20 Hz to 40 GHz

High-performance analyzers for digital mobile radio and universal applications

FSEM30 (photo 43421-2)

Brief description

FSEA, FSEB, FSEM and FSEK are advanced, high-speed and high-performance analyzers tailored to the requirements of modern digital communication systems. They can also be used as general-purpose analyzers for many applications. High measurement speed, modular design and excellent technical features make for an excellent price/performance ratio.

In addition to measurement functions for digital communication systems, such as 1 µs sweep time in ZERO SPAN mode, pretrigger and trigger delay, gated sweep and adjacent-channel power measurement, these spectrum analyzers feature a wide dynamic range, a very low measurement uncertainty of 1 dB and a low-noise synthesizer.

FSE analyzers have low inherent noise and a wide dynamic range, so that for instance measurement of GSM power ramps is no problem.

An extremely wide intermodulation-free dynamic range of 105 dB (with 10 Hz resolution bandwidth) ensures reliable measurements on highly linear amplifiers as well as correct analysis of broadband complex signals. From the available frequency ranges, the basic models 20 and the high-performance models 30 the right instrument can be chosen for every application. Models 20 can easily be upgraded to give almost the full range of functions of models 30.

To ensure correct measurement of time variants or pulse-modulated signals, the FSE features digital resolution filters (1 Hz to 1 kHz) with a response corresponding to that of analog filters. It additionally provides FFT bandwidths from 1 Hz to 1 kHz (models 30 or models 20 + FSE-B5).

Main features

- Resolution bandwidths 1 Hz (up to 10 MHz), adjustable in steps of 1/2/3/5
- Displayed noise floor down to –150 dBm (FSEA, RBW 10 Hz)
- 3rd-order intercept point typ. +18 dBm (FSEA)
- 1 dB compression point of RF input +10 dBm
- Phase noise at 10 kHz from carrier: typ. –123 dBc/Hz (FSEA)
- Intermodulation-free dynamic range 105 dB (RBW 10 Hz)
- Total measurement uncertainty up to 1 GHz: <1 dB
- Headphones connector and built-in loudspeaker for AM/FM
- Internal RF trigger for GATED SWEEP measurements
- High speed:
  - FULL SPAN sweep time is 5 ms (for FSEA or FSEB) with a fully synchronized sweep – added speed is not at the expense of frequency accuracy but even enhances it
  - Shortest ZERO SPAN sweep time is 1 µs (100 ns/div) – ideal for high-resolution measurements on pulse edges
  - More than 20 sweeps/s – an optimal prerequisite for fast alignments or applications in production

From AF to microwave

FSEM or FSEK allow with option FSE-B21 **frequency range extension by means of external mixers**. Continuous automatic signal identification, which is used to suppress unwanted image frequency bands and mixture products, ensures fast and easy measurements. Due to the built-in diplexer, three-port as well as two-port mixers can be used.

The external mixer measurement function features great ease of operation:

- Definition of frequency range and harmonics by selection of a waveguide band
- Definition of all important parameters for each waveguide band separately
- Frequency-dependent consideration of mixer conversion loss
- Storage of parameters on hard disk
- Frequency range extension through external mixers up to 75 GHz with options FS-Z60 (40...60 GHz) and FS-Z75 (50...75 GHz)

Measurement functions

- Up to 8 markers
- Marker functions for the direct measurement of
  - phase noise and phase power density
  - NEXT MIN/PEAK, NEXT MIN/PEAK RIGHT, NEXT MIN/PEAK LEFT
- Frequency counter with selectable resolution
- LOW NOISE, NORMAL and LOW DISTORTION modes to cater for low-intermodulation and low-noise operation
- Measuring curves printout in background operation or file saving in standard graphic formats
- Simultaneous display of four traces
- Selectable colour setup
- Numerous level and frequency lines
- Split-screen display with independent windows
- Frequency zoom
- Limit lines
- User-configurable menu and keyboard macros
- Adjacent-channel power measurement for up to 7 channels
- RMS detector

Operation

A combination of hardkeys and softkeys makes for extremely fast and easy operation. The operating convenience based on a wide variety of evaluation routines and marker functions can be accessed via the menus. There are no complicated tree structures by using menus of lateral structure and fixed control keys. Complete setups and traces, limit lines as well as macros can be stored on the hard disk or on floppy disks.

Overview of configurations and options

The analyzers of the FSE family are of modular design throughout. In the table below the right solution tailored to the needs of the various applications can be found.

Designation, characteristics (hardware)	Type	Order No.	FSEA 20	FSEA 30	FSEB 20	FSEB 30	FSEM 20	FSEM 30	FSEK 20	FSEK 30
7 GHz Frequency Extension	FSE-B2	1073.5040.02	○	○	●	●	–	–	–	–

Designation, characteristics (hardware)	Type	Order No.	FSEA 20	FSEA 30	FSEB 20	FSEB 30	FSEM 20	FSEM 30	FSEK 20	FSEK 30
Low Phase Noise and OCXO Typ. phase noise only –123 dBc (BW = 1 Hz, at 10 kHz from carrier), ideal for measuring phase noise of oscillators or adjacent-channel power of radio equipment	FSE-B4	1073.5396.02	❍	●	❍	●	❍	●	❍	●
FFT Filter (1 Hz to 1 kHz)	FSE-B5	1073.5544.02	❍	●	❍	●	❍	●	❍	●
Vector Signal Analyzer Demodulation of digitally modulated signals	FSE-B7	1066.4317.02	❍	❍	❍	❍	❍	❍	❍	❍
Tracking Generator (9 kHz to 3.5 GHz)	FSE-B8	1066.4469.02	❍	❍	–	–	–	–	–	–
Tracking Generator with I/Q Modulator (9 kHz to 3.5 GHz)	FSE-B9	1066.4617.02	❍	❍	–	–	–	–	–	–
Tracking Generator (9 kHz to 7 GHz)	FSE-B10	1066.4769.02	–	–	❍	❍	–	–	–	❍
Tracking Generator with I/Q Modulator (9 kHz to 7 GHz)	FSE-B11	1066.4917.02	–	–	❍	❍	–	–	–	❍
Switchable Attenuator for Tracking Generators FSE-B8/9/10/11 (0 to 70 dB)	FSE-B12	1066.5065.02	❍	❍	❍	❍	–	–	–	❍
1-dB Attenuator	FSE-B13[1]	1119.6499.02	❍	❍	❍	❍	–	❍	–	❍
Controller inclusive Mouse and Keyboard	FSE-B15[3]	1073.5696.06	❍	❍	❍	❍	❍	❍	❍	❍
Ethernet Interface AUI connector, 15 poles Thin-wire connector, BNC RJ-45 connector (Twisted Pair)	FSE-B16[2]	1073.5973.02 1073.5973.03 1073.5973.04	❍	❍	❍	❍	❍	❍	❍	❍
2nd IEC/IEEE-Bus Interface	FSE-B17[2]	1066.4017.02	❍	❍	❍	❍	❍	❍	❍	❍
Exchangeable Hard Disk	FSE-B18[3]	1088.6993.02	❍	❍	❍	❍	❍	❍	❍	❍
2nd Hard Disk to FSE-B18 (Firmware included)	FSE-B19	1088.7248.02	❍	❍	❍	❍	❍	❍	❍	❍
External Mixer	FSE-B21	1084.7243.02	–	–	–	–	❍	❍	❍	❍
Increased Level Accuracy up to 2 GHz	FSE-B22[3]	1073.5544.02	❍	❍	❍	❍	❍	❍	❍	❍
Broadband Output 741,4 MHz	FSE-B23[3]	1088.7348.02	❍	❍	❍	❍	❍	❍	❍	❍

1) In conjunction with option FSE-B22 only factory-fitted.

2) Options FSE-B16 and FSE-B17 require option FSE-B15.

3) Factory-fitted only.

Designation, characteristics (software)	Type	Order No.	FSEA 20	FSEA 30	FSEB 20	FSEB 30	FSEM 20	FSEM 30	FSEK 20	FSEK 30
Application Firmware for mobile radio transmitter measurements to GSM900 specs 11.20 (mobiles), GSM1800 and GSM1900	FSE-K10	1057.3092.02	❍	❍	❍	❍	❍	❍	❍	❍
Application firmware for mobile radio transmitter measurements to GSM900 specs 11.20 (BTS), GSM1800 and GSM1900	FSE-K11	1057.3392.02	❍	❍	❍	❍	❍	❍	❍	❍
Noise Measurement Software Noise figure or noise temperature measurement (Y-factor method) from 100 kHz, 2nd-stage correction, measurements on frequency converters, editor for ENR tables, consideration of isolator/cable attenuation, runs under Windows	FS-K3	1057.3028.02	❍	❍	❍	❍	❍	❍	❍	❍
Phase noise measurement software: Easy to use phase noise measurements, measurement of residual FM an PM, logarithmic plot over 8 decades, runs under Windows	FSE-K4	1108.0088.02	❍	❍	❍	❍	❍	❍	❍	❍

● Fitted in basic model ❍ Option

Model-dependent specifications in brief

Frequency	FSEA20	FSEA30	FSEB20	FSEB30	FSEM20	FSEM30	FSEK20	FSEK30
Frequency range	9 kHz to 3.5 GHz	20 Hz to 3.5 GHz	9 kHz to 7 GHz	20 Hz to 7 GHz	9 kHz to 26.5 GHz	20 Hz to 26.5 GHz	9 kHz to 40 GHz	20 Hz to 40 GHz
Refer. frequency (aging)	1 x 10^{-6}/year	2 x 10^{-7}/year	1 x 10^{-6}/year	2 x 10^{-7}/year	1 x 10^{-6}/year	2 x 10^{-7}/year	1 x 10^{-6}/year	2 x 10^{-7}/year
With option FSE-B4	2 x 10^{-7}/year	—	2 x 10^{-7}/year	—	2 x 10^{-7}/year	—	2 x 10^{-7}/year	—
Spectral purity								
SSB phase noise, referred to 1 Hz bandwidth, f ≤500 MHz								
100 Hz[1]	—	<–87 dBc	—	<–81 dBc	—	<–81 dBc	—	<–81 dBc
1 kHz[1]	<–85 dBc	<–107 dBc	<–79 dBc	<–100 dBc	<–79 dBc	<–100 dBc	<–79 dBc	<–100 dBc
10 kHz[1]	<–95 dBc	<–120 dBc	<–90 dBc	<–114 dBc	<–90 dBc	<–114 dBc	<–90 dBc	<–114 dBc
100 kHz[2]	<–119 dBc	<–119 dBc	<–113 dBc	<–113 dBc	<–113 dBc	<–113 dBc	<–113 dBc	<–113 dBc
1 MHz[2]	<–135 dBc	<–138 dBc	<–129 dBc	<–132 dBc	<–129 dBc	<–132 dBc	<–129 dBc	<–132 dBc
Resolution bandwidths								
3 dB bandwidths	10 Hz to 10 MHz	1 Hz to 10 MHz	10 Hz to 10 MHz	1 Hz to 10 MHz	10 Hz to 10 MHz	1 Hz to 10 MHz	10 Hz to 10 MHz	1 Hz to 10 MHz
Steps	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5
Shape factor 60 : 3 dB (1 kHz to 2 MHz)	<15	<12	<15	<12	<15	<12	<15	<12
Video bandwidths	1 Hz to 10 MHz	1 Hz to 10 MHz	1 Hz to 10 MHz	1 Hz to 10 MHz	1 Hz to 10 MHz	1 Hz to 10 MHz	1 Hz to 10 MHz	1 Hz to 10 MHz
Steps	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5	1/2/3/5

Level

Displayed noise floor, average level in dBm (10 Hz bandwidth, 0 dB RF attenuation,VBW = 1 Hz, no signal at RF input)								
20 Hz	—	–80	—	–74	—	<–74	—	<–74
1 kHz	—	–110	—	–104	—	<–104	—	<–104
10 kHz	–90	–125	–84	–119	<–84	<–119	<–84	<–119
100 kHz	–110	–135	–104	–129	<–104	<–129	<–104	<–129
1 MHz	<–130, typ.–135	<–145, typ. –150	<–125, typ. –130	<–142 typ. –145	<–124, typ. –129	<–142, typ. –145	<–124, typ. –129	<–142, typ. –145
10 MHz to 3.5/6 GHz	<–145, typ. –150	<–145, typ. –150	<–142, typ. –147	<–142, typ. –147	<–138, typ. –140	<–138, typ. –140	<–138, typ. –140	<–138, typ. –140
6 GHz to 7 GHz	—	—	<–139	<–139	<–135, typ. –138	<–135, typ. –138	<–135, typ. –138	<–135, typ. –138
7 GHzto 18 GHz	—	—	—	—	<–138, typ. –140	<–138, typ. –140	<–138, typ. –140	<–138, typ. –140
18 GHz to 26.5 GHz	—	—	—	—	<–135, typ. –138	<–135, typ. –138	<–135, typ. –138	<–135, typ. –138
26.5 GHz to 30 GHz	—	—	—	—	—	—	<–120, typ. –125	<–120, typ. –125
30 GHz to 40 GHz	—	—	—	—	—	—	<–116, typ. –122	<–116, typ. –122
Max. dynamic range	10 Hz bandwidth	1 Hz bandwidth	10 Hz bandwidth	1 Hz bandwidth	10 Hz bandwidth	1 Hz bandwidth	10 Hz bandwidth	1 Hz bandwidth
Displayed noise floor at 1 dB compression	155 dB	165 dB	152 dB	162 dB	150 dB	160 dB	150 dB	160 dB
Max. intermodulation-free range								
50 MHz to 3.5/7 GHz	105 dB	115 dB	—	—	—	—	—	—
100 MHz to 26.5 GHz	—	—	105 dB	115 dB	103 dB	112 dB	103 dB	112 dB

Total measurement uncertainty (0 to 50 dB below reference level, span/RBW <100, rss 95% reliability)

<1 GHz	<1 dB
1 GHz to 3,5/7 GHz	<1,5 dB

Intermodulation			
3rd-order intermod., intermodulation-free dynamic range, level 2 × –20 dBm, Δf >5 × RBW or 10 kHz, whichever is the greater value	>64 dBc for f >50 MHz (T.O.I. >12 dBm, typ. 18 dBm)	>70 dBc for f >150 MHz (T.O.I. ≥15 dBm, typ. 20 dBm)	>74 dBc for f >100 MHz >60 dBc for f >7 GHz (T.O.I. ≥17 dBm, typ. 22 dBm; >10 dBm for f >7 GHz)
Intermodulation-free range at –40 dBm mixer level	105 dB		
Intercept point k2 (dBm)	>25, typ. >40 for f<50 MHz, >45, typ. >50 for f >50 MHz		>25 for f <150 MHz, >35 typ. >40 for f >150 MHz, >45 typ.

1) Models 20: valid for span ≤50 kHz, RBW <1 kHz.

2) Valid for span >100 kHz.

Common specifications in brief

Frequency

Frequency display	with marker
Resolution	0.1 Hz to 10 kHz (depending on span)
Frequency counter	measures the marker frequency
Resolution	0.1 Hz to 10 kHz (selectable)
Display range of frequency axis	0 Hz, 10 Hz to full span
Sweep time	
Display range	0 Hz 1 µs to 2500 s ≥10 Hz 5 ms to 16000 s
Picture refresh rate	>20 updates/s with 1 trace >15 updates/s with 2 traces
Sampling rate	50 ns (20 MHz A/D converter)
Sweep trigger	free run, single, line, video, gated, delayed, external
Zero span	additionally pretrigger, posttrigger, trigger delay

Level

Display range	noise floor displayed to 30 dBm
Max. input level	
RF attenuation 0 dB/≥10 dB	
DC voltage	0 V
CW RF power	20 dBm (= 0.1 W)/30 dBm (= 1 W)
Pulse spectral density	97 dBµV/MHz
Max. pulse energy (10 µs)	1 mWs/FSEM/K: 0.5 mWs (RF attenuation ≥10 dB)
Max. pulse voltage (RF attenuation ≥10 dB)	FSEA/B: 150 V, FSEM/K: 50 V
1 dB compression of input mixer (0 dB RF attenuation)	+10 dBm nominal
Max. harmonics suppression	90 dB (f >50 MHz)
Level display	
Trace	500 × 400 pixels (one diagram)
Log level axis	10 to 200 dB in 10 dB steps
Linear level axis	10% of reference level per level division, 10 divisions
Setting range of reference level	
Log level display	–130 to +30 dBm in 0.1 dB steps
Linear level display	7 nV to 7.07 V in 1% steps
Units of level axis	dBm, dBµV, dBµA, dBpW (log level display); mV, µV, mA, µA, pW, nW (linear level display)
Pulse amplitude accuracy (single pulses)	
Bandwidth <1 MHz	0.5 dB nominal
≥1 MHz	2 dB nominal

Trigger function

Trigger	free run, line, video, RF, external
Delayed sweep	
Trigger source	free run, line, external, video
Delay time	100 ns to 10 s, 1 µs
Delayed sweep time	2 µs to 1000 s
Gated sweep	
Trigger source	external, RF level
Gate delay	1 µs to 100 s
Gate length	1 µs to 100 s, resolution 1 µs

Demodulation

Modulation modes	AM and FM
Audio output	loudspeaker and headphones output
Marker stop time	100 ms to 60 s

External Mixer FSE-B21

LO output/IF input (front panel)	SMA female, 50 Ω
LO signal	7.5 GHz to 15.2 GHz
Level	+15.5 dBm ±3 dB
IF signal	741.4 MHz
Full level	–20 dBm
Level measurement uncertainty	<1 dB
IF input (front panel)	SMA female, 50 Ω
Frequency	741.4 MHz
Full level	–20 dBm
Level measurement uncertainty	<1 dB

Inputs and outputs (front panel)

RF input	N female, 50 Ω (FSEA/FSEB), Microwave Adapter System (FSEM/K)
VSWR (RF attenuation >10 dB), f <3.5 GHz	<1.5
Attenuator	0 to 70 dB, selectable in 10 dB steps
Probe power	+15 V/–12.6 V (DC) and ground, ≥150 mA
Power supply and coding connector for antennas etc (antenna code)	12-contact Tuchel connector
Supply voltages	±10 V, max. 100 mA, ground
AF output	jack, adjustable up to 1.5 V (Z_{in} = 10 Ω)

Inputs and outputs (rear panel)

IF 21.4 MHz	BNC female 50 Ω, bandwidth >1 kHz or resolution bandwidth
Level	0 dBm at reference level, mixer level >–60 dBm
Video output	BNC female 50 Ω, 0 to 1 V (open-circuit voltage)
Reference frequency	
Output, usable as input	BNC female 10 MHz, 10 dBm nominal
Input	1/.../16 MHz, >0 dBm into 50 Ω
Sweep output	BNC female, 0 to 10 V, proportional to displayed frequency
Noise source connector	BNC female, 0/28 V, switch-selected
Ext. trigger/gate input	BNC, –5/+5 V, adjustable
IEC/IEEE-bus control	interface to IEC625-2 (IEEE488.2), Command set SCPI 1994.0
Serial interface	RS-232 interface (COM1 and COM2), 9-contact female connectors
Mouse interface	PS/2-compatible
Plotter[1)]	via IEC/IEEE bus or RS-232-C, HP-GL
Printer interface	parallel (Centronics) or serial (RS-232-C)
Keyboard connector	5-contact female for MF2 keyboard
User interface	25-contact Cannon female
Connector for external monitor (VGA)	15-contact female

General data

Display (640 × 480)	24 cm colour LCD (9.5")
Mass memory	3½", 1.44 MByte; hard disk
Power supply, AC	100 to 120 V: 50 Hz to 400 Hz 200 to 240 V: 50 Hz to 60 Hz
Power consumption	170 to 230 VA (depending on model)
Dimensions (W × H × D; 5 HU)	
Models 20	435 mm × 236 mm × 460 mm
Models 30	435 mm × 236 mm × 570 mm
Weight	21.5 to 25,8 kg (depending on model)

4) Plot function is not available, if FSE-B15 is fitted.

Ordering information

Spectrum Analyzer	FSEA20	1065.6000.25
	FSEA30	1065.6000.35
	FSEB20	1066.3010.25
	FSEB30	1066.3010.35
	FSEM20	1080.1505.25
	FSEM30	1079.8500.35
	FSEK20	1088.1491.25
	FSEK30	1088.3494.35

Options

7 GHz Frequency Extension for FSEA	FSE-B2	1073.5044.02
Low Phase Noise and OCXO (for models 20)	FSE-B4	1073.5396.02
FFT Filter 1 Hz to 1 kHz (for models 20)	FSE-B5	1073.5544.02
Vector Signal Analyzer	FSE-B7	1066.4317.02
Tracking Generator 3.5 GHz	FSE-B8	1066.4469.02
Tracking Generator 3.5 GHz with I/Q Modulator	FSE-B9	1066.4617.02
Tracking Generator 7 GHz	FSE-B10	1066.4769.02
Tracking Generator 7 GHz with I/Q Modulator	FSE-B11	1066.4917.02
Switchable Attenuator for Tracking Generator	FSE-B12	1066.5065.02
1 dB Attenuator	FSE-B13[2]	1119.6499.02
Controller for FSE (mouse and keyboard included (English))	FSE-B15[2]	1073.5696.06
Ethernet Interface 15-contact AUI connector	FSE-B16[1]	1073.5973.02
Thin-wire BNC connector	FSE-B16[1]	1073.5973.03
RJ-45 connector	FSE-B16[1]	1073.5973.04
2nd IEC/IEEE-Bus Interface for FSE	FSE-B17[1]	1066.4017.02
Removable Hard Disk	FSE-B18[2]	1088.6993.02
Second Hard Disk for FSE-B18 (firmware included)	FSE-B19	1088.7248.02
External Mixer	FSE-B21	1084.7243.02
Increased Level Accuracy up to 2 GHz	FSE-B22[2]	1106.3480.02
Broadband Output 741.4 MHz	FSE-B23[2]	1088.7348.02

Software

Noise Measurement Software, Windows	FS-K3	1057.3028.02
Phase Noise Measurement Software, Windows	FSE-K4	1108.0088.02
GSM Application Firmware, Mobile	FSE-K10	1057.3092.02
GSM Application Firmware, BTS	FSE-K11	1057.3392.02

Extras

Service Kit	FSE-Z1	1066.3862.02
DC Block, 5 to 7000 MHz (Type N)	FSE-Z3	4010.3895.00
DC Block, 10 kHz to 18 GHz, Type N	FSE-Z4	1084.7443.02
Microwave Measurement Cable and Adapter Set for FSEM	FS-Z15	1046.2002.02
Harmonics Mixer 40 to 60 GHz	FS-Z60[3]	1089.0799.02
Harmonics Mixer 50 to 75GHz	FS-Z75[3]	1089.0847.02
Service Manual	–	1065.6016.24
Headphones	–	0708.9010.00
German Keyboard	PSA-Z2	1007.3001.31
American Keyboard	PSA-Z2	1007.3001.02
PS/2 Mouse	FSE-Z2	1084.7043.02
Colour Monitor, 15", 230 V	PMC3	1082.6004.02
IEC/IEEE-Bus Cable, 1 m	PCK	0292.2013.10
IEC/IEEE-Bus Cable, 2 m	PCK	0292.2013.20
19" Rack Adapter with front handles	ZZA-95	0396.4911.00
Transit Case	ZZK-954	1013.9395.00
Transit Case (FSEM 30 and FSEK 30 only)	ZZK-955	1013.9408.00
Matching Pads, 75 Ω		
L section	RAM	0358.5414.02
Series resistor, 25 Ω	RAZ	0358.5714.02
Accessories for current, voltage and field-strength measurement	see accessories for Test Receiver ESS, data sheet PD 756.9768	
SWR Bridge, 5 MHz to 3000 MHz	ZRB2	0373.9017.52
SWR Bridge, 40 kHz to 4 GHz	ZRC	1039.9492.52
High-Power Attenuators, 100 W, 3/6/10/20/30 dB	RBU 100	1073.8820.xx (xx=03/06/10/20/30)
High-Power Attenuators, 50 W 3/6/10/20/30 dB	RBU 50	1073.8895.xx (xx=03/06/10/20/30)
Preamplifier, 20 MHz to 1000 MHz	ESV-Z3	0397.7014.52
For FSEM only:		
Test-Port Adapter, N (male)	–	1021.0541.00
3.5 mm (male)	–	1021.0529.00
For FSEK only:		
Test-Port Adapter, N (male)	–	1036.4783.00
K (male)	–	1036.4802.00
2.4 mm (male)	FSE-Z5	1088.1627.02

[1] Options FSE-B16 and FSE-B17 require option FSE-B15.

[2] Cannot be retrofitted, factory-fitted only.

[3] For all FSEM/K, option FSE-B21 required