

Industrial Femtosecond Lasers

FemtoLux Series

Award winning tools for micromachining applications







Industrial Femtosecond Lasers

SPECIFICATIONS AT A GLANCE

Not all output specifications may be available simultaneously. Please refer to the catalog page for exact specifications and available options.

Model	Available output wavelengths	Pulse duration ¹⁾	Max output power ¹⁾	Max repetition rate	Max pulse energy ¹⁾	Page
FemtoLux 50	1030 nm 515 nm 343 nm	400 fs – 1 ps	> 45 W (typical 50 W)	2 MHz	300 µJ	4
FemtoLux 30	1030 nm 515 nm 343 nm	350 fs – 1 ps	> 27 W (typical 30 W)	4 MHz	100 µJ or 1 mJ	4
FemtoLux 3	1030 nm 515 nm	300 fs – 5 ps	3 W	10 MHz	3 µJ	14
At fundamental wavelengt	'n					

Due to the constant product improvements, EKSPLA reserves its right to change specifications without advance notice.



Learn more about EKSPLA



Latest information about Industrial Lasers www.ekspla.com



Material processing examples Made with **FemtoLux** laser

Glass

Processing glass substrates presents significant challenges due to their fragility and susceptibility to cracking under excessive thermal loads.

Femtosecond lasers are ideal for processing glass substrates due to their ultra-short pulse duration that minimizes thermal accumulation, resulting in superior quality.



300 μm hole drilling in thin borosilicate glass. Courtesy of FTMC.



GHz burst assisted percussion drilling of high aspect ratio holes in EXG glass. Courtesy of Akoneer.



Fused-silica milling. Courtesy of FTMC.



Bottom-up milling of fused-silica glass. Courtesy of FTMC.



Femtosecond laser induced selective etching of bistable switch. Courtesy of Femtika.



UVFS milling. Courtesy of FTMC.



Laser-based Bessel beam scribing of soda-lime glass. Courtesy of FTMC.

Polymer

Polymers are widely used in various applications, including automotive, medicine, and consumer electronics. However, due to their inherent property of low heat conductivity, polymers are quite sensitive to heat.

Femtosecond lasers, with their very short pulse durations, offer a solution to this problem by enabling the precise machining of polymers while preserving process quality.



Photo-polymerization. Courtesy of Femtika.



Photo-polymerization. Courtesy of WOP.



Insulation layer removal from PCB. Courtesy of FTMC.



Polymide cutting. Courtesy of FTMC.

Material Processing Examples

Metal

Femtosecond lasers enable the production of complex shapes and features, while also providing the capability to perform black/white marking and coloring without the need for chemical additives.



Laser milled aluminium Fresnel lens mould, diameter 35 mm. Courtesy of FTMC.



Grid surface texturing with LIPSS of nitinol. Courtesy of UNIMORE.



Stainless steel cutting. Courtesy of FTMC.



Nitinol stent cutting. Courtesy of Vactronix Scientific



Stainless steel cutting. Courtesy of FTMC.



Black marking of tweezers. Courtesy of FTMC.



Stainless steel coloring with GHz burst feature. Courtesy of Akoneer.

Other materials

Femtosecond lasers, with pulse durations in the hundreds of femtoseconds, generate high intensities that make it possible to process almost material. Complex 3D structures, as well as non-conventional shapes can be obtained.



Crystalline silicon cutting. Courtesy of FTMC.



Crystalline silicon cutting. Courtesy of FTMC.



50 µm depth groove formation in ceramic. Courtesy of FTMC.



Optical 3D profilometer image showing milled square patterns in aluminum oxide ceramics.



SSAIL technology on PI. Courtesy of Akoneer.



Groove formation in GaAs in water environment. Courtesy of FMTC.



Heat-sensitive organic material cutting. Courtesy of FTMC.

*EKSPLA /3



Reliability Redefined

A reliable & versatile tool for micromachining

/ Glass, sapphire and ceramics micro processing

/ Microelectronics manufacturing

/ Glass intra volume structuring

/ Micro processing of different polymers and metals

/ LCD, LED, OLED drilling, cutting and repair



Industrial Dry Cooled Femtosecond Laser

FemtoLux

Designed from the get-go for maximum reliability, seamless integration and non-stop 24/7/365 zero maintenance operation with innovative "dry" cooling.

The FemtoLux femtosecond laser has a tunable pulse duration from <350 fs to 1 ps and can operate in a broad AOM controlled range of pulse repetition rates from a single shot to 4 MHz.

The maximum pulse energy is more than 300 μJ operating with single pulses and can reach more than 750 μJ in burst mode, ensuring higher ablation rates and processing throughput for different materials.

The FemtoLux beam parameters will meet the requirements of the most demanding materials and micro-machining applications.

Innovative laser control electronics ensure simple control of the FemtoLux laser by external controllers that could run on different platforms, be it Windows, Linux or others using REST API commands.

This makes easy integration and reduces the time and human resources required to integrate this laser into any laser micromachining equipment.

Seamless User Experience

Easy integration - remote control using REST API via RS232 and LAN.

Reduced integration time – demo electronics is available for laser control programming in advance.

Easy and quick installation – no water, fully disconnectable laser head. Can be installed by the end-user.

Easy troubleshooting – integrated detectors and constant system status logging.

No periodic maintenance required.

maintenance

Features

Typical max output power 50 W at 1030 nm, 20 W at 515 nm, 10 W at 343 nm

Typical max output energies > 300 μJ at 1030 nm, > 50 μJ at 515 nm, > 25 μJ at 343 nm

Up to 1 mJ high energy version available

MHz, GHz, MHz+GHz burst modes

> 750 µJ in a burst mode

< 350 fs – 1 ps

Pulse duration extension **up to 1 ns**

Single shot – up to 4 MHz (AOM controlled)

Pulse-on-demand (PoD), with jitter as low as 20 ns (peak-to-peak)

<0.5% RMS power long term stability over 100 hours

 $M^2 < 1.2$

Beam circularity > 0.85



Learn more about FemtoLux www.ekspla.com

Zero

"Dry" cooling



"Dry" Cooling Direct Refrigerant Cooling System

The FemtoLux laser employs an innovative cooling system and sets new reliability standards among industrial femtosecond lasers. No additional bulky and heavy water chiller is needed.

The chiller requires periodic maintenance – cooling system draining and rinsing and water and particle filter replacement. Moreover, water leakage can cause damage to the laser head and other equipment. Instead of using water for transferring heat from a laser head, the FemtoLux laser uses an innovative Direct Refrigerant Cooling method.

The refrigerant agent circulates from a PSU-integrated compressor and condenser, to a cooling plate via armored flexible lines.

The entire cooling circuit is permanently hermetically sealed and requires no maintenance.

Benefits

Military-grade reliability

Permanently hermetically sealed system >90,000 hour MTBF

No maintenance

High cooling efficiency

>45% lower power consumption compared to water cooling equipment

Compact and light





Simple & Reliable Cooling Plate Attachment

The cooling plate is detachable from the laser head for more convenient laser installation. The laser cooling equipment is integrated with the laser power supply unit into a single 4U rack-mounted housing with a total weight of 15 kg.



Integrated cooling equipment with the laser power supply



Simple and reliable cooling plate attachment



GHz Burst Option

Patent-Pending Method for Ultra-High Rate Bursts

Short GHz burst

Fig 1. Measured 2.2 GHz intra-burst PRR burst of pulses containing a different number of pulses of equal amplitudes at 31.5 W average output power



Long GHz burst

Fig 2. Measured 2.2 GHz pre-shaped bursts of 1000 pulses at 233 kHz burst repetition rate for the desired rectangular-like burst shape



Fig 3. Measured 2.2 GHz non-pre-shaped bursts of 1100 pulses at 233 kHz burst repetition rate



MHz + GHz burst mode

Fig 4. Measured 4 bursts of 50 MHz BRR containing 4 pulses of 2.5 GHz intra-burst PRR



Fig 5. Measured 10 bursts of 50 MHz BRR containing 10 pulses of 2.5 GHz intra-burst PRR



Benefits

The Femtolux laser can operate in the **single-pulse** mode, **MHz burst** mode, **GHz burst** mode, and **MHz + GHz burst** mode.

The burst formation technique based on the use of the AFL is a very versatile method as it allows to overcome many limitations encountered by other fiber- and/or solid-statebased techniques.

Any desired intra-burst PRR can be achieved independently from the initial PRR of the master oscillator

Identical pulse separation inside the GHz bursts is maintained

Short- and long-burst formation modes can be provided.

/ A short burst is up to about10 ns burst width (from 2 to tens of pulses in the GHz burst).

/ A long burst is from ~20 ns up to a few hundred ns in burst width (from tens to thousands of pulses in the GHz burst)

MHz+GHz burst mode

An adjustable amplitude envelope of the GHz bursts is provided

No pre/post pulses in GHz burst. Pure GHz bursts

Ultrashort pulse duration is maintained inside the bursts



A new versatile patent-pending method to form ultra-high repetition rate bursts of ultrashort laser pulses.

The developed method is based on the use of an all-in-fiber active fiber loop (AFL). A detailed description of the invention can be found on:

[1] Andrejus Michailovas, and Tadas Bartulevičius. 2021 Int. patent application published under the Patent Cooperation Treaty (PCT) WO2021059003A1.

[2] Tadas Bartulevičius, Mykolas Lipnickas, Virginija Petrauskienė, Karolis Madeikis, and Andrejus Michailovas, (2022), "30 W-average-power femtosecond NIR laser operating in a flexible GHz-burst-regime," Opt. Express 30, 36849-36862.

Specifications

Burst repetition rate	up to 650 l	kHz	
Intra-burst pulse repetition rate ¹⁾	2 GHz		
GHz burst mode	short	long	
GHz burst length	0.5 – 10 ns	20 – 500 ns	
Number of pulses ²⁾	2 – 20	40 - 1000	
Shape	square, rising, falling	falling, pre-shaped ³⁾	
MHz + GHz burst mode			
Number of pulses in MHz burst	2 – 10		
Number of pulses in GHz burst ²⁾	2 – 20		
 ¹ Custom intra-pulse PRR is available upon a request. ² Depends on the intra-pulse PRR. ³ For more information, please inquire sales@ekspla.com. 			

Principle of AFL Technology





Pulse-on-Demand (PoD)

Traditional laser triggering techniques struggle to maintain equally spaced pulses at high speeds (Fig.1, 2). Pulse-on-demand feature tackles this challenge and enables high-speed micromachining (Fig. 3).

Time based laser triggering

Fig 1. Complex shape scanned with time based laser triggering mode with a pulse repetition of 200 kHz and scanning speed of 6 m/s. The scanning started from the top right to the bottom right area. Overlapping pulses result in an overheated area.



Position based laser triggering

Fig 2. Complex shape scanned with position based laser triggering mode with a pitch of 30 μ m and scanning speed of 6 m/s. The scanning started from the top right to the bottom right area. Jitter of tens of μ s results in random pulse spacing.



Pulse-on-demand (PoD)

Fig 3. Complex shape scanned with pulse-on-demand (PoD) and position based laser triggering mode with a pitch of 30 μm and scanning speed of 6 m/s. The scanning started from the top right to the bottom right area. PoD feature preserves equidistant pulse spacing at high speeds.



Benefits

Jitter lower than 20 ns ensures consistent and equidistant pulse spacing for high-speed micromachining

Adjustable repetition rate for processing complex geometries

Faster processing speeds, increased productivity

PoD feature enables the laser to fire a pulse only when required, rather than at a constant rate, enabling precise control over the laser's output and resulting in higher efficiency, accuracy and quality.

This capability is especially valuable in various micromachining applications where a high processing speed, constant energy, and accuracy are essential. To follow complex curvature at high speed and to maintain equidistant spacing it is necessary to ensure that the repetition rate of the pulses is adjusted. To achieve these requirements, it is necessary to ensure that the repetition rate of the pulses is adjusted to follow complex curvature at high speed and to maintain equidistant spacing. One may try to use position based laser triggering but, due to laser system limitations, the jitter will be from several µs to tens of µs, which will result in random spacing of the pulses. On the other hand, the usage of time based laser triggering results in overheat areas, due to excessive overlap of pulses. The FemtoLux laser has the pulse-on-demand feature with jitter as low as 20 ns (peak-to-peak), and it can therefore tackle all the challenges and maximize process efficiency, precision and quality at high speed.

Specifications ¹⁾



Model		FemtoLux 30	FemtoLux 50		
Main specifications					
	fundamental	1030	nm		
Central wavelength	with second harmonic option	515	515 pm		
	with third harmonic option	3/3 nm			
Pulse repetition rate (PRR) ²⁾		200 kHz = 4 MHz 100 kHz = 2 MHz			
Pulse repetition frequency (PR	RE) after frequency divider	$PRF = PRR / N N = 1.2.3 \qquad 65000^{\circ} \text{ single shot}$			
Average output power	at 1030 nm ³⁾	> 27 W (typical 30 W)	> 45 W (typical 50 W)		
	at 515 nm	> 11 W ⁴)	> 20 W ⁵⁾		
	at 343 nm	> 6 W ⁴)	> 10 W ⁵⁾		
	at 1030 nm	> 100 µJ or 1 mJ ⁶⁾	> 300 µJ ⁷)		
Pulse energy	at 515 nm	> 55 µJ ⁴⁾	> 50 µJ ⁵⁾		
·	at 343 nm	> 30 µJ ⁴⁾	> 25 µJ ⁵⁾		
Number of pulses in MHz burst ⁸⁾		2 – 10			
Maximal energy in burst mod	e ⁹⁾	> 450 µJ	> 750 µJ		
Power long term stability (Std	. dev.) ¹⁰⁾	< 0.5 %			
Pulse energy stability (Std. de	V.) ¹¹⁾	<1%			
Pulse duration (FWHM) @ 1 MHz		tunable, < 350 fs ¹²⁾ – 1 ps ¹³⁾	tunable, < 400 fs 12 – 1 ps 13		
Optional pulse duration extension		tunable, u	ip to 1 ns		
Beam quality		M ² < 1.2 (typical < 1.1)			
Beam circularity, far field		> 0.85			
Beam divergence (full angle)		< 1 mrad			
Beam pointing thermal stability		< 20 µrad/°C			
Beam diameter (1/e ²) @ 1030 nm		2.5 ± 0.4 mm @ 65 cm			
Polarization		vertical			
Triggering mode		internal / external			
Pulse output control		frequency divider, pulse picker, burst mode, packet triggering, power attenuation, pulse-on-demand ¹⁴⁾			
Control interfaces		RS232 / LAN			
Length of the umbilical cord		3 m, detachable. Custom length option available			
Laser head cooling type		dry (direct refrigerant cooling through detachable cooling plate)			
Physical characteristics					
Laser head (W \times L \times H)		434 × 569 × 150 mm			
Power supply unit (W \times L \times H)		449 × 496 × 184 mm			
Operating requirements					
Mains requirements		100 – 240 V AC, single phase, 50/60 Hz			
Maximal power rating		800 W			
Operating ambient temperature		18 – 27 °C			
Relative humidity		10-80 % (non	-condensing)		
Air contamination level		ISO 9 (room	air) or better		
Due to continuous improvement, all to change without notice. Paramete specifications. They are indications c will vary with each unit we manufact	specifications are subject 7 At 100 kl rs marked typical are not 8 Oscillato f typical performance and 9 pulses.	Hz. r frequency ~50 MHz, ~20 ns separation between	DANGER: VISIBLE AND/OR INVISIBLE LASER RADIATION AVOID EVE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION CLASS 4 LASER PRODUCT		

to change without notice. Parameters marked typical are not specifications. They are indications of typical performance and will vary with each unit we manufacture. All parameters are specified for a shortest pulse duration. Unless stated otherwise, all specifications are measured at 1030 nm and for basic system without options.

- $^{\scriptscriptstyle 2)}$ $\,$ When frequency divider is set to transmit every pulse. Fully controllable by integrated AOM.
- 3) At 1 MHz.
- 4) At 200 kHz.
- 5) At 400 kHz.
- ⁶⁾ Other combinations of energy and repetition rate available.

- ⁸⁾ Oscillator frequency ~50 MHz, ~20 ns separation between pulses.
- ⁹⁾ MHz burst mode or MHz+GHz burst mode at 50 kHz PRR. $^{\scriptscriptstyle 10)}\,$ Over 100 h after warm-up under constant environmental
 - conditions.
- ¹¹⁾ Under constant environmental conditions.
- $^{\mbox{\tiny 12)}}$ At PRR > 500 kHz. At PRR < 500 kHz shortest pulse duration is < 400 fs.
- ¹³⁾ Custom pulse duration by request. For example fixed 50 fs available.
- $^{\mbox{\tiny 14)}}$ Optional feature. Jitter < 20 ns. Trigger-to-pulse delay < 1 $\mu s.$



Performance of FemtoLux 50



Fig 1. Typical dependence of output power and pulse energy of FemtoLux 50 laser at 1030 nm on pulse repetition rate



Fig 3. Typical M² measurement of FemtoLux 50 laser at 1030 nm



Fig 2. Typical FemtoLux 50 laser output pulse autocorrelation function at 1030 nm @ 1 MHz $\,$



Fig 4. Typical long term average power stability of FemtoLux 50 laser at 1030 nm under constant environmental conditions

Performance of FemtoLux 30











Fig 9. Typical M² measurement of FemtoLux 30 laser at 1030 nm



Fig 6. Typical dependence of output power and pulse energy of FemtoLux 30 laser at 515 nm on pulse repetition rate



Fig 8. Typical FemtoLux 30 laser (at 1030 nm) output pulse autocorrelation function



Fig 10. Typical pulse-to-pulse energy stability of FemtoLux 30 laser at 200 kHz over 30 000 pulses. RMS was calculated by using a set of mean values of 10 consecutive laser shots





Fig 11. Long-term average power stability of the FemtoLux 30 laser at 1030 nm under constant environmental conditions over an extended duration of 25,000 hours



Fig 13. Typical beam direction stability of FemtoLux 30 under harsh environmental conditions



Fig 12. Typical long term average power stability of FemtoLux 30 laser at 1030 nm under constant environmental conditions



Fig 14. Average output power dependance of FemtoLux 30 laser on ambient temperature at 1030 nm



FemtoLux with harmonics module and power supply

Drawings



Fig 11. FemtoLux laser head outline drawing





Fig 12. FemtoLux with harmonics module. Laser head outline drawing



Fig 13. Power supply outline drawing

Laser control application

Ekspla Control Application is a software tool intended for day-to-day routine operation control. It is used to control the laser in API level through LAN or RS-232 communication types, the control capabilities are stored in the laser system itself, software is self-adaptive to the system, one application can be used with multiple systems and can run on different platforms – be it Windows, Linux or others using REST API commands.







Applications

 / Inner volume marking of transparent materials
 / Marking and structuring
 / Micromachining of brittle materials
 / Photopolymerization
 / Photopolymerization
 / Ophthalmologic surgery
 / Biological Imaging
 / Pumping of femtosecond OPO/OPA
 / Microscopy

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1030 nm

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Microjoule Class Femtosecond Industrial Lasers

FemtoLux 3

FemtoLux 3 is a modern femtosecond fiber laser aimed for both R&D use and industrial integration.

Tunable pulse duration in a range of 300 fs – 5 ps, adjustable pulse repetition rate up to 10 MHz and adjustable pulse energy up to 3 μ J allows optimization of laser parameters for the desired application. These include marking and volume structuring of transparent materials, photopolymerization, biological imaging, nonlinear microscopy and many others. To expand the scope of applications even further this laser can be equipped with a second harmonics module.

With burst mode enabled, FemtoLux 3 can generate bursts of pulses with energy above 10 μJ which can significantly improve the efficiency of processes.

Having a rigid, compact, passive air-cooled laser head FemtoLux 3 can be integrated with different equipment, be it laser equipment for material micro-processing, microscopy or any other research equipment.



FemtoLux 3 laser with control unit

Features

Output power 3 W at 1030 nm, 1.2 W at 515 nm

Up to **3 µJ/pulse** and **10 µJ/burst** (at 1030 nm)

Up to **1.2 µJ/pulse** and **5 µJ/burst** (at 515 nm)

< **300 fs ... 5 ps** tunable pulse duration

M² < 1.2

Versatile laser control and syncronisation capabilities

Up to **10 MHz** pulse repetition rate

Smart triggering for synchronous operation with polygon scanner and PSO

Instant amplitude control

Passive air cooling of the laser head

* EKSPI

24/7 operation



Specifications ¹⁾

Model		FemtoLux 3		
Main specifications				
	fundamental	1030 nm		
Central wavelength	with second harmonic option	515 nm		
Minimal pulse duration (FWHM) at 1030 nm		< 300 fs (typical ~230 fs)		
Pulse duration tuning range		300 fs – 5 ps		
Maximal average output power ²	at 1030 nm	> 3 W		
Maximal average output power	at 515 nm	> 1.2 W		
Power long term stability (Std. dev.) 3)		≤ 0.5 %		
Maximal pulse energy 2)	at 1030 nm	> 3 µJ		
	at 515 nm	> 1.2 µJ		
Pulse energy stability (Std. dev.) 4)		< 2 %		
Pulse repetition rate (PRR) ⁵⁾	1 – 10 MHz			
Pulse repetition frequency (PRF) after freque	PRF = PRR / N, N=1, 2, 3, , 65000; single shot			
External pulse gating		via TTL input		
Burst mode 6)		1 – 10 pulses		
Max burst energy	at 1030 nm	> 10 µJ		
max barst energy	at 515 nm	> 5 µJ		
Burst shape control		via analog input		
Power attenuation		0 – 100 % from remote control application or via analog input		
Polarization orientation		linear, vertical		
Polarization extinction ratio		>1000:1		
M ²		< 1.2		
Beam divergence (full angle)		<1.0 mrad		
Beam circularity (far field)		> 0.85		
Beam pointing stability (pk-to-pk) 7		< 30 µrad		
Beam diameter (1/e ²) at 20 cm distance	at 1030 nm	2.0 ± 0.3 mm		
from laser aperture	at 515 nm	1.0 ± 0.2 mm		
Operating requirements				
Mains requirements	100-240 V AC, single phase 47-63 Hz			
Maximal power consumption		< 500 W		
Operating ambient temperature		15 – 30 °C		
Relative humidity		10 – 80 % (non-condensing)		
Air contamination level ISO 9 (room air) or better				
Physical characteristics				
Cooling of the laser head		air, passive		
Lacor boad size (Ly)M(yH)	at 1030 nm	459.5 × 362 × 111 mm		
	at 515 nm 615.3 × 362 × 139 mm			
Power supply unit size (LXWXH)	stand-alone	496 × 483 × 184 mm		
Power supply unit size (L×W×H)	19" rack mountable	548 × 483 × 184 mm		
Umbilical length		5 m		
Classification				
Classification according EN60825-1		CLASS 4 laser product		
 Due to continuous improvement, all specifications are subject to change without notice. Parameters marked typical are not specifications. They are indications of typ performance and will vary with each unit we manufactul See typical power and energy curves for other pulse repetition rates at Fig 1, Fig 2, and Fig 4. At 1 MHz PRR during 24 h of operation after warm-up upder coefficient and incompetition catter and the second seco	 At 1 MHz PRR under constant enviconditions. When pulse picker is set to transmire. Pulse separation inside the burst in Beam pointing stability is evaluate movement of the beam centroid in plane of a focusing element. 	ironmental hit every pulse. s about 20 ns. vid as a n the focal		

Performance











Fig 2. Typical dependence of output power and pulse energy of FemtoLux 3 laser at 515 nm on pulse repetition rate



Fig 4. Typical dependence of output power and pulse energy of FemtoLux 3 laser at 1030 nm when repetition rate is reduced by pulse picker. Internal repetition rate of the laser in this case is 1 MHz

Stability



Fig 5. Average output power dependance on ambient temperature at 1030 nm



Fig 6. Typical long term average output power stability of FemtoLux 3 laser at 1030 nm under constant environmental conditions



Fig 7. Typical M² measurement of FemtoLux 3 at 1030 nm (left) and 515 nm (right)



Fig 8. Typical beam profiles along propagation axis of FemtoLux 3 series laser



Drawings



Fig 10. Outline drawings of FemtoLux 3 laser head





Fig 11. Outline drawings of FemtoLux 3 laser head with second harmonic option



Fig 12. Outline drawings of FemtoLux 3 power supply and control unit

Ordering Information

Delivery	Products are made and dispatched within agreed term. Shipping charges are object of agreement between EKSPLA and customer.
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Specifations	Due to the constant product improvements, EKSPLA reserves its right to change specifications without advance notice.

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