MODULE *pluscal_tribulle*

EXTENDS *TLC*, *Integers*, *Naturals*

$n \triangleq 5$

$t0 \triangleq [k \in 0 \,..\, n-1 \mapsto$
IF $k = 0$ THEN 3
ELSE IF $k = 1$ THEN 6
ELSE IF $k = 2$ THEN $2 * k$
ELSE IF $k = 3$ THEN 9
ELSE 5]

```
--algorithm tribulle{
variables t, i, j, d = TRUE, temp ;
{
    t := t0 ;
    i := 0 ;
    while ( i < n ∧ d )
        {
                d := FALSE ;
                j := 1 ;
                while ( j <  (n − i) )
                {
                        if ( t[j − 1] > t[j] )
                        {
                                temp := t[j − 1] ;
                                t[j − 1] := t[j]   ;
                                t[j] := temp ;
                                d := TRUE ;
                         } ;
                        j := j + 1 ;
                 } ;
                i := i + 1 ;
         }
 }

 }
```

BEGIN TRANSLATION

CONSTANT *defaultInitValue*

VARIABLES *t*, *i*, *j*, *d*, *temp*, *pc*

$vars \triangleq \langle t, i, j, d, temp, pc \rangle$

$Init \triangleq$ Global variables
$\land\ t = defaultInitValue$

$\land\ i\ = \mathit{defaultInitValue}$
$\land\ j\ = \mathit{defaultInitValue}$
$\land\ d = \text{TRUE}$
$\land\ \mathit{temp} = \mathit{defaultInitValue}$
$\land\ pc = \text{“Lbl\_1”}$

$\mathit{Lbl\_1} \triangleq$ $\land\ pc = \text{“Lbl\_1”}$
$\land\ t'\ = t0$
$\land\ i'\ = 0$
$\land\ pc' = \text{“Lbl\_2”}$
$\land\ \text{UNCHANGED}\ \langle j,\ d,\ \mathit{temp}\rangle$

$\mathit{Lbl\_2} \triangleq$ $\land\ pc = \text{“Lbl\_2”}$
$\land\ \text{IF}\ i < n \land d$
THEN $\land\ d' = \text{FALSE}$
$\land\ j' = 1$
$\land\ pc' = \text{“Lbl\_3”}$
ELSE $\land\ pc' = \text{“Done”}$
$\land\ \text{UNCHANGED}\ \langle j,\ d\rangle$
$\land\ \text{UNCHANGED}\ \langle t,\ i,\ \mathit{temp}\rangle$

$\mathit{Lbl\_3} \triangleq$ $\land\ pc = \text{“Lbl\_3”}$
$\land\ \text{IF}\ j <\ (n - i)$
THEN $\land\ \text{IF}\ t[j-1] > t[j]$
THEN $\land\ \mathit{temp}' = t[j-1]$
$\land\ t' = [t\ \text{EXCEPT}\ ![j-1] = t[j]]$
$\land\ pc' = \text{“Lbl\_4”}$
ELSE $\land\ pc' = \text{“Lbl\_5”}$
$\land\ \text{UNCHANGED}\ \langle t,\ \mathit{temp}\rangle$
$\land\ i' = i$
ELSE $\land\ i' = i + 1$
$\land\ pc' = \text{“Lbl\_2”}$
$\land\ \text{UNCHANGED}\ \langle t,\ \mathit{temp}\rangle$
$\land\ \text{UNCHANGED}\ \langle j,\ d\rangle$

$\mathit{Lbl\_5} \triangleq$ $\land\ pc = \text{“Lbl\_5”}$
$\land\ j'\ = j + 1$
$\land\ pc' = \text{“Lbl\_3”}$
$\land\ \text{UNCHANGED}\ \langle t,\ i,\ d,\ \mathit{temp}\rangle$

$\mathit{Lbl\_4} \triangleq$ $\land\ pc = \text{“Lbl\_4”}$
$\land\ t'\ = [t\ \text{EXCEPT}\ ![j] = \mathit{temp}]$
$\land\ d' = \text{TRUE}$
$\land\ pc' = \text{“Lbl\_5”}$
$\land\ \text{UNCHANGED}\ \langle i,\ j,\ \mathit{temp}\rangle$

$\mathit{Next} \triangleq\ \mathit{Lbl\_1} \lor \mathit{Lbl\_2} \lor \mathit{Lbl\_3} \lor \mathit{Lbl\_5} \lor \mathit{Lbl\_4}$

$\lor$ Disjunct to prevent deadlock on termination
$(pc = \text{“Done”} \land \text{UNCHANGED } vars)$

$Spec \triangleq Init \land \Box[Next]_{vars}$

$Termination \triangleq \Diamond(pc = \text{“Done”})$

END TRANSLATION

$Safe1 \triangleq pc \neq \text{“Done”}$
$Safe2 \triangleq pc = \text{“Done”} \Rightarrow \forall\, e \in 0 \,..\, n-1 : t[e] \leq t[e+1]$
$Safe3 \triangleq pc = \text{“Done”} \Rightarrow \{e \in 0 \,..\, n-1 : t[e] \leq t[e+1]\} = 0 \,..\, n-1$
$Safe4 \triangleq pc = \text{“Done”} \Rightarrow (t[0] \leq t[1]) \land (t[1] \leq t[2])$