18 April 2020

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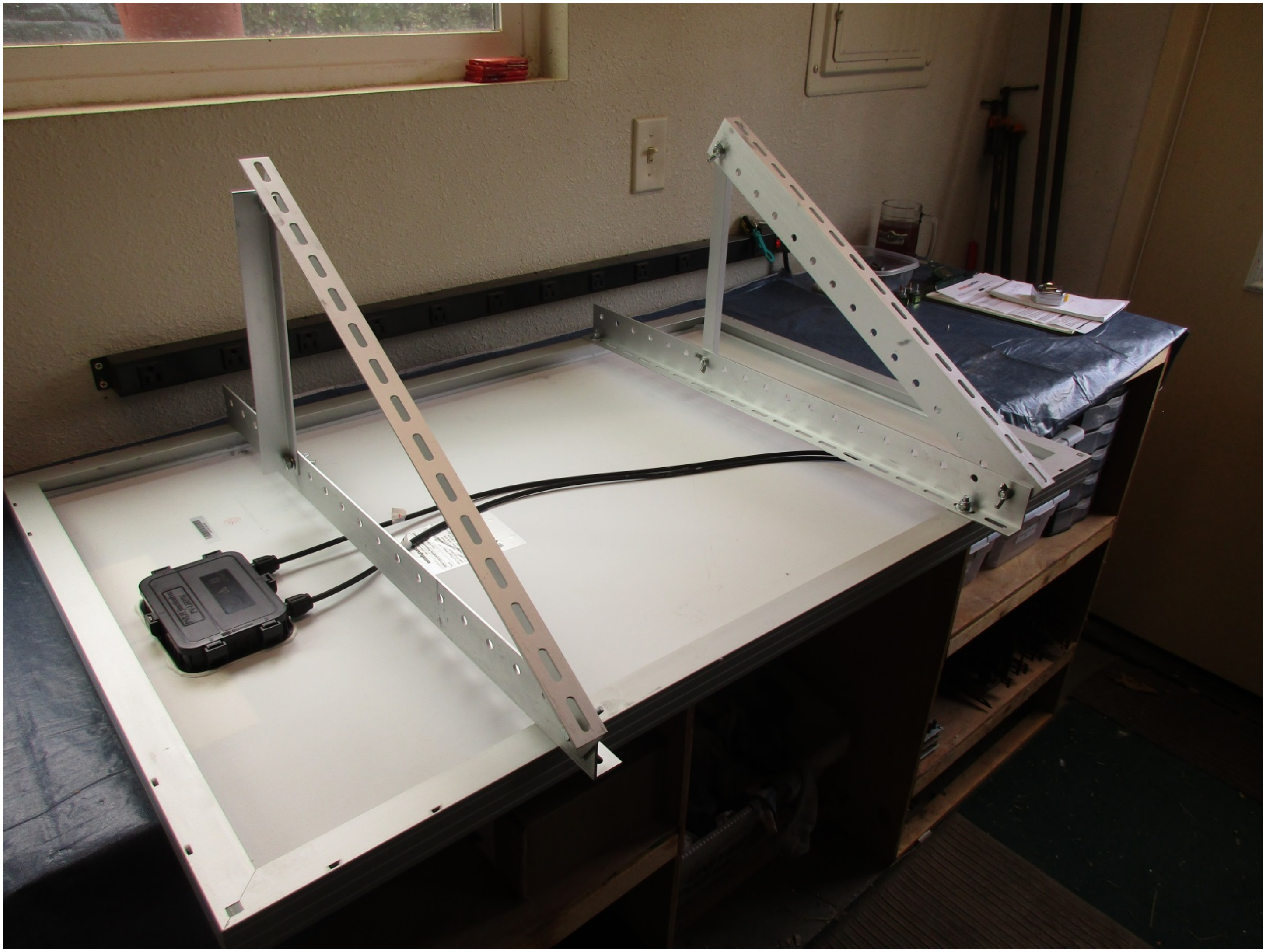
MOUNT CALCULATIONS

It has come down to calculating how to make a mount so that we can set that pitch angle correctly. Depending on your point of view, the calculations are quite easy, confusing, or horribly complex. I'll try and do some easing you into the process.

First of all, we have a typical solar panel with a typical mount made of angle metal. Aluminum or steel are the preferred materials, but if you have a reason to use wood or some other material the calculations are identical.



Here is a representative setup on a 100 watt solar panel (back view). The black box to the far left is the electrical connection to the solar panel cells and play a very minor role in the calculations. The solar mount consists of two "triangles" of angle metal, one attached to the left side of the panel and one to the right side.

There is one long leg bolted directly to the solar panel itself. Now I'm not a Luddite, and I really admire the metric system of measurement. If I didn't have a toolbox with a few thousand dollars worth of "Imperial" ("English") tools I'd certainly love to be working in the millimeter-kilogram system. Unfortunately, almost all American-built aircraft use the Imperial standard. This panel and mount came with metric hardware and my first job was to go to the hardware store to get "American-English" hardware.

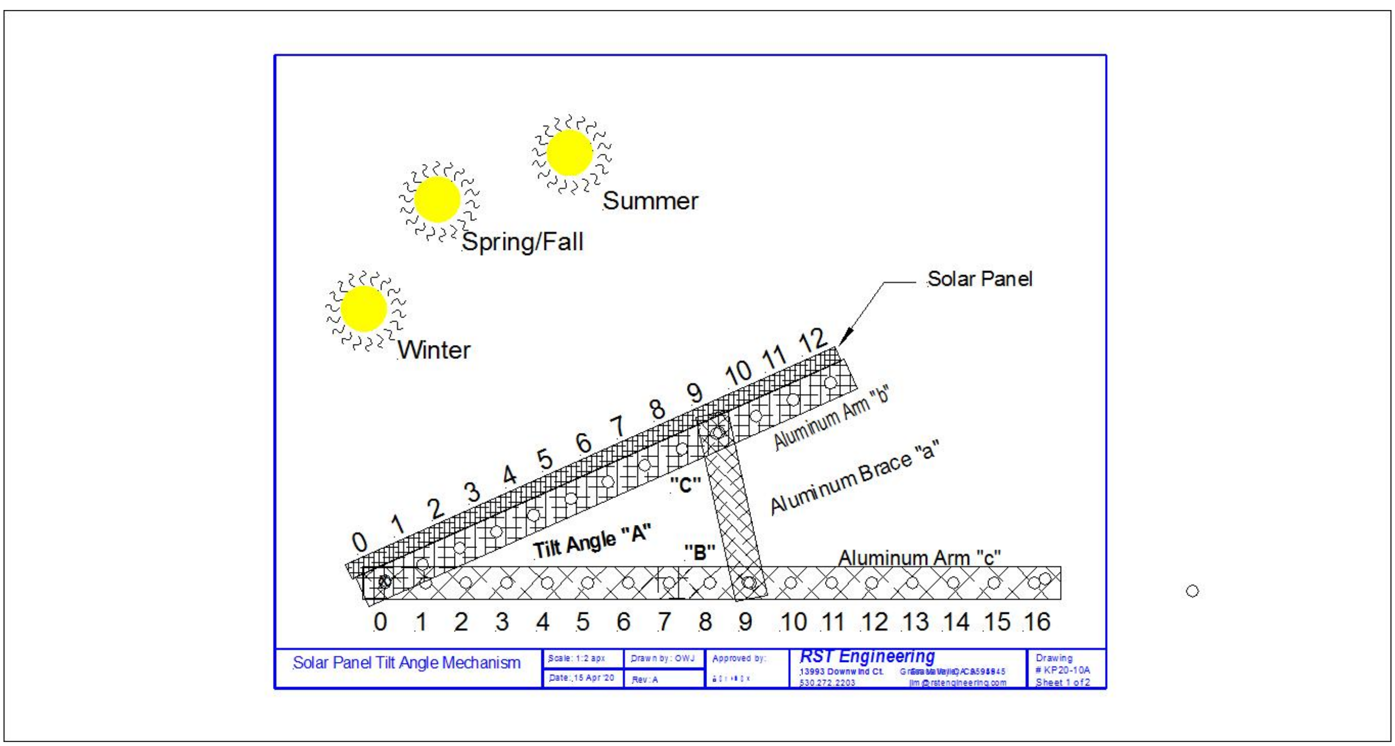
Not only that, but the hardware was stainless steel. There is a caveat in the installation manual that cautions that stainless has a nasty tendency to gall and freeze over time. According to the manual, you are supposed to use antiseize on the stainless threads, but those of us who have been using antiseize (both the graphite and copper-loaded versions) know how messy that stuff is on spark plug threads inside the engine head. You can only imagine how messy it is on threads exposed to the environment. I used plain old galvanized hardware with galvanized nylon insert locknuts and galvanized washers. I will probably redo the hardware on 10 year intervals as the galvanize slowly wears off.

So, you have one 28" long leg made of 1" x 2" x 0.12" aluminum angle bracket material that fastens onto the solar panel with hex head galvanized steel bolts, flatwashers, and galvanized steel nylon insert locknuts. There are holes on both sides of this bracket, one for attachment to the solar panel and one for attachment to the "brace" (see below). These holes are spaced on 1.5" centers. We will call this leg "c"

Then, fastened to the bottom end (and it is arbitrary which end you call "bottom") is a 22" long pivot arm reasonably allowed (but snug) to rotate from flat against the solar panel (0° pitch angle) to vertical (90° pitch angle). Holes as in the long leg above and on the same centers. One of these hole patterns is going to be used to fasten your solar panel to your roof and the other one will be attached to the brace. This is leg "b".

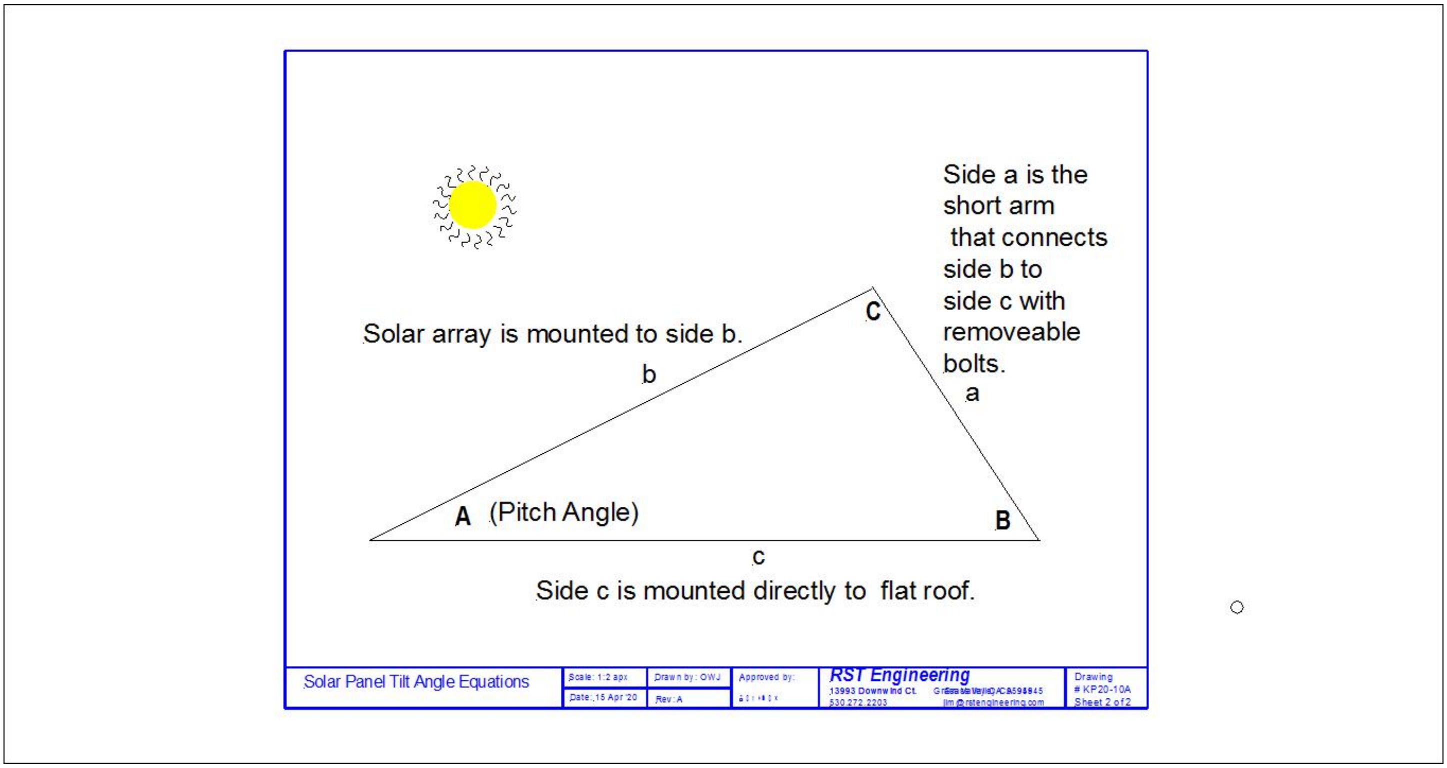
One more piece and our triangle is complete. There is an 11" brace made from ¾" x 1¼" angle aluminum with two holes on 10¾" spacing. This brace will be vital to our calculation of pitch angle. I'm not a mechanical engineer, just a poor electronic hack. Some ME is going to have to explain to me why I wouldn't use the same heavy angle material on the brace as on the other two arms. Seems to me the brace is taking the brunt of the stress. This is leg "a"

Schematically, this is what our triangle looks like:



Now, on to the mathematics to make that Tilt Angle "A".

From a math point of view, this is what our triangle looks like:



We have the side that is connected to the roof, and we call it "c" where c is measured in inches (or centimeters, or cubits, or anything you want, just use the same units for all three sides). We have side "b" that is bolted to the solar panel, and we have little side "a", the brace. What we really want to calculate is angle A, the pitch angle. We can also calculate angles B and C without too much extra math and you might just want that information for your records.

You may be a math wiz and the term arc-cosine does not ruffle your feathers. You may have had trouble with freshman algebra and never wanted to see another equation in your life. We can accommodate all in this explanation.

One perfectly understandable definition: arc-cosine, arc-cos, and $\cos^{-1}$ on your scientific calculator mean exactly the same thing. If you can't find $\cos^{-1}$ on your calculator, most any competent current 8th grader can find it for you. Don't worry about WHAT it does, just accept it as a modern miracle of electronics.

We have three measurements that we've taken. The lengths of a and b and c. Here is how to calculate A (Pitch Angle).

A (in degrees) = $\cos^{-1}((b^2 + c^2 - a^2) / (2 * b * c))$

Let's do an example to see how this works.

We number the holes that we can use on arms "c" and "b" from 0 (zero) to the maximum available on that arm. Let's say just for information that we use hole 9 on arm "c" and 7 on arm "b". With a distance of 1.5" between each hole center-to-center.

Length "a" = 10.75" (a constant from the two holes on the brace)

Length “b” = 7 * 1.5 = 10.5”

Length “c” = 9 * 1.5 = 13.5”

$a^2 = 10.75^2 = 115.6$ (a constant in all these calculations)

$b^2 = 10.5^2 = 110.3$

$c^2 = 13.5^2 = 182.3$

So, $(b^2 + c^2 – a^2) = 177.0$

And $(2 * b * c) = 283.5$

So $((b^2 + c^2 - a^2) / (2 * b * c)) = 0.624$

And using the handy calculator, $\cos^{-1}(0.624) = 51°$

So, using the “c9” hole and the “b7” hole as described above, the pitch angle is 51°

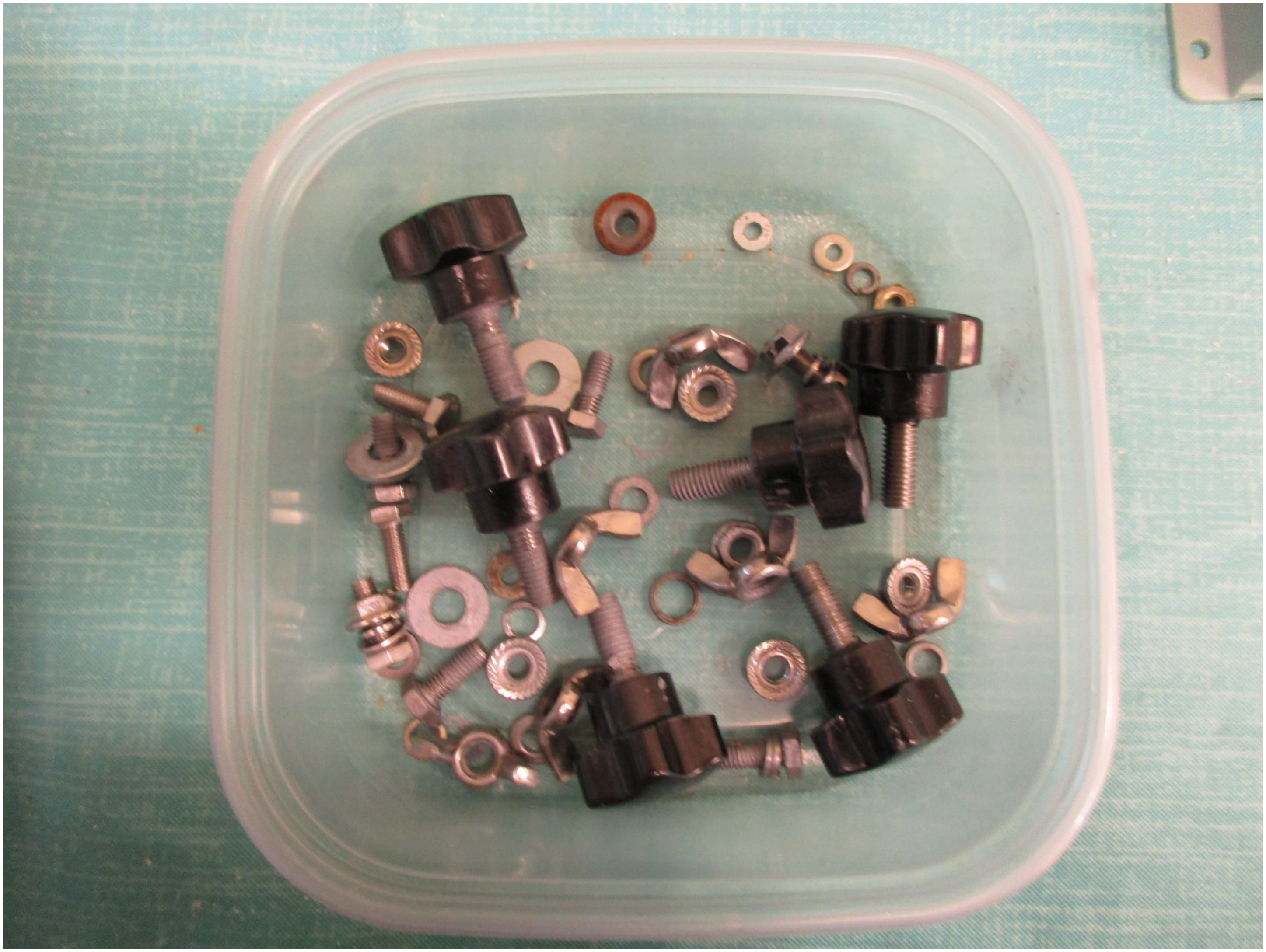
As best I can determine using lab instruments accurate to a tenth of a degree, this is exactly the pitch angle on my solar panel.

Of course, these calculations just took me half an hour to be sure I didn’t make a math or a calculator entry error. You only have to do it ONCE for your array, your latitude, and your magnetic deviation. But once is once too often when we now have wonderful things like spreadsheet calculators. That allows us to do “what if” I change holes, does that make it better. That spreadsheet is on this website.

Let me make a couple of observations.

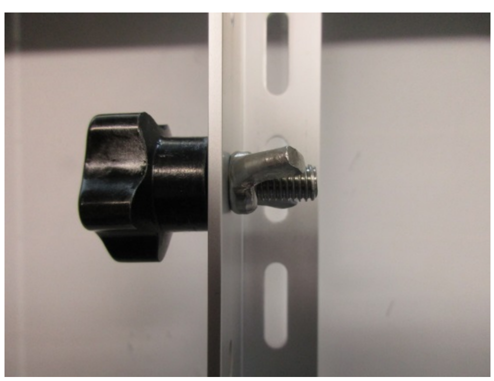
1. For high pitch angles (winter conditions with high winds) it is mechanically more robust to use “b” and “c” holes to be about the same on each arm, plus or minus two holes from each other.

2. You may wish to reconsider again what the brace material is. Again, I’m not an ME, but it seems to me that keeping the “a” brace angle nearly 90° between the b and c arms is best for the brace.



This image shows the wasted hardware that comes with this particular model of solar panel mount. I would really like to encourage providers of mounts to do three things:

1. Use Imperial-American hardware sizes;
2. Use plain old galvanized steel hardware instead of stainless;
3. Forget the fancy hand-wheel bolts …



…. and use plain old hex bolts you can turn with a wrench.

And finally, one last reminder:

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