R/V Thomas G. Thompson Voltage Notching Issue Update

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Timeline

- Dec 2017 − Mid-life refit & repowering complete
- Feb 2018 − transit to Auckland, NZ
- Mar 2018 −
  - First cruise, JASON onboard − electrical problems with JASON systems
  - Onload deck generator to provide dedicated power to JASON
  - Ockerman rep onboard for assessing power quality
- Apr 2018 − Vigor summary of issues
  - Recommend installation of 15 tuned line filters (“lineators”)
- June 2018 − Ockerman Power Quality Report
- Aug 2018 − installed 5 lineators during Kaohsiung port call Nov 2018
  - had to use a portable generator on deck again for Sikes cruise
  - Dynacon winch couldn’t work with lineator L-13 - too much voltage drop
- June 2019 − planning for install of remaining lineators

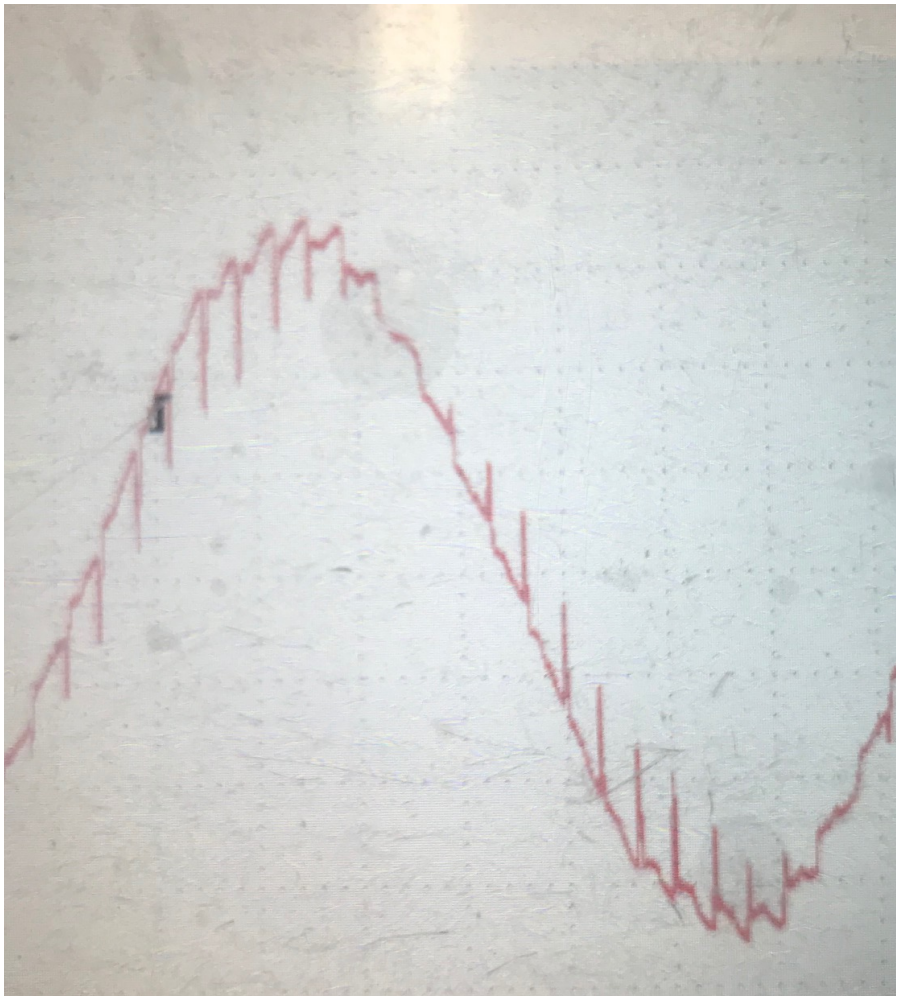
Problems encountered during transit to NZ & Brothers Volcano Cruise

- Science UPS unusual behaviors
- Coffee maker control board 120v
- UV Sterilizer boards 120v (at power input to main ctrl circuit board)
- Welding machine 480v
- Elevator Power supply 480v
- RO Watermaker Dump solenoid coil
- Aft Deck Halogen light transformer 120v
- JASON air conditioner controller (sourced from 480)
- JASON winch solenoid coil for brake (reported) (sourced from 480)
- Winch room Fan motor (480v)

Ockerman Assessment

- The harmonic distortion measured on the vessel under varying conditions during sea trials and on the latest science mission indicates relatively low %Vthd at the 480V ship service bus.
- The notches measured in the attached waveform *IMG_2382.jpg* are the most likely source of power quality related equipment problems**. The notches are sensed by the harmonic measurement equipment but only in a very high frequency range and add just a little bit to a total harmonic distortion**. By their nature the notches are not harmonics, they are transients, However, they are repeating transients. In this regard, the attached original spec*S03-Repower Performance Specification RevB.pdf* requires voltage transient tolerances of +/- 16% with recovery time of 2 seconds. The measured transients appear to be within this spec.
- The **notches observed are not unusual and typical with an SCR drive system thus the need for a separate clean power source for sensitive consumers**.
- Based upon review of the P614, P615 loads, there are a number of different consumers which most likely interact with each other. For instance, the ROV 3 phase electronic power converters and VFDs will likely generate some electrical noise. Noticeable sensitive loads are the tool van loads which are supplied through a 30A breaker with typical operating currents of 10A. Everything else, HPU, VFDs, soft starters, etc. should cope unless they are interacting with each other. If so, this should be taken care of by their suppliers . All of these loads are supposed to be designed for marine environment and be properly protected. Again, the only sensitive loads on the list are the van tools which could be protected with separate small filters.

Voltage Notching



Ockerman on Voltage Notching

- DC drives technology is well known and understood. They are very simple and reliable . DC drives create harmonic distortion in the power system. Harmonic mitigation is always required in the systems with large DC drives**. One of the main disadvantages of DC drives is a notch phenomenon**. The nature of this phenomenon is connected to thyristor **commutation when one thyristor in one phase is opening but another thyristor in a different phase is not closed yet** . The severity of the notch problems depends on the system parameters and it is very difficult to reliably evaluate it in advance. In most of the cases, standard electrical equipment tolerates notches well except when the notches are really deep and they create additional zero crossings in voltage waveform. In this case some electronic equipment might malfunction.

- It is important to emphasize that DC drive **harmonics and notches** have different nature and physically **are different phenomena**.

Lineator Details

Lineator No.	Priority	Circuit	Load Description	Breaker Trip Rating	FLA	Voltage	Freq	Lineator Input A Rating	Weight	Dimensions	Suggestion
L1-A	Med	P413-1	Staging Bay Receptacle	60A	48A	480V	60HZ	57A	186 LBS	29.5"H x 13.25"W x 12.75"D	Science Hold,Location 7
L1-B	Med	P413-11	Main Deck-Port Receptacle / Jason Van	60A	48A	480V	60HZ	57A	186 LBS	29.5"H x 13.25"W x 12.75"D	Science Hold,Location 7
L2	High	P414	Port Portable Deck Crane Receptacle	80A	64A	480V	60HZ	69A	218 LBS	34"H x 20.25"W x 16"D	SCR Rm, Location 1
L3	Very High	P415	Stbd Portable Deck Crane Receptacle	80A	64A	480V	60HZ	69A	218 LBS	34"H x 20.25"W x 16"D	SCR Rm, Location 1
L4	High	P419-7	Bow Thruster Rm Power Panel	40A	32A	480V	60HZ	34A	142 LBS	29.5"H x 13.25"W x 12.75"D	Bow Thruster Rm. Location 3
L5		P423-9	HVAC Panel P423	15A	12A	480V	60HZ	12A	78 LBS	23.5"H x 11.25"W x 11.25"D	Upper Engine Rm. Aft, Location 4
L6	High	P423-11		15A	12A	480V		12A	78 LBS	23.5"H x 11.25"W x 11.25"D	Upper Engine Rm. Aft, Location 4
L7	High	P423-12		15A	12A	480V		12A	78 LBS	23.5"H x 11.25"W x 11.25"D	Upper Engine Rm. Aft, Location 4
L8		P426	Workshop Power Panel	150A	120A	480V	60HZ	141A	345 LBS	34"H x 20.25"W x 16"D	Science Hold, Location 5
L9	Med	P430	Clean Power Stbd Bus Tie	320A	240A	480V	60HZ	281A	578 LBS	45"H x 26"W x 25"D	Science Hold, Location 5
L10	Low	P418-5	Pauluhn Plug	25A	20A	480V	60HZ	23A	118 LBS	29.5"H x 13.25"W x 12.75"D	Location 6, Galley Plenum
L11	Low	P420a	120V transformer	113A	90A	480V	60HZ	113A	323 LBS	34"H x 20.25"W x 16"D	
L12	Very High	T3-CB1**	Aft Deck Science Power	400A	320A	480V	60HZ	337A	585 LBS	45"H x 26"W x 25"D	Winch Room Stbd, Location 2
L13	Very High	T4-CB1*	Aft Deck Science Power	200A	160A	480V	60HZ	169A	365 LBS	40"H x 22"W x 23"D	Winch Room Stbd, Location 2
L14	Very High	T4-CB2*	Aft Deck Science Power	100A	80A	480V	60HZ	85A	304 LBS	34"H x 20.25"W x 16"D	Winch Room Stbd, Location 2

Lineator List

- 12A, 480V, 3PH, 60HZ – L5, L6, L7 – Engine Room
- 23A, 480V, 3PH, 60HZ – L10 - Galley Plenum
- 34A, 480V, 3PH, 60HZ – L4 - Bow Thruster Space
- 57A, 480V, 3PH, 60HZ – L1A, L1B - Science Hold
- 69A, 480V, 3PH, 60HZ – L2, L3 - Aft Bos'n Locker & Trawl Winch Space
- 85A, 480V, 3PH, 60HZ – L14 - Trawl Winch Space
- 113A, 480V, 3PH, 60HZ – L11 - Galley Plenum
- 141A, 480V, 3PH, 60HZ – L8 - Science Hold
- 169A, 480V, 3PH, 60HZ – L13 - Trawl Winch space
- 281A, 480V, 3PH, 60HZ – L9 - Science Hold
- 337A, 480V, 3PH, 60HZ – L12 - Trawl Winch Space

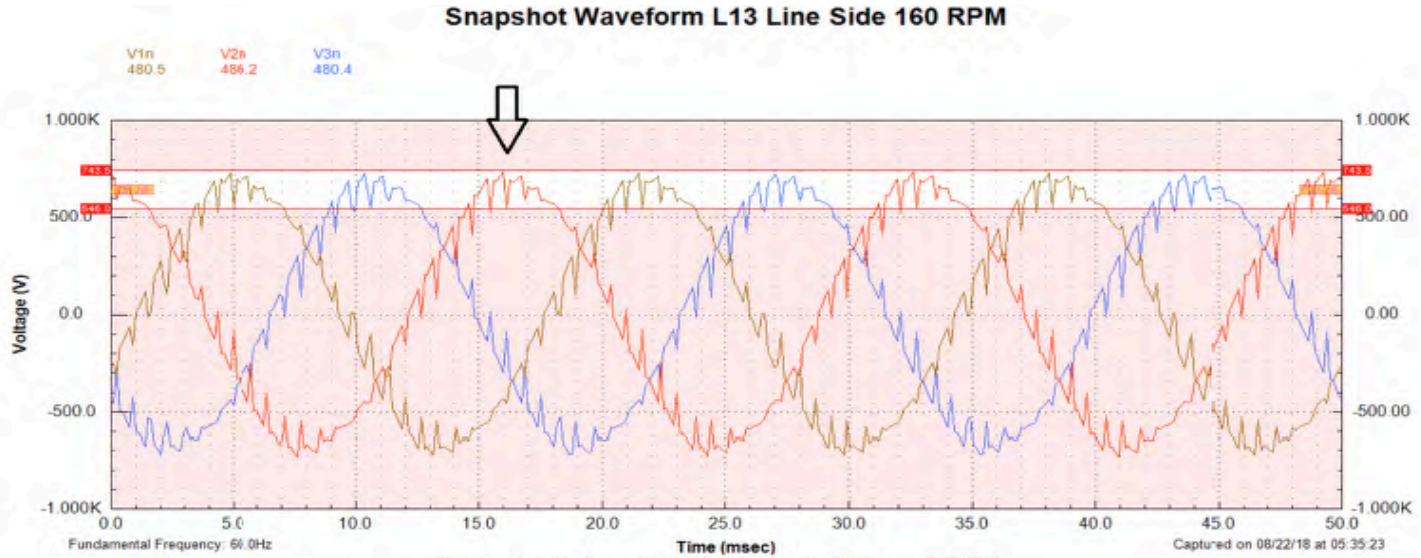
Green – Install Summer 2019
Red – Installed & Operating
Blue – Re-evaluating

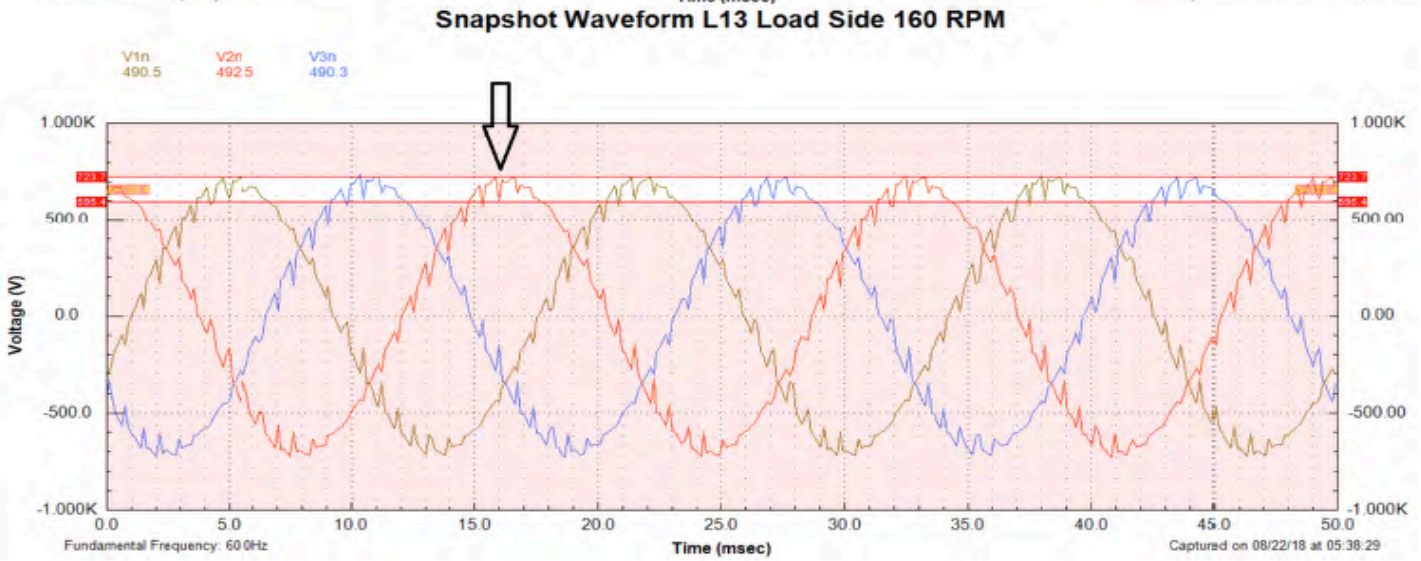
Winch Room Lineators

Summary of Results from First 5 Lineators Installed

- At each of the lineators locations and under each test condition, the voltage waveforms show significant improvement in reduced notch depth and measured harmonic distortion.

35% Notch Depth Reduction at L13 at 160 RPM





Outcomes / Future

- 5 circuits now improved
- 6 lineators to be installed June 2019
- Will develop guidance/specifications for science parties bringing electrical gear onboard