
1824 \newcommand*\TestMin}[3]{%
1825   \Test{\bigintcalcMin{#1}{#2}}{#3}%
1826 }
1827 \newcommand*\TestMax}[3]{%
1828   \Test{\bigintcalcMax{#1}{#2}}{#3}%
1829 }
1830 \newcommand*\TestCmp}[3]{%
1831   \Test{\bigintcalcCmp{#1}{#2}}{#3}%
1832 }
1833 \newcommand*\TestOdd}[2]{%
1834   \Test{\bigintcalcOdd{#1}}{#2}%
1835   \edef\x{%
1836     \noexpand\Test{%
1837       \noexpand\BigIntCalcOdd
1838       \bigintcalcAbs{#1}!%
1839     }{#2}%
1840   }%
1841   \x
1842 }
1843 \newcommand*\TestInc}[2]{%
1844   \Test{\bigintcalcInc{#1}}{#2}%
1845   \ifnum\bigintcalcSgn{#1}>-1 %
1846     \edef\x{%
1847       \noexpand\Test{%
1848         \noexpand\BigIntCalcInc\bigintcalcNum{#1}!%
1849       }{#2}%
1850     }%
1851     \x
1852   \fi
1853 }
1854 \newcommand*\TestDec}[2]{%
1855   \Test{\bigintcalcDec{#1}}{#2}%
1856   \ifnum\bigintcalcSgn{#1}>0 %
1857     \edef\x{%
1858       \noexpand\Test{%
1859         \noexpand\BigIntCalcDec\bigintcalcNum{#1}!%
1860       }{#2}%
1861     }%
1862     \x
1863   \fi
1864 }
1865 \newcommand*\TestAdd}[3]{%
1866   \Test{\bigintcalcAdd{#1}{#2}}{#3}%
1867   \ifnum\bigintcalcSgn{#1}>0 %
1868     \ifnum\bigintcalcSgn{#2}> 0 %
1869       \ifnum\bigintcalcCmp{#1}{#2}>0 %
1870         \edef\x{%
1871           \noexpand\Test{%
1872             \noexpand\BigIntCalcAdd
1873             \bigintcalcNum{#1}!\bigintcalcNum{#2}!%
1874           }{#3}%
1875         }%
1876         \x
1877       \else
1878         \edef\x{%
1879           \noexpand\Test{%
1880             \noexpand\BigIntCalcAdd
1881             \bigintcalcNum{#2}!\bigintcalcNum{#1}!%
1882           }{#3}%

```

```

1883     }%
1884     \x
1885     \fi
1886     \fi
1887     \fi
1888 }
1889 \newcommand*{\TestSub}[3]{%
1890   \Test{\bigintcalcSub{#1}{#2}}{#3}%
1891   \ifnum\bigintcalcSgn{#1}>0 %
1892     \ifnum\bigintcalcSgn{#2}> 0 %
1893       \ifnum\bigintcalcCmp{#1}{#2}>0 %
1894         \edef\x{%
1895           \noexpand\Test{%
1896             \noexpand\BigIntCalcSub
1897             \bigintcalcNum{#1}!\bigintcalcNum{#2}!%
1898           }{#3}%
1899         }%
1900         \x
1901       \fi
1902     \fi
1903   \fi
1904 }
1905 \newcommand*{\TestShl}[2]{%
1906   \Test{\bigintcalcShl{#1}}{#2}%
1907   \edef\x{%
1908     \noexpand\Test{%
1909       \noexpand\BigIntCalcShl\bigintcalcAbs{#1}!%
1910     }{\bigintcalcAbs{#2}}%
1911   }%
1912   \x
1913 }
1914 \newcommand*{\TestShr}[2]{%
1915   \Test{\bigintcalcShr{#1}}{#2}%
1916   \edef\x{%
1917     \noexpand\Test{%
1918       \noexpand\BigIntCalcShr\bigintcalcAbs{#1}!%
1919     }{\bigintcalcAbs{#2}}%
1920   }%
1921   \x
1922 }
1923 \newcommand*{\TestMul}[3]{%
1924   \Test{\bigintcalcMul{#1}{#2}}{#3}%
1925   \edef\x{%
1926     \noexpand\Test{%
1927       \noexpand\BigIntCalcMul
1928       \bigintcalcAbs{#1}!\bigintcalcAbs{#2}!%
1929     }{\bigintcalcAbs{#3}}%
1930   }%
1931   \x
1932 }
1933 \newcommand*{\TestSqr}[2]{%
1934   \Test{\bigintcalcSqr{#1}}{#2}%
1935 }
1936 \newcommand*{\TestFac}[2]{%
1937   \expandafter\TestExch\expandafter{%
1938     \the\numexpr#2%
1939   }{\bigintcalcFac{#1}}%
1940 }
1941 \newcommand*{\TestFacBig}[2]{%
1942   \Test{\bigintcalcFac{#1}}{#2}%
1943 }
1944 \newcommand*{\TestPow}[3]{%

```

```

1945 \Test{\bigintcalcPow{#1}{#2}}{#3}%
1946 }
1947 \newcommand*{\TestDiv}[3]{%
1948 \Test{\bigintcalcDiv{#1}{#2}}{#3}%
1949 \TestTeXDivide{#1}{#2}%
1950 }
1951 \newcommand*{\TestDivBig}[3]{%
1952 \Test{\bigintcalcDiv{#1}{#2}}{#3}%
1953 \edef\x{%
1954 \noexpand\Test{%
1955 \noexpand\BigIntCalcDiv\bigintcalcAbs{#1}!\bigintcalcAbs{#2}!%
1956 }\bigintcalcAbs{#3}}%
1957 }%
1958 }
1959 \newcommand*{\TestMod}[3]{%
1960 \Test{\bigintcalcMod{#1}{#2}}{#3}%
1961 \ifcase\ifcase\bigintcalcSgn{#1} 0%
1962 \or
1963 \ifcase\bigintcalcSgn{#2} 1%
1964 \or 0%
1965 \else 1%
1966 \fi
1967 \else
1968 \ifcase\bigintcalcSgn{#2} 1%
1969 \or 1%
1970 \else 0%
1971 \fi
1972 \fi\relax
1973 \edef\x{%
1974 \noexpand\Test{%
1975 \noexpand\BigIntCalcMod
1976 \bigintcalcAbs{#1}!\bigintcalcAbs{#2}!%
1977 }\bigintcalcAbs{#3}}%
1978 }%
1979 \x
1980 \fi
1981 }

```

3.2.2 Time

```

1982 \beginingroup\expandafter\expandafter\expandafter\endgroup
1983 \expandafter\ifx\csname pdfresettimer\endcsname\relax
1984 \else
1985 \makeatletter
1986 \newcount\SummaryTime
1987 \newcount\TestTime
1988 \SummaryTime=\z@
1989 \newcommand*{\PrintTime}[2]{%
1990 \typeout{%
1991 [Time #1: \strip@pt\dimexpr\number#2sp\relax\space s]%
1992 }%
1993 }%
1994 \newcommand*{\StartTime}[1]{%
1995 \renewcommand*{\TimeDescription}{#1}%
1996 \pdfresettimer
1997 }%
1998 \newcommand*{\TimeDescription}{}%
1999 \newcommand*{\StopTime}{%
2000 \TestTime=\pdfelapsedtime
2001 \global\advance\SummaryTime\TestTime
2002 \PrintTime\TimeDescription\TestTime
2003 }%
2004 \let\saved@qstest\qstest
2005 \let\saved@endqstest\endqstest

```



```

2006 \def\qstest#1#2{%
2007     \saved@qstest{#1}{#2}%
2008     \StartTime{#1}%
2009 }%
2010 \def\endqstest{%
2011     \StopTime
2012     \saved@endqstest
2013 }%
2014 \AtEndDocument{%
2015     \PrintTime{summary}\SummaryTime
2016 }%
2017 \makeatother
2018 \fi

```

3.2.3 Test sets

```

2019 \makeatletter
2020
2021 \begin{qstest}{inv}{inv}%
2022     \TestInv{0}{0}%
2023     \TestInv{1}{-1}%
2024     \TestInv{-1}{1}%
2025     \TestInv{10}{-10}%
2026     \TestInv{-10}{10}%
2027     \TestInv{2147483647}{-2147483647}%
2028     \TestInv{-2147483647}{2147483647}%
2029     \TestInv{12345678901234567890}{-12345678901234567890}%
2030     \TestInv{-12345678901234567890}{12345678901234567890}%
2031     \TestInv{ 0 }{0}%
2032     \TestInv{ 1 }{-1}%
2033     \TestInv{--1}{-1}%
2034     \TestInv{\number\z@}{0}%
2035     \TestInv{\ifx\relax\relax1\fi}{-1}%
2036     \TestInv{\ifx\relax\relax-\fi\ifx234\else1\fi}{1}%
2037 \end{qstest}
2038
2039 \begin{qstest}{abs}{abs}%
2040     \TestAbs{0}{0}%
2041     \TestAbs{1}{1}%
2042     \TestAbs{-1}{1}%
2043     \TestAbs{10}{10}%
2044     \TestAbs{-10}{10}%
2045     \TestAbs{2147483647}{2147483647}%
2046     \TestAbs{-2147483647}{2147483647}%
2047     \TestAbs{12345678901234567890}{12345678901234567890}%
2048     \TestAbs{-12345678901234567890}{12345678901234567890}%
2049     \TestAbs{ 0 }{0}%
2050     \TestAbs{ 1 }{1}%
2051     \TestAbs{--1}{1}%
2052     \TestAbs{-++1}{1}%
2053     \TestAbs{00000000000}{0}%
2054     \TestAbs{00000001000}{1000}%
2055     \TestAbs{\ifx\relax\relax 0\else 1\fi}{0}%
2056 \end{qstest}
2057
2058 \begin{qstest}{sign}{sign}%
2059     \TestSgn{0}{0}%
2060     \TestSgn{1}{1}%
2061     \TestSgn{-1}{-1}%
2062     \TestSgn{10}{1}%
2063     \TestSgn{-10}{-1}%
2064     \TestSgn{2147483647}{1}%
2065     \TestSgn{-2147483647}{-1}%
2066     \TestSgn{12345678901234567890}{1}%

```

```

2067 \TestSgn{-12345678901234567890}{-1}%
2068 \TestSgn{ 0 }{0}%
2069 \TestSgn{ 2 }{1}%
2070 \TestSgn{ -2 }{-1}%
2071 \TestSgn{--2}{1}%
2072 \TestSgn{\number\z@}{0}%
2073 \TestSgn{\number\@ne}{1}%
2074 \TestSgn{\number\m@ne}{-1}%
2075 \TestSgn{%
2076   -++\number\z@\number\z@
2077   \iftrue1\fi\iftrue2\fi\iftrue3\fi
2078 }{1}%
2079 \end{qstest}
2080
2081 \begin{qstest}{min}{min}%
2082 \TestMin{0}{1}{0}%
2083 \TestMin{1}{0}{0}%
2084 \TestMin{-10}{-20}{-20}%
2085 \TestMin{ 1 }{ 2 }{1}%
2086 \TestMin{ 2 }{ 1 }{1}%
2087 \TestMin{1}{1}{1}%
2088 \TestMin{\number\z@}{\number\@ne}{0}%
2089 \TestMin{\number\@ne}{\number\m@ne}{-1}%
2090 \end{qstest}
2091
2092 \begin{qstest}{max}{max}%
2093 \TestMax{0}{1}{1}%
2094 \TestMax{1}{0}{1}%
2095 \TestMax{-10}{-20}{-10}%
2096 \TestMax{ 1 }{ 2 }{2}%
2097 \TestMax{ 2 }{ 1 }{2}%
2098 \TestMax{1}{1}{1}%
2099 \TestMax{\number\z@}{\number\@ne}{1}%
2100 \TestMax{\number\@ne}{\number\m@ne}{1}%
2101 \end{qstest}
2102
2103 \begin{qstest}{cmp}{cmp}%
2104 \TestCmp{0}{0}{0}%
2105 \TestCmp{-21}{17}{-1}%
2106 \TestCmp{3}{4}{-1}%
2107 \TestCmp{-10}{-10}{0}%
2108 \TestCmp{-10}{-11}{1}%
2109 \TestCmp{100}{5}{1}%
2110 \TestCmp{9}{10}{-1}%
2111 \TestCmp{10}{9}{1}%
2112 \TestCmp{ 3 }{ 3 }{0}%
2113 \TestCmp{-9}{-10}{1}%
2114 \TestCmp{-10}{-9}{-1}%
2115 \TestCmp{-3}{-3}{0}%
2116 \TestCmp{0}{-2}{1}%
2117 \TestCmp{0}{2}{-1}%
2118 \TestCmp{2}{0}{1}%
2119 \TestCmp{-2}{0}{-1}%
2120 \TestCmp{12}{11}{1}%
2121 \TestCmp{11}{12}{-1}%
2122 \TestCmp{2147483647}{-2147483647}{1}%
2123 \TestCmp{-2147483647}{2147483647}{-1}%
2124 \TestCmp{2147483647}{2147483647}{0}%
2125 \TestCmp{\number\z@}{\number\@ne}{-1}%
2126 \TestCmp{\number\@ne}{\number\m@ne}{1}%
2127 \TestCmp{ 4 }{ 5 }{-1}%
2128 \TestCmp{ -3 }{ -7 }{1}%

```

```

2129 \end{qstest}
2130
2131 \begin{qstest}{odd}{odd}
2132 \tracingmacros=1
2133 \TestOdd{0}{0}%
2134 \TestOdd{1}{1}%
2135 \TestOdd{2}{0}%
2136 \TestOdd{3}{1}%
2137 \TestOdd{14}{0}%
2138 \TestOdd{15}{1}%
2139 \TestOdd{12345678901234567896}{0}%
2140 \TestOdd{12345678901234567897}{1}%
2141 \end{qstest}
2142
2143 \begin{qstest}{inc}{inc}%
2144 \TestInc{0}{1}%
2145 \TestInc{1}{2}%
2146 \TestInc{-1}{0}%
2147 \TestInc{10}{11}%
2148 \TestInc{-10}{-9}%
2149 \TestInc{ 3 }{4}%
2150 \TestInc{999}{1000}%
2151 \TestInc{-1000}{-999}%
2152 \TestInc{129}{130}%
2153 \TestInc{2147483646}{2147483647}%
2154 \TestInc{-2147483647}{-2147483646}%
2155 \TestInc{12345678901234567890}{12345678901234567891}%
2156 \TestInc{9999999999999999999}{10000000000000000000}%
2157 \TestInc{-12345678901234567891}{-12345678901234567890}%
2158 \TestInc{-10000000000000000000}{-9999999999999999999}%
2159 \end{qstest}
2160
2161 \begin{qstest}{dec}{dec}%
2162 \TestDec{0}{-1}%
2163 \TestDec{1}{0}%
2164 \TestDec{-1}{-2}%
2165 \TestDec{10}{9}%
2166 \TestDec{-10}{-11}%
2167 \TestDec{1000}{999}%
2168 \TestDec{-999}{-1000}%
2169 \TestDec{130}{129}%
2170 \TestDec{2147483647}{2147483646}%
2171 \TestDec{-2147483646}{-2147483647}%
2172 \TestDec{12345678901234567891}{12345678901234567890}%
2173 \TestDec{10000000000000000000}{9999999999999999999}%
2174 \TestDec{-12345678901234567890}{-12345678901234567891}%
2175 \TestDec{-9999999999999999999}{-10000000000000000000}%
2176 \end{qstest}
2177
2178 \begin{qstest}{add}{add}%
2179 \TestAdd{0}{0}{0}%
2180 \TestAdd{1}{0}{1}%
2181 \TestAdd{0}{1}{1}%
2182 \TestAdd{1}{2}{3}%
2183 \TestAdd{-1}{-1}{-2}%
2184 \TestAdd{2147483646}{1}{2147483647}%
2185 \TestAdd{-2147483647}{2147483647}{0}%
2186 \TestAdd{20}{-5}{15}%
2187 \TestAdd{-4}{-1}{-5}%
2188 \TestAdd{-1}{-4}{-5}%
2189 \TestAdd{-4}{1}{-3}%
2190 \TestAdd{-1}{4}{3}%

```

```

2191 \TestAdd{4}{-1}{3}%
2192 \TestAdd{1}{-4}{-3}%
2193 \TestAdd{-4}{-1}{-5}%
2194 \TestAdd{-1}{-4}{-5}%
2195 \TestAdd{ -4 }{ -1 }{-5}%
2196 \TestAdd{ -1 }{ -4 }{-5}%
2197 \TestAdd{ -4 }{ 1 }{-3}%
2198 \TestAdd{ -1 }{ 4 }{3}%
2199 \TestAdd{ 4 }{ -1 }{3}%
2200 \TestAdd{ 1 }{ -4 }{-3}%
2201 \TestAdd{ -4 }{ -1 }{-5}%
2202 \TestAdd{ -1 }{ -4 }{-5}%
2203 \TestAdd{876543210}{111111111}{987654321}%
2204 \TestAdd{999999999}{2}{1000000001}%
2205 \end{qstest}
2206
2207 \begin{qstest}{sub}{sub}
2208 \TestSub{0}{0}{0}%
2209 \TestSub{1}{0}{1}%
2210 \TestSub{1}{2}{-1}%
2211 \TestSub{-1}{-1}{0}%
2212 \TestSub{2147483646}{-1}{2147483647}%
2213 \TestSub{-2147483647}{-2147483647}{0}%
2214 \TestSub{-4}{-1}{-3}%
2215 \TestSub{-1}{-4}{3}%
2216 \TestSub{-4}{1}{-5}%
2217 \TestSub{-1}{4}{-5}%
2218 \TestSub{4}{-1}{5}%
2219 \TestSub{1}{-4}{5}%
2220 \TestSub{-4}{-1}{-3}%
2221 \TestSub{-1}{-4}{3}%
2222 \TestSub{ -4 }{ -1 }{-3}%
2223 \TestSub{ -1 }{ -4 }{3}%
2224 \TestSub{ -4 }{ 1 }{-5}%
2225 \TestSub{ -1 }{ 4 }{-5}%
2226 \TestSub{ 4 }{ -1 }{5}%
2227 \TestSub{ 1 }{ -4 }{5}%
2228 \TestSub{ -4 }{ -1 }{-3}%
2229 \TestSub{ -1 }{ -4 }{3}%
2230 \TestSub{1000000000}{2}{999999998}%
2231 \TestSub{987654321}{111111111}{876543210}%
2232 \end{qstest}
2233
2234 \begin{qstest}{shl}{shl}
2235 \TestShl{0}{0}%
2236 \TestShl{1}{2}%
2237 \TestShl{2}{4}%
2238 \TestShl{5621}{11242}%
2239 \TestShl{1073741823}{2147483646}%
2240 \end{qstest}
2241
2242 \begin{qstest}{shr}{shr}
2243 \TestShr{0}{0}%
2244 \TestShr{1}{0}%
2245 \TestShr{2}{1}%
2246 \TestShr{3}{1}%
2247 \TestShr{4}{2}%
2248 \TestShr{5}{2}%
2249 \TestShr{6}{3}%
2250 \TestShr{7}{3}%
2251 \TestShr{8}{4}%
2252 \TestShr{9}{4}%

```

```

2253 \TestShr{10}{5}%
2254 \TestShr{11}{5}%
2255 \TestShr{12}{6}%
2256 \TestShr{13}{6}%
2257 \TestShr{14}{7}%
2258 \TestShr{15}{7}%
2259 \TestShr{16}{8}%
2260 \TestShr{17}{8}%
2261 \TestShr{18}{9}%
2262 \TestShr{19}{9}%
2263 \TestShr{20}{10}%
2264 \TestShr{21}{10}%
2265 \TestShr{22}{11}%
2266 \TestShr{11241}{5620}%
2267 \TestShr{73054202}{36527101}%
2268 \TestShr{2147483646}{1073741823}%
2269 \end{qstest}
2270
2271 \begin{qstest}{mul}{mul}
2272 \TestMul{0}{0}{0}%
2273 \TestMul{1}{0}{0}%
2274 \TestMul{0}{1}{0}%
2275 \TestMul{1}{1}{1}%
2276 \TestMul{3}{1}{3}%
2277 \TestMul{1}{-3}{-3}%
2278 \TestMul{-4}{-5}{20}%
2279 \TestMul{3}{7}{21}%
2280 \TestMul{7}{3}{21}%
2281 \TestMul{3}{-7}{-21}%
2282 \TestMul{7}{-3}{-21}%
2283 \TestMul{-3}{7}{-21}%
2284 \TestMul{-7}{3}{-21}%
2285 \TestMul{-3}{-7}{21}%
2286 \TestMul{-7}{-3}{21}%
2287 \TestMul{12}{11}{132}%
2288 \TestMul{999}{333}{332667}%
2289 \TestMul{1000}{4321}{4321000}%
2290 \TestMul{12345}{173955}{2147474475}%
2291 \TestMul{1073741823}{2}{2147483646}%
2292 \TestMul{2}{1073741823}{2147483646}%
2293 \TestMul{-1073741823}{2}{-2147483646}%
2294 \TestMul{2}{-1073741823}{-2147483646}%
2295 \TestMul{6706022400}{13}{87178291200}%
2296 \end{qstest}
2297
2298 \begin{qstest}{sqr}{sqr}
2299 \TestSqr{0}{0}%
2300 \TestSqr{1}{1}%
2301 \TestSqr{2}{4}%
2302 \TestSqr{3}{9}%
2303 \TestSqr{4}{16}%
2304 \TestSqr{9}{81}%
2305 \TestSqr{10}{100}%
2306 \TestSqr{46340}{2147395600}%
2307 \TestSqr{-1}{1}%
2308 \TestSqr{-2}{4}%
2309 \TestSqr{-46340}{2147395600}%
2310 \end{qstest}
2311
2312 \begin{qstest}{fac}{fac}
2313 \TestFac{0}{1}%
2314 \TestFac{1}{1}%

```

```

2315 \TestFac{2}{2}%
2316 \TestFac{3}{2*3}%
2317 \TestFac{4}{2*3*4}%
2318 \TestFac{5}{2*3*4*5}%
2319 \TestFac{6}{2*3*4*5*6}%
2320 \TestFac{7}{2*3*4*5*6*7}%
2321 \TestFac{8}{2*3*4*5*6*7*8}%
2322 \TestFac{9}{2*3*4*5*6*7*8*9}%
2323 \TestFac{10}{2*3*4*5*6*7*8*9*10}%
2324 \TestFac{11}{2*3*4*5*6*7*8*9*10*11}%
2325 \TestFac{12}{2*3*4*5*6*7*8*9*10*11*12}%
2326 \TestFacBig{13}{6227020800}%
2327 \TestFacBig{14}{87178291200}%
2328 \TestFacBig{15}{1307674368000}%
2329 \TestFacBig{16}{20922789888000}%
2330 \TestFacBig{17}{355687428096000}%
2331 \TestFacBig{18}{6402373705728000}%
2332 \TestFacBig{19}{121645100408832000}%
2333 \TestFacBig{20}{2432902008176640000}%
2334 \TestFacBig{21}{51090942171709440000}%
2335 \TestFacBig{22}{112400072777607680000}%
2336 \end{qstest}
2337
2338 \begin{qstest}{pow}{pow}
2339 \TestPow{-2}{0}{1}%
2340 \TestPow{-1}{0}{1}%
2341 \TestPow{0}{0}{1}%
2342 \TestPow{1}{0}{1}%
2343 \TestPow{2}{0}{1}%
2344 \TestPow{3}{0}{1}%
2345 \TestPow{-2}{1}{-2}%
2346 \TestPow{-1}{1}{-1}%
2347 \TestPow{1}{1}{1}%
2348 \TestPow{2}{1}{2}%
2349 \TestPow{3}{1}{3}%
2350 \TestPow{-2}{2}{4}%
2351 \TestPow{-1}{2}{1}%
2352 \TestPow{0}{2}{0}%
2353 \TestPow{1}{2}{1}%
2354 \TestPow{2}{2}{4}%
2355 \TestPow{3}{2}{9}%
2356 \TestPow{0}{1}{0}%
2357 \TestPow{1}{-2}{1}%
2358 \TestPow{1}{-1}{1}%
2359 \TestPow{-1}{-2}{1}%
2360 \TestPow{-1}{-1}{-1}%
2361 \TestPow{-1}{3}{-1}%
2362 \TestPow{-1}{4}{1}%
2363 \TestPow{-2}{-1}{0}%
2364 \TestPow{-2}{-2}{0}%
2365 \TestPow{2}{3}{8}%
2366 \TestPow{2}{4}{16}%
2367 \TestPow{2}{5}{32}%
2368 \TestPow{2}{6}{64}%
2369 \TestPow{2}{7}{128}%
2370 \TestPow{2}{8}{256}%
2371 \TestPow{2}{9}{512}%
2372 \TestPow{2}{10}{1024}%
2373 \TestPow{-2}{3}{-8}%
2374 \TestPow{-2}{4}{16}%
2375 \TestPow{-2}{5}{-32}%
2376 \TestPow{-2}{6}{64}%

```

```

2377 \TestPow{-2}{7}{-128}%
2378 \TestPow{-2}{8}{256}%
2379 \TestPow{-2}{9}{-512}%
2380 \TestPow{-2}{10}{1024}%
2381 \TestPow{3}{3}{27}%
2382 \TestPow{3}{4}{81}%
2383 \TestPow{3}{5}{243}%
2384 \TestPow{-3}{3}{-27}%
2385 \TestPow{-3}{4}{81}%
2386 \TestPow{-3}{5}{-243}%
2387 \TestPow{2}{30}{1073741824}%
2388 \TestPow{-3}{19}{-1162261467}%
2389 \TestPow{5}{13}{1220703125}%
2390 \TestPow{-7}{11}{-1977326743}%
2391 \end{qstest}
2392
2393 \begin{qstest}{div}{div}
2394 \TestDiv{1}{1}{1}%
2395 \TestDiv{2}{1}{2}%
2396 \TestDiv{-2}{1}{-2}%
2397 \TestDiv{2}{-1}{-2}%
2398 \TestDiv{-2}{-1}{2}%
2399 \TestDiv{15}{2}{7}%
2400 \TestDiv{-16}{2}{-8}%
2401 \TestDiv{1}{2}{0}%
2402 \TestDiv{1}{3}{0}%
2403 \TestDiv{2}{3}{0}%
2404 \TestDiv{-2}{3}{0}%
2405 \TestDiv{2}{-3}{0}%
2406 \TestDiv{-2}{-3}{0}%
2407 \TestDiv{13}{3}{4}%
2408 \TestDiv{-13}{-3}{4}%
2409 \TestDiv{-13}{3}{-4}%
2410 \TestDiv{-6}{5}{-1}%
2411 \TestDiv{-5}{5}{-1}%
2412 \TestDiv{-4}{5}{0}%
2413 \TestDiv{-3}{5}{0}%
2414 \TestDiv{-2}{5}{0}%
2415 \TestDiv{-1}{5}{0}%
2416 \TestDiv{0}{5}{0}%
2417 \TestDiv{1}{5}{0}%
2418 \TestDiv{2}{5}{0}%
2419 \TestDiv{3}{5}{0}%
2420 \TestDiv{4}{5}{0}%
2421 \TestDiv{5}{5}{1}%
2422 \TestDiv{6}{5}{1}%
2423 \TestDiv{-5}{4}{-1}%
2424 \TestDiv{-4}{4}{-1}%
2425 \TestDiv{-3}{4}{0}%
2426 \TestDiv{-2}{4}{0}%
2427 \TestDiv{-1}{4}{0}%
2428 \TestDiv{0}{4}{0}%
2429 \TestDiv{1}{4}{0}%
2430 \TestDiv{2}{4}{0}%
2431 \TestDiv{3}{4}{0}%
2432 \TestDiv{4}{4}{1}%
2433 \TestDiv{5}{4}{1}%
2434 \TestDiv{12345}{678}{18}%
2435 \TestDiv{32372}{5952}{5}%
2436 \TestDiv{284271294}{18162}{15651}%
2437 \TestDiv{217652429}{12561}{17327}%
2438 \TestDiv{462028434}{5439}{84947}%

```

```

2439 \TestDiv{2147483647}{1000}{2147483}%
2440 \TestDiv{2147483647}{-1000}{-2147483}%
2441 \TestDiv{-2147483647}{1000}{-2147483}%
2442 \TestDiv{-2147483647}{-1000}{2147483}%
2443 \TestDiv{0}{3}{0}%
2444 \TestDiv{1}{3}{0}%
2445 \TestDiv{2}{3}{0}%
2446 \TestDiv{3}{3}{1}%
2447 \TestDiv{4}{3}{1}%
2448 \TestDiv{5}{3}{1}%
2449 \TestDiv{6}{3}{2}%
2450 \TestDiv{7}{3}{2}%
2451 \TestDiv{8}{3}{2}%
2452 \TestDiv{9}{3}{3}%
2453 \TestDiv{10}{3}{3}%
2454 \TestDiv{11}{3}{3}%
2455 \TestDiv{12}{3}{4}%
2456 \TestDiv{13}{3}{4}%
2457 \TestDiv{14}{3}{4}%
2458 \TestDiv{15}{3}{5}%
2459 \TestDiv{16}{3}{5}%
2460 \TestDiv{17}{3}{5}%
2461 \TestDiv{18}{3}{6}%
2462 \TestDiv{19}{3}{6}%
2463 \TestDiv{20}{3}{6}%
2464 \TestDiv{21}{3}{7}%
2465 \TestDiv{22}{3}{7}%
2466 \TestDiv{23}{3}{7}%
2467 \TestDiv{24}{3}{8}%
2468 \TestDiv{25}{3}{8}%
2469 \TestDiv{26}{3}{8}%
2470 \TestDiv{27}{3}{9}%
2471 \TestDiv{28}{3}{9}%
2472 \TestDiv{29}{3}{9}%
2473 \TestDiv{30}{3}{10}%
2474 \TestDiv{31}{3}{10}%
2475 \TestDivBig{17363436332507}{24702}{702916214}%
2476 \end{qstest}
2477
2478 \begin{qstest}{mod}{mod}
2479 \TestMod{-6}{5}{4}%
2480 \TestMod{-5}{5}{0}%
2481 \TestMod{-4}{5}{1}%
2482 \TestMod{-3}{5}{2}%
2483 \TestMod{-2}{5}{3}%
2484 \TestMod{-1}{5}{4}%
2485 \TestMod{0}{5}{0}%
2486 \TestMod{1}{5}{1}%
2487 \TestMod{2}{5}{2}%
2488 \TestMod{3}{5}{3}%
2489 \TestMod{4}{5}{4}%
2490 \TestMod{5}{5}{0}%
2491 \TestMod{6}{5}{1}%
2492 \TestMod{-5}{4}{3}%
2493 \TestMod{-4}{4}{0}%
2494 \TestMod{-3}{4}{1}%
2495 \TestMod{-2}{4}{2}%
2496 \TestMod{-1}{4}{3}%
2497 \TestMod{0}{4}{0}%
2498 \TestMod{1}{4}{1}%
2499 \TestMod{2}{4}{2}%
2500 \TestMod{3}{4}{3}%

```



```

2501 \TestMod{4}{4}{0}%
2502 \TestMod{5}{4}{1}%
2503 \TestMod{-6}{-5}{-1}%
2504 \TestMod{-5}{-5}{0}%
2505 \TestMod{-4}{-5}{-4}%
2506 \TestMod{-3}{-5}{-3}%
2507 \TestMod{-2}{-5}{-2}%
2508 \TestMod{-1}{-5}{-1}%
2509 \TestMod{0}{-5}{0}%
2510 \TestMod{1}{-5}{-4}%
2511 \TestMod{2}{-5}{-3}%
2512 \TestMod{3}{-5}{-2}%
2513 \TestMod{4}{-5}{-1}%
2514 \TestMod{5}{-5}{0}%
2515 \TestMod{6}{-5}{-4}%
2516 \TestMod{-5}{-4}{-1}%
2517 \TestMod{-4}{-4}{0}%
2518 \TestMod{-3}{-4}{-3}%
2519 \TestMod{-2}{-4}{-2}%
2520 \TestMod{-1}{-4}{-1}%
2521 \TestMod{0}{-4}{0}%
2522 \TestMod{1}{-4}{-3}%
2523 \TestMod{2}{-4}{-2}%
2524 \TestMod{3}{-4}{-1}%
2525 \TestMod{4}{-4}{0}%
2526 \TestMod{5}{-4}{-3}%
2527 \TestMod{2147483647}{1000}{647}%
2528 \TestMod{2147483647}{-1000}{-353}%
2529 \TestMod{-2147483647}{1000}{353}%
2530 \TestMod{-2147483647}{-1000}{-647}%
2531 \TestMod{ 0 }{ 4 }{0}%
2532 \TestMod{ 1 }{ 4 }{1}%
2533 \TestMod{ -1 }{ 4 }{3}%
2534 \TestMod{ 0 }{ -4 }{0}%
2535 \TestMod{ 1 }{ -4 }{-3}%
2536 \TestMod{ -1 }{ -4 }{-1}%
2537 \TestMod{18362}{25}{12}%
2538 \end{qstest}
2539
2540 \newcommand*{\TestError}[2]{%
2541 \begingroup
2542 \expandafter\def\csname BigIntCalcError:#1\endcsname{%
2543 \Expect*{#2}{0}%
2544 \expandafter\def\csname BigIntCalcError:#1\endcsname{ERROR}%
2545 \Expect*{#2}{OERROR}%
2546 \endgroup
2547 }
2548 \begin{qstest}{error}{error}
2549 \TestError{FacNegative}{\bigintcalcFac{-1}}%
2550 \TestError{FacNegative}{\bigintcalcFac{-2147483647}}%
2551 \TestError{DivisionByZero}{\bigintcalcPow{0}{-1}}%
2552 \TestError{DivisionByZero}{\bigintcalcDiv{1}{0}}%
2553 \TestError{DivisionByZero}{\bigintcalcMod{1}{0}}%
2554 \end{qstest}
2555
2556 \begin{document}
2557 \end{document}
2558 </test2>

```

4 Installation

4.1 Download

Package. This package is available on CTAN¹:

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

TDS refers to the standard “A Directory Structure for \TeX 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- \TeX :

```
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):

```
bigintcalc.sty      → tex/generic/oberdiek/bigintcalc.sty
bigintcalc.pdf      → doc/latex/oberdiek/bigintcalc.pdf
bigintcalc-test1.tex → doc/latex/oberdiek/bigintcalc-test1.tex
bigintcalc-test2.tex → doc/latex/oberdiek/bigintcalc-test2.tex
bigintcalc-test3.tex → doc/latex/oberdiek/bigintcalc-test3.tex
bigintcalc.dtx      → source/latex/oberdiek/bigintcalc.dtx
```

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 \TeX distribution (te \TeX , mi \TeX , ...) relies on file name databases, you must refresh these. For example, te \TeX users run `texhash` or `mktextlsr`.

¹<ftp://ftp.ctan.org/tex-archive/>

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:

Unpacking with L^AT_EX. The .dtx chooses its action depending on the format:

plain-TeX: Run docstrip and extract the files.

L^AT_EX: Generate the documentation.

If you insist on using L^AT_EX for `docstrip` (really, `docstrip` does not need L^AT_EX), then inform the autodetect routine about your intention:

$$\text{latex } \backslash \text{let} \backslash \text{install} = \text{y} \backslash \text{input} \{ \text{bigintcalc.dtx} \}$$

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^AT_EX:

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

[2007/09/27 v1.0]

- First version.

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		
\#	1749	687, 697, 698, 715, 800, 811, 858, 872, 935, 946, 963, 1083,
\%	1752	1169, 1194, 1222, 1270, 1291,
\@	1720, 1745	1301, 1395, 1399, 1427, 1473,
\@firstoftwo	109, 117, <u>126</u>	1620, 1631, 1639, 1661, 1677, 1746
\@one	1729, 1737, 2073,	\{
	2088, 2089, 2099, 2100, 2125, 2126	\}
\@nil	105, 107, 114, 122, 135, 138, 143	\]
\@secondoftwo	111, 119, <u>129</u>	
\[1750	
\\	140, 150, 269, 270, 278, 301, 399, 411, 444, 457, 469, 504, 506, 595, 596, 606, 607, 624, 686,	_
		1753
		A
		\advance

\AtEndDocument	2014	874, 881, 890, 897, 983, 988, 1028, 1053, 1137, 1185, 1189, 1207, 1209, 1218, 1238, 1240, 1261, 1272, 1274, 1303, 1307, 1313, 1365, 1367, 1371, 1377, 1379, 1383, 1408, 1410, 1414, 1419, 1463, 1465, 1471, 1493, 1495, 1517, 1540, 1542, 1548, 1550, 1556, 1558, 1567, 1569, 1590, 1597, 1632, 1634, 1648, 1650, 1654, 1671, 1673, 1683, 1690
B		
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\BIC@@@Shr	891, 892, 898, 899, <u>908</u>	
\BIC@@@Dec	479, 480, 498, <u>503</u>	
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\BIC@@@Shl	802, <u>810</u> , 825, 829	
\BIC@@@Shr	862, 867, <u>871</u> , 909	
\BIC@@AddDigit	647, 648, <u>658</u> , 737	
\BIC@@@Cmp	239, <u>242</u> , 328, 360	
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\BIC@@Expand	105, <u>107</u>	
\BIC@@Inc	401, <u>409</u> , 452	
\BIC@@MinMax	324, <u>327</u>	
\BIC@@MinusOne	1284, <u>1289</u>	
\BIC@@PowRec	1314, <u>1337</u> , 1343	\BIC@AtEnd
\BIC@@ProcessDiv	1485, <u>1490</u>	60, 61, 1717
\BIC@@ProcessFac	1148, <u>1154</u>	\BIC@Cmp
\BIC@@ProcessTim	955, <u>962</u>	235, <u>238</u>
\BIC@@Shl	784, 789, 796, <u>799</u>	\BIC@CmpDiff
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\BIC@@Sqr	1102, 1104, <u>1107</u>	\BIC@CmpLength
\BIC@@SubDigit	736, <u>747</u>	260, 266, <u>268</u>
\BIC@@TestMode	85	\BIC@CmpResult
\BIC@@Tim	<u>934</u>	274, 280, <u>289</u>
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\BIC@Add	522, <u>525</u> , 531	369, 383, 396, <u>456</u> , 1156
\BIC@AddCarry0	<u>665</u>	\BIC@DecSwitch
\BIC@AddCarry10	<u>666</u>	375, <u>378</u>
\BIC@AddCarry[1-9]	<u>667</u>	\BIC@Div
\BIC@AddDigit	629, 634, <u>645</u>	1349, <u>1352</u>
\BIC@AddResult	628, <u>638</u>	\BIC@DivCleanup
\BIC@AddSwitch	527, <u>534</u>	. 1463, 1471, <u>1489</u> , 1493, 1502, 1510, 1540, 1548, 1556, 1567, 1583
\BIC@AddXY	540, 544, 578, 582, 589, <u>594</u> , 785, 790, 797, 991, 1449	\BIC@DivStart
\BIC@AfterFi		1453, <u>1457</u>
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\BIC@AfterFiFi		1420, 1426, 1433
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		1429, <u>1437</u>
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		1438, <u>1442</u>
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		1443, <u>1447</u>
		\BIC@DivStartYviii
		1448, <u>1452</u>
		\BIC@DivSub
		1513, <u>1530</u> , 1559
		\BIC@DivSwitch
		.. 1368, 1372, 1380, 1384, <u>1389</u>
		\BIC@DivSwitchSign ..
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		\BIC@Mod
		1608, <u>1611</u>

\BIC@ModMinus	1680, <u>1700</u>	\BIC@TimDigit	950, 957, <u>973</u>
\BIC@ModSwitch	1635, 1651, 1655, <u>1660</u>	\bigintcalcAbs	4, <u>204</u> , 337, 1819, 1838, 1909, 1910, 1918, 1919, 1928, 1929, 1955, 1956, 1976, 1977
\BIC@ModSwitchSign	1612, 1617, <u>1619</u>	\BigIntCalcAdd	7, <u>588</u> , 1872, 1880
\BIC@ModTwo	1211, 1242, 1249, <u>1269</u> , 1312, 1670	\bigintcalcAdd	5, 520, 1086, 1091, 1866
\BIC@ModX	1684, <u>1707</u>	\bigintcalcCmp	4, <u>233</u> , 1831, 1869, 1893
\BIC@Mul	1016, <u>1019</u>	\BigIntCalcDec	7, 395, 1859
\BIC@MulDigit[3-9]	998	\bigintcalcDec	5, <u>373</u> , 1855
\BIC@MulSwitch	1020, <u>1023</u>	\BigIntCalcDiv	7, <u>1356</u> , 1955
\BIC@Normalize	148, 195	\bigintcalcDiv	6, <u>1347</u> , 1686, 1693, 1807, 1948, 1952, 2552
\BIC@NormalizeDigits	171, 187, <u>192</u>	\BigIntCalcError	432, 482, 492, 671, 762, 1003, 1117, 1134, 1204, 1207, 1215, 1219, 1246, 1258, 1264, 1266, 1332, 1334, 1362, 1422, 1629, 1674, 1697
\BIC@NormalizeZero	167, <u>177</u>	\bigintcalcFac	6, <u>1110</u> , 1939, 1942, 2549, 2550
\BIC@Odd	336, 341, <u>343</u>	\BigIntCalcInc	7, <u>392</u> , 1848
\BIC@PosCmp	265, 538, 548, 563, 576, 1030, 1041, 1056, 1066, 1119, 1144, 1302, 1319, 1390, 1461, 1491, 1500, 1538, 1565, 1581	\bigintcalcInc	5, <u>354</u> , 1844
\BIC@Pow	1161, <u>1164</u>	\bigintcalcInv	3, 200, 1816
\BIC@PowRec	1251, 1256, 1262, <u>1300</u> , 1338	\bigintcalcMax	4, <u>318</u> , 1828
\BIC@PowSwitch	1165, <u>1168</u>	\bigintcalcMin	4, <u>313</u> , 1825
\BIC@ProcessDiv	1426, 1458, <u>1460</u> , 1496, 1505, 1531, 1543, 1551, 1570, 1586	\BigIntCalcMod	7, <u>1615</u> , 1975
\BIC@ProcessDivII	1518, <u>1537</u> , 1575, 1591, 1598	\bigintcalcMod	6, <u>1606</u> , 1960, 2553
\BIC@ProcessDivIV	1564	\BigIntCalcMul	7, <u>1078</u> , 1927
\BIC@ProcessFac	1138, <u>1143</u> , 1155	\bigintcalcMul	6, <u>1014</u> , 1686, 1693, 1924
\BIC@ProcessMul	1032, 1036, 1043, 1047, 1058, 1062, 1068, 1072, 1080, <u>1082</u> , 1108, 1149, 1186, 1190, 1304, 1308, 1322, 1328, 1339	\bigintcalcNum	3, <u>193</u> , 202, 207, 220, 236, 240, 316, 321, 325, 357, 376, 523, 527, 532, 778, 836, 1017, 1021, 1098, 1113, 1162, 1166, 1350, 1354, 1609, 1613, 1848, 1859, 1873, 1881, 1897
\BIC@ProcessTim	937, <u>945</u> , 965, 969	\BigIntCalcOdd	7, <u>339</u> , 1837
\BIC@Sgn	219, <u>222</u> , 379, 1024, 1027, 1052, 1361, 1364, 1376	\bigintcalcOdd	5, <u>334</u> , 1834
\BIC@Shl	777, <u>780</u> , 1439, 1444, 1454	\bigintcalcPow	6, <u>1159</u> , 1945, 2551
\BIC@Shr	835, <u>838</u>	\bigintcalcSgn	4, <u>217</u> , 1822, 1845, 1856, 1867, 1868, 1891, 1892, 1961, 1963, 1968
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\BIC@ShrResult	875, 876, 882, 883, <u>906</u>	\bigintcalcShl	5, <u>775</u> , 1906
\BIC@Space	96, 201, 211, 213, 626, 640, 642, 731, 750, 813, 948, 978, 984, 989, 1085, 1679, 1691, 1710	\BigIntCalcShr	7, <u>850</u> , 1918
\BIC@Sqr	1097, <u>1100</u>	\bigintcalcShr	5, <u>833</u> , 1915
\BIC@StripHexSpace	135, <u>138</u>	\bigintcalcSqr	6, <u>1095</u> , 1934
\BIC@SubCarry0	757	\BigIntCalcSub	7, <u>591</u> , 1896
\BIC@SubCarry10	758	\bigintcalcSub	5, <u>529</u> , 1685, 1692, 1890
\BIC@SubCarry[1-9]	759		
\BIC@SubDigit	718, 723, <u>734</u>		
\BIC@SubResult	717, <u>727</u>		
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\BIC@TestMode	85, 1769		
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\catcode	3, 4, 5, 6, 7, 31, 32, 33, 34, 35, 36, 37, 38, 56, 58, 62, 64, 83, 88, 90, 1720, 1726, 1735, 1745, 1746, 1747, 1748, 1749, 1750, 1751, 1752, 1753, 1754
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<code>\divide</code>	1806	L	
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	2336, 2391, 2476, 2538, 2554, 2557	<code>\NeedsTeXFormat</code>	1763
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	668, 745, 757, 758, 760, 877,		1815, 1818, 1821, 1824, 1827,
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	1052, 1120, 1169, 1194, 1200,	<code>\numexpr</code>	421, 479, 627,
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