Dear Ram,  
  
Thanks for sending my Abdullah Al-Nafisah's report 0b (about  
24-May-2018) and his python code for the two diode model.  I think he  
is making an excellent start.  I can comment on some of the points he  
raises in his report 0b:  
  
- The software package which I used is Maple.  It is available via the  
University's myvlab virtual software capability, I think.  Maple does  
not use hardware floating point, unless you force that.  Hence Maple  
will allow unlimited precision and unlimited exponents.  
  
- The intermediate values, and the high water mark filter, were done  
in Maple.  For instance, suppose a calculation involves a  
multiplication A\*B for two variables.  That can replaced by a function  
evaluation, maybe Mult(A,B,MaxAB) which returns A\*B but also stores  
the maximum value of A\*B encountered so far, in a global variable  
MaxAB.  The run starts by setting MaxAB to zero, then the calculations  
are done -- repeatedly as is appropriate for the model being run or  
graph being drawn. At the end, the MaxAB value is inspected, to see  
how big that product might become.  Hence whether overflow is a  
concern.  It is tedious to set up such instrumentation of a  
calculation, and clearly that is not suitable for production code.  
But it helps to detect if there might be trouble during a future  
implementation of an algorithm.  I think of it as a high-water-mark  
filter because the mental model I have for a draft algorithm, is a  
circuit or a machine, to which one has attached various measuring  
devices during evaluation of the circuit or machine.  
  
- Paper [2] is the Jain and Kapoor paper of 2004.  I think there are a  
couple of errors in the paper, resulting from typesetting slips which  
were not caught during proofreading.  The paper is good in concept,  
but one must be careful not to copy the formulas exactly.  It is  
excellent that Abdullah is being careful.  
  
- I have since late 2015, when our paper [1] was prepared, become  
aware of earlier work by Francisco J. Garcia-Sanchez, and Adelmo  
Ortiz-Conde, about 2000, which predates the Jain and Kapoor paper.  I  
think Garcia-Sanchez, et al, deserve to be recognized as earlier  
proposers of using the Lambert W funcion for exact analytical solution  
of circuit equations which involve the Shockley diode model.  Also,  
Francisco is aware of the wave digital possibility which I mention  
below.  I first learned of the idea from noticing one of his interests  
included that.  We have not had an opportunity to discuss detail.  
  
I would be happy to meet with Abdullah sometime to discuss the work he  
is doing.  However, I cannot be on the critical path for the success  
of his project and studies.  My availability is intermittent, and it  
is a dis-service to a student to get me involved with his projects and  
reports and other time constraints.  
  
You said that you had shared my email to PCD, regarding the  
possibility of using a rotation of coordinates (like wave digital  
model used for simulation of acoustic circuits) for an improved model  
for solar cells.  I previously discussed the possibility with Abdullah  
when we met in your office a week or two ago, and I am happy that you  
copied him on the email.  The more good minds working on this problem,  
the better.  There is a real need for an improved model, which is  
stable for estimation of parameters from a set of experimental  
observations, and also is stable when parameters are used, for  
instance in a Monte Carlo simulation, to model the behaviour of  
complex circuits or arrays which are made of a population of solar  
cells with fluctuating performance.  The present model is far too  
sensitive to minor errors, in parameter estimation, and in use of  
parameters to describe hypothetical solar cells.  The result is that  
parameters can produce solar cells in theory which are not physically  
realistic, thereby causing garbage in simulation runs.  The  
development of an improved model would be a genuine technological  
advance.  
  
I'll look forward to meeting with Rob and yourself further today.  
Nothing new on my part since our meeting yesterday afternoon,  
regarding the calcs etc relevant to CAP paper.  
  
Best,  
Ken  
24-May-2018

Dear Abdullah,  
  
At our meeting on Weds 30-May-2018, I promised to send you a paper  
about the wave digital idea.  Two papers are attached.  
  
The 2016 paper by Bernardini, and others, "Modeling Nonlinear Wave  
Digital Elements Using the Lambert Function", has a good overview of  
the Wave Digital idea.  The wave digital domain is a linear  
transrformation of the Kirchoff domain.  The Kirchoff domain uses two  
coordinates, current I and voltage V.  The Wave digital domain uses  
two coordinates A and B which are a linear combination of I and V.  
  
Let R0 be a non-zero resistance, to be chosen later.  Let A = V + I\*R0  
and B = V - I\*R0.  Thus the A and B coordinates are lines in the I,V  
plane which make the same angle with the V axis, but A and B are not  
necessarily at right angles to one another in the I,V plane.  The  
point of the wave digital transformation is that it can make the work  
easier for circuit design and simulation, as the transmitted wave and  
reflected wave through a circuit can be made more distinct, even  
separated, by a suitable choice of R0 value.  That can make the  
computations much simpler and more accurate for a circuit simulation  
program.  
  
The Bernardini paper shows how this transformation can be adapted for  
a non-linear circuit, such as a circuit with a diode.  That might be  
applicable to the solar cell model.   The paper itself is more  
concerned with acoustic circuits.  
  
The other paper attached, 2017 by Verasani, Bernardini and Sarti,  
discusses how the wave digital transformation can be used in another  
application, called a Sallen-Key filter, which is another analog audio  
circuit.  It is just another example.  The first paper, 2016 by  
Bernardini, is the more important paper for developing an alternative  
solar cell model, I believe.  
  
I hope these papers help.  You can look for other papers involving  
these authors or which have "wave digital" in the title or abstract..  
  
Best wishes,  
Ken Roberts  
31-May-2018