FM-IF IC for the DYNAS [1] System

Description

The U42922B is a bipolar integrated FM-IF circuit, which is controlled by software. It performs all the function of the DYNAS system. The device is designed for car radio and home receiver applications.

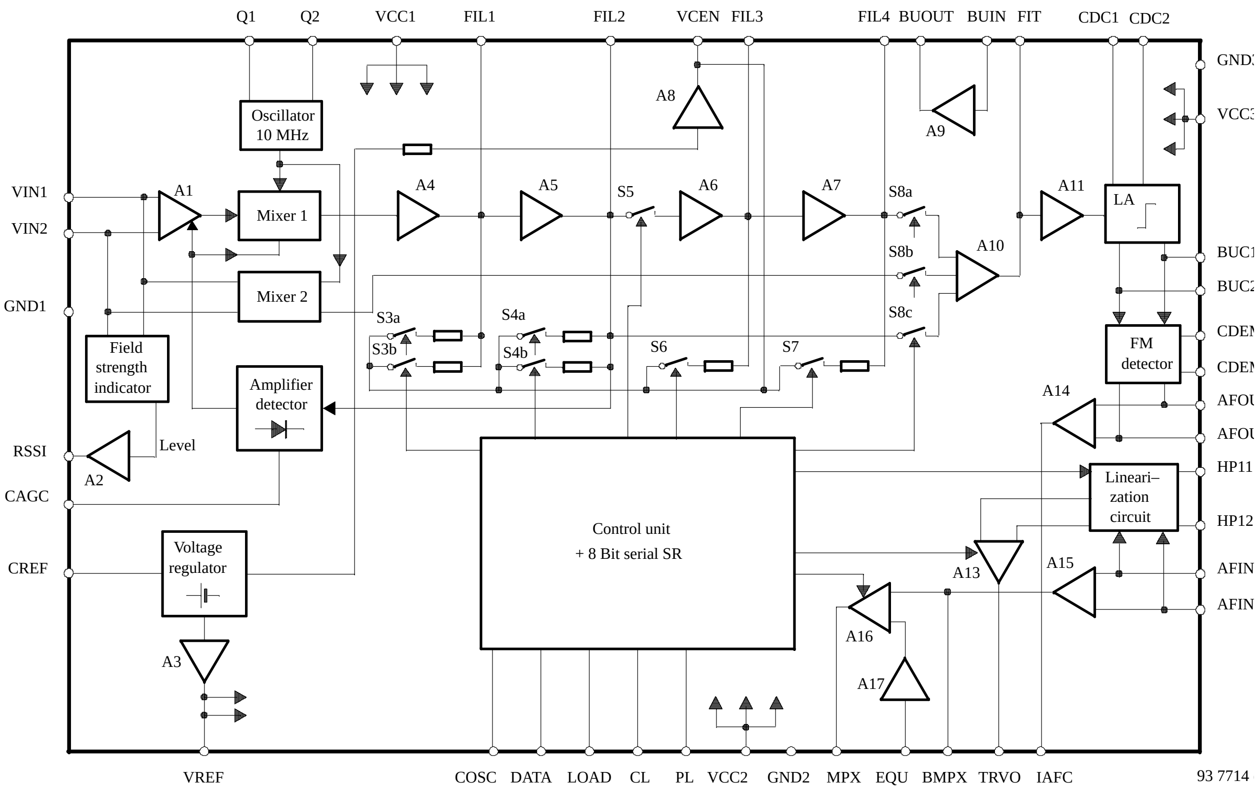
DYNAS is a complete new system of FM-IF processing. It uses bandpass filters with a bandwidth down to about 20 kHz compared to 160 kHz for a conventional bandpass filter, and tracks the resonant frequency to the actual frequency. Implementation of the DYNAS system drastically enhances both of the basic, classic characteristics of radio reception: selectivity and reception sensitivity.

DYNAS ensures enhancement up to levels which until now were not considered physically feasible. A complete system description can be found in “DYNAS system & it’s application in car radios” (Jan. 1992).

Features

- In comparison to conventional FM-IF systems:
  - More than 26 dB better selectivity in case of directly (100 kHz) adjacent transmitters
  - Higher sensitivity of typical 6 dB due to the reduction of the effective noise bandwidth
- Higher flexibility by software
- Easy adaption of RDS (Radio data system) and Noise Blanker

Block Diagram



1) DYNAS stands for dynamic selectivity.

Figure 1.

Pin Description

Pin	Symbol	Function
1	CAGC	Time constant for the AGC mixer
2	CREF	Noise filter for internal reference
3	VREF	Reference voltage 5 V
4	COSC	Time constant for MPX limiting during adjacent channel carry over
5	DATA	Data input for DYNAS filter status. 7-bit serial data. TTL-CMOS input synchronic to CL
6	LOAD	Load input data, TTL-CMOS input
7	CL	Clock signal for data transmission (frequency see Electrical Characteristics table)
8	PL	Input of the comparator for adjacent channel carry over (plop-noise)
9	VCC 2	Supply voltage for logic and audio circuits
10	GND 2	Ground for logic and audio circuits
11	BUIN	Buffer input of filter tracking for bandpass filter
12	EQU	Input for high pass filtering and equalizing of MPX. Use of capacitors U 2 J (N 750) for temperature compensation are recommended, as indicated in the circuit diagram.
13	MPX	Output of MPX-signal
14	BMPX	Output buffer of the unequalized MPX-signal
15	TRVO	Tracking voltage for filter circuits
16	IAFC	Current source/sink output for tuning control. Connect to VREF if not used
17	HP 12	Highpass filter in order to pre-emphasize the tracking voltage
18	HP 11	Highpass filter in order to pre-emphasize the tracking voltage
19	AFIN 1	Input of the AF processing network
20	AFIN 2	Input of the AF processing network
21	AFOUT 2	Differential amplifier output of the demodulator
22	AFOUT 1	Differential amplifier output of the demodulator
23	BUC 2	Buffer output for driving quadrature capacitor of the demodulator (Use of TC –220 ppm/°C for the capacitor 1.2 nF is recommended)
24	CDEM 2	Resonant circuit for the demodulator (Use of TC –220 ppm/°C for the capacitor 120 pF is recommended)
25	CDEM 1	Resonant circuit for the demodulator (Use of TC –220 ppm/°C for the capacitor 120 pF is recommended)
26	BUC 1	Buffer output for driving quadrature capacitor of the demodulator (Use of TC –220 ppm/°C for the capacitor 1.2 nF is recommended)
27	VCC 3	Supply voltage for demodulator and filter circuit
28	GND 3	Ground of demodulator and filter circuit
29	FIT	Test output for adjustment of the filter circuits
30	CDC 2	Low passfilter for the offset cancellation of the limiting amplifier
31	FIL 4	Resonant circuit 4, L4 166 uH TOKO 0555, Varicap TOKO KV 1234Z or equivalent
32	CDC 1	Low passfilter for the offset cancellation of the limiting amplifier
33	FIL 3	Resonant circuit 3, L3 157 uH TOKO 0555, Varicap TOKO KV 1234Z or equivalent
34	VCEN	Center voltage 2.5 V for filter circuits
35	FIL 2	Resonant circuit 2, L2 112 uH TOKO 0554, Varicap TOKO KV 1234Z or equivalent
36	BUOUT	Buffer output of filter tracking voltage for bandpass filter
37	FIL 1	Resonant circuit 1, L1 143 uH TOKO 0555, Varicap TOKO KV 1234Z or equivalent
38	VCC 1	Supply voltage for mixer, oscillator, IF detector
39	GND 1	Ground for mixer, oscillator, IF detector
40	VIN 1	IF input 10.7 MHz
41	VIN 2	Center voltage for the input 10.7 MHz
42	RSSI	Signal fieldstrength 0 to 100 μA to ground
43	Q 2	X’tal 10 MHz
44	Q 1	X‘tal 10 MHz

System Description

DYNAS is a completely new system of intermediate-frequency signal processing in order to reduce interference in FM radio reception. The principle function of the system is shown in figure 2, 3 and 4. It describes the relationship between the receiving signal condition and the system's reaction.

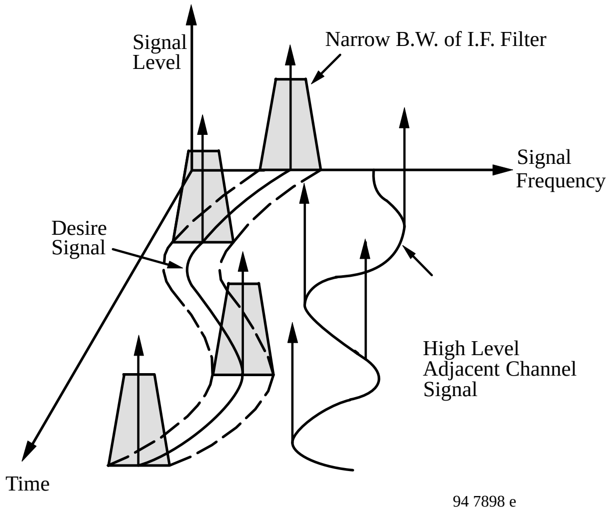


Figure 2.

Figure 2 shows a very high adjacent channel interference. In this case, the system has to be switched to the narrow bandwidth and the resonant frequency of the IF-filter will track the desired signal frequency. Because of the narrow bandwidth, the undesired signal cannot interfere with the desired channel. In this way, DYNAS avoids channel interference, the stereo reception will change to mono, which minimizes the interference noise.

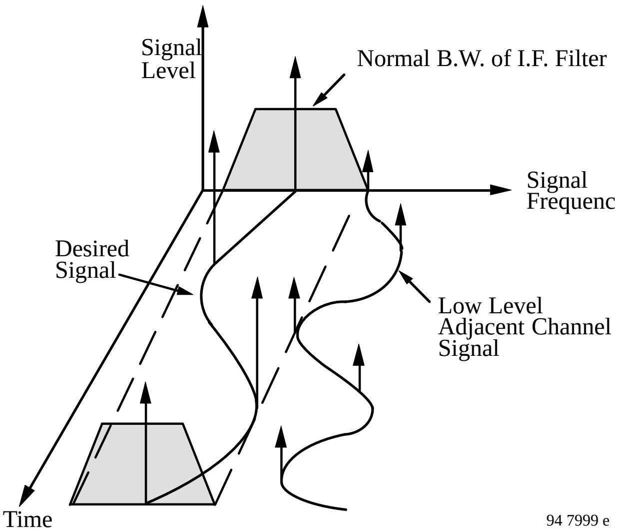


Figure 3.

In case of a reasonable desired signal level and no or weak interference signal level, as shown in figure 3, the system has to be switched to the wide I.F. bandwidth. Therefore, the usual high-fidelity stereo performance is achieved.

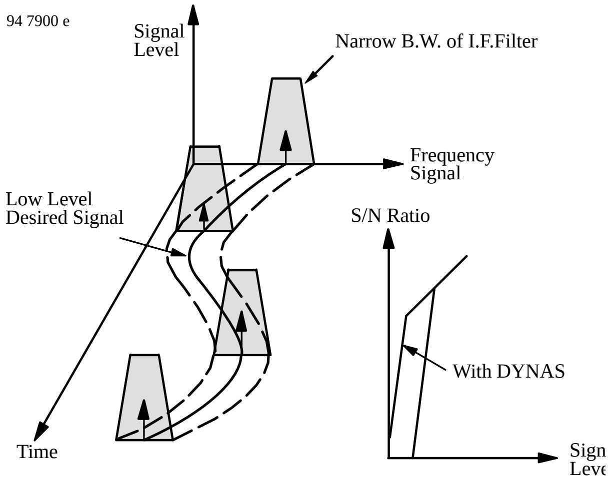


Figure 4.

Figure 4 shows DYNAS's reaction to very low desired signal level. In this case, the system has to be switched to "mixed" narrow I.F. bandwidth in order to reduce the noise level feeding the FM discriminator. This increases the sensitivity of the receiver as seen from the S/N curve in figure 4. Certainly, because of the low signal and narrow bandwidth, only mono reception is possible.

The DYNAS system using the U4292B provides 8 different I.F. bandpass characteristics, which are controlled by software according to the receiving conditions. Some of these characteristics have a "mixed" structure of narrow bandpass and wide bandpass characteristics.

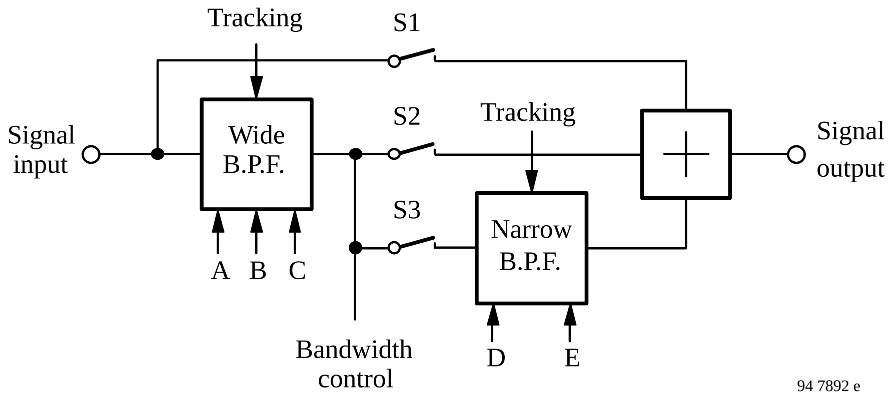


Figure 5.

Receiving Conditions		Characteristic	System Bandwidth	Switch Position		
Desired Signal	Adjacent Channel Signal			S1	S2	S3
Strong	No	BYP	Bypassed	On	Off	Off
↑↑↑↑	↑	ACH0	100 kHz	Off	On	Off
↑↑↑	↑↑	ACH1	70 kHz	Off	On	Off
↑↑	↑↑↑	ACH2	Mixed	Off	On	On
↑	↑↑↑↑	ACH3	23 kHz	Off	Off	On
↑	Strong	ACH4	18 kHz	Off	Off	On
↑	Weak	F1	Mixed	Off	On	On
Weak	Weak	F2	Mixed	Off	On	On

Figure 6.

Figure 5 shows the structure of the DYNAS filter block, which mainly consists of 2 tracking bandpass filters: the “wide” bandpass filter and the “narrow” bandpass filter. The bandwidth of these bandpass filters can be changed by damping of the filter tanks. The signal path can be switched by the “symbolic” switches S1 to S3.

The table of figure 6 shows all possible bandpass characteristics of the system which can be achieved by combining of filter damping and signal path switching depending on the condition of the receiving signals (desired signal and adjacent channel signal).

If the desired signal is strong and there is no or very low adjacent channel interference, the system has to be switched in the “Bypass-Mode”, which allows a maximum of bandwidth.

In some special situation of multipath reception or common channel interference, the system’s filter structure should be switched to the wide band characteristic BYP.

The characteristics ACH2, F1 and F2 (mixed mode) are obtained by adding the signals of the wide band and the narrow band signal paths (S2 and S3 are switched on). In this case a wide bandpass filter characteristic with a added “peak” of a narrow bandpass filter characteristic is achieved. Certainly characteristics like these cannot be characterized by a normal 3 dB bandwidth value in the table. Such “step bandwidth” characteristics are useful for given signal conditions where the advantage of the narrow band pass characteristic is required but on the other side its disadvantages should be minimized by superimposing the signal from the wide band signal path as mentioned above.

Functional Description

Figure 1 shows the block diagram of the U4292B. In the BYP mode (bypass function) the signal of mixer 2 is fed to the summing amplifier A 10, bypassing the DYNAS filters FIL 1, FIL 2, FIL 3 and FIL 4. In the other modes, the incoming signal is fed via a gain controlled amplifier A1 to the mixer 1. The filter characteristics are set according to the condition of the incoming signal by switches S 3 to S 8 which are controlled by software.

The 700 kHz DYNAS IF signal is available at output FIT for test and alignment purposes. In addition it is fed via the limiting amplifier LA to the FM DETECTOR which is a normal Quad-Demodulator. The demodulated signal is fed out at AFOUT 1 and AFOUT 2 to an external bandpass filter and reenters at AFIN 1 and AFIN 2, where it is fed to the buffer amplifier A 15 and the linearization circuit.

The MPX signal is available at output MPX. The tracking signal for the DYNAS filters is derived from the linearization circuit and it is available at output TRVO.

Depending on the condition of the tuned signal, the filter characteristics of the DYNAS IC U4292B are controlled by software according to figure 7.

Condition	Data						
	MSB						LSB
	8	7	6	5	4	3	2	1
BYP	0	0	0	0	0	0	0	x
ACH 0	1	0	0	0	0	0	0	x
ACH 1	1	0	1	0	0	0	0	x
ACH 2	1	0	1	1	0	0	0	x
ACH 3	1	0	1	1	1	0	0	x
ACH 4	1	0	1	1	1	1	0	x
F 1	1	1	0	0	0	0	0	x
F 2	1	1	0	0	0	0	1	x

Figure 7.

The U4292B has a 8-bit-shift register which is controlled by software via a 3 wire bus consisting of Clock, Data and Load. The timing diagrams of the bus are shown in figure 8.

The system can be forced directly to the bypass function by switching Load, Clock and Data to "low" and it remains as long as Load and Data are "low" (see figure 9).

After releasing these conditions, the system will go back to the previous status of the shift register.

Only in the ACH 4-status, a "Plop"-recognition is possible. During this time, the Load is internally disabled and a data-transfer cannot be executed. The signal at BMPX is fed via a low pass filter to the "Plop"-comparator. The internal switching threshold is determined at 400 mV_{PP} ± 20% and the MPX signal is limited to 500 mV_{pp} (see figure 10).

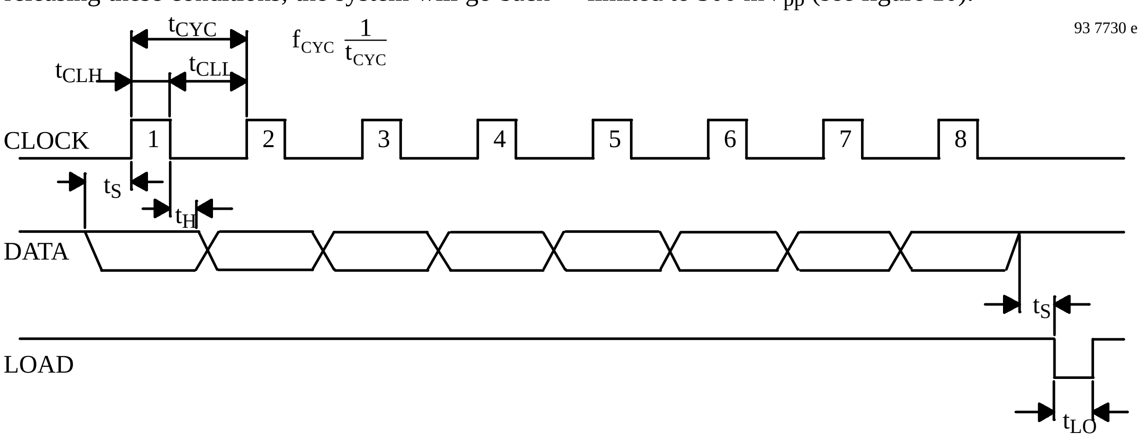


Figure 8.

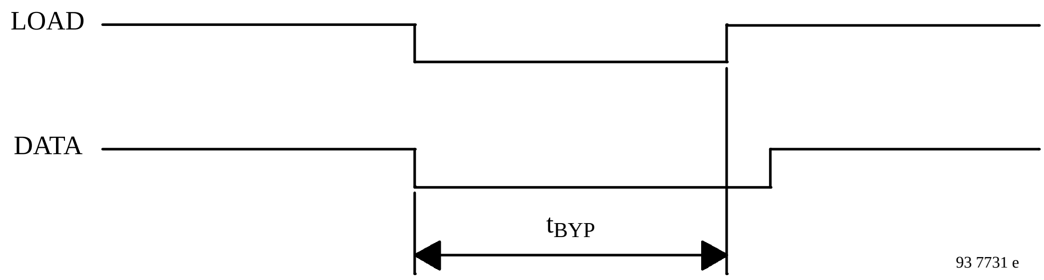


Figure 9.

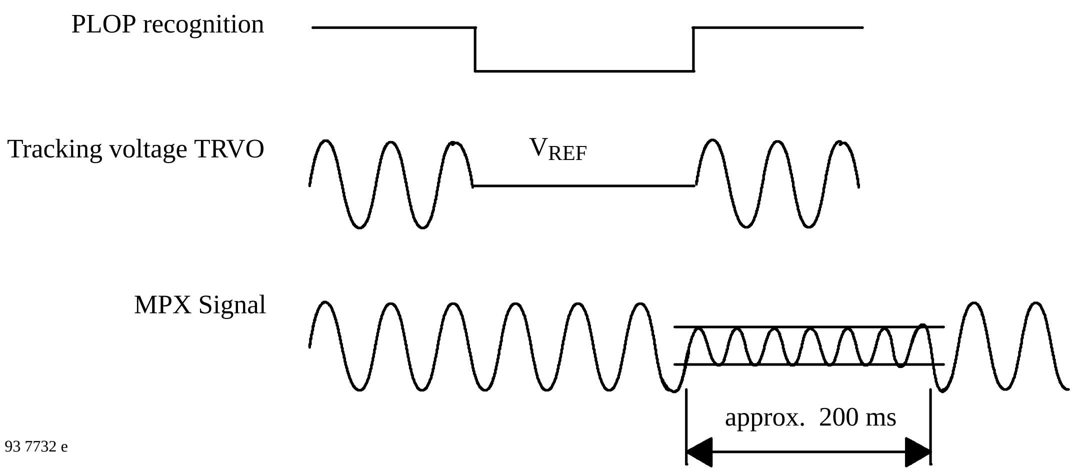


Figure 10.

Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	V_{CC}	13	V
Power dissipation	P_{tot}	750	mW
Storage temperature range	T_{stg}	–50 to +125	°C
Ambient temperature range	T_{amb}	–30 to +85	°C
Junction temperature	T_j	125	°C
Electrostatic handling	$\pm V_{ESD}$	2000	V

Thermal Resistance

Parameters	Symbol	Value	Unit
Thermal resistance	R_{thJA}	120	K/W

Electrical Characteristics

V_S = 8.2 V, T_{amb} = 25°C, V_{IN1} = 30 mV, 10.7 MHz, FM = ±75 kHz deviation, fmod = 1 kHz, unless otherwise specified. Ve is the input voltage of the front end imitation (FEI) with 40 dB voltage gain and 6 dB noise figure.

The voltage V_e is defined under a termination of 50 Ω. V_{IN1} is the applied input voltage at pin VIN1 of the U4292B, reference point is ground, de-emphasis is 75 µs, normally out. AF bandwidth for audio measurement is 30 kHz.

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	Pins 38, 27 and 9	V_{CC1} V_{CC2} V_{CC3}	7.5	8.2	9	V
Supply quiescent current	Pins 38, 27 and 9 $I_{CC} = I_{CC1} + I_{CC2} + I_{CC3}$	I_{CC}		63	75	mA
Reference voltage output	**Pin 3**					
Reference voltage		V_{REF}	4.7	5	5.3	V
Output resistance		R_{OUT}		2.5		Ω
Load current		I_L			10	mA
TC				0.1		mV/°C
Center voltage output	**Pin 34**					
Center voltage		V_{CEN}	2.3	2.5	2.7	V
Output resistance		R_{OUT}		1		Ω
Load current		I_L			1	mA
TC				–1.4		mV/°C
Demodulator outputs	**Pins 22 and 21**					
Output resistance		R_{OUT}		2.4		kΩ
Tracking voltage output	**Pin 15**					
Bias voltage		V_{BIAS}		5		V
IF input	**Pin 40**					
Input voltage (rms)		V_{IN1}			200	mV
Input resistance		R_{IN}		1.2		kΩ
AGC-threshold input voltage	Mode F1	V_{AGC}		130		µV
MPX output	**Pin 13**					
Recovered audio output voltage (rms)	22.5 kHz deviation 75 kHz deviation	V_{OUT}		180 600		mV
THD without de-emphasis	Mode BYP Ve = 60 dBµV 1 kHz, 22.5 kHz deviation 8 kHz, 22.5 kHz deviation 1 kHz, 75 kHz deviation			0.31 0.70 0.63		%
THD without de-emphasis	Mode ACH0 V_e = 30 dBµV 1 kHz, 22.5 kHz deviation 8 kHz, 22.5 kHz deviation 1 kHz, 75 kHz deviation			0.65 0.90 1.00		%
THD with de-emphasis	Mode ACH0 V_e = 30 dBµV 1 kHz, 22.5 kHz deviation			0.13		%
THD with de-emphasis	Mode F1 V_e = 10 dBµV 1 kHz, 22.5 kHz deviation			0.8		%

Electrical Characteristics

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
(S+N)/N ratio with de-emphasis	Mode BYP V_e = 60 dBµV 22.5 kHz deviation 75 kHz deviation			 75 85		dB
(S+N)/N ratio with de-emphasis	Mode ACH0 V_e = 30 dBµV 22.5 kHz deviation 75 kHz deviation			 61 72		dB
(S+N)/N ratio with de-emphasis	Mode F1 V_e = 60 dBµV 22.5 kHz deviation 75 kHz deviation			 42 53		dB
AM suppression	V_{IN1} = 5 mV, 90 % modulation 22.5 kHz deviation			–38		dB
Adjacent channel selectivity	SINAD = 30 dB, Desired signal: f_{IF} = 10.7 MHz, V_e = 10 dBµV, f_{mod} = 1 kHz, deviation = 35 kHz, Adjacent signal: f_{mod} = 400 kHz, deviation = 35 kHz f = 10.5 MHz f = 10.6 MHz f = 10.8 MHz f = 10.9 MHz			 84 44 40 83		dBµV
Usable sensitivity	40 kHz deviation and input voltage V_e –3 dBµV			30		dB
Tracking range	Ve = 10 dBµV and SINAD = 26 dB fmod = 1 kHz fmod = 8 kHz (de-emphasis on)			 >75 50		kHz
Voltage gain $\frac{V_{MPX}}{V_{BMPX}}$	Mode BYP, ACH0, ACH1 or ACH2 f = 1 kHz ,without mute			12.5		dB
AFC output	**Pin 16**					
Output current sensitivity	I_{AFC} vs. frequency deviation	$\frac{I_{AFC}}{\Delta f_{IF}}$		0.2		µA/kHz
Oscillator	**Pins 43 and 44**					
Oscillator 10 MHz voltage swing		V_{OSC}		0.8		V_{PP}
BMPX output	**Pin 14**					
Voltage gain $\frac{V_{BMPX}}{\Delta V_{AFIN}}$	f = 1 kHZ			0		dB

Electrical Characteristics

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Tracking voltage output	**Pin 15**					
Voltage gain $\frac{V_{TRVO}}{\Delta V_{AFIN}}$	Mode ACH3, ACH4 other modes, f = 1 kHz			12.6 10.2		dB
Buffer output	**Pin 36**					
Voltage gain $\frac{V_{BUOUT}}{V_{BUIN}}$	f = 1 kHz			0		dB
Field strength output RSSI	**Pin 42**					
Output voltage	R_{LOAD} = 10 kΩ V_{IN1} = 100 µV V_{IN1} = 100 mV	V_O	0.2 0.85		0.45 1.35	V
Deviation of RSSI from linearity (RSSI vs. input voltage level in dB), with respect to the ideal value on a straight line connecting the start and end values defined before	V_{IN1} = 1 mV V_{IN1} = 10 mV		–6 –6		6 6	%
Test output	**Pin 29**					
Voltage swing	V_{IN1} = 5 mV, without modulation			85		mV_{PP}
Input Data, Load, Clock	**Pins 5, 6 and 7**					
Input voltage High Low		 V_{IH} V_{IL}	 2.5 0		 5 0.8	V
Input current High Low		 I_{SOURCE} I_{SINK}		 +1 –1	 +5 –5	µA
Transfer clock cycle time		f_{CYC}			300*[1]	kHz
Transfer clock high level width		t_{CLH}	1			µs
Transfer clock low level width		t_{CLL}	1			µs
Transfer Load low level width		t_{LO}	1			µs
Data set up time		t_S	1			µs
Data hold time		t_H	100			ns

*[1] Frequencies between 200 and 266 kHz are not allowed.

Application Circuit

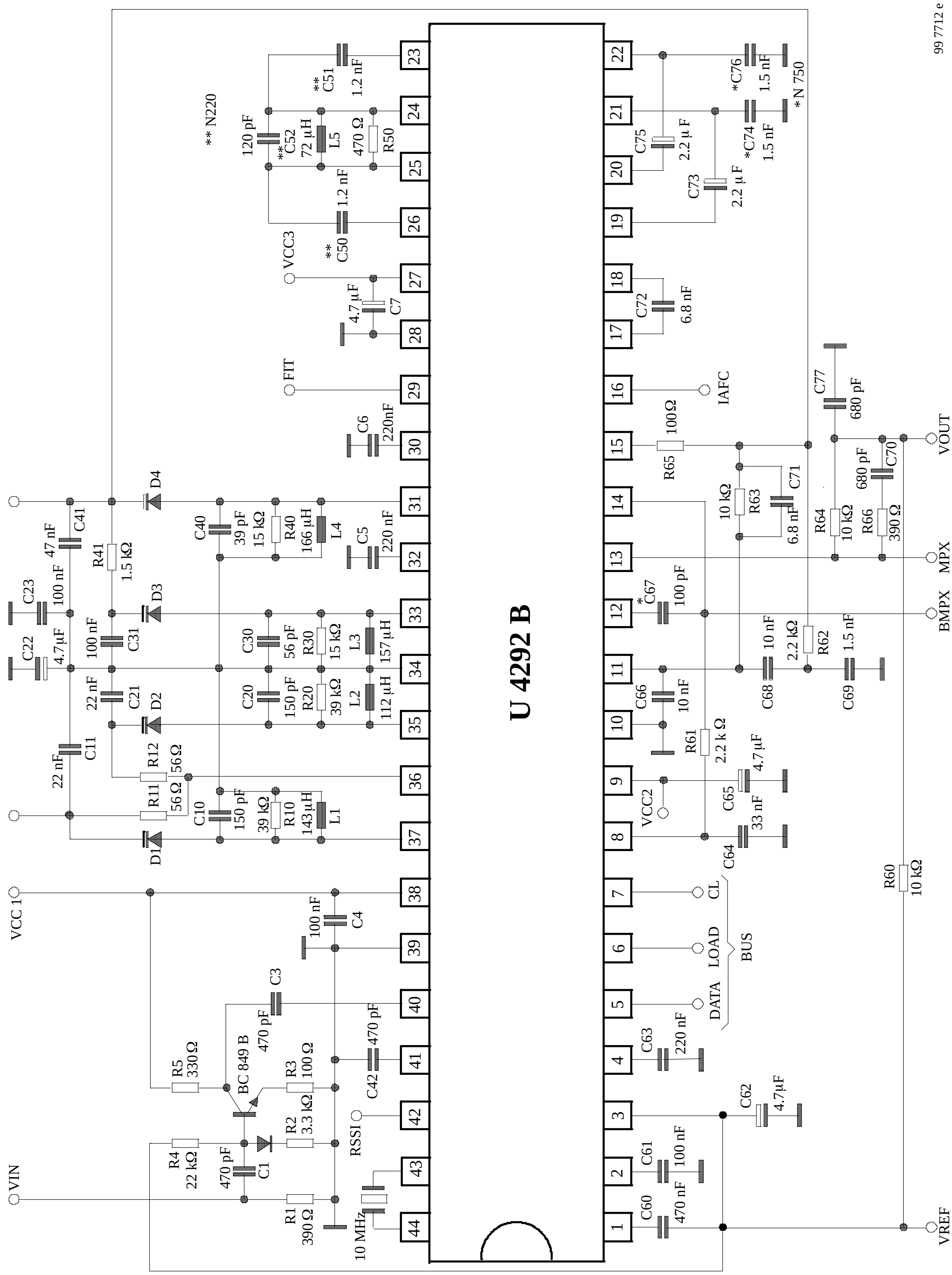


Figure 11.

Filter Adjustment Procedure

Connect the generator to input VIN and an oscilloscope to output FIT. Connect a dc current meter (this may be a DVM in connection with a 100 kΩ resistor) between pins IAFC and VREF.

1. Set the IF center frequency of the FM-front end to 10.7 MHz (± filter offset) with a signal level of approx. 1 mV and adjust L 3 and L 4 to the maximum voltage at output FIT.
2. Reduce the generator output voltage until the AGC switches off and V_{FIT} decreases.
3. Tune L 2 and L 1 to resonance whilst maintain a low signal at FIT to prevent AGC action.
4. Note a value V of V_{FIT} at a given generator output voltage.
5. Increase the generator output voltage by about 7 dB and adjust L 1 to a lower frequency until the value V_a is reached again.
6. Increase the generator output voltage by about 7 dB and adjust L 2 to a higher frequency until the value V_a is reached once again.
7. Tune L 5 until $I_{IAFC} = 0$

An alternative procedure is:

4b. Set the generator to 10.7 MHz – 16 kHz (± filter offset)

5b. Tune L 1 to resonance

6b. Set the generator to 10.7 MHz + 16 kHz (± filter offset)

7b. Tune L 2 to resonance

This procedure appears more accurate then the first.

Temperature compensation of the demodulator circuit:

Low TC of the demodulator centre frequency requires about TC-220 ppm of the capacitors C 50, C 51, C 52.

Specification of external elements

Crystal 10 MHz

Frequency tolerance at 25°C: ±100 ppm
TC of frequency: < 5 ppm/°C
Equivalent series resistance: < 80 Ω

Varactors D1 to D4:
TOKO KV 1234Z is recommended

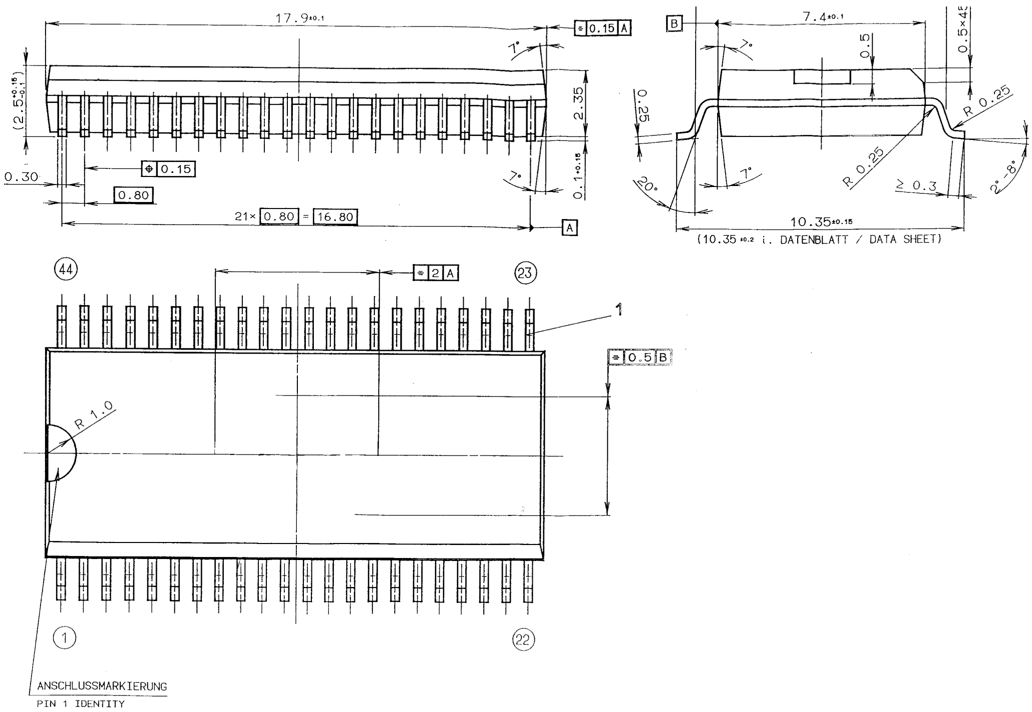
Coils:
L2, L5: Q > 110, TOKO 0554 is recommended
L3, L4, L1: Q > 120, TOKO 0555 is recommended

Ordering and Package Information

Extended Type Number	Package	Remarks
U4292B-AFS	SSO44	

Dimensions in mm

Package: SSO44



Ozone Depleting Substances Policy Statement

It is the policy of **TEMIC TELEFUNKEN microelectronic GmbH** to

1. Meet all present and future national and international statutory requirements.

2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

TEMIC TELEFUNKEN microelectronic GmbH semiconductor division has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively

2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA

3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

TEMIC can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

TEMIC TELEFUNKEN microelectronic GmbH, P.O.B. 3535, D-74025 Heilbronn, Germany
Telephone: 49 (0)7131 67 2831, Fax number: 49 (0)7131 67 2423