Table 15: Vendor parameter specification for SLED system.

Parameter	Value
Operating temperature	25°C
Operating frequency	2856 MHz
Unloaded Q	> 95,000
Coupling coefficient, β	5.0
Cavity mode	TE 0,1,5
Maximum peak power	300 MW
Pulse length (depends upon phase flip)	~ 1 μs
Repetition frequency (Maximum)	50 Hz
Average power	< 23 kW

The SLED system is tuned to operate precisely at the operating frequency. The tuning of the SLED system is done by the vendor with mechanical tuners to precisely set the operating frequency at the chosen operating temperature. The operating temperature is set to 25°C, which is maintained by one channel of the module chiller system (discussed in Section 4.4.2.3.6). This temperature setting is also used to fine tune the SLED system to assure it operates at the desirable performance. In addition, due to the high Q of the SLED system, a large temperature change of several degrees can be used to completely detune the system so that the RF pulse effectively bypasses the system. This SLED detuning may be useful for initial commissioning and diagnosis, but it is not used for regular operation in the VEGA system.

4.4.2.3.5 Klystron and modulator system

The purpose of the klystron and modulator system is to amplify a 4 μs pulse of lower power RF delivered from the low-level RF system, so that it has sufficient power for accelerating the electron beam in the LINAC. The klystron is a narrow band RF amplifier, and the modulator acts as a pulsed power supply to give the energy to the RF pulse. The pulse of RF travels to the SLED system described above, and then on to the accelerator structure system.

The klystron for the VEGA system will be a Canon/Toshiba amplifier (or equivalent) and is shown in Figure 34 with parameters following in Table 16. Further detail is available in the vendor spec sheet. The modulator for the VEGA system will be the Scandinova K-300 as shown in Figure 35. Main parameters for the modulator system are shown in Table 17.

Figure 34: LINAC Klystron.

Table 16: Vendor specifications for LINAC klystrons.

Parameter	**Value**
Frequency [MHz]	2856
Maximum peak output power	50 MW
Nominal RF Pulse length	4 μs
Maximum repetition rate	50 Hz
Maximum average output power	10 kW
LTI reference	SP000108

Figure 35: Scandinova Modulator K-300.

Table 17: Modulator parameters

Parameter	Value
Modulator peak power	110 MW
Modulator average power	32 kW
Operational voltage range	340 kV
Operational current range	360 A
PRF range	0-50 Hz
Pulse length (flat top)	0.1-4 μs
Top flatness	±0.1%
Rate of rise	250-325 kV/μs
Pulse to pulse time Jitter	<±5 ns
Pulse width time jitter	<±8 ns

The modulators operating at high power can cause electricity waveform distortions. The higher order harmonics can adversely affect other electronics connected to the same power line. To protect from this effect, active isolation AC filters will be added to the upstream of each modulator.

LTI will use commercial AC filters such as the ADF P100 by Comsys (see Figure 36 below) or equivalent. They have all the essential features needed, including dynamic VAR compensation, harmonics elimination as well load balancing. The key specifications of the ADF P100 are shown in Table 18 and meet the requirements for this application.

Figure 36: Comsys ADF P100, actively compensated AC filter.

Table 18: Comsys ADF P100 Technical Specifications.

Model	**ADF P100-75/480**	**ADF P100-90/480**	**ADF P100-120/480**
Rated power *	52 / 62 kVA	62 / 75 kVA	83 / 100 kVA
Compensation current capacity at 50/60 Hz	75 ARMS	90 ARMS	120 ARMS
System voltage (± 10 %)	480 V (208 – 480 V)		
Number of phases	3 phase 3 wire		
Harmonic current compensated	individual compensation up to 49th order		
Rate of harmonic reduction	better than 98%		
Current compensation of cos φ	up to 1.0		
Response time	< 1 ms		
Power dissipation	< 2535 W	< 3180 W	< 3155 W
Operating temperature	0 to 50 °C, up to 40 °C without derating		
Certificates	CE, ABS, DNV GL		

4.4.2.3.6 Precision cooling

Most of the cooling of the VEGA systems is performed utilizing the house water system described in Sections 4.4.9.2 and 6.6. However, specific devices that store RF energy must be controlled to higher precision (±0.05° C) and therefore have dedicated chillers for this precise control. In the case of the LINAC module, the accelerator structures and the SLED system must have precise temperature control. The requirements for these systems are shown in Table 19.

Specific multichannel chillers have been specified for each of the modules in the LINAC. One of these chillers is shown in Figure 37. A chiller like that shown is presently used for the Lyncean CLS product. The parameters for the chiller are shown in Table 20. In each module, each pair of structures has a dedicated channel (loop 1 and loop 2) and the SLED system has a dedicated channel (loop 3). The klystron, modulator, waveguide system and loads are cooled with house water as discussed in Section 6.6.

Table 19: RF heat load and cooling of SLED and accelerator structures

Module Component	**Operating Temperature**	**Heat load to H_2O (Maximum)**	**Temperature Precision**
SLED	25°C	2.06 kW	±0.05° C
One accelerator structure	25°C	1.125 kW	±0.05° C
One accelerator load	House Water	<1.0 kW	±2° C
LTI Reference		TN000288	