Home Mining Technical Notes
Jon Wonsettler
@won4jon

Problems:

1. How do I know what my electrical capacity is for my house and how do I know how many miners my house can support?
2. How do I get the heat out of the house?
3. How do I mitigate the sound of the fans and not get in trouble with my wife?
4. What can I do to improve the longevity of my miners?



Part 1: How do I know what my electrical capacity is for my house and how do I know how many miners my house can support?

1. I performed a quick load study on my house. Turn on every major load in your house (oven, electric range, A/C units, lights, etc).
2. Go to your breaker panel and take off the panel cover (you will probably want to get an electrician for this).
3. Measure the incoming amperage of both hot phases with a clamp-on ammeter. Use the highest phase current reading in the following analysis.
4. Determine the available capacity by subtracting your highest phase current from the incoming protective device rating (ckt breaker/fuses). Multiply the result by 80%.
5. Avail. Capacity = 0.8 x (bkr rating - phase current).

6. I have a 200A panel and my load study reading was ~65 A. 0.8 x (200-65) is about 100 amps. This is my available capacity.
7. It's best practice to never design an electrical circuit over 80% load… especially a constant load circuit like a crypto miner. The duty cycle is 100%. This means it is ALWAYS on and running at max output. Not like a home computer that is off most of the day and runs at 20% even when in use.
8. Knowing that my house can support about 100A, I designed and installed a 100A sub panel in the basement room where I wish to set up my mining rigs. Ensure you oversize the wire gauge due to the duty cycle mentioned above. This is very important. Don't go cheap here. Even on the branch circuits, #12 minimum.
9. My miner of choice was the Antminer S19 by Bitmain. I won't go into the details why, I think there are many resources out there to help you make this decision.
10. The electrical requirements of the S19 are 240V and 13.5A (~3,200W). This allows me to have 6 total S19 miners in my 100A subpanel (13.5A x 6 = 81A… ~80% of available ampacity). This is the methodology on how to calculate how many miners you can support. If using a miner other than the S19, plug in the numbers and calculate.

Part 2: How do I handle the heat load?

1. My first attempt at running the S19 was in the unfinished portion of my basement. I figured the space was large enough to naturally dissipate the heat since the ambient temperature was 66F. The space is large (20'x60'), but not large enough.
2. The miner quickly increased the ambient temperature by 10^{o}F! Even though the space is large and cool, the exhaust heat doesn't have anywhere to go!
3. Consider this, the S19 consumes ~3,200 Watts of power to mine BTC. The vast majority of this power is converted into heat. This is the equivalent of having a 3KW space heater in a room. It's gonna get hot! And this is only with one miner… I designed the electrical for 6!
4. It didn't take long to realize I must get the exhaust out of the house. Back to Google to research how mining farms exhaust the heat out of their buildings.
5. I learned industrial miners use the concept of a cold aisle and a hot aisle. The cold aisle uses relatively cool air (doesn't need to be air conditioned, just <u>not hot</u>). The miners then exhaust into the hot aisle and get blown out of the building. But a home is not conducive to the hot/cold aisle theory.
6. This led me to the "hotbox" concept. If I could develop an insulated box to exhaust the hot air into, then I could contain the heat and blow it out of the house. I decided to use a 2"x4" frame insulated with Owens Corning 2" F250 XPS Foam insulation. Mainly because of its R value of 10 and I work at the plant… so I can get it cheap!
7. Once constructed, I cut holes in the box just large enough to stick the S19 and its power supply thru.

8. The HotBox allows the miners to breathe cool air and exhaust the hot air into the insulated box. Then an exhaust fan will pull the hot air out of the box and blow it out of a basement window.
9. HotBox design criteria: I knew the HotBox needed to be large enough to accomodate 6 miners. I initially struggled to find S19 data related to air flow. I knew I needed to at least pull as much air out of the HotBox as the miner pushed into it, otherwise the box would build pressure. So I decided to buy a 6" duct fan that has 350 CFM of air flow.
10. I have since found data from a replacement fan datasheet that one S19 fan is rated for ~250CFM. The S19 has two inlet fans and two exhaust fans. I brushed up on my centrifugal fan knowledge and recalled that fans in series do not increase CFM, they increase pressure. And fans in parallel do not increase pressure, they increase CFM.
11. Looking into the S19 fan and heat sink section, it is difficult to know what the exact air flow is since the fans are both in series and in parallel. I estimate the air flow is around 400 - 500 CFM. This seems to follow my indications that I am pressurizing the HotBox since any small leak seems to have air coming out vs flowing in. This corresponds with 400 - 500 CFM in and 350 CFM out.
12. I bought a differential pressure meter and found a way to mount it on the hotbox. I confirmed my gut was right and learned I have a slight positive pressure in the hotbox (+0.44" H2O differential pressure). This is not ideal. Additional exhaust airflow is required. When I installed the 2nd S19, I also bought an 8" fan with ~800 CFM. Now I had ~1,000 CFM in and ~1,200 CFM out. This slight negative pressure is perfect for miner temperature and overall system balance.
13. The HotBox needs to be as sealed well as to not let the hot air find its way back into the room. I used aluminum duct tape to seal the inside of the HotBox with the lid off. Then with the lid installed, I taped the outside of the lid to ensure she was as pressure tight as possible. This seemed to work well.
14. The most important area to tape well is the outside of the miner where she penetrates the HotBox :). If air leaks out here, it will be pulled by the fans back through the miner. This "thermal short-circuit" is very detrimental to our cause. The miner internal temperature spikes instantly if not sealed up properly. The aluminum tape did a great job here.
15. In terms of air exhaust (aside from the blower previously mentioned), I prefer to use an insulated duct. This really helps to keep any hot exhaust from influencing the room's ambient temperature.
16. I removed the existing window and for safety reasons, installed a piece of hard maple and anchored it to the window frame. Then with a 6" flange, I connected the exhaust duct to the maple with a 6" hole so I could get the heat out of the house. The other end of the duct is connected to the outlet of the blower. The blower is pushed into a 6" opening in the top of the HotBox. This method was duplicated with the 8" blower as well.
17. Next step… recycling the hotbox exhaust heat to heat the house in the winter.

Part 3: How do I mitigate the sound of the fans and not get in trouble with my wife?

1. My original location had the miner in the unfinished part of the basement, it was directly under a two story foyer which has hardwood floors. This meant the sound propagated up through the floorboard, through the hardwood floor and into the foyer. The high pitched fan hum could be heard upstairs in the hallway.
2. Needless to say, the Mrs. wasn't happy. She's a trouper though. Her direct quote was "you know that obnoxious sound coming from the basement can't be like that forever don't you? I'm trying to remain calm, because I know you will make it right." LOL.
3. The room I moved into has carpet and a drop ceiling. Both are critical to keep sound waves from bouncing around.
4. The S19 has a dB rating of 81 dB @ one meter. Decibels measured at the door were 67 dB with the miner blowing into the hotbox. Down from 70 dB with the miner sitting on the floor (no HotBox)
5. Once I installed the filter box (described in the longevity section below) dB @ the door was lowered to 57 dB. Now you cannot hear the miner upstairs at all. Needless to say, the Mrs is happy with the results.

Part 4: What can I do to improve the longevity of my miners?

1. Basic electronics reliability theory: keep the equipment dry, cool and clean. This will do a mining computer well.
2. Keep the miner dry: If the miner is getting wet, you have other problems. But we do need to consider humidity. Since I am in the basement, I measure a relatively constant humidity @ 40%... not too bad.
3. Keep the miner cool: the HotBox described above seems to work well here. An old reliability concept regarding failure rates is MTBF (Mean Time Between Failures). Studies have shown that temperature increases of 10º C above 20º C ambient (70º Fahrenheit) reduce long-term electronics reliability by 50 percent.
4. For example, imagine a power management product designed to run in environments up to 50º C with an MTBF of, say, 20,000 hours. Operating at 60ºC will effectively cut its life in half. Alternatively, if the environment were cooled to 40ºC, the MTBF could be extended to 40,000 hours.
5. Keep the miner clean: I built a filter box to lay over the miner that works well to keep any foreign material out of the fans and heat sinks of the S19. The idea is to have a filter box that is able to be removed any time so I can inspect the miner, but protects the miner from dust and dirt at the same time.
6. I ended up with a box that contains a 10" x 20" x 1" MERV 5 filter that seems to filter out contaminants well but doesn't restrict air flow. The Filtrete 3M filter is rated for 600 CFM at max pressure drop… just right for my 400 - 500 CFM S19.

7. The devil is in the details: Remember to seal the joints of the filter box with aluminum duct tape. I used a foam window seal on the back of the box that pressed up against the HotBox to make a good seal… no leaks!
8. Also, cut small holes to get the CAT6 and power cables out. If not, that is another way for air to short circuit the air filter and have a negative impact on miner reliability.

https://support.bitmain.com/hc/en-us/articles/900000554406-Mining-Farm-Operation-and-Maintenance-Teaching-Materials

Good luck, keep improving the system and remember to get an electrician to help you!