Flag Indentifier Circuit
PC/CP120 Project Phase II

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Truth Table

For this particular problem, it would be easy to write out equations directly, but a simplified truth table may be more descriptive. For the following table, these abbreviations will be used:

BE Belgium

DE Germany

BG Bulgaria

FR France

HU Hungary

IT Italy

AT Austria

NL Netherlands

RU Russia

Here is a simplified truth table. (It is simplified, because this only shows combinations which make any output **true**. All other combinations make the outputs **false**.

colour	BE	DE	BG	FR	HU	IT	AT	NL	RU
Black	1	1	0	0	0	0	0	0	0
White	0	0	1	1	1	1	1	1	1
Red	1	1	1	1	1	1	1	1	1
Blue	0	0	0	1	0	0	0	1	1
Green	0	0	1	0	1	1	0	0	0
Yellow	1	1	0	0	0	0	0	0	0
orientation (v= 1)	1	0	0	1	0	1	0	0	0

Table 1: Truth table

So the equation for *Belgium* is:

$$Belgium = Black \wedge \overline{White} \wedge Red \wedge \overline{Blue} \wedge \overline{Green} \wedge Yellow \wedge orientation$$

(Remember that *orientation* is '1' for vertical stripes and '0' for horizontal stripes.) Similarly

$$Germany = Black \wedge \overline{White} \wedge Red \wedge \overline{Blue} \wedge \overline{Green} \wedge Yellow \wedge \overline{orientation}$$

$$Belgium = Black \wedge \overline{White} \wedge Red \wedge \overline{Blue} \wedge \overline{Green} \wedge Yellow \wedge orientation$$

$$France = \overline{Black} \wedge White \wedge Red \wedge Blue \wedge \overline{Green} \wedge \overline{Yellow} \wedge orientation$$

$$Italy = \overline{Black} \wedge White \wedge Red \wedge \overline{Blue} \wedge Green \wedge \overline{Yellow} \wedge orientation$$

$$Austria = \overline{Black} \wedge White \wedge Red \wedge \overline{Blue} \wedge \overline{Green} \wedge \overline{Yellow} \wedge \overline{orientation}$$

$$Hungary = \overline{Black} \wedge White \wedge Red \wedge \overline{Blue} \wedge Green \wedge \overline{Yellow} \wedge \overline{orientation}$$

$$Russia = \overline{Black} \wedge White \wedge Red \wedge Blue \wedge \overline{Green} \wedge \overline{Yellow} \wedge \overline{orientation}$$

Note that

$$Bulgaria = Hungary$$

and

$$Netherlands = Russia$$

so there are actually only 7 outputs. (This is not to say that the flags of Bulgaria and Hungary are the same, just that they are the same *as far as our circuit is concerned.* The same is true for the Netherlands and Russia.)

Simplifications

First of all, notice that *Red* is in *all* of the flags, it can be simply ANDed with everything at the end. (It can't be eliminated, since if it's NOT included we don't have a valid flag.)

Note that *Black* and $Yellow$ are only used together or not at all, so we can AND them together to make BY. Also, $White$ is complementary to BY; i.e. it is **true** when BY is **false**, so we can invert it and **AND** it with BY to make $BY\bar{W}$.

$$BY\bar{W} = Black \wedge Yellow \wedge \overline{White}$$

Germany and Belgium only differ by their orientations, as do Italy and Bulgaria/Hungary and France and Netherlands/Russia. Thus we can make intermediate signals like this:

$$BeDe = BY\bar{W} \wedge \overline{Blue} \wedge \overline{Green}$$

$$FrNlRu = \overline{BY\bar{W}} \wedge White \wedge Blue \wedge \overline{Green}$$

$$ItBgHu = \overline{BY\bar{W}} \wedge White \wedge \overline{Blue} \wedge Green$$

Final output equations

With the simplifications, the output equations become:

$$Belgium = BeDe \wedge Red \wedge orientation$$

$$Germany = BeDe \wedge Red \wedge \overline{orientation}$$

$$France = FrNlRu \wedge Red \wedge orientation$$

$$Italy = ItBgHu \wedge Red \wedge orientation$$

$$Austria = \overline{BeDe} \wedge Red \wedge \overline{orientation}$$

$$Bulgaria = Hungary = ItBgHu \wedge Red \wedge \overline{orientation}$$

$$Netherlands = Russia = FrNlRu \wedge Red \wedge \overline{orientation}$$

Testing Logic

Maple can be used to test the equations. This will be useful to see that the intermediate terms that were created are correct. For instance,

$$Belgium = BeDe \wedge Red \wedge orientation$$

where

$$BeDe = BY\bar{W} \wedge \overline{Blue} \wedge \overline{Green}$$

and

$$BY\bar{W} = Black \wedge Yellow \wedge \overline{White}$$

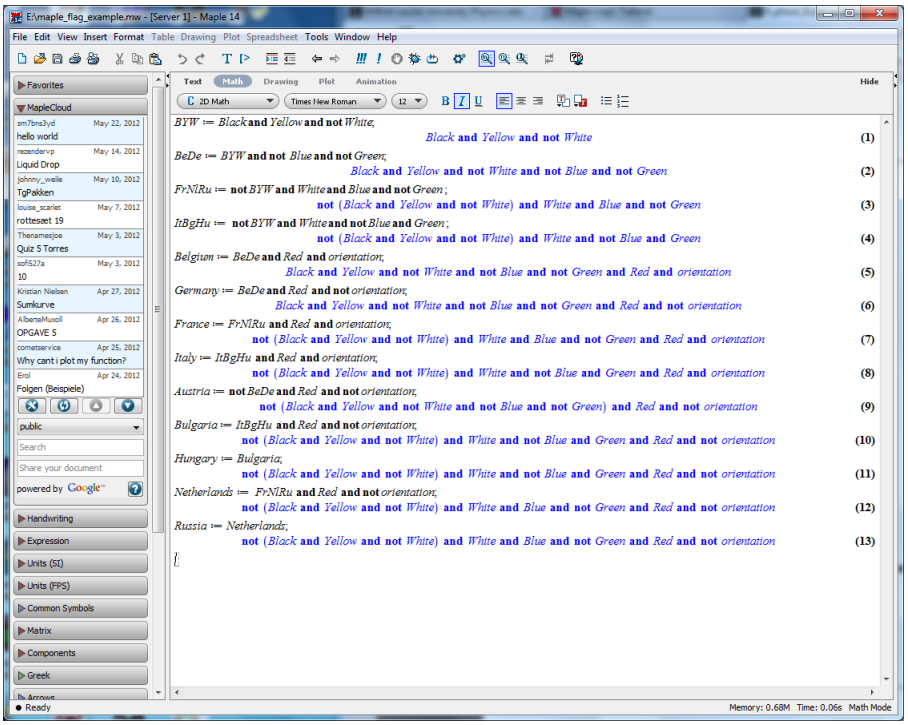
Similarly,

$$FrNlRu = \overline{BY\bar{W}} \wedge White \wedge Blue \wedge \overline{Green}$$

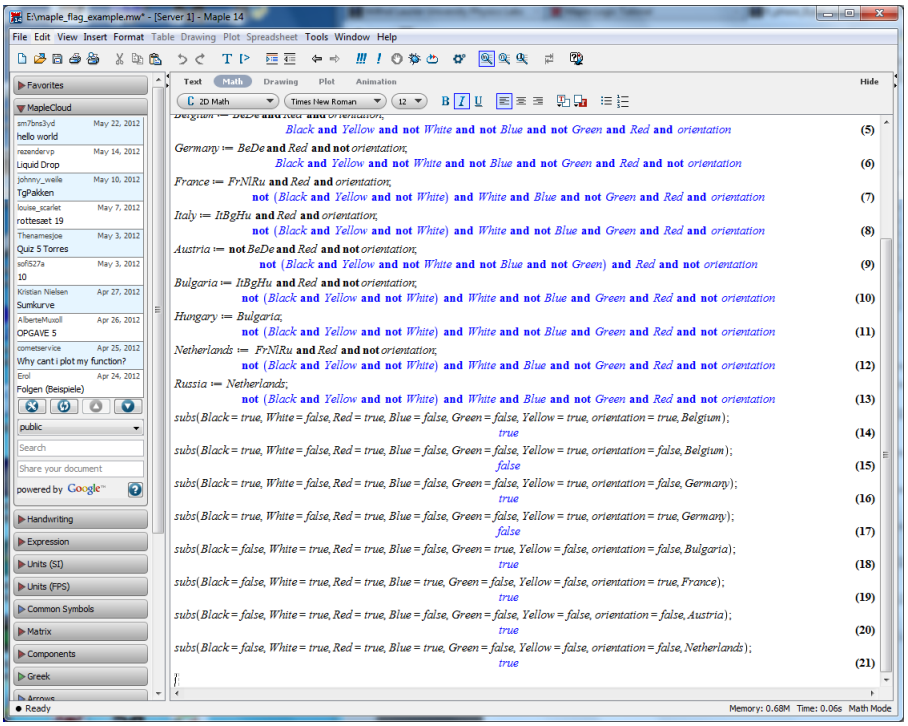
and

$$ItBgHu = \overline{BY\bar{W}} \wedge White \wedge \overline{Blue} \wedge Green$$

Here are the equations in a Maple session:



Here are tests for the cases where each of the outputs should be true, and a couple of tests where outputs should be false. All of the true cases



work correctly. The false cases tested also work correctly, so it appears the equations are correct. (To be completely sure, all of the false cases should be tested for each output.)