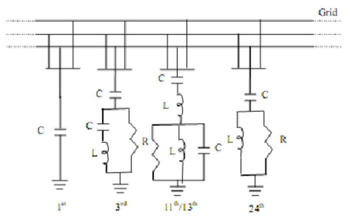
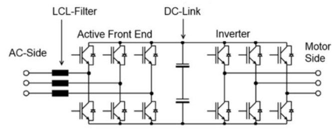
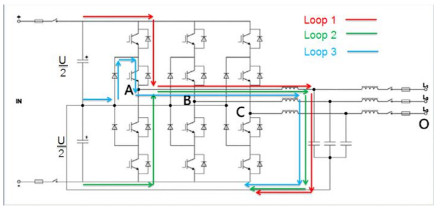
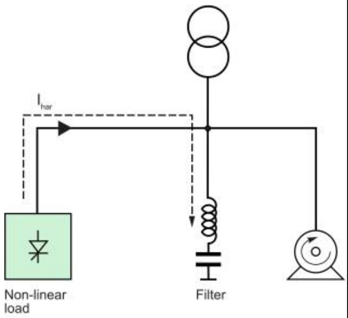
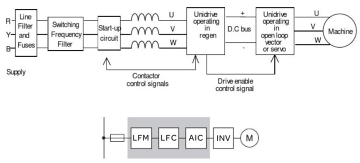
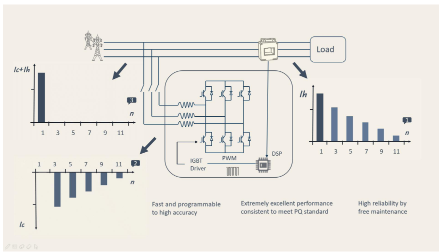
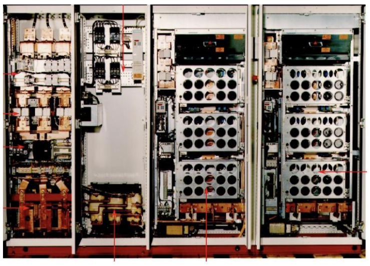
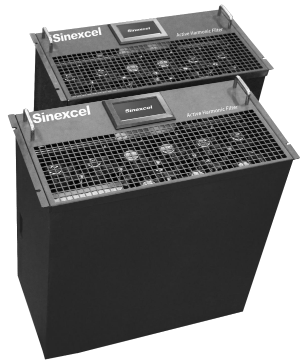
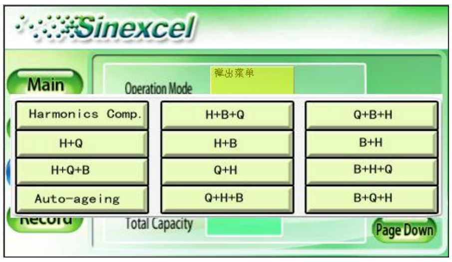
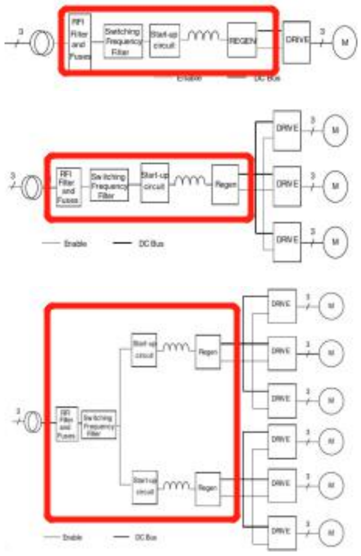
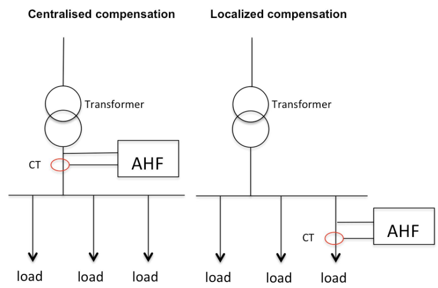
	Passive Filter	Active Front End	Active Harmonic Filter
Topology			
	Passive filters are built using a series of capacitors and reactors forming an LC circuit in parallel with the power source, some of which may also include a resistor. It absorbs th e harmonic current to which it is tuned.	In a regular variable speed drive, the rectifier is controlled through diodes. With an AFE these are replaced with an active, generally IGBT based, controlled rectifier. Including the active rectifier, DC energy storage, and the inverter..	The rectifier and inverter part are integrated together. Using intelligent electronics and IGBTs to inject corrective current into the power system to correct for the harmonics generated by non-linear loads.
Connection	Parallel	Series	Parallel
Working Principle			
	The impedance of passive filters varies with the current frequency. At a certain frequency like 150Hz (3rd order harmonic), passive filter impedance appears to be low, near zero.So the 3rd harmonic current will flow into the filter bypass, and be mitigated from the grid.	AFE rectification feedback unit provides sinusoidal voltage output AFE feedback voltage is integrated into the grid through input reactance Afe feedback output sinusoidal voltage through LCL filtering Afe feedback output sinusoidal current through LCL filtering	External CT detects the load current and sends the current information to inner DSP. DSP analyzes and calculate harmonic content of the load current. Then DSP controls the IGBT turning off and on to generate the opposite direction harmonic current to realize the compensation.

Footprint		  	   
	The inductors and capacitors are large and heavy, taking up much space.	AFE has three individual parts: LFM, LFC, AIC. Each of these parts needs a cabinet. With extra cabinets, it becomes physically larger and expensive, if manufacture requires to reduce the ripple current by increasing the switching frequency. It requires a dv/dt filter to avoid ripple and protect the motor/ load.	Both rack mount and wall mount Dimension: Smallest: 440x470x150mm (25A/35A module) Largest: 500x510x270mm (150A module) Weight: Lightest: 18kg (25A module) Heaviest: 48kg (150A module) A cabinet for AHF has a maximum capacity of 750A with high energy density.
Investment cost	Low	High	High

<table>
<tr><td rowspan="2">Operating cost</td><td>High</td><td>Medium</td><td>None
(No extra maintenance cost)</td></tr>
<tr><td>Capacitors are easily to blow or swell under high voltage harmonic situation, asking for extra cost on capacitors and human resource.</td><td>AFEs are series in the grid. Once broken down, the following power line will be shut down. The chain reaction could cause much trouble and cost.</td><td>With modular design, AHF is much more convenient for maintenance. If one module shut down, the system will continue to operate.</td></tr>
<tr><td rowspan="2">Resonance</td><td>Large possibility</td><td>Possible</td><td>Remote possibility</td></tr>
<tr><td>Passive filters can result in a parallel resonance viewed from the load and a series resonance viewed from the AC source.</td><td>There is a LCL-filter part in AFE which can possibly cause resonance.</td><td>Sinexcel AHF uses intelligent FFT algorithm. AHF can learn the impedance of system and to avoid resonance point. If the resonance point changes, AHF is also able to adapt to the change.</td></tr>
<tr><td>Efficiency</td><td>Low</td><td>93%~94%</td><td>>97%</td></tr>
<tr><td></td><td>Electric power turns into heat on resistance, wasting energy.</td><td>There are LFM, LFC and AIC modules and they will consume extra energy.</td><td>AHF combines rectifier and inverter together in one circuit which significantly saves energy.</td></tr>
<tr><td rowspan="2">Function</td><td rowspan="2">Harmonic mitigation for only selected orders of harmonic current</td><td rowspan="2">Harmonic mitigation (only for low order harmonics)
Power factor from 1.0 capacitive to 0.8 inductive
Energy feed back relying on 4-quadrant operation</td><td>Harmonic mitigation (from 2^{nd} to 50^{th} orders)
Power factor from 1.0 capacitive to 1.0 inductive
3-phase load balancing</td></tr>
<tr><td>Up to 12 working modes including different priorities and different combinations for “harmonic compensation”, “power factor correction” and “3-phase load balancing”.


(Different combinations represent different priority. e.g. the combination of H+Q+B means preferential harmonic compensation, then reactive power, and three-phase imbalance; H+B+Q means preferential compensation of harmonics, then three-phase imbalance, and reactive power; mode H means sole compensation of harmonics, Q+H means preferential compensation of reactive power, and then harmonics compensation.)</td></tr>
</table>

Switching frequency	/	From 1.5kHz to 5kHz	Average 20kHz, maximum 35kHz
Sizing & Calculation	Complicated.	A little complicated.	Simple.
	Calculation varies in different points of the power net. Also, one set of passive filter only eliminates a certain order harmonic. When the system contains harmonics of different orders, multiple sets of passive filters are needed. Much simulation work is also needed.	AFE capacity must go with VFD capacity and cannot affect the power consuming of following circuit. 	Only need the load current or VFD capacity. Localized compensation and centralized compensation available  Centralised compensation solution: $I_h = THD_i \times \frac{I_{rms}}{\sqrt{1+THD_i^2}}$ $I_h = K \times \frac{S}{\sqrt{3} \times U} \times \frac{THD_i}{\sqrt{1+THD_i^2}}$ Localized compensation solution: $I_h = K \times I_n \times \frac{THD_i}{\sqrt{1+THD_i^2}}$
Performance	THDi 5%~10%	THDi < 5%, commonly 6% ~ 9%	THDi < 5%
	A set of passive filter can only mitigate harmonic of one particular order. But the system consists of harmonics in many different orders and multiple sets of passive filters are needed which can probably cause resonance.	An AFE can reach IEEE519 standard only when working on full load rate, which actually is no need for VFD. The ripple current caused by lower switching frequency could affect other equipment. There's a chance that AFE will increase THDu	The switching frequency could up to 35kHz with less ripple current, the THDi always below 5% more and get IEEE 519 standard whatever working under low load rate or full load rate or voltage unbalanced condition.
Installation and Commission	Complicated	Complicated	Simple and Flexible.
	The system impedance changes and will affect the commission of passive filters.	AFE requires complete replacement of each existing drive and needs lots of wiring.	Outside wiring only needs the connection for CT wires and power wires. All commission work can be done with 6 hits on a touchscreen monitor.