EMP32 – 32-STATION PROGRAM MEMORY SYSTEM FOR TV

INTRODUCTION

The EPM32 system has been developed to replace the EPM16 system in new TV designs, where its use is recommended because of its greater memory capability (32 programs instead of 16) and because of some functional improvements.
The EPM32 uses the principle of voltage synthesis for tuning of the station.

The heart of the system is the M293, which is fabricated with N-channel double polysilicon gate MOS technology using both enhancement and depletion transistors, and includes a 32 word non-volatile RAM together with the control logic and the D/A converter for the tuning voltage.

Like the M193, also the EPM32 system can be used in different modes of operation (automatic, semiautomatic and manual) and applications can be implemented also in radio-receiver field.

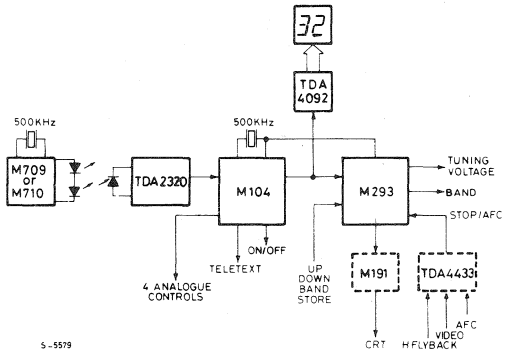
GENERAL SYSTEM INFORMATION

The EMP32 system uses the following devices (see fig. 1):

M293 - Electronic Program Memory

- Non Volatile Memory for 32 programs.
- Memory Address and Copy capability.
- Standard binary code at program inputs.
- 13 bit BRM/PWM converter for tuning.
- 3 bit PWM converter for fine tuning (storable for each program separately).
- 4 band outputs (step-by-step selection and possibility of skipping unwanted bands).
- Automatic, Semiautomatic and Manual TV station control.
- Externally adjustable search speed (in manual operation the search speed is automatically smoothly increased with time).
- Mutue available during search, band change, program change and supply voltage ON/OFF.
- 445 to 510 kHz cheap ceramic oscillator (compatible with M104 clock).
- Integrated digital Power-on reset (1 second).
- Single supply (+5V) for logic; +25V only for memory operations.

Fig. 1 - Block diagram of the EPM 32 system.



TDA 4092 - 5 bit binary to 7-segment decoder driver

- Direct driving of two 7-segment common anode LED displays (no resistor required).
- Stand-by mode display.
- Brightness control.
- Provides binary + 1 decoding.
- AV output on program 32.

M191 - "On screen" tuning scale and band display

- Symbolic band display optional.
- Vertically adjustable position.
- Positive and negative horizontal flyback inputs.
- Normal and inverted information outputs.

TDA 4433 - TV signal identification circuit and digital AFC interface

- 2 digital outputs for automatic search and AFC operation.
- Station identification output.
- Adjustable, high sensitivity.
- Thermally compensated voltage regulator.

M709/M710 - PCM remote control transmitters

- M709 : 40 commands, 16 addresses.
- M710 : 64 commands, 16 addresses.
- Keyboard matrix scanning 5x8 (M709) or 8x8 (M710)
- Single contact of the keyboard matrix.
- Integrated antibounce and interlock.
- Wide range of the reference frequency (445 to 510 kHz).
- 4 bit binary address input.
- End of transmission code.
- Very low power consumption during transmission: duty cycle 0.15%.

M104 - PCM remote control receiver

- 128 (64 x 2) channel decoding.
- 15 local controls available.
- 5 binary static program outputs.
- 4 analogue controls.
- Wide range of reference frequency (445 to 510 kHz).
- Serial "I-bus" output.
- Integrated digital power-on reset (115 ms).

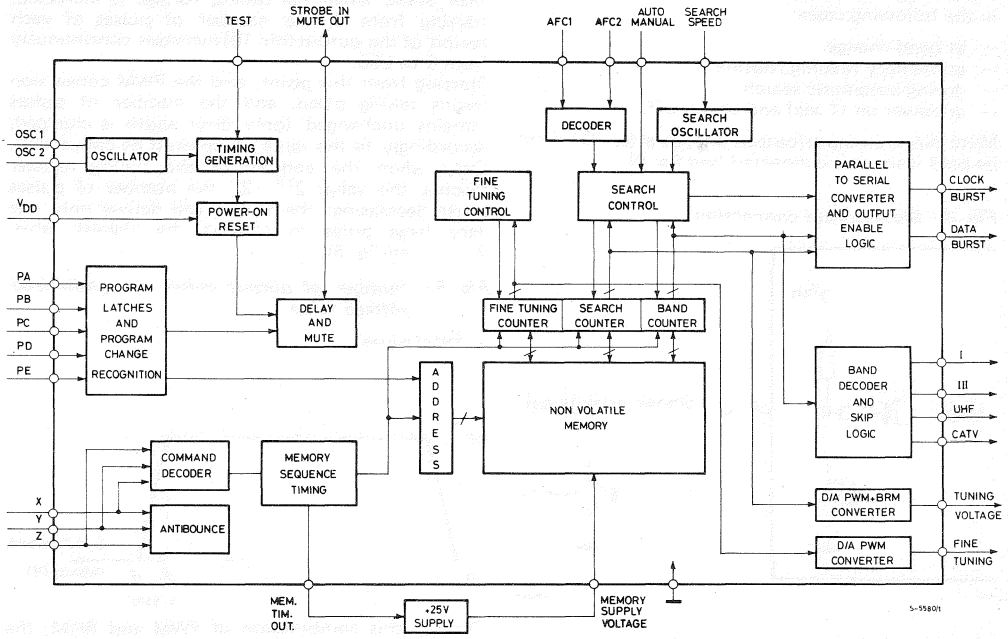
Thus, the main features of the EPM32 system are:

- up to 32 different stations can be memorized;
- simple and reliable memory operation;
- 8192 step synthesis, with high stability over the operating temperature range;
- identification of TV signal during search, with automatic stop if AFC is used (automatic mode);
- center positioning of fine tuning offset after each search command (fine tuning may be adjusted on the tuned station);
- during automatic search, mirror stations are ignored;
- digital AFC loop;
- reduced stability requirements for the tuner, D/A converter and refefence voltage because of a subtraction logic (8 step value) at program change (to compensate for the AFC capture range asymmetry).

If a system has to be designed without remote control, a keyboard encoder circuit should be used for direct program calling: the M190 can be used, which is suitable for up to 16 program addressing, together with an external switch (in order to expand addressing capability to 32 programs).
Features of the **M190** are:

- Single pole key.
- Program 1 selection at Power-on.
- Keyboard interlock (to prevent incorrect selection).
- Antibounce and antinoise circuitry.

Fig. 2 - M293 block diagram



SYSTEM COMPONENTS

The main functions of each device are described here below.
For more details please refer to the single data sheet.

M293 - Electronic Program Memory

Technology: double polysilicon NMOS

This device is used to generate the tuning voltage for the VCO, by means of the voltage synthesis principle.
A block diagram of the device is shown in fig. 2.

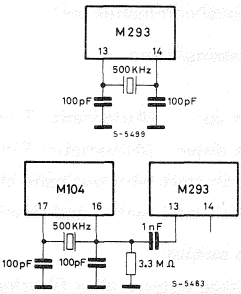
Supply voltages

The device needs a single supply for all the logic: V_{DD}= 5V ± 5%, with a moderate current sinking Memory operations need also a 25V ± 1V supply (20 mA typ. at room temperature).

Oscillator

An internal oscillator is provided, which operates with a cheap 455 to 500 kHz ceramic resonator. If an external clock in this range of frequency is provided, it can be applied to pin 13 of the M293 ($V_{PP\ min}$= 2V).
For connections, see fig. 3.

Fig. 3 - M293 clock connections



Program inputs

Five TTL compatible inputs are provided for addressing 32 programs. A standard static binary code has to be applied to these inputs (for example the program outputs of the M104). Every time the input code is changed, a memory reading routine is started and the new addressed program is tuned. Also when a negative pulse is fed to the strobe input, pin 2, (for example from the M104) the memory reading routine is started. During each memory routine the Mute output is activated.

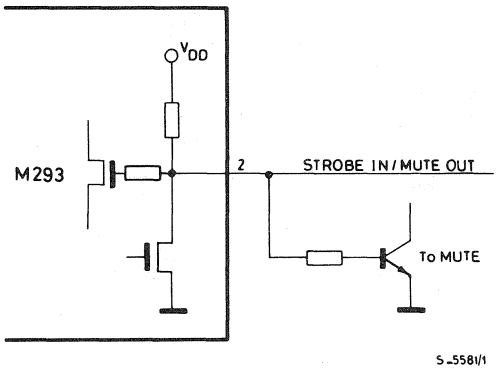
Mute output

Mute output is active (pin 2 is switched to ground) in the following cases:

- at band change
- at memory reading routine
- during automatic search
- at power on (1 sec) and power off.

Mute pin is an input/output one, so attention must be paid when it is connected (see fig. 4).

Fig. 4 - Mute output connection



Command inputs

A keyboard with a diode matrix can be connected to these three inputs to give the device up to six different commands.
These commands, which are binary coded, are accepted by the device after 30 ms of continuous presence (an antibounce circuit is integrated for this purpose).
The available local commands are:

Memory Addressing/Store

Band up

Manual: search up (Automatic: Fine Tuning +)

Manual: search down (Automatic: Fine Tuning -)

Automatic search start (without band change)

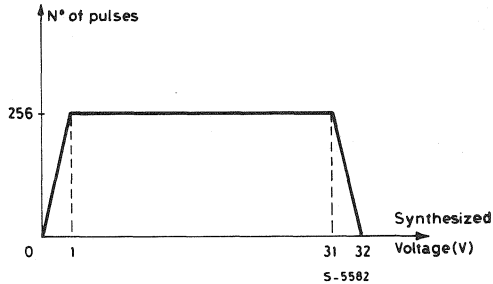
Automatic search start (with band change)

Tuning voltage output

The tuning voltage output, after filtering, is applied to the varicap, in order to tune the TV set. The tuning voltage is synthesized by the device, starting from the related binary value, in 8192 steps (13 bits are used for this purpose). If the maximum tuning voltage is 32V, one step means a voltage change of 3.9 mV (equal to ~ 75kHz in UHF). The conversion is made by the M293 starting from the clock frequency (f_{nom}= 500 kHz), so the minimum pulse width is 2 μs and the repetition frequency of the converted output is about 61 Hz. The conversion is made combining the two basic principles of such a kind of conversion, pulse width modulation (PWM) and bit rate multipler (BRM).

The 5 most significant bits are converted with PWM, and the 8 least significant bits are converted with BRM. When the tuning voltage is increased, starting from 0, the number of pulses of each period of the output (pin 19) increases continuously from 0 to 256.
Starting from this point, also the PWM conversion begins taking place, and the number of pulses remains unchanged (only their width is changed, accordingly to the value which must be converted). Only when the content of the tuning register reaches the value 2^{13} -2^{8} the number of pulses starts decreasing: the output will deliver only one very large pulse to convert the highest value, 2^{13-1} (see fig. 5).

Fig. 5 - Number of output pulses vs. synthesized voltage value.



Due to this combination of PWM and BRM, the temperature and voltage dependence of pulse leading and trailing edges, and of switching times is carefully controlled and a very good stability in tuning is achieved. Furthermore, the number of pulses per second at the real working tuning voltage (~ 0.5V to ~ VZ -0.5V) is high, so that the ripple in the external filter is reduced and any visible noise is avoided on the TV picture screen. (VZ = Varicap voltage reference).

Fine tuning output

Fine tuning is necessary to the system to achieve a small detuning, while maintaining the action of the AFC. For this purpose a square wave (f = 15.625 kHz) is output from pin 11: this wave has a duty cycle variable in 8 steps (which corresponds to 3 bits of binary information); after filtering, this voltage can be applied to a varactor diode in parallel with the AFC discriminator to perform the fine tuning function.
The D/A conversion is made by the M293 using the PWM principle (ripple problems on this voltage are not heavy). Fine tuning up and down commands may be given manually by means of the local keyboard or, if desired, by means of remote control (see TV Application Notes). Each program can have a separate storage of the fine tuning information.

Band outputs

4 band open drain outputs are provided, which can operate up to 13.5V.
In this way up to 4 bands can be selected via external PNP transistors.

Normally band selection is performed by means of step-by-step command by local keyboard. The sequence of band change is the following:

VHF I
CATV
VHF III
UHF
VHF I
and so on

Another way in which the selected band can change is by means of automatic search start command with band change: in this case, when the system has scanned a whole band, changes band, following the above sequence and begins scanning the new band. If one or more bands have to be skipped because they do not correspond to any possible station, the corresponding outputs have simply to be short-circuited to V_{SS}: in this way device will automatically skip this band.

Automatic/Manual mode switch

The system can operate in both automatic and manual modes. The selection between the two modes is made by means of pin 16 (if it is connected to V_{DD} the system works in Automatic mode, if it is connected to V_{SS} the system works manually) and it can be made at every time without any block of the system which will therefore go on working correctly.

Manual mode

When the system works in manual mode, digital AFC operation is inhibited (effects of STOP/AFC pins, 20 and 21, are internally disabled in the M293).
Changes in tuning voltage can be made only manually, by means of local keyboard commands. When a manual up/down command is accepted, a "manual search" is started which will go on until the user releases the key. The speed at which this search is effected, increases with time and reaches its maximum value after 3 seconds, following the table below:

Search speed	Time
max/8	Command accepted
max/4	After 1 second
max/2	After 2 seconds
max	After 3 seconds

Due to this feature, both a small change in tuning and a manual search can be easily performed without extra-charge components. Maximum speed is not the same for all the bands: in order to optimize manual search, without adding any external component to the RC oscillator needed for automatic search, it has been scaled from the external rate in the following way:

VHF I/III	external rate / 3
UHF, CATV	external rate / 12

When the end of a band is reached, the search restarts from the beginning of the same band after a delay of 480 ms: this delay (which is equal to the delay provided at band beginning also in automatic search) is necessary to get the discharge of the external circuitry, so that the search can really restart from the beginning of the band. When a program is recalled from memory, no detuning is performed.

Automatic mode

In this mode ditigal AFC is enabled and, by means of it, both exact tuning is achieved during normal operation and automatic station search can be performed. For a good use of digital AFC, the TDA 4433 must be used, connecting its pins 2 and 6 to pins 20 and 21 of the M293 respectively. The relationship between the TDA 4433 outputs and the tuning position of the system with respect to a perfectly centered tuning is shown in the table below, where f_0 is the very narrow range (38.8 to 39.0 MHz) in which the system is perfectly tuned.

TDA4433 pin 2	TDA4433 pin 6	Tuning position
H	L	Low ($f_0 - \Delta f_1 < f < f_0$)
L	H	High ($f_0 < f < f_0 + \Delta f_2$)
L	L	Centered (or out of tuning)
H	H	– –

The range $f_0 - \Delta f_1$ to $f_0 + \Delta f_2$ is the AFC capture range and is the frequency range within which the system can go on controlling tuning.

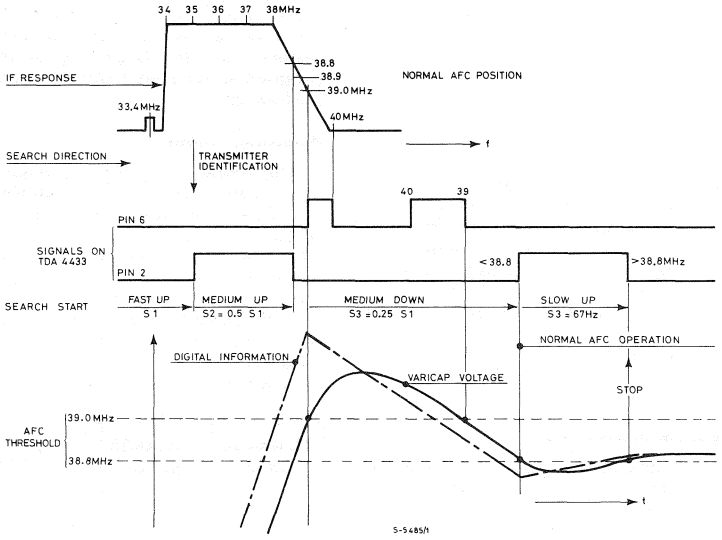
A) NORMAL OPERATION

In this case pins 20 and 21 of M293 act as AFC commands. When a station is perfectly tuned (L L, Center position) no change is made on the tuning voltage. When the tuning moves lower than 38.8 MHz, a signal HL (Low tuning) comes from TDA 4433 and the M293 reacts moving tuning upwards (till when tuning is centered again). This re-tuning is performed at an internally generated slow up speed (61 Hz). In a similar way, when a detuning occurs in the opposite direction, a signal L H (High tuning) comes from TDA 4433 and the tuning voltage will be decreased at an internally generated very slow down speed (7.6 Hz) till when correct tuning is reached. In such a way the system will always be perfectly tuned.

B) RECALL FROM MEMORY

When a program is recalled from memory, a fixed value of 8 steps (~ 31.2 mV) is subtracted from the tuning voltage. During this operation, of course, AFC is disabled and it will be enabled again only when program calling routine is ended: from now on the system will work in normal operation mode (the exact tuning will be reached in ~ 0.2 s).

Fig. 6 - Automatic station capture diagram



C) AUTOMATIC SEARCH

To perform an automatic search, the corresponding command (with or without band change) must be given via local keyboard. The signals coming from pins 2, 6 of TDA 4433 act as search control commands and determine also when the TV station has been tuned, thus stopping the search. The search routine is performed as described below, referring to fig. 6.

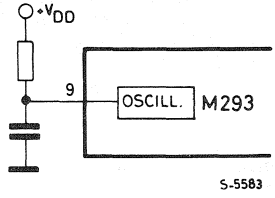
At first the search occurs at fast up speed and eventual transitions present on inputs 20, 21 are ignored during the first steps (15 if the system is searching in UHF or CATV bands, 60 if it is searching in VHF bands).
This delay in transition acceptance has been introduced in order to avoid the system stopping on the previously tuned station (for example if the search command has been accepted just before an AFC command input to pins 20,21). After this delay the tuning increasing speed is automatically halved during each low tuning signal (because this means a station may be near).
A high tuning signal preceeded by at least a low tuning signal will set the search to "medium down" mode (speed is decreased to fast up/4).
The next low tuning signal will stop the search (after these successive transitions, of course, a station has been found), and the system will go back to normal operation.

In order to optimize automatic search, fast up speed is not the same for all the bands: for VHF bands it is equal to the externally fixed rate, while for UHF and CATV bands it is equal to this rate divided by 4. A search routine can be stopped by the user or by recalling a program or by switching to manual operation.

Search speed

The M293 has an internal circuitry which automatically adjusts the tuning increasing/decreasing rate, both in automatic and in manual mode, both in VHF and in UHF/CATV bands. Due to this circuitry, in order to generate all the required search speeds, the M293 needs only two external components (R and C), connected to pin 9 as shown below, which make the internal oscillator work.

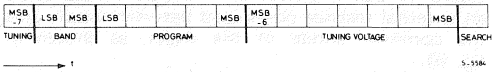
Fig. 7 - Search speed oscillator



Tuning voltage display

Two outputs are provided in the M293 to give the serial information necessary to the M191 to generate the correct tuning scale and band rectangles to be displayed on the TV screen. Pin 17 carries the data information and pin 18 the related clock pulses.
Both data and clock are delivered as 16 pulse bursts, with an internal frequency of 15.63 kHz and a repetition period of ~ 16 ms. The data output carries the following information: the 8 most significant bits of tuning voltage, the 2 bits for band, 5 bits for program information and 1 bit which indicates whether the system is in the search mode (manual and automatic). The data is inverted and the order is as shown in fig. 8.

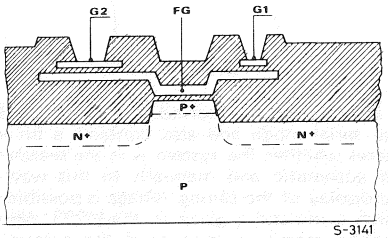
Fig. 8 - Data information



Non volatile memory

A non volatile RAM organized in 32 words of 17 bits is integrated in the device. Each word stores the information necessary to identify and recall one TV (or radio) station. The stored bits are: 12 for the tuning voltage, 2 for the selected band and 3 for the fine tuning.
The NVRAM is a "two stacked electrode" one, fabricated with the SGS double polysilicon gate technology which allows the integration in a single chip of the NVRAM together with all the control logic, thus giving the system the advantages of simplicity and economy. Each cell of the memory consists mainly of a heavily implanted transistor, whose gate is floating and coupled to two polycrystalline silicon electrodes (see fig. 9).

Fig. 9 - Memory cell section



Writing mechanism is similar to that used in FAMOS devices: hot electrons are injected into the floating gate from the substrate and thus a change results in the threshold voltage of the transistor. Charge erasure is achieved controlling electrodes G1 and G2 (G1 has an area much lower than G2): by applying a pulsed high voltage to G1 while keeping G2 low, electrons are removed from the floating gate and the previous threshold voltage is restored for the transistor. Each word of the memory can be written and erased for more than 10000 times and the accelerated data retention tests show that the information will remain stored for more than 10 years.

STORE OPERATION

To store a new station in a memory word, the "Store" routine must be started. In the M293 the Memory Addressing capability is provided which means that selection of the memory position can be made after having performed the station search. In this way the user can perform the search starting from the previous tuned station: when a new station has been tuned he can select the program where he prefers to store that station. After storing he can start a new search and so on.
The typical sequence of storage will be the following:

- press "Memory Addressing/Store" key;
- while holding this key pressed, select the program where the station has to be stored;
- release "Memory Addressing/Store" key.

At this moment the store routine is started;
If this "Memory Addressing" capability is not used, the store routine can be started simply by pressing and releasing the same "Store" key: the routine will start at the release of the key and the station will be stored in the previously selected program. The store operation is inhibited during automatic search.

STORE ROUTINE

When a store routine is started, a timing sequence is internally generated and delivered to the output pin 10. This timing must be buffered externally and applied to pin 8, in order to drive the memory (see application diagrams). In order to optimize the memory life, a particular sequence has been designed for the store routine:

- "1" is written in all the bits of the selected word;
- all bits of the selected word are erased;
- the new content is finally written.

The store operation lasts until the new content is stored in the selected row. The time necessary to perform the complete operation can vary considerably (from some tens to hundreds of milliseconds) during the life of the memory; so an internal maximum time of 1s has been fixed. If the store operation has not been completed within this time, the operation itself is stopped and the device returns to normal operation. This maximum time has been introduced in order to allow the use of the device also when some memory words have been aged too much.
The maximum peak current required when writing all "1s" is 40 mA (with 26V) during writing, with a duty cycle equal to 25%. The maximum average current is therefore 11 mA: a capacitor is used externally to store the charge in the off period (75%) and is discharged during the on period (25%) to provide the energy required for memory storing. During the whole store cycle any command to the device is internally disabled in order to prevent any change in the content to be stored and in the selected memory word. In order to optimize memory life, the store function is internally inhibited after any store routine: it is enabled again after a program change or a tuning operation.

MEMORY READING

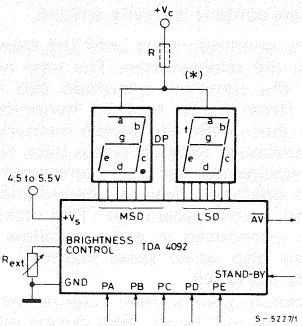
A memory reading routine is automatically started whenever a new program is selected and when a program strobe pulse is applied to input pin 2. When a memory word has to be read, at first mute output is activated in order to avoid noise on TV loudspeaker during program change. In parallel to this, a timing sequence is internally generated, which must be externally buffered and input to pin 8 of the device, as for memory store.
The memory reading routine lasts about 480 ms and maximum peak current required is 6 mA, with a duty cycle equal to ~ 35% (maximum average current is therefore ~ 2.1 mA).

TDA 4092 - 5 bit binary to 7-segment decoder driver

Technology: I^2L

This device is used to display the number of the selected program. Program 1 to 32 can be displayed by means of two 7-segment common anode LED display digits. The circuit accepts 5 bit binary code with TTL levels and has internal pull-up resistors on these inputs. It provides binary plus one decoding (that means 00000 input code is displayed as 1 and 11111 input code is displayed as 32). When program 32 is addressed, an AV output is automatically switched on.
If the TV set is in the stand-by mode, no program number will be displayed but the decimal point will be switched on to indicate the stand-by mode.
A brightness input is provided: connecting a resistor between this input and GND, brightness can be adjusted to a desired value. If 5V is used to supply LEDs, no external resistor is required and the application diagram is as shown below:

Fig. 10 - Application circuit for TDA 4092



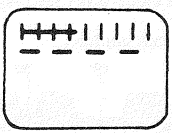
(*) R is necessary only with V_c greater than 5.5V

When a voltage higher than 5V is used to supply LEDS, IC power dissipation must be limited using an external resistor connected between supply and the common anode of the digits, as shown in fig. 10.
In any case, the power dissipation in the device must never exceed the Absolute Maximum Ratings Power Dissipation (which is 800 mW at T_{amb} = 55°C).

M191 - "On screen" tuning scale and band display generator

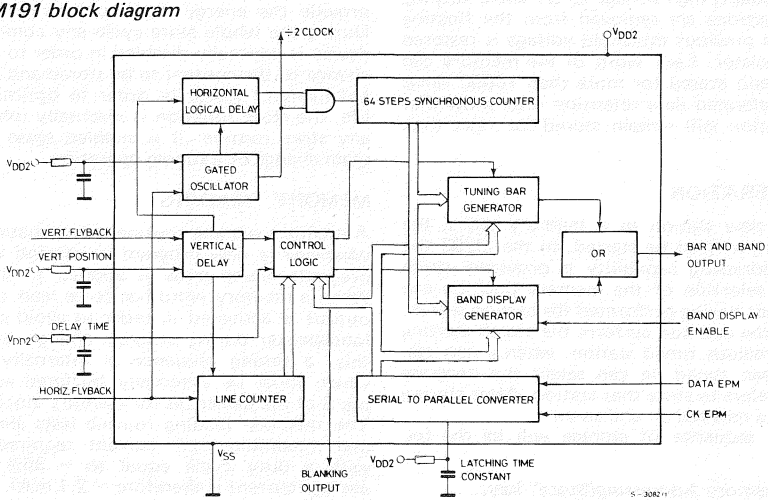
Technology: NMOS

This circuit (see fig. 11) provides the video signals to display on the screen of the television receiver a variable length strip with 64 steps of resolution and corresponding to the voltage applied to the varicap tuner. A variable number of rectangles symbolizing the selected band can also be displayed.



The information is received from the M293 in a digital serial mode and also contains a bit which indicates whether the system is in the search mode (both automatic and manual). In this way automatic display of the tuning voltage is possible when a search command is given to the M293. When the automatic search is over or if the system is in manual mode at the release of the key, the display is held on the screen for a certain time fixed by an RC network. Display with manual command is always possible. The vertical position of the strip can be adjusted with an external potentiometer over the whole screen.

Fig. 11 - M191 block diagram



TDA 4433 - TV signal identification circuit and digital AFC interface

Technology: Bipolar

This circuit essentially consists of two parts (see fig. 12): one is the TV signal detector including a TV sync separator and the other one is a threshold detector for the Digital Automatic Frequency Control. A voltage regulator is also integrated to supply the internal circuit. It is available externally and can be used as reference voltage when filtering the pulse-width modulated fine tuning information coming from the M293. It also has a high and adjustable sensitivity and an output which gives the information of "station identified".

TV signal identification block

The coincidence between the line flyback pulse and the sync video pulses is used to identify a TV video signal. The control is effected on a number of lines defined by an external capacitor charged slightly each time there is a coincidence. When the capacitor reaches a fixed threshold voltage, a Schmitt trigger switches and enabled the AFC control. The criteria used to check the coincidence is the following.

A gate circuit checks whether the sync pulse is within the line flyback pulse. When it happens the integration capacitor is slightly charged. The discharge current is a part of the charge current (about 1/15) and is partially correlated to the ratio of the sync pulse with respect to the line time The discharge current can be externally adjusted thus controlling the sensitivity of the system.

AFC interface

This second part is a threshold detector which recognizes whether the AFC-S--Curve is above or below the zero point (38.9 MHz), giving on the outputs the commands to the M293 to control the tuning voltage.

Program addressing

The kit can be completed or with the M190 (for on-panel operation: to address up to 32 programs a switch must be used in addition) or with remote control circuits (M709/M710 + M104).
Here we summarize only the features of the M190; for the remote control circuits please see the dedicated technical note.

M190 – 16 key keyboard encoder

This circuit (see fig. 13) generate the signals to scan a 16 key keyboard matrix. A key closure is retained as valid when the key remains closed for the entire duration of one scan pulse (i.e. when the bounce is over). When this occurs an internal flip-flop is set but the key closure is accepted only if it is detected on a second scan cycle. The acceptance time is between 35 T and 63 T, if T is the period of the external RC clock. At this point a 4 bit word corresponding to the key closed is internally stored and a pulse is generated on the Muting output. During the time this Mute pulse lasts no other key closure will be recognized.
The new output code follows the Mute signal with a delay. All the timing for the M190 is determined by the clock oscillator whose frequency is externally fixed by an RC network. A step-by-step input is also provided. The lock input blocks the circuit on the last selected program. Program 1 is automatically selected at power-on. The output code in this condition is LLLL.

For a complete addressing of the M293 a switch must be added (see application notes).

Fig. 12 - TDA 4433 block diagram

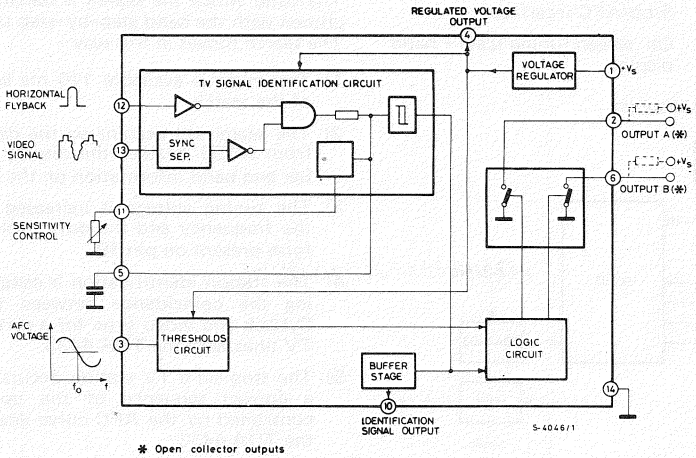
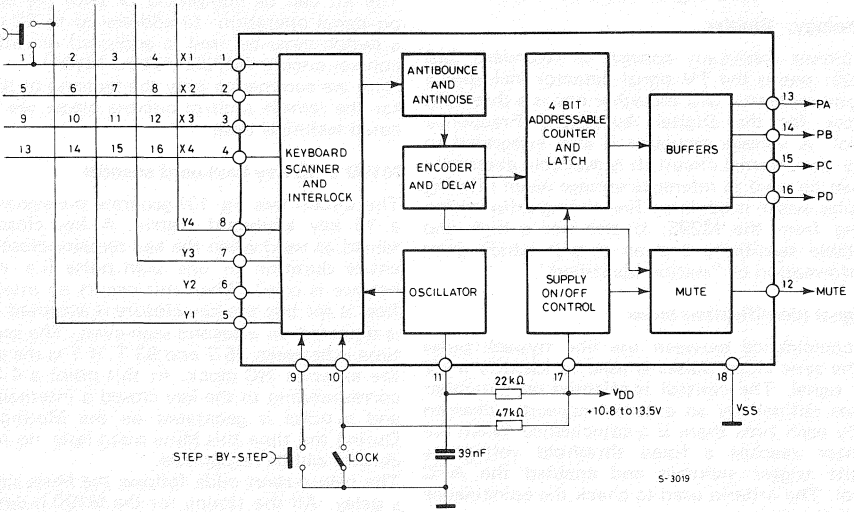


Fig. 13 - M190 block diagram



VARIOUS SYSTEM CONFIGURATIONS

This part describes some system configurations and can be divided into:

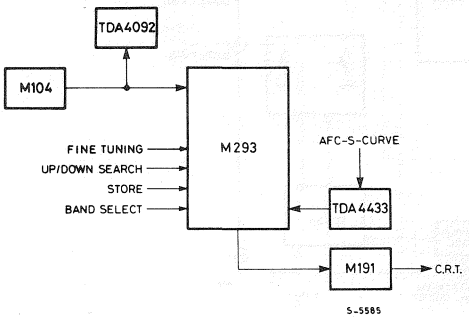
Automatic
Manual
Automatic + Manual
Semiautomatic with digital loop
Manual with linear loop

Automatic (see fig. 14)

System configuration:

– M293	Control and memory
– M104	Remote control receiver
– TDA 4092	Program display
– TDA 4433	Stop/AFC interface
– M191	On screen tuning scale + band display

Fig. 14 a - Block diagram



Operation Sequence

PROGRAM SELECTION

By means of M104: direct or step program selection via remote control or step up/down via local controls (see TV application notes - Program selection). The program selection can be made before or after the search, depending on the method of store desired.

SEARCH START

There are two possibilities:

- Search on the same band.
- Search on all the bands.

The band which the search is starting from, can be chosen with the band step-by-step command.
The search moves in this way:

1) The mute is available 110 ms before the start of the search.
2) The search bit present on the data bus coming from M293 enables the display of the tuning bar and band information on the screen.
3) The tuning voltage is increased by modifying the frequency and the duty cycle of the waveform present on pin 19.
4) The station identification is obtained by checking the coincidence between the horizontal flyback and video sync for a certain number of TV lines with the TDA 4433.
5) The stop on a TV station occurs when there is a correct sequence of the up/down signals controlled by the AFC curve and coming from the TDA 4433.

The correct sequence is a Down signal preceeded by at least an Up signal and followed by an Up transition.

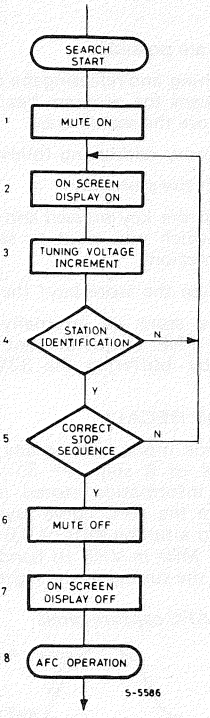
6) As soon as the search is stopped the mute is avoided.

7) The search bit in the data bus disables the on screen display: from this moment the time of presence of the tuning and band information on the screen is due to the RC time constant connected to pin 4 of the M191.

8) After the stop on the TV station the system is switched into the AFC operation mode. In this way the perfect tuning is maintained: every drift with respect to the optimum tuning is digitally correct with the help of the Up/Down signal coming from TDA 4433.

The search speed is a function of the external RC (pin 9) and of the band as shown by the following table:

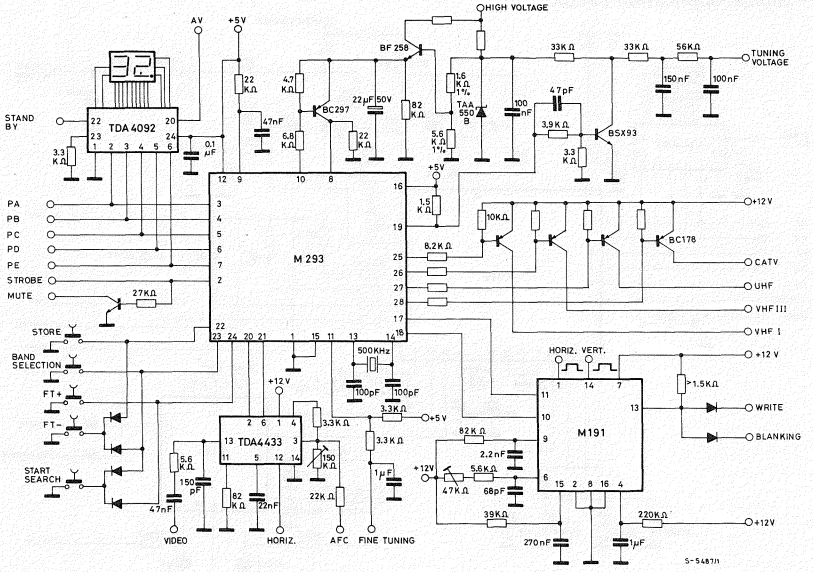
Bands	Speed (f)
UHF – CATV	$\frac{1}{4\,RC}$
VHF I – VHF III	$\frac{1}{RC}$



FINE TUNING

An eventual fine tuning can be performed by local or remote control.

Fig. 14 b - Automatic application circuit



STORE

Two ways are possible:

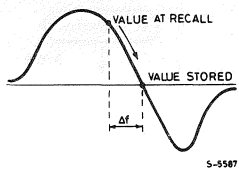
1) by pushing and releasing the corresponding key: that means the program has already been selected before the search start.
2) by memory addressing following this sequence:
   - push the store key;
   - keep the key pressed and select the program in which you want to store the tuning information;
   - release the store key: the store cycle starts.

During the store an internally generated timing controls a PNP transistor that switches the 25V obtained by buffering the 33V reference zener.

PROGRAM RECALL

In automatic mode, during any program recall, a fixed value of 8 steps (≃ 31 mV) is subtracted from the information stored in the memory to compensate the AFC curve asymmetry. This corresponds to a tuning shift of 0.6 MHz in UHF band and of 0.3 MHz in VHF III band. AFC control will then bring the tuning to the right point.

Fig. 15 - AFC capture range

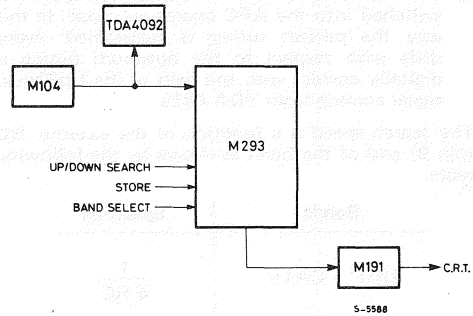


Manual (see fig. 16)

System configuration:

– M293	Control and memory
– M104	Remote control receiver
– TDA 4092	Program display
– M191	On screen display

Fig. 16 a - Block diagram

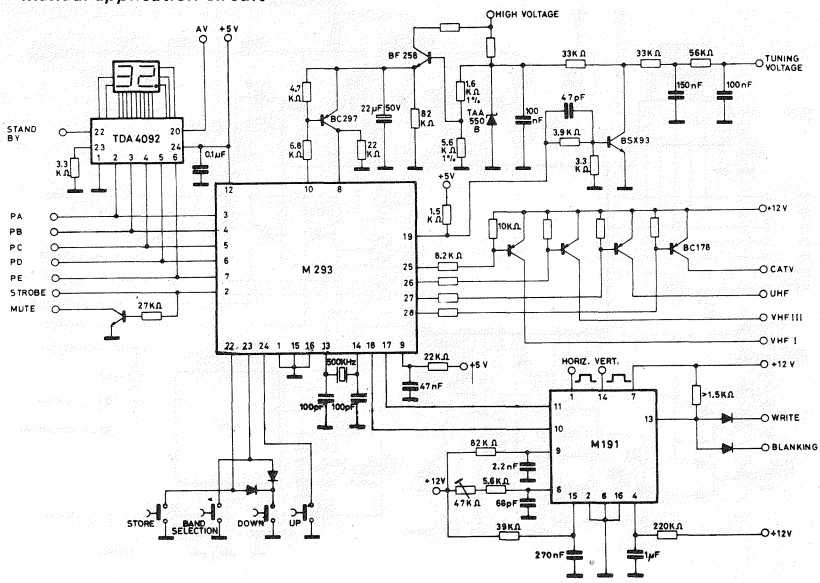


Operation Sequence

PROGRAM SELECTION

Via M104: direct or step program selection by remote control or step up/down by local controls (see TV application notes - Program selection). The program selection can be made before or after the up/down search: that is depending on the store system chosen.

Fig. 16 b - Manual application circuit

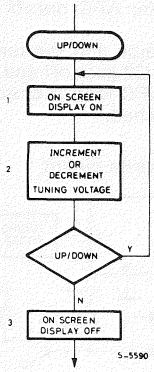


BAND SELECTION

Step-by-step

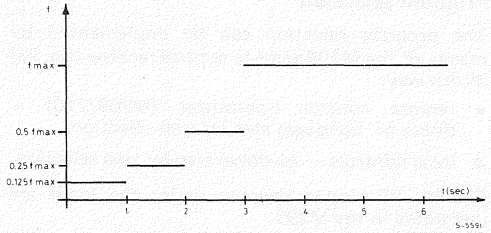
UP/DOWN SEARCH

The up/down search moves in this way:



1) As soon as an up or down command is detected the on screen display is enabled.
2) The tuning voltage is increased or decreased depending on the up or down command. The search starts slowly and is increased every second up to the maximum speed in the following way:

Fig. 17 - Search speed.



The maximum speed is determined by the external RC and the band information as shown by the following table:

Bands	Speed (f)	
CATV – UHF	$\frac{1}{12}$	$\frac{1}{RC}$
VHF I – VHF III	$\frac{1}{3}$	$\frac{1}{RC}$

Every time the up/down keys are released and then pushed again, the search restarts slowly. With this automatic change in the search speed it is possible to obtain a slow and fast search by using only two keys.

3) When the search is stopped the on screen display is disabled: the information will be displayed on the screen for a time due to the RC constant on pin 4 of the M191.

FINE TUNING

STORE

By means of the store or memory addressing way.

PROGRAM RECALL

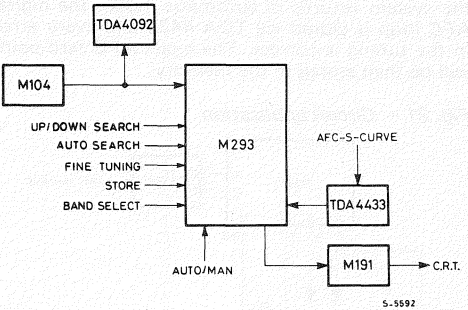
At program recall no step is subtracted from the store value.
The recall of the same program is possible by using the strobe/mute input output.

From automatic and manual application some other configurations can be generated: the application circuits look like the manual or automatic circuits apart from few components.

Automatic + Manual

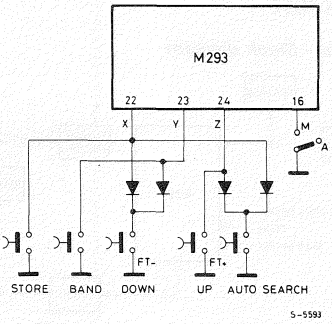
System configuration: see Automatic

Fig. 18 - Block diagram



The change Auto/Manual is obtained by switching pin 16 of the M293 from ground (MAN) or open (AUTO): an internal pull-up is provided to give a high level when the pin is left open.
With this configuration there are two keys with double function: during automatic mode they perform the fine tuning function while during manual mode they are used to have the up/down search.

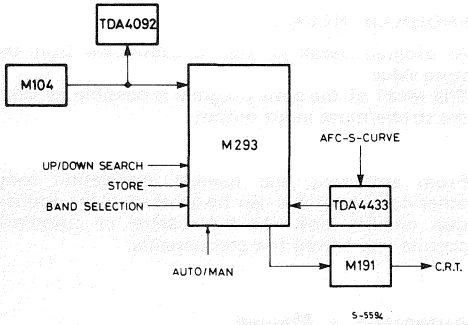
Fig. 19 - Auto/Manual application



Semiautomatic with ditigal loop (see fig. 20)

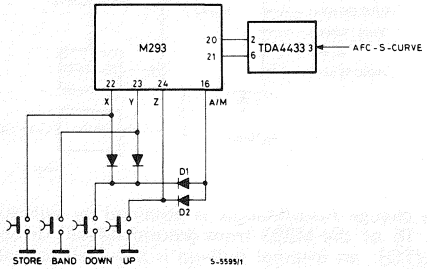
System configuration (see Automatic)

Fig. 20 - Block diagram



The search is effected in manual mode: every time Up or Down key is pressed the system is put in manual by means of D1 or D2 diode and pin 16. When the station is tuned and the keys are released, the system returns in automatic mode: the digital AFC loop is closed via TDA 4433 and every error in the tuning is correct. The exact AFC zero point will be then stored in the memory.

Fig. 21 - Circuit application

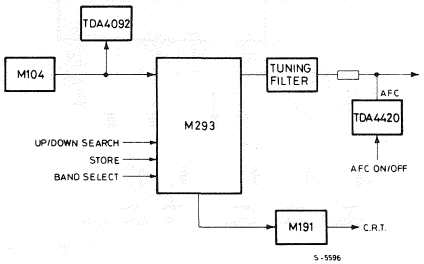


Manual with linear loop (see fig. 22)

System configuration

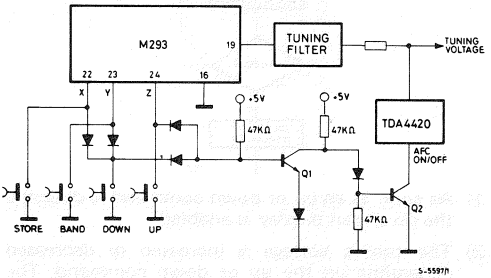
- M293
- M104
- M191
- TDA 4092

Fig. 22 a - Block diagram



Some TV sets have the tuning correction with a linear loop: in these cases a resistor network is connected between the AFC output and the output of the tuning filter. During the search it could be necessary to open this linear loop: for this reason the two keys up/down are connected to a circuit that disables the AFC output. Usually a low level applied on the AFC on/off input makes the AFC output off.
Once made the search and the tuning by releasing the up/down keys Q2 goes off and the AFC output is on: the linear AFC loop is closed and the exact tuning point is reached.

Fig. 22 b - Application circuit



TV APPLICATION NOTES

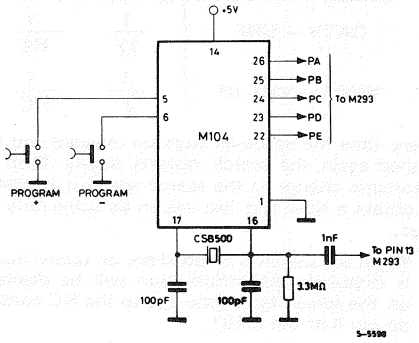
Program selection

The program selection can be implemented by means of the M104 remote control receiver (fig. 23) in this way:

- remote control transmitter (M709/710) — direct or up-down step by step selection;
- local controls — up-down step by step selection.

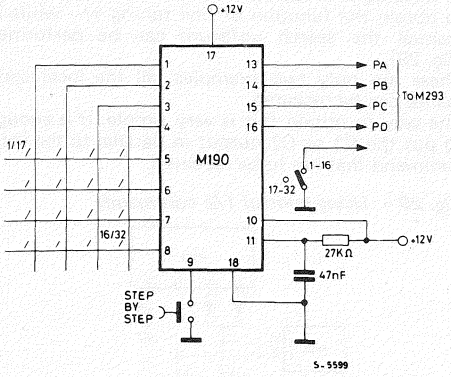
The PA- PE outputs are open drain; the loads are integrated in the M293.
The M104 performs also other functions as analog controls and on/off relay driver: also the clock reference can be taken from it.

Fig. 23 - Program selection with M104



To select the program with a simple local keyboard it is possible to use the M190. The problem is the M190 has only four outputs: the fifth bit can be obtained with a switch (fig. 24).

Fig. 24 - Program selection with M190



Store, memory addressing and copy capability

The M293 has three possible modes of operation regarding the storage phase.
All this is possible without the need of external components.
The sequence of the operations is the following:

Store:

1 Program selection
2 Search and tune
3 Store

Memory addressing:

1 Search and tune
2 Press store key and hold down
3 Select the program where tuning has to be stored
4 Release store key

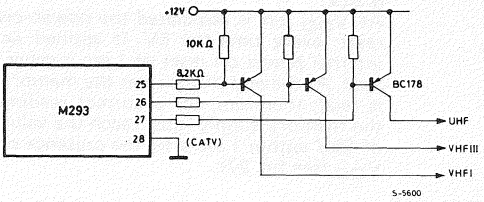
Copy capability:

1 Select the program to be copied
2 Press the store key and hold down
3 Select the new program where the selected program has to be copied
4 Release the store key

Jumping a band

The M293 has four bands: if one or more bands are not used it is possible to jump them by simply putting the corresponding pins to ground.
The outputs grounded are automatically jumped during the band step command or the search with band change (see fig. 25).

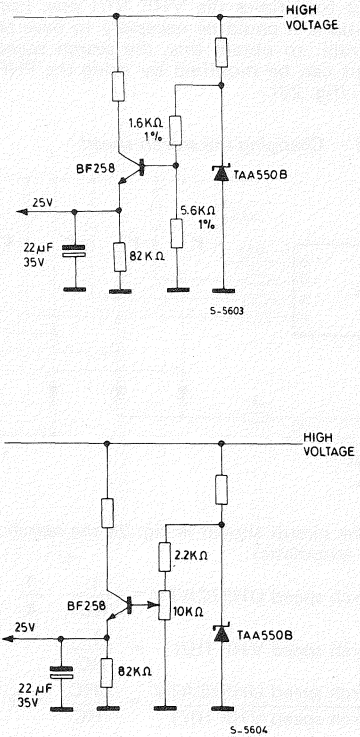
Fig. 25 - Jumping a band (CATV)



M293 Power Supplies

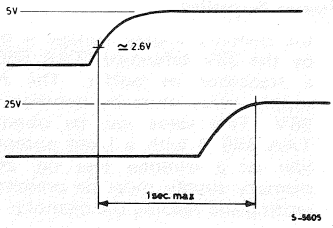
V_{PP} : the memory supply voltage is obtained by the 33V reference (TAA 550B) and a transistor as buffer. The memory supply value must be between 24 and 26V. This value can be obtained by TAA 550 B with a fixed potential divider or a trimmer (see fig. 26). The memory supply must be present during writing and reading the memory.

Fig. 26 - Memory supply



V_{DD} : the value must be between 4.75 and 5.25V.
At V_{DD} pin is associated the power-on reset: every time the 5V is applied an internal power on reset of 1 sec is generated. At the end of the reset the memory is read; therefore, for a correct reading the memory supply must reach the value of 25V within 1 sec after the presence of V_{DD} (see fig. 27).

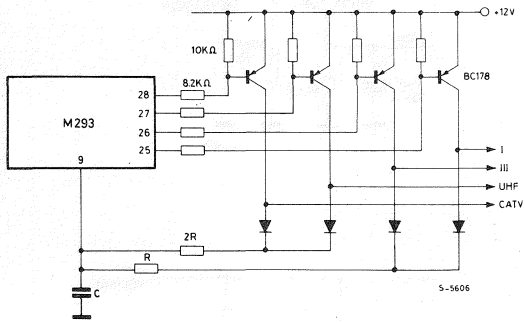
Fig. 27 - Power on sequence



Adjusting the search speed

The M293 was designed to have the search speed correlated with the band: the UHF/CATV search speed is four times the VHF III/I one. For some applications it could be necessary to have another speed rate: to obtain this, the search speed time constant can be modified by using the PNP band drivers, (fig. 28).

Fig. 28 - Changing the search speed



With the circuit shown in fig. 28 the search speeds are (in automatic):

$$\text{search speed UHF/CATV} = \frac{1}{2RC} \quad \frac{1}{4}$$

$$\text{search speed VHF III/I} = \frac{1}{RC}$$

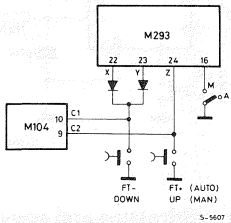
$$\frac{\text{search speed UHF/CATV}}{\text{search speed VHF III/1}} = \frac{8RC}{RC} = 8$$

In manual mode there is a further division (÷ 3) but the ratio remains the same.

Using control 1 and 2 outputs from IR receiver

The control 1 (C1) and 2 (C2) outputs of the M104 can be used in conjunction with the M293 to have some local commands repeated on the Infrared transmitter.
In automatic mode these outputs are usually used to obtain the function of fine tuning +/— while in manual the search up/down can be performed (fig. 29).
These are only two examples: all the local commands can be repeated.
The way to obtain this is very simple: it is enough to put the C1 or C2 output in parallel to the local command that has to be repeated.

Fig. 29 - Using control 1/2 commands



D/A Converter

In fig. 30 and 31 two types of D/A converter are shown.
The second circuit has a better temperature stability and linearity: you can also see how to connect an instrument to display the varicap voltage.

Fig. 30 - D/A converter

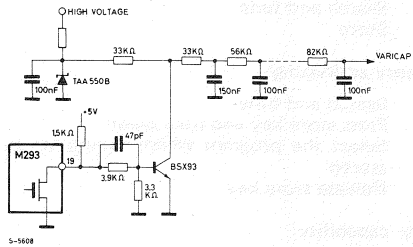
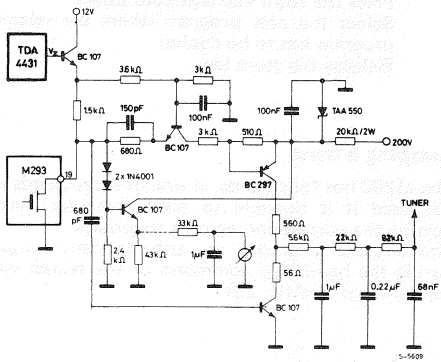


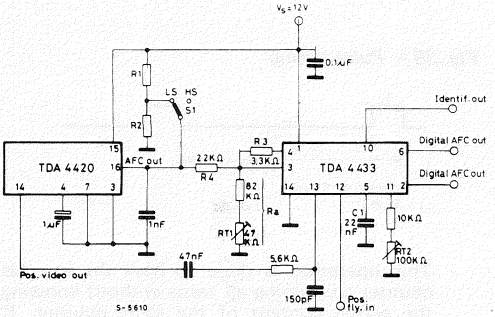
Fig. 31 - D/A converter



Interfacing TDA 4433 with AFC circuits

If the TDA 4420/1 is used, the typical application is shown in fig. 32.

Fig. 32 - Application circuit



The passive components should be chosen as follows:

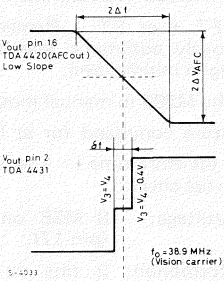
R1 and R2 : these define the AFC response slope. For R1 = R2 = 5.1 KΩ, the typical slope is 750/11 kHz/V (with AFC output unloaded).

S1 : switches between low slope (LS) and high slope (HS). The high slope is typically 88/11 kHz/V.

R3 and R4 : the ratio (R3 + R4)/R3 defines the digital AFC width (δ f) calculated from the linear AFC width (2Δf). Width V_S = 12V, the relation is:

$$f = 0.036\ 2\Delta f\ \frac{R3 + R4}{R3}$$

Fig. 33 - Linear and digital AFC



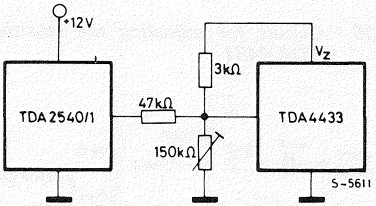
RT1 : by means of this trimmer it is possible to align the linear tuning with the digital one, at the same frequency. The typical relation is:

$$Ra = 33\ R3$$

RT2 : with R3 = 3.3 KΩ, Ra can be a fixed resistor of 110 KΩ. By means of this trimmer it is possible to choose the better sensitivity. It is possible to put a fixed resistor at pin 11 in the range of 68 KΩ to 100 KΩ.

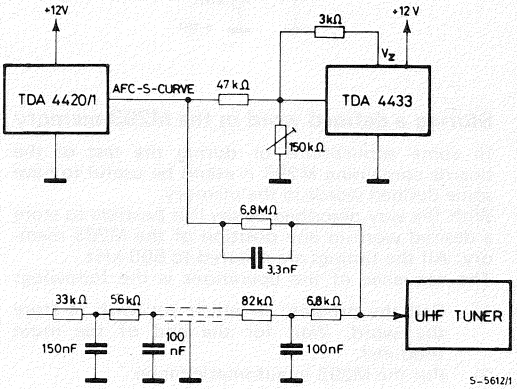
If type TDA 2540/1 is used a good solution is shown in fig. 34.

Fig. 34 - Interface network between TDA 4431 and TDA 2540/1



When a high slope in the AFC curve is used, it is possible to have oscillations around the tuning point due to the relative high updating of the digital AFC (64 Hz) in comparison with the delay of the tuning filter (≅ 150 ms).
To avoid these oscillations which are visible on the screen, a small linear AFC is added to the tuning voltage (fig. 35). In this way a fast correction loop is superimposed to the digital slow loop.

Fig. 35 - Interface network between AFC-S-Curve and the tuner



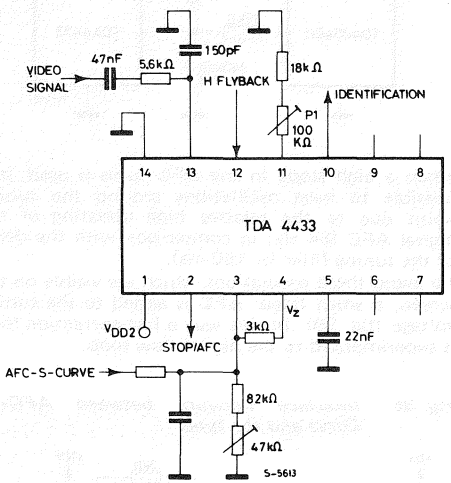
Adjusting the sensitivity of TDA 4433

The capacitor controls the time constant of the coincidence detector. By reducing the value of C, the integration time constant is reduced and the reaction of the system is faster. But in presence of weak TV signals, the circuit can easily make detection errors and, as a consequence, it can cause wrong operation of the system during automatic station search. A control of the sensitivity is possible by controlling the discharge current of the integration capacitor.

A relatively high value capacitor can be chosen in conjunction with a relatively small discharge current, so achieving a high sensitivity and fail proof detection circuit. By applying a signal having the

minimum value the circuit has to recognize to the video input of TDA 4431 it is possible to set the sensitivity. This is done by tuning trimmer P1 and controlling the detection/not detection on pin 10 (see fig. 36).

Fig. 36 - Circuit for adjusting the sensitivity of TDA 4431

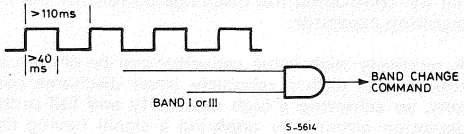


Storing a defined word in the M293 memory

In some applications or during the test of the boards containing M293 it could be useful to have some defined words in the memory.
With the way described below it is possible to store a desired word in any position of the M293 memory. All the timings are referred to 500 kHz.
The sequence of the operations is the following:

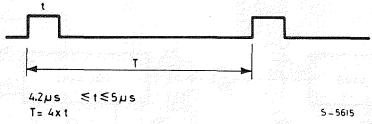
1) Call the program in which you wish to store the word. Wait for the end of the mute (480 ms).
2) Put the M293 in automatic mode.
3) Select band I or III.
   The reason of selecting these bands is that in these conditions the internal counter (tuning counter) is directly connected to pin 9 (search speed). A way of going in band I or III without knowing the actual band selected is to give 4 pulses as shown in fig. 37:

Fig. 37 - Selection band I or III



4) Give an automatic search without band change command for at least 40 ms.
5) Give 8192 pulses on pin 9.
   The waveform of the pulses must be as shown in fig. 38.

Fig. 38 - Pulse timing



This operation is done to have the internal counter containing all zeros without knowing the actual content of the same counter. If you give 8192 pulses, you surely pass through the condition of all zeros: in this condition there is a "break" of 480 ms that disables the search. Since this break is greater than 8192 x 4 x 4 μsec (≃ 131 ms), you are sure that at the end of the 8192 pulses the internal counter contains all zeros. It is better to put a resistor between the pulse generator and pin 9.

6) Wait for 480 ms for the end of the "break".
7) Give on pin 9 the desired number of pulses.
8) Put the M293 in manual mode.
9) Select the band information that you want to store (waveform in fig. 39).
10) If you want to store a certain information of fine tuning:
    - put the M293 in automatic;
    - give FT + or FT -. Remember that the previously automatic search has put fine tuning in middle level.
    - put the M293 in manual mode.
11) Give a store command for at least 40 ms.
12) Wait for the store time (≃ 1 sec).
    For a partial check:

    Tuning Voltage: 8 MSB on data output (pin 17).

    Band Information: 2 bits on data output (pin 17) or band outputs (pins 25, 26, 27, 28).

Fig. 39 - Band select